CHARACTERIZATION OF MUNICIPAL SOLID WASTE IN THE UNITED STATES:

1997 UPDATE

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by

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CHARACTERIZATION OF MUNICIPAL SOLID WASTE IN THE UNITED STATES: 1997 UPDATE

Executive Summary

FEATURES OF THIS REPORT

This report is the latest in a series of reports published by the U.S. Environmental Protection Agency (EPA) describing the national municipal solid waste (MSW) stream. The report characterizes the national solid waste stream for 1996. It also discusses trends and highlights changes that have occurred over the years, both in the types of wastes generated and in the ways they are managed. Although the report does not specifically address local and regional variations in the waste stream, the data in the report can be used to develop approximate estimates of MSW generation and composition in defined areas.

This report includes information on:

- Total MSW generation, recovery, and discards from 1960 to 1996.
- Per capita generation and discard rates.
- Materials (e.g., paper, glass, metals, plastic) that comprise MSW, as well as products (e.g., durable and nondurable goods, containers, packaging) found in the waste stream.
- Aggregate data on the infrastructure for MSW management, including estimates of the number of curbside recycling programs, drop-off centers, materials recovery facilities, and composting programs in the United States.
- Trends in MSW management from 1960 to 1996, including source reduction, recovery for recycling (including composting), and disposal via combustion and landfilling.
- Markets for major recovered materials (paper and paperboard, container glass, aluminum cans, steel in cans and appliances, PET and HDPE plastics, and compost).

REPORT HIGHLIGHTS

1996 MSW Generation and Management:

- A total of 209.7 million tons of MSW was generated in 1996. This reflects a decrease of nearly 2 million tons from 1995, when MSW generation was 211.5 million tons.

- The per capita generation rate in 1996 was 4.3 pounds per person per day, compared to 4.4 pounds per person per day in 1995.

- The per capita discard rate (after recovery for recycling, including composting) was 3.2 pounds per person per day in 1996, down from 3.3 pounds per person per day in 1995.

- Recycling (including composting) recovered 27 percent (57 million tons) of MSW in 1996, up from 26 percent (55 million tons) in 1995.*

- There were nearly 9,000 curbside recycling programs in the United States in 1996, as well as more than 10,000 drop-off centers for recyclables. About 360 materials recovery facilities helped process the recyclables collected. More than 3,000 yard trimmings composting programs were reported.

- Recovery of paper and paperboard reached 41 percent (33 million tons) in 1996, accounting for more than half of the total MSW recovered. In addition, nearly 11 million tons of yard trimmings were recovered for composting in 1996, accounting for the second largest fraction of total recovery. The percentage of yard trimmings composted (38 percent) has more than doubled since 1992.

- Landfills managed 55 percent of MSW generated (116 million tons), down from 57 percent in 1995. Combustion facilities managed 17 percent (36 million tons) of total MSW generated, about the same as in 1995.

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* Data shown for years prior to 1996 have been adjusted to reflect the latest revisions to the methodology and therefore may differ slightly from the same measure reported in previous updates.

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 is a source reduction activity involving the recovery or reapplication of a package, used product, or material in a manner that retains its original form or identity. 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 (including composting), landfilling, or combustion takes place.

Recovery of materials means removing MSW from the waste stream for the purpose of recycling (including 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 (including 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.

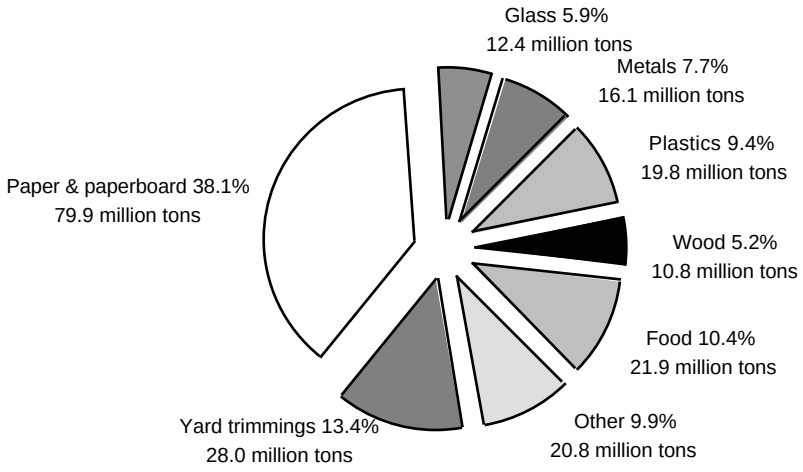
MUNICIPAL SOLID WASTE IN 1996

MSW consists of both materials and products. Materials in MSW include paper and paperboard, yard trimmings, glass, metal, plastics, wood, and food wastes. Each material category (except for food wastes and yard trimmings) is made up of many different products. 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. 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.

Materials in MSW

In 1996, MSW generation totaled 209.7 million tons. Figure ES-1 provides a breakdown, by weight, of the MSW materials generated in 1996. Paper and paperboard products made up the largest component of MSW generated (38 percent), and yard trimmings comprised the second largest material component (13 percent). Glass, metals, plastics, wood, and food wastes each constituted

Figure ES-1. Materials generated in MSW by weight, 1996
(Total weight = 209.7 million tons)



between 5 and 10 percent of the total MSW generated. Other materials in MSW, such as rubber, leather, textiles, and miscellaneous wastes, made up approximately 10 percent of the MSW generated in 1996.

A portion of each material category in MSW was recycled or composted in 1996, as illustrated in Table ES-1. It should be noted, however, that recovery rates for some products within a material category are higher than the overall recovery rate for the material category, because some products are not

Table ES-1

GENERATION AND RECOVERY OF MATERIALS IN MSW, 1996
(In millions of tons and percent of generation of each material)

	Weight Generated	Weight Recovered	Recovery as a Percent of Generation
Paper and paperboard	79.9	32.6	40.8%
Glass	12.4	3.2	25.7%
Metals			
Ferrous metals	11.8	4.5	38.0%
Aluminum	3.0	1.0	34.3%
Other nonferrous metals	1.3	0.8	66.8%
Total metals	16.1	6.4	39.6%
Plastics	19.8	1.1	5.3%
Rubber and Leather	6.2	0.6	9.5%
Textiles	7.7	1.0	12.3%
Wood	10.8	0.5	4.5%
Other materials	3.7	0.8	21.2%
Total Materials in Products	156.6	46.0	29.4%
Other Wastes			
Food Wastes	21.9	0.5	2.4%
Yard Trimmings	28.0	10.8	38.6%
Miscellaneous Inorganic Wastes	3.2	Neg.	Neg.
Total Other Wastes	53.1	11.3	21.3%
TOTAL MUNICIPAL SOLID WASTE	209.7	57.3	27.3%

Includes wastes from residential, commercial, and institutional sources.
Neg. = Less than 50,000 tons or 0.05 percent.

recovered at all. For example, aluminum cans are recovered at rates above 60 percent, but the overall recovery rate for aluminum is 34 percent. Likewise, even though corrugated containers are recovered at a rate of nearly 67 percent, the overall recovery rate for paper and paperboard is 41 percent.

For this Update, significant changes were made in the methodologies and data sources for wood and food wastes. These changes, which were incorporated into revised estimates for 1990 through 1995, result in an increase in the estimated total amount of MSW generation previously published. (See Chapter 2 for discussions of these changes.) Because of the increases in generated tonnage,

revised total recovery percentages for the years 1990 through 1995 declined slightly.

Products in MSW

Figure ES-2 shows the breakdown, by weight, of MSW products generated in 1996. Containers and packaging comprised the largest portion of products generated, at 33 percent (69 million tons) of total MSW generation. Nondurable goods were the second largest fraction, comprising about 27 percent (56 million tons). The third main category of products is durable goods, which comprised 15 percent (32 million tons) of total MSW generation.

Figure ES-2. Products generated in MSW by weight, 1996
(Total weight = 209.7 million tons)

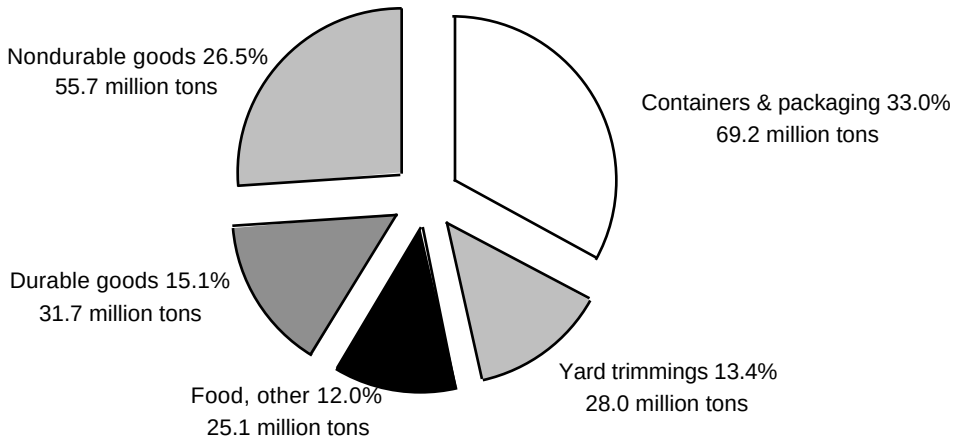


Table ES-2 shows the generation and recovery of the product categories in MSW. Recovery of **containers and packaging** was the highest of the three product categories—40 percent of containers and packaging generated in 1996 were recovered for recycling. About 52 percent of aluminum packaging was recovered (mostly aluminum beverage cans), while more than 56 percent of steel packaging (mostly cans) was recovered. Paper and paperboard packaging recovery was estimated at 54 percent; corrugated containers accounted for most of that figure. Approximately 29 percent of glass containers were recovered overall, while about 8 percent of wood packaging (mostly pallets removed from service)

was recovered for recycling. About 10 percent of plastic containers and packaging was recovered in 1996, mostly soft drink, milk, and water bottles.

Overall recovery of **nondurable goods** was 23 percent in 1996. Newspapers constituted the largest portion of this recovery, with 54 percent of newspapers generated being recovered for recycling. High-grade office papers and magazines were also recovered in significant quantities in 1996, at 48 percent and 24 percent, respectively. About 16 percent of clothing and other textile nondurable products also were recovered for recycling.

Overall, **durable goods** were recovered at a rate of 17 percent in 1996, up from 16 percent in 1995. Nonferrous metals had one of the highest recovery rates, at 67 percent, due to the high rate of lead recovery from lead-acid batteries. Nearly 32 percent of ferrous metals were recovered from appliances and miscellaneous durable goods. Excluding retreads and tire-derived fuel use, over 18 percent of tires also were recovered for recycling.

Residential and Commercial Sources of MSW

Sources of MSW, as characterized in this report, include both residential and commercial locations. Residential waste (including waste from multi-family dwellings) is estimated to be 55 to 65 percent of total MSW generation. Commercial waste (including waste from schools, some industrial sites where packaging is generated, and businesses) constitutes between 35 and 45 percent. Local and regional factors, such as climate and level of commercial activity, contribute to these variations.

Table ES-2

GENERATION AND RECOVERY OF PRODUCTS IN MSW
BY MATERIAL, 1996
(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	8.8	2.8	31.8%
Aluminum	0.8	Neg.	Neg.
Other non-ferrous metals	1.3	0.8	66.8%
Total metals	10.9	3.7	33.4%
Glass	1.3	Neg.	Neg.
Plastics	6.3	0.3	4.0%
Rubber and leather	5.4	0.6	11.0%
Wood	4.3	Neg.	Neg.
Textiles	2.4	0.1	5.3%
Other materials	1.0	0.8	74.7%
Total durable goods	31.7	5.4	17.1%
Nondurable goods			
Paper and paperboard	41.4	12.0	29.0%
Plastics	5.3	Neg.	<1%
Rubber and leather	0.8	Neg.	Neg.
Textiles	5.2	0.8	15.8%
Other materials	2.8	Neg.	Neg.
Total nondurable goods	55.7	12.9	23.1%
Containers and packaging			
Steel	3.0	1.7	56.4%
Aluminum	2.0	1.0	52.2%
Total metals	4.9	2.7	54.7%
Glass	11.0	3.2	28.7%
Paper and paperboard	38.5	20.6	53.5%
Plastics	8.2	0.8	9.8%
Wood	6.5	0.5	7.5%
Other materials	0.1	Neg.	Neg.
Total containers and packaging	69.2	27.7	40.1%
Other wastes			
Food wastes	21.9	0.5	2.4%
Yard trimmings	28.0	10.8	38.6%
Miscellaneous inorganic wastes	3.2	Neg.	Neg.
Total other wastes	53.1	11.3	21.3%
TOTAL MUNICIPAL SOLID WASTE	209.7	57.3	27.3%

Includes wastes from residential, commercial, and institutional sources.
Neg. = less than 50,000 tons or 0.05 percent.

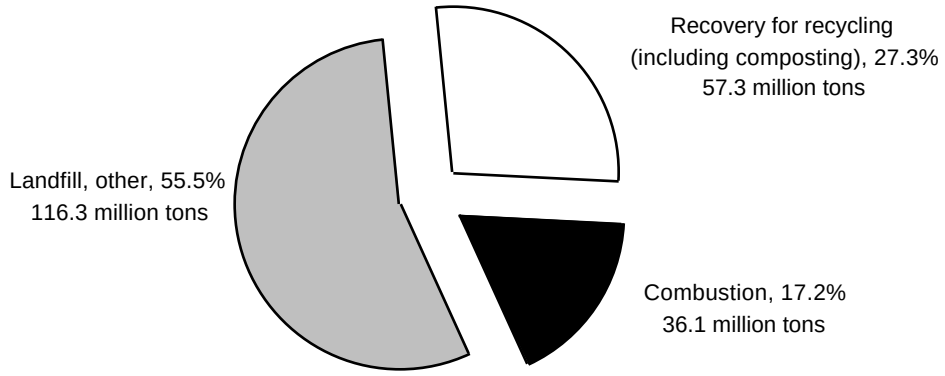
MANAGEMENT OF MSW

EPA's integrated waste management hierarchy includes the following components:

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

Figure ES-3 shows how much MSW was recovered for recycling (including composting) and how much was disposed of by combustion and landfilling in 1996. Approximately 27 percent (57 million tons) of MSW was recycled and composted; an estimated 17 percent (36 million tons) was combusted (nearly all with energy recovery); and the remainder, 55 percent (116 million tons), was landfilled. (Although, of this total small amounts may have been littered or self-disposed rather than landfilled.)

Figure ES-3. Management of MSW in U.S., 1996
(Total weight = 209.7 million tons)



Source Reduction

Source reduction includes the design, manufacture, purchase, or use of materials, such as products and packaging, to reduce their amount or toxicity before they enter the MSW management system. Some examples of source reduction activities are:

- Designing products or packaging to reduce the quantity or the toxicity of the materials used, or to make them easy to reuse.
- Reusing existing products or packaging.
- Lengthening the lives of products to postpone disposal.
- Using packaging that reduces the amount of damage or spoilage to the product.
- Managing nonproduct organic wastes (e.g., food scraps and yard trimmings) through on-site composting or other alternatives to disposal (e.g., leaving grass clippings on the lawn).

Product source reduction activities are not quantified at the national level in this report. The report does include a section discussing source reduction trends in packaging and nondurable paper products.

On a per-person basis, generation of packaging has been about constant, while at the same time, consumption of food and other products has been increasing. Again on a per-person basis, generation of nondurable paper products (newspapers, office papers, mail, and other printed products) has been about constant since 1990, compared to rapid increases in previous years. At the same time, electronic communication media (e-mail, Internet) have been increasing rapidly. There also has been some shift of advertising dollars from printed media to nonprinted media (television, radio, Internet). Trends are not yet clear, but electronic communications and data exchange *may* be slowing the rate of growth of paper products.

Recovery

Recovery for recycling (including composting) continues to be one of the most effective waste management techniques. In it's Annual Survey of solid waste management practices, BioCycle Magazine (April 1997) reports that approximately 51 percent of the U.S. population (135 million people) had access to the nation's nearly 9,000 curbside recycling programs in 1996. Seventy-five percent of the programs were in the Northeast and Midwest. In addition, over 10,000 drop-off centers for recyclables were reported in 1996. About 360 materials recovery facilities helped process the recyclables collected in 1996. An estimated 3,300 yard trimmings composting programs (not backyard composting) existed in 1996; the majority of these programs were in the Northeast and Midwest.

Combustion

Most MSW combustion in the United States involves the recovery of an energy product (generally steam or electricity). Total MSW combustion with energy recovery, referred to as waste-to-energy combustion, currently has a design capacity of 100,000 tons per day. There were 110 waste-to-energy combustion facilities in the United States in 1996; nearly 40 percent of these were located in the Northeast, accounting for 48 percent of total design capacity. In addition, there were 8 facilities preparing refuse-derived fuel, and a small amount of capacity (2,000 tons per day) for incineration without energy recovery.

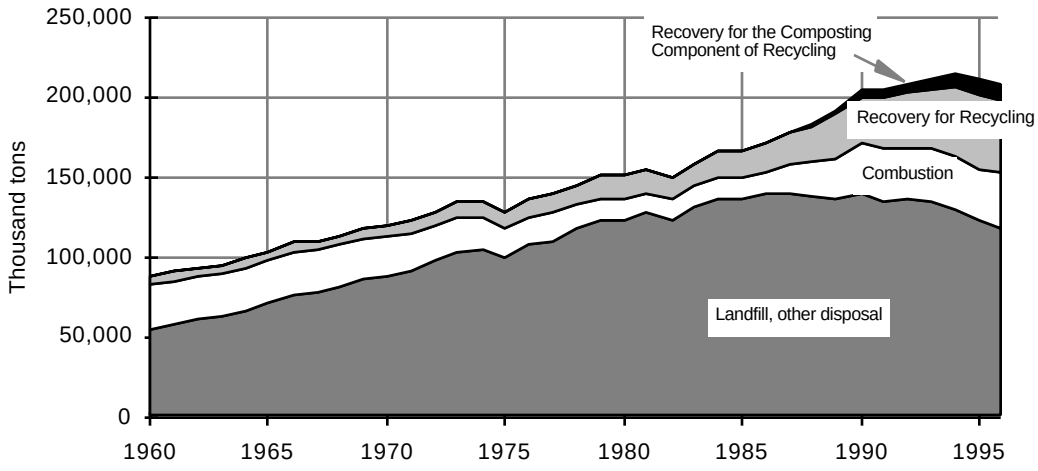
Landfilling

Although the number of landfills in the United States is decreasing, landfill capacity has remained relatively constant. In 1996, approximately 2,400 municipal solid waste landfills were reported in the contiguous United States, with the Southeast and West having the greatest number of landfills. Thirty-five states had landfills reporting more than 10 years of capacity remaining. Only three states reported having less than 5 years of capacity left.

Trends in MSW Management

MSW generation grew from 88 million tons in 1960 to 214 million tons in 1994 but has since dropped off to about 210 million tons in 1996 (Figure ES-4). In the 1960s and early 1970s, a large percentage of MSW was burned. Through the mid-1980s, incineration declined considerably and landfills became more difficult to site. MSW generation continued to rise, however, while materials recovery rates increased slowly. As a result, the burden on the nation's landfills grew dramatically. Although there are now fewer municipal solid waste landfills, their average size has increased and capacity at the national level does not appear to be a problem. However, regional dislocations sometimes occur. As recovery rates increased in the late 1980s and early 1990s—and combustion stayed constant—discards to landfills have steadily decreased.

Figure ES-4. Municipal Solid Waste Management, 1960 to 1996



Chapter 1

INTRODUCTION AND METHODOLOGY

BACKGROUND

This report is the most recent in a 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 36-year characterization (by weight) of the materials and products in MSW.

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 (including 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 (including composting), 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 this chapter.

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. The report is, however, 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 person 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

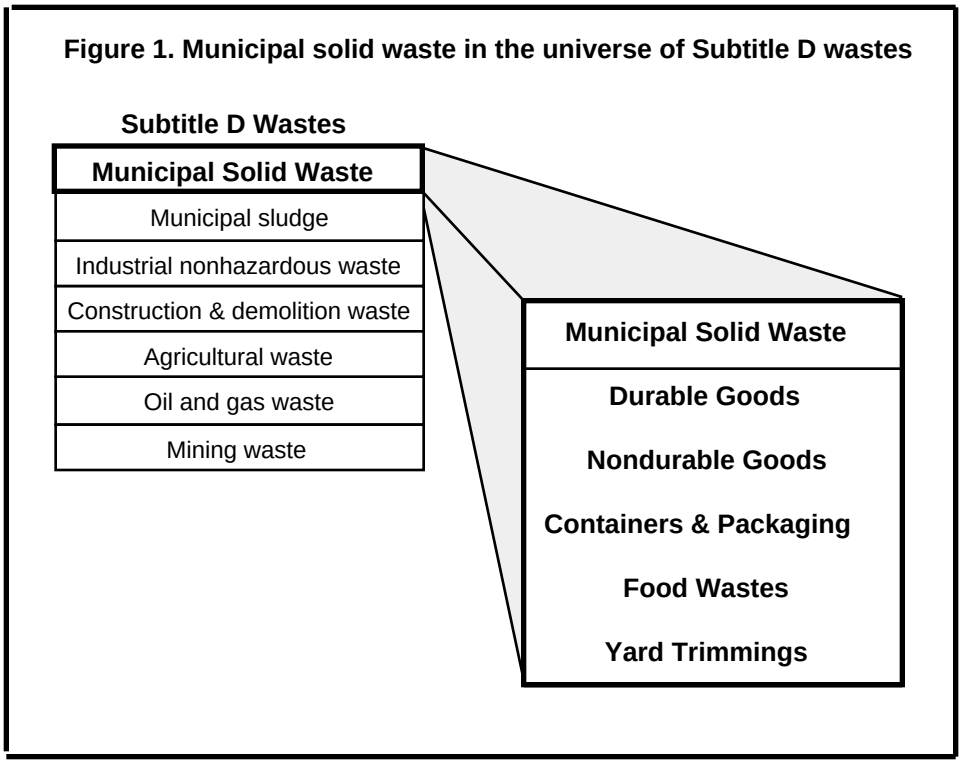
Municipal solid waste includes durable goods, nondurable goods, containers and packaging, food wastes and yard trimmings, and miscellaneous inorganic wastes (Figure 1). Municipal solid wastes characterized in this report come from residential, commercial, institutional, and industrial sources. Some examples 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. Generation data is the result of making specific adjustments to the production data by each material and product category. 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.

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.

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 is a source reduction activity involving the recovery or reapplication of a package, used product, or material in a manner that retains its original form or identity. Reuse of products such as refillable glass bottles, reusable plastic food storage containers, or refurbished wood pallets is considered source reduction, not recycling.

Recovery of materials as estimated in this report includes products and yard trimmings removed from the waste stream for the purpose of recycling (including 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 (including 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.

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 packaging materials. 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.

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 1996 MSW generation, recovery, and discards of products in each material category are included.

In Chapter 3 of the report, estimates of 1996 MSW management by the various alternatives are summarized. These include recovery for recycling (including composting), combustion, and landfilling. Also presented is a discussion of source reduction, including a brief overview of trends in source reduction as it relates to national MSW generation quantities. Summaries of the infrastructure currently available for each waste management alternative are also included in Chapter 3.

New to this update, Chapter 4 highlights a topic of interest in the solid waste management field—markets for recovered materials. This chapter provides an overview for the most commonly recovered materials in MSW, with discussion on industry structure and capacity, and factors driving markets.

Discussion of both trends in source reduction (Chapter 3), and markets for recovered materials is not meant to provide a comprehensive nor final discussion on either topic, but rather, an increased understanding of these two complicated issues.

A discussion of the material flows methodology is presented in Appendix A. In Appendix B, the MSW characterization data summarized in previous chapters of the report are presented again from different perspectives. These perspectives include; generation and management on a pounds per person per day basis, generation by material on a pounds per person per day basis, classification of generation into residential and commercial components, and a ranking of products and materials by tonnage generated, recovered for recycling, and discarded.

Chapter 1

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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 1996. The data presented also incorporate revisions to previously reported data for 1995 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 (including composting, if any). Tables and figures displaying discards of materials and products after recovery for recycling (including 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.

Table 1

MATERIALS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996

(In thousands of tons and percent of total generation)

	Thousands of Tons							
Materials	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Paper and Paperboard	29,990	44,310	55,160	72,730	74,260	80,840	81,670	79,930
Glass	6,720	12,740	15,130	13,100	13,130	13,350	12,830	12,350
Metals								
Ferrous	10,300	12,360	12,620	12,640	12,080	11,780	11,630	11,830
Aluminum	340	800	1,730	2,810	2,870	3,040	2,950	2,980
Other Nonferrous	180	670	1,160	1,100	1,120	1,350	1,260	1,260
Total Metals	*10,820*	*13,830*	*15,510*	*16,550*	*16,070*	*16,170*	*15,840*	*16,070*
Plastics	390	2,900	6,830	17,130	18,410	19,260	18,900	19,760
Rubber and Leather	1,840	2,970	4,200	5,790	5,800	6,210	6,030	6,200
Textiles	1,760	2,040	2,530	5,810	6,620	7,260	7,400	7,720
Wood	3,030	3,720	7,010	12,210	12,270	11,280	10,440	10,840
Other **	70	770	2,520	3,190	3,370	3,700	3,650	3,690
Total Materials in Products	54,620	83,280	108,890	146,510	149,930	158,070	156,760	156,560
Other Wastes								
Food Wastes	12,200	12,800	13,000	20,800	21,000	21,500	21,800	21,900
Yard Trimmings	20,000	23,200	27,500	35,000	35,000	31,500	29,750	28,000
Miscellaneous Inorganic Wastes	1,300	1,780	2,250	2,900	3,000	3,100	3,150	3,200
Total Other Wastes	33,500	37,780	42,750	58,700	59,000	56,100	54,700	53,100
Total MSW Generated-Weight	88,120	121,060	151,640	205,210	208,930	214,170	211,460	209,660
	Percent of Total Generation							
Materials	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Paper and Paperboard	34.0%	36.6%	36.4%	35.4%	35.5%	37.7%	38.6%	38.1%
Glass	7.6%	10.5%	10.0%	6.4%	6.3%	6.2%	6.1%	5.9%
Metals								
Ferrous	11.7%	10.2%	8.3%	6.2%	5.8%	5.5%	5.5%	5.6%
Aluminum	0.4%	0.7%	1.1%	1.4%	1.4%	1.4%	1.4%	1.4%
Other Nonferrous	0.2%	0.6%	0.8%	0.5%	0.5%	0.6%	0.6%	0.6%
Total Metals	*12.3%*	*11.4%*	*10.2%*	*8.1%*	*7.7%*	*7.6%*	*7.5%*	*7.7%*
Plastics	0.4%	2.4%	4.5%	8.3%	8.8%	9.0%	8.9%	9.4%
Rubber and Leather	2.1%	2.5%	2.8%	2.8%	2.8%	2.9%	2.9%	3.0%
Textiles	2.0%	1.7%	1.7%	2.8%	3.2%	3.4%	3.5%	3.7%
Wood	3.4%	3.1%	4.6%	6.0%	5.9%	5.3%	4.9%	5.2%
Other **	0.1%	0.6%	1.7%	1.6%	1.6%	1.7%	1.7%	1.8%
Total Materials in Products	62.0%	68.8%	71.8%	71.4%	71.8%	73.8%	74.1%	74.7%
Other Wastes								
Food Wastes	13.8%	10.6%	8.6%	10.1%	10.1%	10.0%	10.3%	10.4%
Yard Trimmings	22.7%	19.2%	18.1%	17.1%	16.8%	14.7%	14.1%	13.4%
Miscellaneous Inorganic Wastes	1.5%	1.5%	1.5%	1.4%	1.4%	1.4%	1.5%	1.5%
Total Other Wastes	38.0%	31.2%	28.2%	28.6%	28.2%	26.2%	25.9%	25.3%
Total MSW Generated - %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* Generation before materials recovery or combustion. Does not include construction & demolition debris, industrial process wastes, or certain other wastes.

** Includes electrolytes in batteries and fluff pulp, feces, and urine in disposable diapers.

Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 2

RECOVERY* OF MUNICIPAL SOLID WASTE, 1960 TO 1996

(In thousands of tons and percent of generation of each material)

	Thousands of Tons							
Materials	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Paper and Paperboard	5,080	6,770	11,740	20,230	24,470	29,470	32,700	32,610
Glass	100	160	750	2,620	2,890	3,110	3,140	3,170
Metals								
Ferrous	50	150	370	2,580	3,350	4,120	4,230	4,500
Aluminum	Neg.	10	310	1,010	1,110	1,150	1,020	1,020
Other Nonferrous	Neg.	320	540	730	710	990	810	840
Total Metals	*50*	*480*	*1,220*	*4,320*	*5,170*	*6,260*	*6,060*	*6,360*
Plastics	Neg.	Neg.	20	370	600	940	990	1,060
Rubber and Leather	330	250	130	370	380	500	540	590
Textiles	50	60	160	660	780	870	900	950
Wood	Neg.	Neg.	Neg.	130	190	360	450	490
Other **	Neg.	300	500	680	670	910	750	780
Total Materials in Products	5,610	8,020	14,520	29,380	35,150	42,420	45,530	46,010
Other Wastes								
Food Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	480	570	520
Yard Trimmings	Neg.	Neg.	Neg.	4,200	5,400	8,000	9,000	10,800
Miscellaneous Inorganic Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Other Wastes	Neg.	Neg.	Neg.	4,200	5,400	8,480	9,570	11,320
Total MSW Recovered-Weight	5,610	8,020	14,520	33,580	40,550	50,900	55,100	57,330
	Percent of Generation of Each Material							
Materials	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Paper and Paperboard	16.9%	15.3%	21.3%	27.8%	33.0%	36.5%	40.0%	40.8%
Glass	1.5%	1.3%	5.0%	20.0%	22.0%	23.3%	24.5%	25.7%
Metals								
Ferrous	0.5%	1.2%	2.9%	20.4%	27.7%	35.0%	36.4%	38.0%
Aluminum	Neg.	1.3%	17.9%	35.9%	38.7%	37.8%	34.6%	34.2%
Other Nonferrous	Neg.	47.8%	46.6%	66.4%	63.4%	73.3%	64.3%	66.7%
Total Metals	*0.5%*	*3.5%*	*7.9%*	*26.1%*	*32.2%*	*38.7%*	*38.3%*	*39.6%*
Plastics	Neg.	Neg.	0.3%	2.2%	3.3%	4.9%	5.2%	5.4%
Rubber and Leather	17.9%	8.4%	3.1%	6.4%	6.6%	8.1%	9.0%	9.5%
Textiles	2.8%	2.9%	6.3%	11.4%	11.8%	12.0%	12.2%	12.3%
Wood	Neg.	Neg.	Neg.	1.1%	1.5%	3.2%	4.3%	4.5%
Other **	Neg.	39.0%	19.8%	21.3%	19.9%	24.6%	20.5%	21.1%
Total Materials in Products	10.3%	9.6%	13.3%	20.1%	23.4%	26.8%	29.0%	29.4%
Other Wastes								
Food Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	2.2%	2.6%	2.4%
Yard Trimmings	Neg.	Neg.	Neg.	12.0%	15.4%	25.4%	30.3%	38.6%
Miscellaneous Inorganic Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Other Wastes	Neg.	Neg.	Neg.	7.2%	9.2%	15.1%	17.5%	21.3%
Total MSW Recovered - %	6.4%	6.6%	9.6%	16.4%	19.4%	23.8%	26.1%	27.3%

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.

** Recovery of electrolytes in batteries; probably not recycled.

Neg. = Less than 5,000 tons or 0.05 percent.

Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 3

MATERIALS DISCARDED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996

(In thousands of tons and percent of total discards)

	Thousands of Tons							
Materials	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Paper and Paperboard	24,910	37,540	43,420	52,500	49,790	51,370	48,970	47,320
Glass	6,620	12,580	14,380	10,480	10,240	10,240	9,690	9,180
Metals								
Ferrous	10,250	12,210	12,250	10,060	8,730	7,660	7,400	7,330
Aluminum	340	790	1,420	1,800	1,760	1,890	1,930	1,960
Other Nonferrous	180	350	620	370	410	360	450	420
Total Metals	*10,770*	*13,350*	*14,290*	*12,230*	*10,900*	*9,910*	*9,780*	*9,710*
Plastics	390	2,900	6,810	16,760	17,810	18,320	17,910	18,700
Rubber and Leather	1,510	2,720	4,070	5,420	5,420	5,710	5,490	5,610
Textiles	1,710	1,980	2,370	5,150	5,840	6,390	6,500	6,770
Wood	3,030	3,720	7,010	12,080	12,080	10,920	9,990	10,350
Other **	70	470	2,020	2,510	2,700	2,790	2,900	2,910
Total Materials in Products	49,010	75,260	94,370	117,130	114,780	115,650	111,230	110,550
Other Wastes								
Food Wastes	12,200	12,800	13,000	20,800	21,000	21,020	21,230	21,380
Yard Trimmings	20,000	23,200	27,500	30,800	29,600	23,500	20,750	17,200
Miscellaneous Inorganic Wastes	1,300	1,780	2,250	2,900	3,000	3,100	3,150	3,200
Total Other Wastes	33,500	37,780	42,750	54,500	53,600	47,620	45,130	41,780
Total MSW Discarded-Weight	82,510	113,040	137,120	171,630	168,380	163,270	156,360	152,330
	Percent of Total Discards							
Materials	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Paper and Paperboard	30.2%	33.2%	31.7%	30.6%	29.6%	31.5%	31.3%	31.1%
Glass	8.0%	11.1%	10.5%	6.1%	6.1%	6.3%	6.2%	6.0%
Metals								
Ferrous	12.4%	10.8%	8.9%	5.9%	5.2%	4.7%	4.7%	4.8%
Aluminum	0.4%	0.7%	1.0%	1.0%	1.0%	1.2%	1.2%	1.3%
Other Nonferrous	0.2%	0.3%	0.5%	0.2%	0.2%	0.2%	0.3%	0.3%
Total Metals	*13.1%*	*11.8%*	*10.4%*	*7.1%*	*6.5%*	*6.1%*	*6.3%*	*6.4%*
Plastics	0.5%	2.6%	5.0%	9.8%	10.6%	11.2%	11.5%	12.3%
Rubber and Leather	1.8%	2.4%	3.0%	3.2%	3.2%	3.5%	3.5%	3.7%
Textiles	2.1%	1.8%	1.7%	3.0%	3.5%	3.9%	4.2%	4.4%
Wood	3.7%	3.3%	5.1%	7.0%	7.2%	6.7%	6.4%	6.8%
Other **	0.1%	0.4%	1.5%	1.5%	1.6%	1.7%	1.9%	1.9%
Total Materials in Products	59.4%	66.6%	68.8%	68.2%	68.2%	70.8%	71.1%	72.6%
Other Wastes								
Food Wastes	14.8%	11.3%	9.5%	12.1%	12.5%	12.9%	13.6%	14.0%
Yard Trimmings	24.2%	20.5%	20.1%	17.9%	17.6%	14.4%	13.3%	11.3%
Miscellaneous Inorganic Wastes	1.6%	1.6%	1.6%	1.7%	1.8%	1.9%	2.0%	2.1%
Total Other Wastes	40.6%	33.4%	31.2%	31.8%	31.8%	29.2%	28.9%	27.4%
Total MSW Discarded - %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* Discards after materials and compost recovery. Does not include construction & demolition debris, industrial process wastes, or certain other wastes.

** Includes electrolytes in batteries and fluff pulp, feces, and urine in disposable diapers.

Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

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

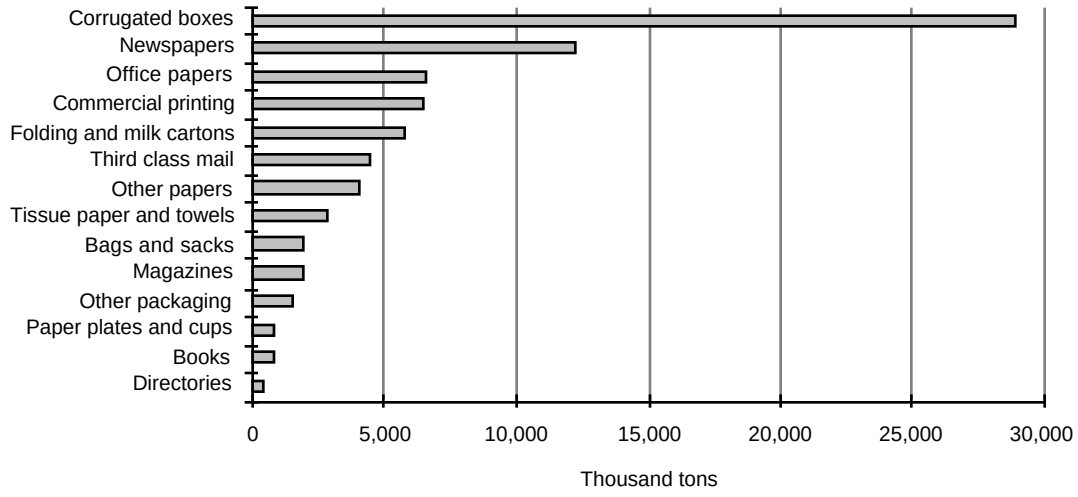
PAPER AND PAPERBOARD PRODUCTS IN MSW, 1996
(In thousands of tons and percent of generation)

Product Category	Generation (Thousands tons)	Recovery (Thousands tons)	Recovery (Percent of generation)	Discards (Thousands tons)
Nondurable Goods				
Newspapers				
Newsprint	9,810	5,480	55.9%	4,330
Groundwood inserts	2,480	1,170	47.2%	1,310
Total Newspapers	12,290	6,650	54.1%	5,640
Books	940	170	18.1%	770
Magazines	1,970	480	24.4%	1,490
Office Papers	6,660	3,190	47.9%	3,470
Telephone Directories	470	60	12.8%	410
Third Class Mail	4,510	670	14.9%	3,840
Other Commercial Printing	6,560	810	12.3%	5,750
Tissue Paper and Towels	2,980	Neg.	Neg.	2,980
Paper Plates and Cups	950	Neg.	Neg.	950
Other Nonpackaging Paper*	4,120	Neg.	Neg.	4,120
Total Paper and Paperboard Nondurable Goods	41,450	12,030	29.0%	29,420
Containers and Packaging				
Corrugated Boxes	29,020	19,340	66.6%	9,680
Milk Cartons	460	Neg.	Neg.	460
Folding Cartons	5,390	980	18.2%	4,410
Other Paperboard Packaging	230	Neg.	Neg.	230
Bags and Sacks	1,980	260	13.1%	1,720
Wrapping Papers	50	Neg.	Neg.	50
Other Paper Packaging	1,350	Neg.	Neg.	1,350
Total Paper and Paperboard Containers and Packaging	38,480	20,580	53.5%	17,900
Total Paper and Paperboard	79,930	32,610	40.8%	47,320

* 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, 1996

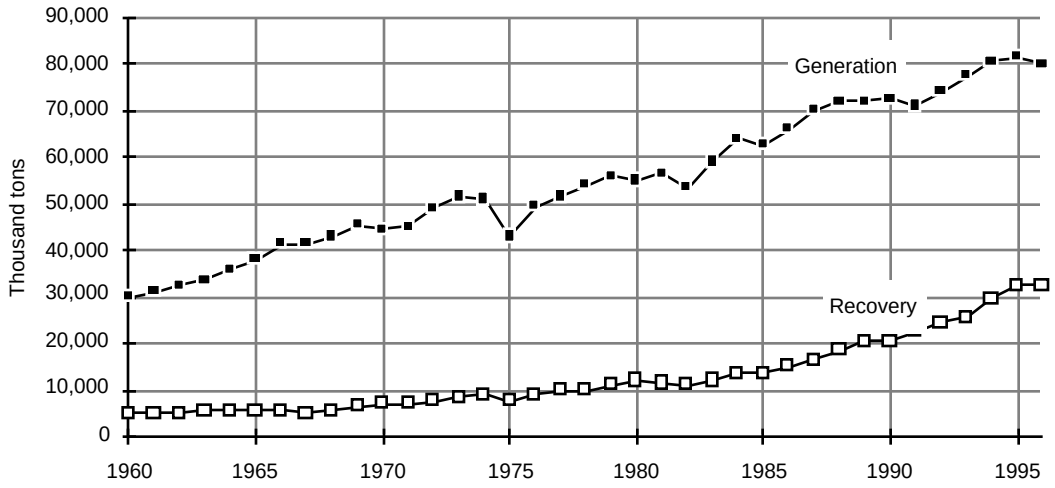


Total generation of paper and paperboard in MSW has grown steadily from 30 million tons in 1960 to 79.9 million tons in 1996 (Table 1). As a percentage of total MSW generation, paper represented 34 percent in 1960 (Table 1). The percentage has varied over time, but increased to 38.1 percent of total MSW generation in 1996.

(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 with a few more recent revisions as new data became available. 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 1996



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 newspapers 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 recent updates, various converting scrap recovery rates ranging from 70 percent to 98 percent were applied to the estimates for 1990 through 1996. The converting scrap recovery rates were developed for a 1992 report for the Recycling Advisory Council. Because converting scrap and overissue are 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, 66.6 percent of all corrugated boxes were recovered for recycling in 1996. Newspapers were recovered at a rate of 54.1 percent, and high grade office papers at 47.9 percent, with lesser percentages of other papers being recovered also. Approximately 32.6 million tons of postconsumer paper were recovered in 1996—40.8 percent of total paper and paperboard generation.

Discards After Recovery. After recovery of paper and paperboard for recycling, discards were 47.3 million tons in 1996, or 31.1 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 15.1 million tons in 1980 to 13.2 million tons in

Table 5

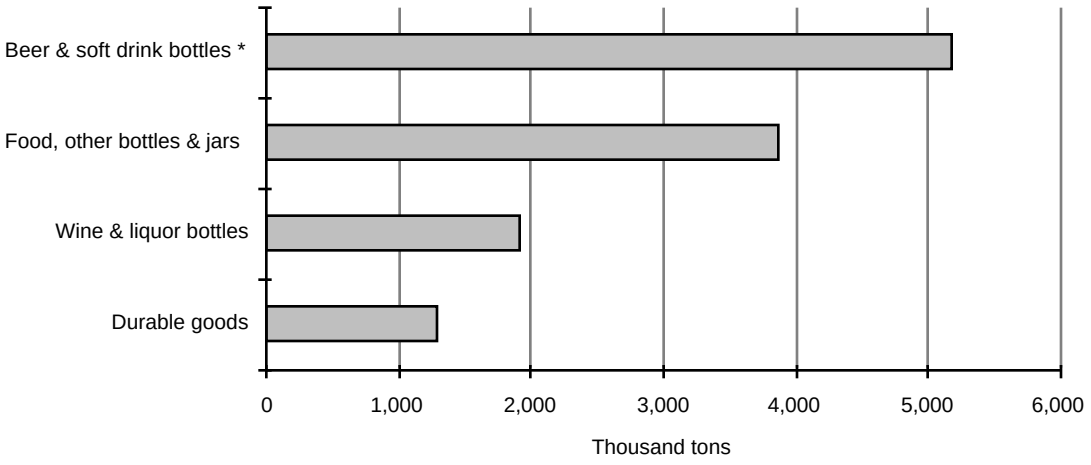
GLASS PRODUCTS IN MSW, 1996
(In thousands of tons and percent of generation)

Product Category	Generation (Thousand tons)	Recovery (Thousand tons)	Recovery (Percent of generation)	Discards (Thousand tons)
Durable Goods*	1,310	Neg.	Neg.	1,310
Containers and Packaging				
Beer and Soft Drink Bottles	5,210	1,680	32.2%	3,530
Wine and Liquor Bottles	1,940	480	24.7%	1,460
Food and Other Bottles and Jars	3,890	1,010	26.0%	2,880
Total Glass Containers	11,040	3,170	28.7%	7,870
Total Glass	12,350	3,170	25.7%	9,180

* 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.

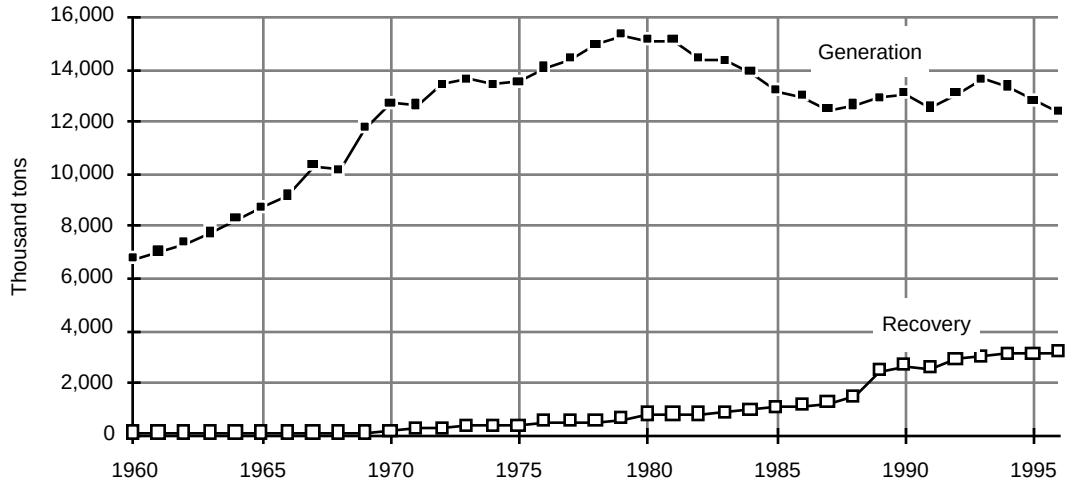
Figure 4. Glass products generated in MSW, 1996



* Includes carbonated drinks and non-carbonated waters, teas, and flavored drinks containing < 10% fruit juice.

1985. Beginning about 1987, however, the decline in generation of glass containers slowed (Figure 5), and glass generation in 1996 was 12.4 million tons, about the same as 1987. During the 1990's glass generation has varied from 12.4 to 13.6 million tons per year. Glass was 10 percent of MSW generation in 1980, declining to 5.9 percent in 1996.

Figure 5. Glass generation and recovery, 1960 to 1996



Recovery. Published estimates indicate 3.2 million tons of glass containers were recovered for recycling in 1996. Based on 1996 glass generation, an estimated 28.7 percent of glass containers was recovered for recycling, with a 25.7 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 38 percent for glass containers in 1996; 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 28.7 percent of glass containers.

Discards After Recovery. Recovery for recycling lowered discards of glass to 9.2 million tons in 1996 (6.0 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 from 1960 to 1996 are shown in Figure 7.

Figure 6. Metal products generated in MSW, 1996

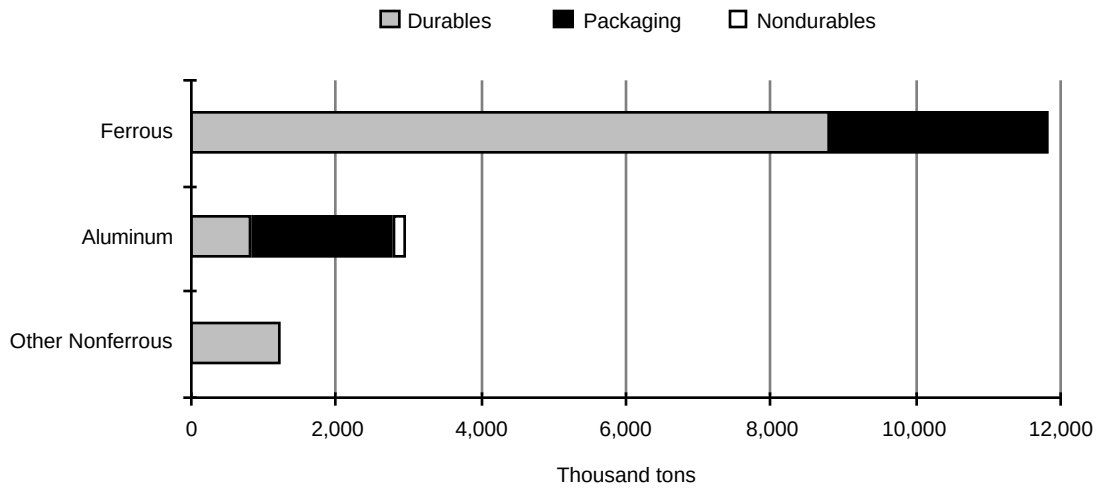


Table 6

METAL PRODUCTS IN MSW, 1996
(In thousands of tons and percent of generation)

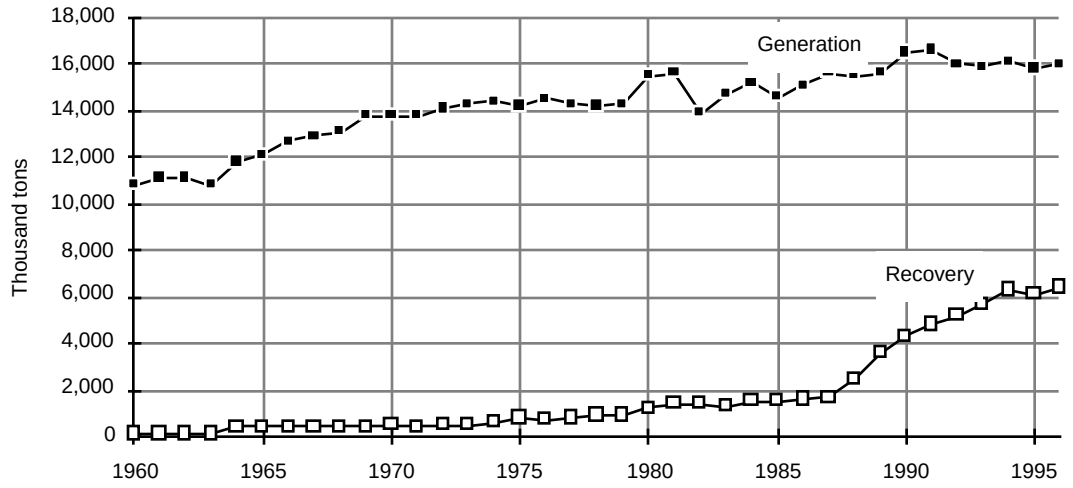
Product Category	Generation (Thousand tons)	Recovery (Thousand tons)	Recovery (Percent of generation)	Discards (Thousand tons)
Durable Goods				
Ferrous metals*	8,840	2,810	31.8%	6,030
Aluminum**	840	Neg.	Neg.	840
Lead†	900	840	93.3%	60
Other nonferrous metals‡	360	Neg.	Neg.	360
Total Metals in Durable Goods	10,940	3,650	33.4%	7,290
Nondurable Goods				
Aluminum	180	Neg.	Neg.	180
Containers and Packaging				
Steel				
Food and other cans	2,820	1,640	58.2%	1,180
Other steel packaging	170	50	29.4%	120
Total Steel Packaging	2,990	1,690	56.5%	1,300
Aluminum				
Beer and soft drink cans	1,560	990	63.5%	570
Food and other cans	40	Neg.	7.0%	40
Foil and closures	360	30	8.3%	330
Total Aluminum Packaging	1,960	1,020	52.0%	940
Total Metals in Containers and Packaging	4,950	2,710	54.7%	2,240
Total Metals	16,070	6,360	39.6%	9,710
Ferrous	11,830	4,500	38.0%	7,330
Aluminum	2,980	1,020	34.2%	1,960
Other nonferrous	1,260	840	66.7%	420

* 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 10.3 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 1991, then dropped to 11.8 million tons in 1996. The percentage of ferrous metals generation in MSW has declined from 11.7 percent in 1960 to 5.6 percent in 1996.

Recovery. The renewed emphasis on recovery and recycling in recent years has included ferrous metals. Based on data from the Steel Recycling

Figure 7. Metals generation and recovery, 1960 to 1996



Institute, recovery of ferrous metals from appliances ("white goods") was estimated to be 2.2 million tons of the total ferrous in appliances in 1996. Overall recovery of ferrous metals from durable goods (large and small appliances, furniture, and tires) was estimated to be 31.8 percent (2.8 million tons) in 1996 (Table 6).

Steel beverage cans, food cans, and other cans were estimated to be recovered at a rate of 58.2 percent (1.6 million tons) in 1996. Approximately 50,000 tons of other steel packaging, such as steel strapping, was estimated to have been recovered for recycling in 1996.

Discards After Recovery. Discards of ferrous metals after recovery were 7.3 million tons in 1996, or 4.8 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 1996, approximately 2.0 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—3.0 million tons—represented 1.4 percent of total MSW generation in 1996. Aluminum generation was only 340,000 tons (0.4 percent of MSW generation) in 1960.

Recovery. Aluminum beverage containers were recovered at a rate of 63.5 percent of generation (990,000 tons) in 1996, and 52.0 percent of all aluminum in containers and packaging was recovered for recycling in 1996.

Discards After Recovery. In 1996, 2.0 million tons of aluminum were discarded in MSW after recovery, which was 1.3 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 cars, 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 1.3 million tons in 1996. Lead in batteries accounted for 900,000 tons of this amount. Generation of these metals has increased slowly, up from 180,000 tons in 1960. As a percentage of total generation, nonferrous metals have never exceeded one percent.

Recovery. Recovery of the other nonferrous metals was 840,000 tons in 1996, with most of this being lead recovered from batteries. It was estimated that 93.3 percent of battery lead was recovered in 1996.

Discards After Recovery. In 1996, 420,000 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 (Table 7 and Figure 8).

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, medical devices,

Table 7

PLASTICS IN PRODUCTS IN MSW, 1996
(In thousands of tons, and percent of generation by resin)

Product Category	Generation (Thousand tons)	Recovery (Thousand tons)	Recovery (Percent of Gen.)	Discards (Thousand tons)
Durable Goods				
PET	340	30		310
HDPE	450	50		400
PVC	370	Neg.		370
LDPE/LLDPE	540	20		520
PP	1,030	100		930
PS	530	10		520
Other resins	3,000	30		2,970
Total Plastics in Durable Goods	6,260	240	3.8%	6,020
Nondurable Goods				
Plastic Plates and Cups				
LDPE/LLDPE	20			20
PS	790	10		780
Subtotal Plastic Plates and Cups	810			800
Trash Bags				
HDPE	230			230
LDPE/LLDPE	630			630
Subtotal Trash Bags	860			860
All other nondurables*				
PET	180			180
HDPE	350			350
PVC	500			500
LDPE/LLDPE	1,340			1,340
PP	740			740
PS	490			490
Other resins	80			80
Subtotal All Other Nondurables	3,680			3,680
Total Plastics in Nondurable Goods, by resin				
PET	180			180
HDPE	580			580
PVC	500			500
LDPE/LLDPE	1,990			1,990
PP	740			740
PS	1,280	10		1,270
Other resins	80			80
Total Plastics in Nondurable Goods	5,350	10	0.2%	5,340
Plastic Containers & Packaging				
Soft drink bottles				
PET	680	270		410
HDPE	20	10		10
Subtotal Soft Drink Bottles	700	280	40.0%	420
Milk and water bottles				
HDPE	650	200	30.8%	450

HDPE=High density polyethylene
LDPE=Low density polyethylene
LLDPE=Linear Low density polyethylene
PET=Polyethylene terephthalate
PP=Polypropylene
PS=Polystyrene
PVC=Polyvinyl chloride

Source: Franklin Associates, Ltd.

Table 7 (continued)

PLASTICS IN PRODUCTS IN MSW, 1996

(In thousands of tons, and percent of generation by resin)

Product Category	Generation (Thousand tons)	Recovery (Thousand tons)	Recovery (Percent of Gen.)	Discards (Thousand tons)
Plastic Containers & Packaging, cont.				
Other plastic containers				
PET	390	50		340
HDPE	670	140		530
PVC	70	Neg.		70
LDPE/LLDPE	30	Neg.		30
PP	70	Neg.		70
PS	40	Neg.		40
Other resins	10	Neg.		10
Subtotal Other Containers	1,280	190	14.8%	1,090
Bags, sacks, & wraps				
HDPE	520	10		510
PVC	60			60
LDPE/LLDPE	2,150	90		2,060
PP	430			430
PS	60			60
Subtotal Bags, Sacks, & Wraps	3,220	100	3.1%	3,120
Other Plastics Packaging**				
PET	110	Neg.		110
HDPE	1,230	Neg.		1,230
PVC	230	Neg.		230
LDPE/LLDPE	300	Neg.		300
PP	310	30		280
PS	80	10		70
Other resins	40	Neg.		40
Subtotal Other Packaging	2,300	40	1.7%	2,260
Total Plastics in Containers & Packaging, by resin				
PET	1,180	320		860
HDPE	3,090	360		2,730
PVC	360	Neg.		360
LDPE/LLDPE	2,480	90		2,390
PP	810	30		780
PS	180	10		170
Other resins	50	Neg.		50
Total Plastics in Containers & Packaging	8,150	810	9.9%	7,340
Total Plastics in MSW, by resin				
PET	1,700	350		1,350
HDPE	4,120	410		3,710
PVC	1,230	Neg.		1,230
LDPE/LLDPE	5,010	110		4,900
PP	2,580	130		2,450
PS	1,990	30		1,960
Other resins	3,130	30		3,100
Total Plastics in MSW	19,760	1,060	5.4%	18,700

HDPE=High density polyethylene
LDPE=Low density polyethylene
LLDPE=Linear Low density polyethylene
PET=Polyethylene terephthalate
PP=Polypropylene
PS=Polystyrene
PVC=Polyvinyl chloride

* All other nondurables include plastics in disposable diapers, clothing, footwear, etc.

** Other plastic packaging includes coatings, closures, caps, trays, shapes, etc.

Neg. = Less than 5,000 tons or 0.05 percent. Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

household items such as 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. Production data on plastics resin use in products is taken from the ***Modern Plastics*** annual statistical issue and the American Plastics Council annual plastic recovery survey. The basic data are adjusted for product service life, fabrication losses, and for net imports of plastic products to derive generation of plastics in the various products in MSW.

Plastics comprised an estimated 390,000 tons of MSW generation in 1960. The quantity has increased relatively steadily to 19.8 million tons in 1996 (Figure 9). As a percentage of MSW generation, plastics were less than one percent in 1960, increasing to 9.4 percent in 1996.

Recovery for Recycling. While overall recovery of plastics for recycling is relatively small—1.1 million tons, or 5.4 percent of plastics generation in 1996 (Table 9)—recovery of some plastic containers has generally increased. Plastic PET soft drink bottles and their base cups were recovered at a rate of about 40.0 percent in 1996. Recovery of high-density polyethylene milk and water bottles was estimated at about 30.8 percent in 1996. Significant recovery of plastics from lead-acid battery casings and from some other containers was also reported.

Figure 8. Plastics products generated in MSW, 1996

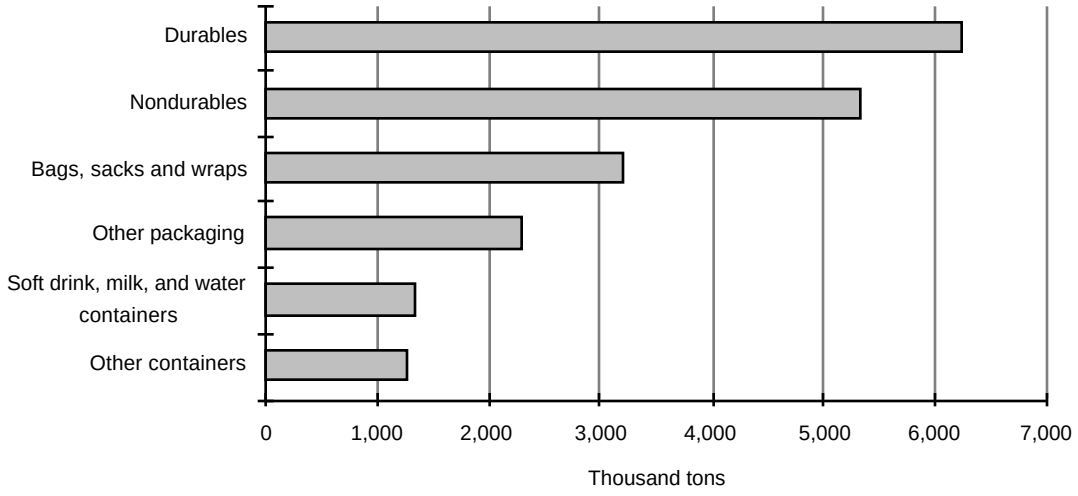
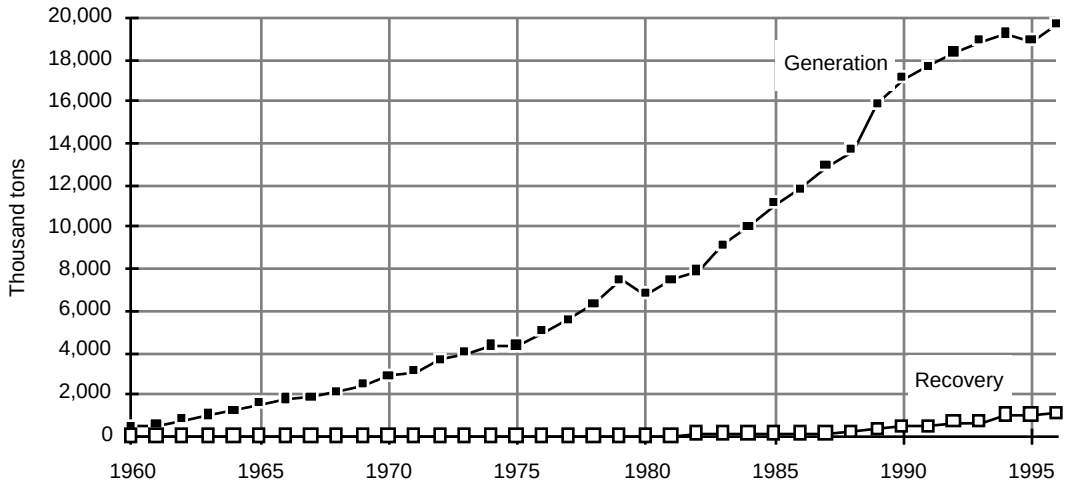


Figure 9. Plastics generation and recovery, 1960 to 1996



The primary source of data on plastics recovery is an annual survey conducted for the American Plastics Council (APC). In recent years 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. Starting in 1994 data reported by APC are recovery for recycling before processing at the reclaimer. Thus, the plastics data are now more consistent with the data reported for the other materials.

Discards After Recovery. Discards of plastics in MSW after recovery were 18.7 million tons, or 12.3 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 1.8 million tons in 1960 to 6.2 million tons in 1996. 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.

Table 8

RUBBER AND LEATHER PRODUCTS IN MSW, 1996
(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 in Tires*	3,170	590	18.6%	2,580
Other Durables**	2,220	Neg.	Neg.	2,220
Total Rubber & Leather Durable Goods	5,390	590	10.9%	4,800
Nondurable Goods				
Clothing and Footwear	560	Neg.	Neg.	560
Other Nondurables	230	Neg.	Neg.	230
Total Rubber & Leather Nondurable Goods	790	Neg.	Neg.	790
Containers and Packaging	20	Neg.	Neg.	20
Total Rubber & Leather	6,200	590	9.5%	5,610

* 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.

Recovery for Recycling. The only recovery for recycling identified in this category is rubber from tires, and that was estimated to be 590,000 tons (18.6 percent of rubber in tires in 1996) (Table 8). (This recovery estimate does not include tires retreaded or energy recovery from tires.) Overall, 9.5 percent of rubber and leather in MSW was recovered in 1996.

Discards After Recovery. Discards of rubber and leather after recovery were 5.6 million tons in 1996 (3.7 percent of total discards).

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 7.7 million tons of textiles were generated in 1996 (3.7 percent of total MSW generation).

Recovery for Recycling and Discards. A significant amount of textiles is recovered for reuse. However, 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 12.3 percent of textiles in clothing and items such as sheets and pillowcases was recovered for export or reprocessing in 1996 (950,000 tons) leaving discards of 6.8 million tons of textiles in 1996.

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 10.8 million tons in 1996 (5.2 percent of total MSW generation).

Recovery for Recycling and Discards. Wood pallets recovered for recycling (usually by chipping for uses such as mulch or bedding material, but excluding wood combusted as fuel) was estimated at 490,000 tons in 1996. *This figure (along with wood generation) represents a change over previous estimates.* Recent studies on the pallet industry (Bush, Reddy, Araman) provided new information on recovery and recycling of reusable pallets, including data on the number of reusable pallets refurbished and returned to service.

Nearly 200 million pallets—representing over 5 million tons of wood packaging—were estimated to be refurbished and returned to service in 1996. This EPA report classifies pallets refurbished and returned to service as reuse (source reduction) rather than recovery for recycling. Therefore, the 5 million tons represents a reduction in the amount of wood packaging discarded to the waste stream (i.e., a reduction in waste generation) rather than an increase in recycling.

Accounting for pallet reuse and recovery for recycling, wood discards were 10.3 million tons in 1996, or 6.8 percent of total MSW discards. (Note: wood generation, recovery for recycling, and discards in the Chapter 2 Tables have been revised for the years 1990 through 1996.)

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. Food waste generated during the

preparation and packaging of food products is considered industrial waste and therefore not included in MSW food waste estimates.

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, grocery store sales, restaurant sales, numbers of employees, and numbers of prisoners and students in institutions.

Generation of food wastes was estimated to be over 21 million tons in 1996. *This estimate represents a substantial change over previous estimates.* Recent studies, including a USDA Economic Research Service study and curbside sampling studies in Seattle, Washington and Crawford County, Illinois, indicate higher residential food waste generation than has been estimated in earlier editions of the MSW Update.

The curbside sort data, which is viewed as more representative of current food waste generation, was combined with recent waste sorts to develop a new residential food waste estimate. Because the MSW waste stream (especially yard trimmings) has changed since the early 1990s, the use of older waste sort data from the 1980s was discontinued. Food waste estimates from 1990 to 1995 were adjusted upward on a per capita basis.

Recovery for Composting and Discards. Beginning in 1994 for this series of reports, a significant amount of food waste composting from commercial sources was identified. In 1996 this amount was estimated at over 500,000 tons, or 2.4 percent of food waste generation. As discussed in Chapter 3, composting of food wastes in backyard composting projects is classified as source reduction. Discards of food wastes in 1996 were 21.4 million tons, or 14.0 percent of MSW total discards.

Yard Trimmings

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

Generation. In earlier versions of this report, 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 (i.e., constant generation on a per capita

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* 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.

basis), in recent years there has been a new trend. That is local and state legislation is affecting yard trimmings disposal in landfills.

Using data published by the Composting Council as updated from more recent sources, legislation affecting yard trimmings disposal in landfills was tabulated. In 1992, 11 states and the District of Columbia—accounting for over 28 percent of the nation's population—had in effect legislation banning or discouraging yard trimmings disposal in landfills. The tabulation of existing legislation also shows that by 1996-97, 23 states representing more than 50 percent of the nation's population had legislation requiring source separation or banning of yard trimmings from landfills. Also, data compiled by ***BioCycle*** magazine indicates that there were about 3,000 composting facilities for yard trimmings in 1992, increasing to over 3,200 facilities in 1996.

Using these facts, it was estimated that the effect of this legislation was no increase in yard trimmings generation (i.e., entering the waste management system) between 1990 and 1992 (i.e., the increase in yard trimmings due to natural population increases was offset by source reduction efforts). Furthermore, with 50 percent of the population expected to have yard trimmings legislation in 1996-97, it was also estimated that yard trimmings declined approximately 5.5 percent annually between 1992 and 1996. Because of this phenomenon, yard trimmings generation is shown to be declining. An estimated 28 million tons of yard trimmings were generated in MSW in 1996 (this compares to an estimated 35 million tons of yard trimmings generated in 1992).

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, telephone survey of state officials, and data on numbers of composting programs. Recovery data from state officials were adjusted where appropriate to exclude quantities of non-yard trimmings, such as disaster wastes, included in recovery values. Some states consider landspreading of yard trimmings or yard trimmings used as landfill cover as recovery. Average tons recovered per compost facility from states with data was used to account for facilities in states without recovery quantity data. The states with and without data were subdivided further into the categories with and without yard trimmings legislation. States with yard trimmings legislation composted more per facility than compost facilities in states without yard trimmings legislation.

Removal of yard trimmings for composting was estimated to be 39 percent of generation in 1996 (10.8 million tons), leaving 17.2 million tons of yard trimmings to be discarded. (It should be noted that the estimated 10.8 million tons recovered for composting does not include yard trimmings recovered for landspreading disposal.)

It should also be noted that these recovery estimates do not account for backyard composting by individuals or practices such as less bagging of grass clippings; 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 further 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.

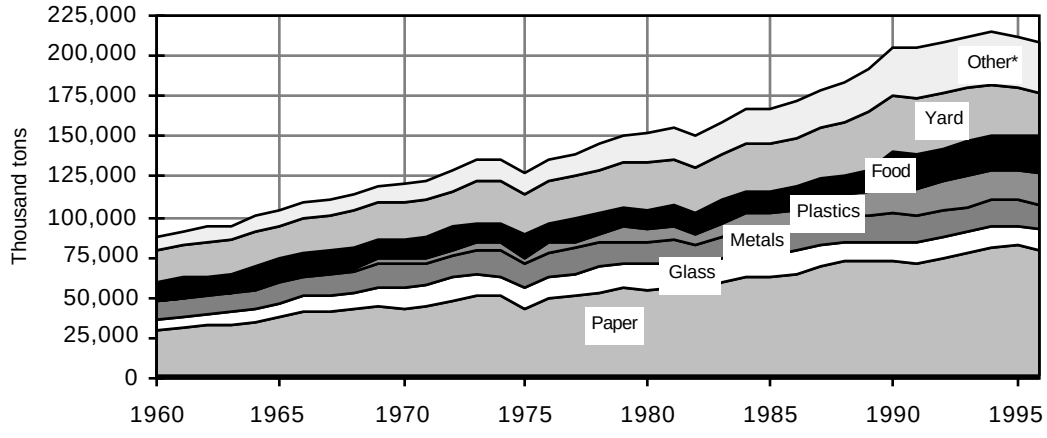
Generation, Recovery, and Discards. This category contributed an estimated 3.2 million tons of MSW in 1996. No recovery of these products was identified; discards are the same as generation.

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 relatively steadily, from 88.1 million tons in 1960 to 209.7 million tons in 1996.

Over the years paper and paperboard has been the dominant material generated in MSW, accounting for 38.1 percent of generation in 1996. Yard trimmings, the second largest material component of MSW (13.4 percent of MSW generation) have been declining as a percentage of MSW in recent years due to state and local legislated landfill bans and increased emphasis on backyard

Figure 10. Generation of materials in MSW, 1960 to 1996

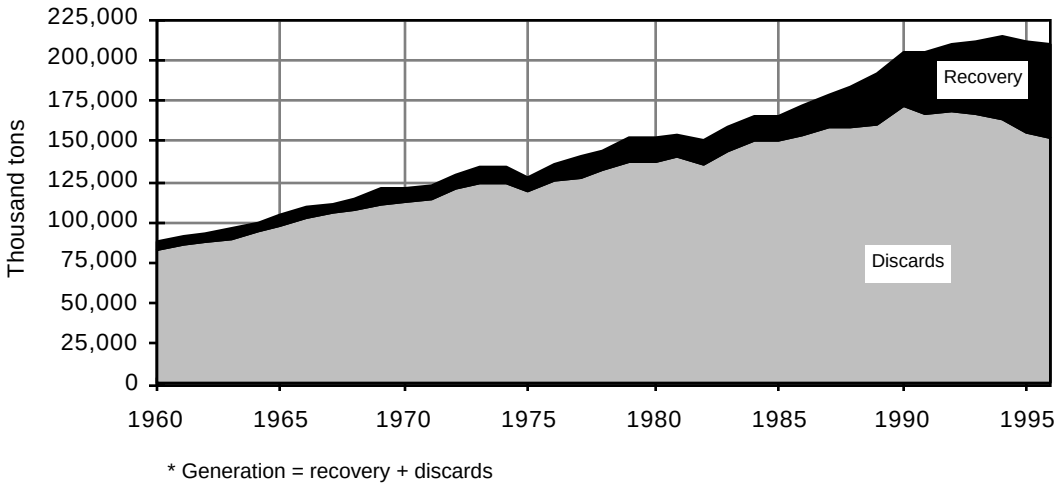


* All other primarily includes wood, rubber and leather, and textiles.

composting and other source reduction measures such as the use of mulching mowers. Metals account for 7.7 percent of MSW generation and 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. In 1996 glass represented 5.9 percent of MSW generation. Food wastes have remained fairly constant in terms of MSW tonnage (10.4 percent of generation). 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 fourth in 1996 (behind paper, yard trimmings, and food waste), and account for 9.4 percent of MSW generation.

Recovery and Discards. The effect of recovery on MSW discards is illustrated in Figure 11. Recovery of materials for recycling and composting grew at a rather slow pace during most of the historical period covered by this data series, increasing only from 6.4 percent of generation in 1960 to 10.9 percent in 1985. Renewed interest in recycling (including composting) as waste management alternatives came about in the late 1980s, and the recovery rate in 1990 was estimated to be 16.4 percent of generation, increasing to 27.3 percent in 1996.

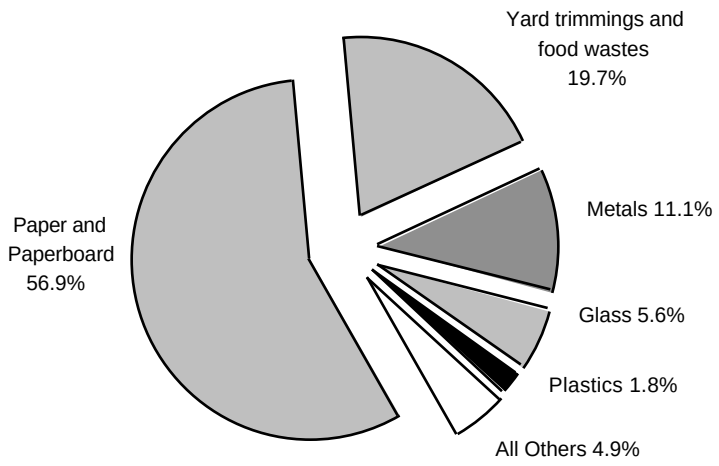
Figure 11. Materials recovery and discards of MSW*, 1960 to 1996



* Generation = recovery + discards

Estimated recovery of materials (including composting) is shown in Figure 12. In 1996, recovery of paper and paperboard dominated materials recovery at 56.9 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 12. Materials recovery*, 1996

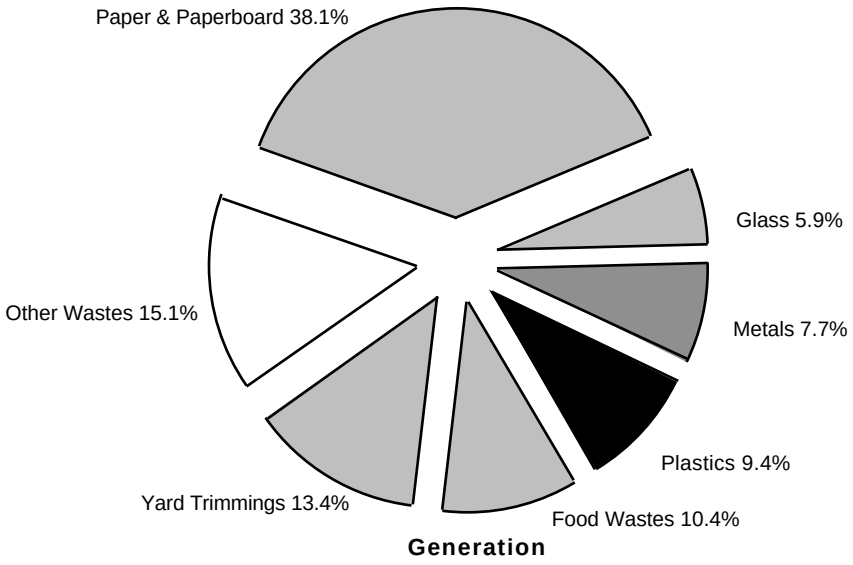


* In percent by weight of total recovery.

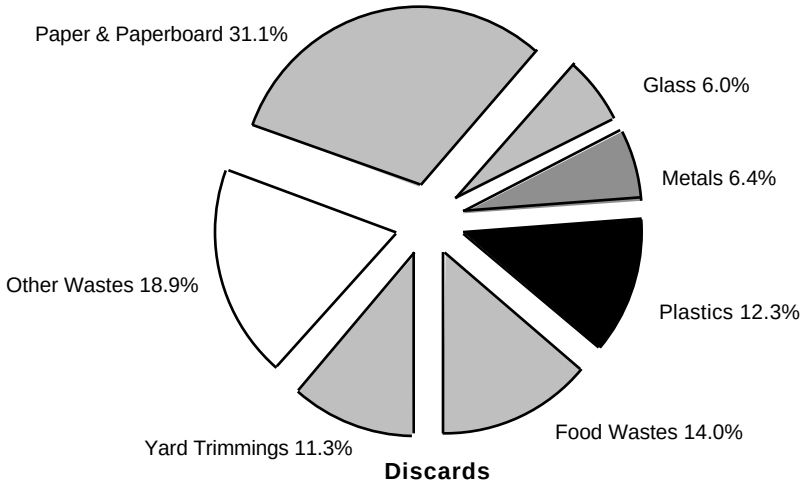
Figure 13 illustrates the effect of recovery of materials for recycling, including composting, on the composition of MSW discards. For example, paper and paperboard were 38.1 percent of MSW generated in 1996, but after recovery, paper and paperboard were 31.1 percent of discards.

Materials that have little or no recovery exhibit a larger percentage of MSW discards compared to generation. For instance, food wastes were 10.4 percent of MSW generation in 1996, but 14.0 percent of discards.

Figure 13. Materials generated and discarded in municipal solid waste, 1996
(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 1996, these include: ferrous metals, plastics, rubber and leather, wood, textiles, glass, other nonferrous metals (e.g., lead, copper), and aluminum.

Generation of durable goods in MSW totaled 31.7 million tons in 1996 (15.1 percent of total MSW generation). After recovery for recycling, 26.3 million tons of durable goods remained as discards in 1996.

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 Market Profile***. 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 3.5 million tons in 1996 (1.7 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.

Table 9

CATEGORIES OF PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996

(In thousands of tons and percent of total generation)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 12)*	9,920	14,660	21,800	29,810	30,430	31,120	31,140	31,660
Nondurable Goods *(Detail in Table 15)*	17,330	25,060	34,420	52,170	52,780	56,850	57,240	55,650
Containers and Packaging *(Detail in Table 18)*	27,370	43,560	52,670	64,530	66,720	70,100	68,380	69,250
***Total Product** Wastes*	54,620	83,280	108,890	146,510	149,930	158,070	156,760	156,560
Other Wastes								
Food Wastes	12,200	12,800	13,000	20,800	21,000	21,500	21,800	21,900
Yard Trimmings	20,000	23,200	27,500	35,000	35,000	31,500	29,750	28,000
Miscellaneous Inorganic Wastes	1,300	1,780	2,250	2,900	3,000	3,100	3,150	3,200
Total Other Wastes	33,500	37,780	42,750	58,700	59,000	56,100	54,700	53,100
Total MSW Generated-Weight	88,120	121,060	151,640	205,210	208,930	214,170	211,460	209,660
	Percent of Total Generation							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 12)*	11.3%	12.1%	14.4%	14.5%	14.6%	14.5%	14.7%	15.1%
Nondurable Goods *(Detail in Table 15)*	19.7%	20.7%	22.7%	25.4%	25.3%	26.5%	27.1%	26.5%
Containers and Packaging *(Detail in Table 19)*	31.1%	36.0%	34.7%	31.4%	31.9%	32.7%	32.3%	33.0%
***Total Product** Wastes*	62.0%	68.8%	71.8%	71.4%	71.8%	73.8%	74.1%	74.7%
Other Wastes								
Food Wastes	13.8%	10.6%	8.6%	10.1%	10.1%	10.0%	10.3%	10.4%
Yard Trimmings	22.7%	19.2%	18.1%	17.1%	16.8%	14.7%	14.1%	13.4%
Miscellaneous Inorganic Wastes	1.5%	1.5%	1.5%	1.4%	1.4%	1.4%	1.5%	1.5%
Total Other Wastes	38.0%	31.2%	28.2%	28.6%	28.2%	26.2%	25.9%	25.3%
Total MSW Generated - %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* Generation before materials recovery or combustion. Does not include construction & demolition debris, industrial process wastes, or certain other wastes.

** Other than food products.

Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 10

RECOVERY* OF MUNICIPAL SOLID WASTE, 1960 TO 1996

(In thousands of tons and percent of generation of each category)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 13)*	350	940	1,360	3,810	4,140	5,230	5,110	5,410
Nondurable Goods *(Detail in Table 16)*	2,390	3,730	4,670	8,790	11,070	12,610	13,610	12,860
Containers and Packaging *(Detail in Table 20)*	2,870	3,350	8,490	16,780	19,940	24,580	26,810	27,740
***Total Product** Wastes*	5,610	8,020	14,520	29,380	35,150	42,420	45,530	46,010
Other Wastes								
Food Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	480	570	520
Yard Trimmings	Neg.	Neg.	Neg.	4,200	5,400	8,000	9,000	10,800
Miscellaneous Inorganic Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Other Wastes	Neg.	Neg.	Neg.	4,200	5,400	8,480	9,570	11,320
Total MSW Recovered-Weight	5,610	8,020	14,520	33,580	40,550	50,900	55,100	57,330
	Percent of Generation of Each Category							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 13)*	3.5%	6.4%	6.2%	12.8%	13.6%	16.8%	16.4%	17.1%
Nondurable Goods *(Detail in Table 16)*	13.8%	14.9%	13.6%	16.8%	21.0%	22.2%	23.8%	23.1%
Containers and Packaging *(Detail in Table 21)*	10.5%	7.7%	16.1%	26.0%	29.9%	35.1%	39.2%	40.1%
***Total Product** Wastes*	10.3%	9.6%	13.3%	20.1%	23.4%	26.8%	29.0%	29.4%
Other Wastes								
Food Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	2.2%	2.6%	2.4%
Yard Trimmings	Neg.	Neg.	Neg.	12.0%	15.4%	25.4%	30.3%	38.6%
Miscellaneous Inorganic Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Other Wastes	Neg.	Neg.	Neg.	7.2%	9.2%	15.1%	17.5%	21.3%
Total MSW Recovered - %	6.4%	6.6%	9.6%	16.4%	19.4%	23.8%	26.1%	27.3%

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.

** Other than food products.

Neg. = Less than 5,000 tons or 0.05 percent.

Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 11

CATEGORIES OF PRODUCTS DISCARDED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996

(In thousands of tons and percent of total discards)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 14)*	9,570	13,720	20,440	26,000	26,290	25,890	26,030	26,250
Nondurable Goods *(Detail in Table 17)*	14,940	21,330	29,750	43,380	41,710	44,240	43,630	42,790
Containers and Packaging *(Detail in Table 22)*	24,500	40,210	44,180	47,750	46,780	45,520	41,570	41,510
***Total Product** Wastes*	49,010	75,260	94,370	117,130	114,780	115,650	111,230	110,550
Other Wastes								
Food Wastes	12,200	12,800	13,000	20,800	21,000	21,020	21,230	21,380
Yard Trimmings	20,000	23,200	27,500	30,800	29,600	23,500	20,750	17,200
Miscellaneous Inorganic Wastes	1,300	1,780	2,250	2,900	3,000	3,100	3,150	3,200
Total Other Wastes	33,500	37,780	42,750	54,500	53,600	47,620	45,130	41,780
Total MSW Discarded-Weight	82,510	113,040	137,120	171,630	168,380	163,270	156,360	152,330
	Percent of Total Discards							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 14)*	11.6%	12.1%	14.9%	15.1%	15.6%	15.9%	16.6%	17.2%
Nondurable Goods *(Detail in Table 17)*	18.1%	18.9%	21.7%	25.3%	24.8%	27.1%	27.9%	28.1%
Containers and Packaging *(Detail in Table 23)*	29.7%	35.6%	32.2%	27.8%	27.8%	27.9%	26.6%	27.3%
***Total Product** Wastes*	59.4%	66.6%	68.8%	68.2%	68.2%	70.8%	71.1%	72.6%
Other Wastes								
Food Wastes	14.8%	11.3%	9.5%	12.1%	12.5%	12.9%	13.6%	14.0%
Yard Trimmings	24.2%	20.5%	20.1%	17.9%	17.6%	14.4%	13.3%	11.3%
Miscellaneous Inorganic Wastes	1.6%	1.6%	1.6%	1.7%	1.8%	1.9%	2.0%	2.1%
Total Other Wastes	40.6%	33.4%	31.2%	31.8%	31.8%	29.2%	28.9%	27.4%
Total MSW Discarded - %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* Discards after materials and compost recovery. Does not include construction & demolition debris, industrial process wastes, or certain other wastes.

** Other than food products.

Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

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 2.2 million tons in 1996, leaving 1.3 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 780,000 tons of small appliances were generated in 1996. 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 7.3 million tons in 1996 (3.5 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 1996, which was 1.1 percent of total generation.

A small amount of recycling of carpet fiber was identified—estimated to be one percent recovery in 1996.

Vehicle Tires. The methodology for estimating generation of rubber tires for automobiles and trucks 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 3.9 million tons in 1996 (1.9 percent of total MSW).

Data on recovery of tires in recent years are based on data from 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 1996, an estimated 18.7 percent of tires generated were recovered for recycling, leaving 3.2 million tons to be discarded. (Tires going to combustion facilities as fuel are included in the combustion estimates in Chapter 3.)

Lead-Acid Batteries. The methodology for estimating generation of lead-acid batteries is similar to the methodology for rubber tires as described above. An estimated 1.8 million tons of lead-acid batteries from automobiles, trucks, and motorcycles were generated in MSW in 1996 (0.9 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 98 percent or higher; recovery has increased since 1980 as a growing number of communities have restricted batteries from disposal at landfills or combustors. In 1996, 93.8 percent of the lead in these batteries was estimated to be recovered for recycling as well as substantial quantities of the polypropylene battery casings; so discards after recycling of these batteries were decreased to 112,000 tons in 1996. (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 12.0 million tons of these goods were generated in 1996, amounting to 5.7 percent of MSW generated. Small amounts of ferrous metals are estimated to be recovered from this category, decreasing discards to 11.3 million tons. In addition to ferrous metals, this category includes plastics, glass, rubber, wood, and other metals.

Table 12

PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996
(WITH DETAIL ON DURABLE GOODS)
(In thousands of tons and percent of total generation)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods								
Major Appliances	1,630	2,170	2,950	3,310	3,280	3,280	3,420	3,520
Small Appliances**				460	520	650	710	780
Furniture and Furnishings	2,150	2,830	4,760	6,790	6,940	6,980	7,170	7,320
Carpets and Rugs**				1,660	1,820	2,120	2,230	2,310
Rubber Tires	1,120	1,890	2,720	3,610	3,610	4,080	3,770	3,910
Batteries, lead acid	Neg.	820	1,490	1,510	1,530	2,010	1,810	1,810
Miscellaneous Durables	5,020	6,950	9,880	12,470	12,730	12,000	12,030	12,010
Total Durable Goods	9,920	14,660	21,800	29,810	30,430	31,120	31,140	31,660
Nondurable Goods *(Detail in Table 15)*	17,330	25,060	34,420	52,170	52,780	56,850	57,240	55,650
Containers and Packaging *(Detail in Table 18)*	27,370	43,560	52,670	64,530	66,720	70,100	68,380	69,250
Total Product Wastes†	54,620	83,280	108,890	146,510	149,930	158,070	156,760	156,560
Other Wastes								
Food Wastes	12,200	12,800	13,000	20,800	21,000	21,500	21,800	21,900
Yard Trimmings	20,000	23,200	27,500	35,000	35,000	31,500	29,750	28,000
Miscellaneous Inorganic Wastes	1,300	1,780	2,250	2,900	3,000	3,100	3,150	3,200
Total Other Wastes	33,500	37,780	42,750	58,700	59,000	56,100	54,700	53,100
Total MSW Generated-Weight	88,120	121,060	151,640	205,210	208,930	214,170	211,460	209,660
	Percent of Total Generation							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods								
Major Appliances	1.8%	1.8%	1.9%	1.6%	1.6%	1.5%	1.6%	1.7%
Small Appliances**				0.2%	0.2%	0.3%	0.3%	0.4%
Furniture and Furnishings	2.4%	2.3%	3.1%	3.3%	3.3%	3.3%	3.4%	3.5%
Carpets and Rugs**				0.8%	0.9%	1.0%	1.1%	1.1%
Rubber Tires	1.3%	1.6%	1.8%	1.8%	1.7%	1.9%	1.8%	1.9%
Batteries, Lead-Acid	Neg.	0.7%	1.0%	0.7%	0.7%	0.9%	0.9%	0.9%
Miscellaneous Durables	5.7%	5.7%	6.5%	6.1%	6.1%	5.6%	5.7%	5.7%
Total Durable Goods	11.3%	12.1%	14.4%	14.5%	14.6%	14.5%	14.7%	15.1%
Nondurable Goods *(Detail in Table 15)*	19.7%	20.7%	22.7%	25.4%	25.3%	26.5%	27.1%	26.5%
Containers and Packaging *(Detail in Table 19)*	31.1%	36.0%	34.7%	31.4%	31.9%	32.7%	32.3%	33.0%
Total Product Wastes†	62.0%	68.8%	71.8%	71.4%	71.8%	73.8%	74.1%	74.7%
Other Wastes								
Food Wastes	13.8%	10.6%	8.6%	10.1%	10.1%	10.0%	10.3%	10.4%
Yard Trimmings	22.7%	19.2%	18.1%	17.1%	16.8%	14.7%	14.1%	13.4%
Miscellaneous Inorganic Wastes	1.5%	1.5%	1.5%	1.4%	1.4%	1.4%	1.5%	1.5%
Total Other Wastes	38.0%	31.2%	28.2%	28.6%	28.2%	26.2%	25.9%	25.3%
Total MSW Generated - %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* Generation before materials recovery or combustion. Does not include construction & demolition debris, industrial process wastes, or certain other wastes. Details may not add to totals due to rounding.

** Not estimated separately prior to 1990.

† Other than food products.

Neg. = Less than 5,000 tons or 0.05 percent.

Source: Franklin Associates, Ltd.

Table 13

RECOVERY* OF PRODUCTS IN MUNICIPAL SOLID WASTE, 1960 TO 1996

(WITH DETAIL ON DURABLE GOODS)

(In thousands of tons and percent of generation of each product)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods								
Major Appliances	10	50	130	1,070	1,450	1,910	2,070	2,200
Small Appliances**				10	10	10	10	10
Furniture and Furnishings	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Carpets and Rugs**				Neg.	10	10	20	30
Rubber Tires	330	250	150	440	470	620	660	730
Batteries, lead acid	Neg.	620	1,040	1,480	1,450	1,980	1,620	1,700
Miscellaneous Durables	10	20	40	810	750	700	730	740
Total Durable Goods	350	940	1,360	3,810	4,140	5,230	5,110	5,410
Nondurable Goods	2,390	3,730	4,670	8,790	11,070	12,610	13,610	12,860
(Detail in Table 16)								
Containers and Packaging	2,870	3,350	8,490	16,780	19,940	24,580	26,810	27,740
(Detail in Table 20)								
Total Product Wastes†	5,610	8,020	14,520	29,380	35,150	42,420	45,530	46,010
Other Wastes								
Food Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	480	570	520
Yard Trimmings	Neg.	Neg.	Neg.	4,200	5,400	8,000	9,000	10,800
Miscellaneous Inorganic Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Other Wastes	Neg.	Neg.	Neg.	4,200	5,400	8,480	9,570	11,320
Total MSW Recovered-Weight	5,610	8,020	14,520	33,580	40,550	50,900	55,100	57,330
	Percent of Generation of Each Product							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods								
Major Appliances	0.6%	2.3%	4.4%	32.3%	44.2%	58.2%	60.5%	62.5%
Small Appliances**				2.2%	1.9%	1.5%	1.4%	1.3%
Furniture and Furnishings	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Carpets and Rugs**				Neg.	0.5%	0.5%	0.9%	1.3%
Rubber Tires	29.5%	13.2%	5.5%	12.2%	13.0%	15.2%	17.5%	18.7%
Batteries, Lead-Acid	Neg.	75.6%	69.8%	98.0%	94.8%	98.5%	89.5%	93.9%
Miscellaneous Durables	0.2%	0.3%	0.4%	6.5%	5.9%	5.8%	6.1%	6.2%
Total Durable Goods	3.5%	6.4%	6.2%	12.8%	13.6%	16.8%	16.4%	17.1%
Nondurable Goods	13.8%	14.9%	13.6%	16.8%	21.0%	22.2%	23.8%	23.1%
(Detail in Table 16)								
Containers and Packaging	10.5%	7.7%	16.1%	26.0%	29.9%	35.1%	39.2%	40.1%
(Detail in Table 21)								
Total Product Wastes†	10.3%	9.6%	13.3%	20.1%	23.4%	26.8%	29.0%	29.4%
Other Wastes								
Food Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	2.2%	2.6%	2.4%
Yard Trimmings	Neg.	Neg.	Neg.	12.0%	15.4%	25.4%	30.3%	38.6%
Miscellaneous Inorganic Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Other Wastes	Neg.	Neg.	Neg.	7.2%	9.2%	15.1%	17.5%	21.3%
Total MSW Recovered - %	6.4%	6.6%	9.6%	16.4%	19.4%	23.8%	26.1%	27.3%

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.

** Not estimated separately prior to 1990.

† Other than food products.

Neg. = Less than 5,000 tons or 0.05 percent.

Source: Franklin Associates, Ltd.

Table 14

PRODUCTS DISCARDED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996
(WITH DETAIL ON DURABLE GOODS)
(In thousands of tons and percent of total discards)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods								
Major Appliances	1,620	2,120	2,820	2,240	1,830	1,370	1,350	1,320
Small Appliances**				450	510	640	700	770
Furniture and Furnishings	2,150	2,830	4,760	6,790	6,940	6,980	7,170	7,320
Carpets and Rugs**				1,660	1,810	2,110	2,210	2,280
Rubber Tires	790	1,640	2,570	3,170	3,140	3,460	3,110	3,180
Batteries, lead acid	Neg.	200	450	30	80	30	190	110
Miscellaneous Durables	5,010	6,930	9,840	11,660	11,980	11,300	11,300	11,270
Total Durable Goods	9,570	13,720	20,440	26,000	26,290	25,890	26,030	26,250
Nondurable Goods	14,940	21,330	29,750	43,380	41,710	44,240	43,630	42,790
(Detail in Table 17)								
Containers and Packaging	24,500	40,210	44,180	47,750	46,780	45,520	41,570	41,510
(Detail in Table 22)								
Total Product Wastes†	49,010	75,260	94,370	117,130	114,780	115,650	111,230	110,550
Other Wastes								
Food Wastes	12,200	12,800	13,000	20,800	21,000	21,020	21,230	21,380
Yard Trimmings	20,000	23,200	27,500	30,800	29,600	23,500	20,750	17,200
Miscellaneous Inorganic Wastes	1,300	1,780	2,250	2,900	3,000	3,100	3,150	3,200
Total Other Wastes	33,500	37,780	42,750	54,500	53,600	47,620	45,130	41,780
Total MSW Discarded-Weight	82,510	113,040	137,120	171,630	168,380	163,270	156,360	152,330
	Percent of Total Discards							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods								
Major Appliances	2.0%	1.9%	2.1%	1.3%	1.1%	0.8%	0.9%	0.9%
Small Appliances**				0.3%	0.3%	0.4%	0.4%	0.5%
Furniture and Furnishings	2.6%	2.5%	3.5%	4.0%	4.1%	4.3%	4.6%	4.8%
Carpets and Rugs**				1.0%	1.1%	1.3%	1.4%	1.5%
Rubber Tires	1.0%	1.5%	1.9%	1.8%	1.9%	2.1%	2.0%	2.1%
Batteries, Lead-Acid	Neg.	0.2%	0.3%	0.0%	0.0%	0.0%	0.1%	0.1%
Miscellaneous Durables	6.1%	6.1%	7.2%	6.8%	7.1%	6.9%	7.2%	7.4%
Total Durable Goods	11.6%	12.1%	14.9%	15.1%	15.6%	15.9%	16.6%	17.2%
Nondurable Goods	18.1%	18.9%	21.7%	25.3%	24.8%	27.1%	27.9%	28.1%
(Detail in Table 17)								
Containers and Packaging	29.7%	35.6%	32.2%	27.8%	27.8%	27.9%	26.6%	27.3%
(Detail in Table 23)								
Total Product Wastes†	59.4%	66.6%	68.8%	68.2%	68.2%	70.8%	71.1%	72.6%
Other Wastes								
Food Wastes	14.8%	11.3%	9.5%	12.1%	12.5%	12.9%	13.6%	14.0%
Yard Trimmings	24.2%	20.5%	20.1%	17.9%	17.6%	14.4%	13.3%	11.3%
Miscellaneous Inorganic Wastes	1.6%	1.6%	1.6%	1.7%	1.8%	1.9%	2.0%	2.1%
Total Other Wastes	40.6%	33.4%	31.2%	31.8%	31.8%	29.2%	28.9%	27.4%
Total MSW Discarded - %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* Discards after materials and compost recovery. Does not include construction & demolition debris, industrial process wastes, or certain other wastes. Details may not add to totals due to rounding.

** Not estimated separately prior to 1990.

† Other than food products.

Neg. = Less than 5,000 tons or 0.05 percent.

Source: Franklin Associates, Ltd.

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 55.7 million tons in 1996 (26.5 percent of total generation). Recovery of paper products in this category is quite significant, resulting in 12.9 million tons of nondurable goods recovered in 1996 (23.1 percent of nondurables generation). This means that 42.8 million tons of nondurable goods were discarded in 1996 (28.1 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 1996 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 12.3 million tons generated in 1996 (5.9 percent of total MSW). In 1996, 54.1 percent of newspapers generated were recovered for recycling, leaving 5.6 million tons discarded (3.7 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 940,000 tons, or 0.4 percent of total MSW generation, in 1996. Recovery of books is not well documented, but it was estimated that approximately 170,000 tons of books were recovered in 1996. Books are made of both groundwood and chemical pulp.

- Magazines accounted for an estimated 2.0 million tons, or 0.9 percent of total MSW generation, in 1996. Like books, recovery of magazines is not

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* 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 480,000 tons of magazines were recovered in 1996. 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. (6.7 million tons, or 3.2 percent of total MSW generation, in 1996). 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 3.2 million tons of office-type papers were recovered in 1996.

- Telephone directories were estimated to generate 470,000 tons (0.2 percent of total MSW) in 1996. These directories are made of groundwood. It was estimated that 50,000 tons of directories were recovered in 1996. 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. Beginning in 1993 the generation data in this report are taken from YPPA data; therefore, there is some discontinuity with the data published for earlier years, which was estimated. YPPA has discontinued its practice of estimating recovery of directories.

- Third-class mail includes catalogs and other direct bulk mailings; these amounted to 4.5 million tons, or 2.2 percent of MSW generation, in 1996. Both groundwood and chemical pulps are used in these mailings. It was estimated that 670,000 tons were recovered in 1996. 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 6.6 million tons, or 3.1 percent of MSW generation, in 1996, with recovery at 810,000 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 3.0 million tons (1.4 percent of total MSW generation) in 1996. 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 950,000 tons (0.5 percent of total MSW generation) in 1996. No significant recovery of these products was identified.

- Other nonpackaging papers—including posters, photographic papers, cards and games, etc.—accounted for 4.1 million tons (1.9 percent of total MSW generation) in 1996. No significant recovery of these papers was identified.

Overall, generation of paper and paperboard products in nondurable goods was 41.5 million tons in 1996 (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 29.0 percent in 1996. Thus 29.4 million tons of paper in nondurables were discarded in 1996.

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 primarily of polystyrene resin. An estimated 810,000 tons of these products were generated in 1996, or 0.4 percent of total MSW (see Table 15). An estimated 11,000 tons of these products were recovered for recycling in 1996.

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 1996, or 1.5 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.

No significant recycling or composting of disposable diapers was identified in 1996.

Clothing and Footwear. Generation of clothing and footwear was estimated to be 5.3 million tons in 1996 (2.5 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.

Previously, The Council for Textile Recycling has reported on recovery of textiles for exports, reprocessing, and reuse. Based on their data, it was estimated that 700,000 tons of textiles in clothing were recovered for export or recycling in 1996. (Reuse is not counted as recycling and is discussed in Chapter 3.)

Towels, Sheets, and Pillowcases. An estimated 750,000 tons of towels, sheets, and pillowcases were generated in 1996. Generation was estimated using a methodology similar to that for clothing. An estimated 130,000 tons of these textiles were recovered for export or recycling in 1996.

Other Miscellaneous Nondurables. Generation of other miscellaneous nondurables was estimated to be 3.4 million tons in 1996 (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.

Table 15

PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996
(WITH DETAIL ON NONDURABLE GOODS)
(In thousands of tons and percent of total generation)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods	9,920	14,660	21,800	29,810	30,430	31,120	31,140	31,660
(Detail in Table 12)								
Nondurable Goods								
Newspapers	7,110	9,510	11,050	13,430	12,680	13,680	13,140	12,290
Books and Magazines	1,920	2,470	3,390					
Books**				970	930	1,180	1,150	940
Magazines**				2,830	2,370	2,250	2,530	1,970
Office Papers	1,520	2,650	4,000	6,410	6,660	6,970	6,630	6,660
Telephone Directories**				610	680	470	490	470
Third Class Mail**				3,820	3,560	4,400	4,620	4,510
Other Commercial Printing	1,260	2,130	3,120	4,460	5,500	6,080	6,770	6,560
Tissue Paper and Towels	1,090	2,080	2,300	2,960	2,750	2,860	2,970	2,980
Paper Plates and Cups	270	420	630	650	680	870	970	950
Plastic Plates and Cups†			190	650	680	810	780	810
Trash Bags**				780	840	940	780	860
Disposable Diapers	Neg.	350	1,930	2,700	2,870	2,980	3,010	3,050
Other Nonpackaging Paper	2,700	3,630	4,230	3,840	4,120	4,470	4,270	4,070
Clothing and Footwear	1,360	1,620	2,170	4,010	4,400	4,870	5,070	5,340
Towels, Sheets and Pillowcases**				710	720	750	740	750
Other Miscellaneous Nondurables	100	200	1,410	3,340	3,340	3,270	3,320	3,440
Total Nondurable Goods	17,330	25,060	34,420	52,170	52,780	56,850	57,240	55,650
Containers and Packaging	27,370	43,560	52,670	64,530	66,720	70,100	68,380	69,250
(Detail in Table 18)								
Total Product Wastes‡	54,620	83,280	108,890	146,510	149,930	158,070	156,760	156,560
Other Wastes	33,500	37,780	42,750	58,700	59,000	56,100	54,700	53,100
Total MSW Generated-Weight	88,120	121,060	151,640	205,210	208,930	214,170	211,460	209,660
	Percent of Total Generation							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods	11.3%	12.1%	14.4%	14.5%	14.6%	14.5%	14.7%	15.1%
(Detail in Table 12)								
Nondurable Goods								
Newspapers	8.1%	7.9%	7.3%	6.5%	6.1%	6.4%	6.2%	5.9%
Books and Magazines	2.2%	2.0%	2.2%					
Books**				0.5%	0.4%	0.6%	0.5%	0.4%
Magazines**				1.4%	1.1%	1.1%	1.2%	0.9%
Office Papers	1.7%	2.2%	2.6%	3.1%	3.2%	3.3%	3.1%	3.2%
Telephone Directories**				0.3%	0.3%	0.2%	0.2%	0.2%
Third Class Mail**				1.9%	1.7%	2.1%	2.2%	2.2%
Other Commercial Printing	1.4%	1.8%	2.1%	2.2%	2.6%	2.8%	3.2%	3.1%
Tissue Paper and Towels	1.2%	1.7%	1.5%	1.4%	1.3%	1.3%	1.4%	1.4%
Paper Plates and Cups	0.3%	0.3%	0.4%	0.3%	0.3%	0.4%	0.5%	0.5%
Plastic Plates and Cups†			0.1%	0.3%	0.3%	0.4%	0.4%	0.4%
Trash Bags**				0.4%	0.4%	0.4%	0.4%	0.4%
Disposable Diapers	Neg.	0.3%	1.3%	1.3%	1.4%	1.4%	1.4%	1.5%
Other Nonpackaging Paper	3.1%	3.0%	2.8%	1.9%	2.0%	2.1%	2.0%	1.9%
Clothing and Footwear	1.5%	1.3%	1.4%	2.0%	2.1%	2.3%	2.4%	2.5%
Towels, Sheets and Pillowcases**				0.3%	0.3%	0.4%	0.3%	0.4%
Other Miscellaneous Nondurables	0.1%	0.2%	0.9%	1.6%	1.6%	1.5%	1.6%	1.6%
Total Nondurables	19.7%	20.7%	22.7%	25.4%	25.3%	26.5%	27.1%	26.5%
Containers and Packaging	31.1%	36.0%	34.7%	31.4%	31.9%	32.7%	32.3%	33.0%
(Detail in Table 19)								
Total Product Wastes‡	62.0%	68.8%	71.8%	71.4%	71.8%	73.8%	74.1%	74.7%
Other Wastes	38.0%	31.2%	28.2%	28.6%	28.2%	26.2%	25.9%	25.3%
Total MSW Generated - %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* Generation before materials recovery or combustion. Does not include construction & demolition debris, industrial process wastes, or certain other wastes. Details may not add to totals due to rounding.
** Not estimated separately prior to 1990.
† Not estimated separately prior to 1980.
‡ Other than food products.
Neg. = Less than 5,000 tons or 0.05 percent.
Source: Franklin Associates, Ltd.

Table 16

RECOVERY* OF PRODUCTS IN MUNICIPAL SOLID WASTE, 1960 TO 1996
(WITH DETAIL ON NONDURABLE GOODS)
(In thousands of tons and percent of generation of each product)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 13)*	350	940	1,360	3,810	4,140	5,230	5,110	5,410
Nondurable Goods								
Newspapers	1,820	2,250	3,020	5,110	6,000	6,250	7,010	6,650
Books and Magazines	100	260	280					
Books**				100	140	220	220	170
Magazines**				300	380	630	650	480
Office Papers	250	710	870	1,700	2,440	2,940	3,040	3,190
Telephone Directories**				40	50	50	60	50
Third Class Mail**				200	350	690	710	670
Other Commercial Printing	130	340	350	700	1,000	1,050	1,120	810
Tissue Paper and Towels	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Paper Plates and Cups	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Plastic Plates and Cups†			Neg.	10	20	10	10	10
Trash Bags**				Neg.	Neg.	Neg.	Neg.	Neg.
Disposable Diapers				Neg.	Neg.	Neg.	Neg.	Neg.
Other Nonpackaging Paper	40	110	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Clothing and Footwear	50	60	150	510	570	640	660	700
Towels, Sheets and Pillowcases**				120	120	130	130	130
Other Miscellaneous Nondurables	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Nondurable Goods	2,390	3,730	4,670	8,790	11,070	12,610	13,610	12,860
Containers and Packaging *(Detail in Table 20)*	2,870	3,350	8,490	16,780	19,940	24,580	26,810	27,740
Total Product Wastes‡	5,610	8,020	14,520	29,380	35,150	42,420	45,530	46,010
Other Wastes	Neg.	Neg.	Neg.	4,200	5,400	8,480	9,570	11,320
Total MSW Recovered-Weight	5,610	8,020	14,520	33,580	40,550	50,900	55,100	57,330
	Percent of Generation of Each Product							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 13)*	3.5%	6.4%	6.2%	12.8%	13.6%	16.8%	16.4%	17.1%
Nondurable Goods								
Newspapers	25.6%	23.7%	27.3%	38.0%	47.3%	45.7%	53.3%	54.1%
Books and Magazines	5.2%	10.5%	8.3%					
Books**				10.3%	15.1%	18.6%	19.1%	18.1%
Magazines**				10.6%	16.0%	28.0%	25.7%	24.4%
Office Papers	16.4%	26.8%	21.8%	26.5%	36.6%	42.2%	45.9%	47.9%
Telephone Directories**				6.6%	7.4%	10.6%	12.2%	10.6%
Third Class Mail**				5.2%	9.8%	15.7%	15.4%	14.9%
Other Commercial Printing	10.3%	16.0%	11.2%	15.7%	18.2%	17.3%	16.5%	12.3%
Tissue Paper and Towels	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Paper Plates and Cups	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Plastic Plates and Cups†			Neg.	1.5%	2.9%	1.2%	1.3%	1.2%
Trash Bags**				Neg.	Neg.	Neg.	Neg.	Neg.
Disposable Diapers				Neg.	Neg.	Neg.	Neg.	Neg.
Other Nonpackaging Paper	1.5%	3.0%	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Clothing and Footwear	Neg.	Neg.	Neg.	12.7%	13.0%	13.1%	13.0%	13.1%
Towels, Sheets and Pillowcases**				16.9%	16.7%	17.3%	17.6%	17.3%
Other Miscellaneous Nondurables	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Nondurables	13.8%	14.9%	13.6%	16.8%	21.0%	22.2%	23.8%	23.1%
Containers and Packaging *(Detail in Table 21)*	10.5%	7.7%	16.1%	26.0%	29.9%	35.1%	39.2%	40.1%
Total Product Wastes‡	10.3%	9.6%	13.3%	20.1%	23.4%	26.8%	29.0%	29.4%
Other Wastes	Neg.	Neg.	Neg.	7.2%	9.2%	15.1%	17.5%	21.3%
Total MSW Recovered - %	6.4%	6.6%	9.6%	16.4%	19.4%	23.8%	26.1%	27.3%

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
** Not estimated separately prior to 1990.
† Not estimated separately prior to 1980.
‡ Other than food products.
Neg. = Less than 5,000 tons or 0.05 percent.
Source: Franklin Associates, Ltd.

Table 17

PRODUCTS DISCARDED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996
(WITH DETAIL ON NONDURABLE GOODS)
(In thousands of tons and percent of total discards)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 14)*	9,570	13,720	20,440	26,000	26,290	25,890	26,030	26,250
Nondurable Goods								
Newspapers	5,290	7,260	8,030	8,320	6,680	7,430	6,130	5,640
Books and Magazines	1,820	2,210	3,110					
Books**				870	790	960	930	770
Magazines**				2,530	1,990	1,620	1,880	1,490
Office Papers	1,270	1,940	3,130	4,710	4,220	4,030	3,590	3,470
Telephone Directories**				570	630	420	430	420
Third Class Mail**				3,620	3,210	3,710	3,910	3,840
Other Commercial Printing	1,130	1,790	2,770	3,760	4,500	5,030	5,650	5,750
Tissue Paper and Towels	1,090	2,080	2,300	2,960	2,750	2,860	2,970	2,980
Paper Plates and Cups	270	420	630	650	680	870	970	950
Plastic Plates and Cups†			190	640	660	800	770	800
Trash Bags**				780	840	940	780	860
Disposable Diapers	Neg.	350	1,930	2,700	2,870	2,980	3,010	3,050
Other Nonpackaging Paper	2,660	3,520	4,230	3,840	4,120	4,470	4,270	4,070
Clothing and Footwear	1,310	1,560	2,020	3,500	3,830	4,230	4,410	4,640
Towels, Sheets and Pillowcases**				590	600	620	610	620
Other Miscellaneous Nondurables	100	200	1,410	3,340	3,340	3,270	3,320	3,440
Total Nondurable Goods	14,940	21,330	29,750	43,380	41,710	44,240	43,630	42,790
Containers and Packaging *(Detail in Table 22)*	24,500	40,210	44,180	47,750	46,780	45,520	41,570	41,510
Total Product Wastes‡	49,010	75,260	94,370	117,130	114,780	115,650	111,230	110,550
Other Wastes	33,500	37,780	42,750	54,500	53,600	47,620	45,130	41,780
Total MSW Discarded-Weight	82,510	113,040	137,120	171,630	168,380	163,270	156,360	152,330
	Percent of Total Discards							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 14)*	11.6%	12.1%	14.9%	15.1%	15.6%	15.9%	16.6%	17.2%
Nondurable Goods								
Newspapers	6.4%	6.4%	5.9%	4.8%	4.0%	4.6%	3.9%	3.7%
Books and Magazines	2.2%	2.0%	2.3%					
Books**				0.5%	0.5%	0.6%	0.6%	0.5%
Magazines**				1.5%	1.2%	1.0%	1.2%	1.0%
Office Papers	1.5%	1.7%	2.3%	2.7%	2.5%	2.5%	2.3%	2.3%
Telephone Directories**				0.3%	0.4%	0.3%	0.3%	0.3%
Third Class Mail**				2.1%	1.9%	2.3%	2.5%	2.5%
Other Commercial Printing	1.4%	1.6%	2.0%	2.2%	2.7%	3.1%	3.6%	3.8%
Tissue Paper and Towels	1.3%	1.8%	1.7%	1.7%	1.6%	1.8%	1.9%	2.0%
Paper Plates and Cups	0.3%	0.4%	0.5%	0.4%	0.4%	0.5%	0.6%	0.6%
Plastic Plates and Cups†			0.1%	0.4%	0.4%	0.5%	0.5%	0.5%
Trash Bags**				0.5%	0.5%	0.6%	0.5%	0.6%
Disposable Diapers	Neg.	0.3%	1.4%	1.6%	1.7%	1.8%	1.9%	2.0%
Other Nonpackaging Paper	3.2%	3.1%	3.1%	2.2%	2.4%	2.7%	2.7%	2.7%
Clothing and Footwear	1.6%	1.4%	1.5%	2.0%	2.3%	2.6%	2.8%	3.0%
Towels, Sheets and Pillowcases**				0.3%	0.4%	0.4%	0.4%	0.4%
Other Miscellaneous Nondurables	0.1%	0.2%	1.7%	1.9%	2.0%	2.0%	2.1%	2.3%
Total Nondurables	18.1%	18.9%	21.7%	25.3%	24.8%	27.1%	27.9%	28.1%
Containers and Packaging *(Detail in Table 23)*	29.7%	35.6%	32.2%	27.8%	27.8%	27.9%	26.6%	27.3%
Total Product Wastes‡	59.4%	66.6%	68.8%	68.2%	68.2%	70.8%	71.1%	72.6%
Other Wastes	40.6%	33.4%	31.2%	31.8%	31.8%	29.2%	28.9%	27.4%
Total MSW Discarded - %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* Discards after materials and compost recovery. Does not include construction & demolition debris, industrial process wastes, or certain other wastes. Details may not add to totals due to rounding.
** Not estimated separately prior to 1990.
† Not estimated separately prior to 1980.
‡ Other than food products.
Neg. = Less than 5,000 tons or 0.05 percent.
Source: Franklin Associates, Ltd.

Containers and Packaging

Containers and packaging make up a major portion of MSW, amounting to 69.3 million tons of generation in 1996 (33.0 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 1996, 40.1 percent of containers and packaging generated was recovered for recycling. Because of this recovery, containers and packaging comprised 27.3 percent of total MSW discards in 1996.

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. Material categories are discussed separately below.

Glass Containers. Glass containers include beer and soft drink bottles (which includes carbonated drinks and non-carbonated waters, teas, and flavored drinks containing not more than 10 percent fruit juice), 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 11 million tons in 1996, or 5.3 percent of MSW generation (Tables 18 and 19). This is a slight decrease in generation compared to 1995.

Resource Recycling's Container Recycling Report (May 1997) reports the Glass Packaging Institute's (GPI) recovery rate for glass containers, but GPI 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 3.2 million tons of glass containers were recovered for recycling in 1996, or 28.7 percent of generation. Glass container discards were 7.8 million tons in 1996, or 5.2 percent of total MSW discards.

Steel Containers and Packaging. Steel food and other cans, and other steel packaging (e.g., strapping), totaled 3.0 million tons in 1996 (1.4 percent of total MSW generation), with most of that amount being cans for food products (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). Estimates include adjustments for net imports.

Recovery data for steel containers and packaging were provided by the Steel Recycling Institute. An estimated 1.7 million tons of steel packaging were recovered in 1996, or 56.5 percent of generation. The SRI estimates include both

recovery from residential sources and magnetic separation of steel cans and other ferrous products at waste-to-energy combustion facilities.

Aluminum Containers and Packaging. Aluminum containers and packaging include beer and soft drink cans (including all carbonated and non-carbonated soft drinks, tea, tonic, waters and juice beverages), 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 1995 was 2.0 million tons, or 0.9 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 63.5 percent rate in 1996. Recovery of all aluminum packaging was estimated to be 52.0 percent of total generation in 1996. After recovery for recycling, 940,000 tons of aluminum packaging were discarded in 1996.

Paper and Paperboard Containers and Packaging. Corrugated boxes are the largest single product category of MSW at 29.0 million tons generated, or 13.8 percent of total generation, in 1996. Corrugated boxes also represent the largest single category of product recovery, at 19.3 million tons of recovery in 1996 (66.6 percent of boxes generated were recovered). After recovery, 9.7 million tons of corrugated boxes were discarded, or 6.4 percent of MSW discards in 1996.

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 38.5 million tons of MSW generation in 1996, or 18.4 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 1.2 million tons in 1996). The overall recovery rate for paper and paperboard packaging in 1996 was 53.5 percent. Other paper packaging like folding boxes and sacks is mostly recovered as 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, and the American Plastics Council annual plastic recovery survey.

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 8.2 million tons in 1996 (3.9 percent of MSW 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 38.9 percent rate in 1996 (271,000 tons). Recovery of plastic milk and water bottles was estimated to have been 202,000 tons, or 30.8 percent of generation. Overall, recovery of plastic containers and packaging was estimated to be 800,000 tons, or 9.8 percent in 1996. Discards of plastic packaging were thus 7.4 million tons in 1996, or 4.8 percent of total MSW discards.

Wood Packaging. Wood packaging includes wood crates and pallets (mostly pallets). Data on production of wood packaging is from the Wooden Pallet and Container Association, as well as recent studies on the pallet industry (Busch, Reddy, Araman). In 1996, 6.5 million tons of wood pallets and other wood packaging were estimated to have been generated, or 3.1 percent of total MSW generation.

Wood pallets recovered for recycling (usually by chipping for uses such as mulch or bedding material, but excluding wood combusted as fuel) was estimated at 480,000 tons in 1996. *This figure (along with wood generation) represents a change over previous estimates.* Recent studies on the pallet industry (Bush, Reddy, Araman) provided new information on recovery and recycling of reusable pallets, including data on the number of reusable pallets refurbished and returned to service.

Nearly 200 million pallets—representing over 5 million tons of wood packaging—were estimated to be refurbished and returned to service in 1996. This EPA report classifies pallets refurbished and returned to service as reuse (source reduction) rather than recovery for recycling. Therefore, the 5 million tons represents a reduction in the amount of wood packaging discarded to the waste stream (i.e., a reduction in generation) rather than an increase in recycling.

Accounting for pallet reuse and recovery for recycling, wood packaging discards were 6.0 million tons in 1996, or 3.9 percent of total MSW discards. (Note: wood packaging generation, recovery for recycling, and discards in the Chapter 2 Tables have been revised for the years 1990 through 1996.)

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 150,000 tons generated in 1996.

Table 18

PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996
(WITH DETAIL ON CONTAINERS AND PACKAGING)
(In thousands of tons)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods	9,920	14,660	21,800	29,810	30,430	31,120	31,140	31,660
(Detail in Table 12)								
Nondurable Goods	17,330	25,060	34,420	52,170	52,780	56,850	57,240	55,650
(Detail in Table 15)								
Containers and Packaging								
Glass Packaging								
Beer and Soft Drink Bottles	1,400	5,580	6,740	5,640	5,480	5,250	5,120	5,210
Wine and Liquor Bottles	1,080	1,900	2,450	2,030	1,930	1,800	1,790	1,940
Food and Other Bottles & Jars	3,710	4,440	4,780	4,160	4,350	5,000	4,620	3,890
Total Glass Packaging	6,190	11,920	13,970	11,830	11,760	12,050	11,530	11,040
Steel Packaging								
Beer and Soft Drink Cans	640	1,570	520	150	80	10	Neg.	Neg.
Food and Other Cans	3,760	3,540	2,850	2,540	2,730	2,990	2,690	2,820
Other Steel Packaging	260	270	240	200	170	220	210	170
Total Steel Packaging	4,660	5,380	3,610	2,890	2,980	3,220	2,900	2,990
Aluminum Packaging								
Beer and Soft Drink Cans	Neg.	100	850	1,550	1,580	1,710	1,580	1,560
Other Cans	Neg.	60	40	20	30	40	40	40
Foil and Closures	170	410	380	330	330	340	350	360
Total Aluminum Packaging	170	570	1,270	1,900	1,940	2,090	1,970	1,960
Paper & Paperboard Pkg								
Corrugated Boxes	7,330	12,760	17,080	24,010	25,400	28,140	28,800	29,020
Milk Cartons**			790	510	480	520	510	460
Folding Cartons**			3,820	4,300	4,590	5,150	5,310	5,390
Other Paperboard Packaging	3,840	4,830	230	290	280	300	260	230
Bags and Sacks**			3,380	2,440	2,320	2,300	1,980	1,980
Wrapping Papers**			200	110	80	80	70	50
Other Paper Packaging	2,940	3,810	850	1,020	1,120	1,070	1,150	1,350
Total Paper & Board Pkg	14,110	21,400	26,350	32,680	34,270	37,560	38,080	38,480
Plastics Packaging								
Soft Drink Bottles**			260	430	510	600	650	700
Milk Bottles**			230	530	520	580	620	650
Other Containers	60	910	890	1,430	1,540	1,380	1,180	1,280
Bags and Sacks**			390	940	970	1,320	1,200	1,360
Wraps**			840	1,530	1,820	1,770	1,710	1,860
Other Plastics Packaging	60	1,180	790	2,040	2,160	2,250	2,220	2,300
Total Plastics Packaging	120	2,090	3,400	6,900	7,520	7,900	7,580	8,150
Wood Packaging	2,000	2,070	3,940	8,180	8,090	7,120	6,170	6,480
Other Misc. Packaging	120	130	130	150	160	160	150	150
Total Containers & Pkg	27,370	43,560	52,670	64,530	66,720	70,100	68,380	69,250
Total Product Wastes†	54,620	83,280	108,890	146,510	149,930	158,070	156,760	156,560
Other Wastes								
Food Wastes	12,200	12,800	13,000	20,800	21,000	21,500	21,800	21,900
Yard Trimmings	20,000	23,200	27,500	35,000	35,000	31,500	29,750	28,000
Miscellaneous Inorganic Wastes	1,300	1,780	2,250	2,900	3,000	3,100	3,150	3,200
Total Other Wastes	33,500	37,780	42,750	58,700	59,000	56,100	54,700	53,100
Total MSW Generated - Weight	88,120	121,060	151,640	205,210	208,930	214,170	211,460	209,660

* Generation before materials recovery or combustion.
Details may not add to totals due to rounding.
** Not estimated separately prior to 1980.
† Other than food products.
Neg. = Less than 5,000 tons or 0.05 percent.
Source: Franklin Associates, Ltd.

Table 19

PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996
(WITH DETAIL ON CONTAINERS AND PACKAGING)
(In percent of total generation)

	Percent of Total Generation							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods	11.3%	12.1%	14.4%	14.5%	14.6%	14.5%	14.7%	15.1%
(Detail in Table 12)								
Nondurable Goods	19.7%	20.7%	22.7%	25.4%	25.3%	26.5%	27.1%	26.5%
(Detail in Table 15)								
Containers and Packaging								
Glass Packaging								
Beer and Soft Drink Bottles	1.6%	4.6%	4.4%	2.7%	2.6%	2.5%	2.4%	2.5%
Wine and Liquor Bottles	1.2%	1.6%	1.6%	1.0%	0.9%	0.8%	0.8%	0.9%
Food and Other Bottles & Jars	4.2%	3.7%	3.2%	2.0%	2.1%	2.3%	2.2%	1.9%
Total Glass Packaging	7.0%	9.8%	9.2%	5.8%	5.6%	5.6%	5.5%	5.3%
Steel Packaging								
Beer and Soft Drink Cans	0.7%	1.3%	0.3%	0.1%	Neg.	Neg.	Neg.	Neg.
Food and Other Cans	4.3%	2.9%	1.9%	1.2%	1.3%	1.4%	1.3%	1.3%
Other Steel Packaging	0.3%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%
Total Steel Packaging	5.3%	4.4%	2.4%	1.4%	1.4%	1.5%	1.4%	1.4%
Aluminum Packaging								
Beer and Soft Drink Cans	Neg.	0.1%	0.6%	0.8%	0.8%	0.8%	0.7%	0.7%
Other Cans	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Foil and Closures	0.2%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%
Total Aluminum Packaging	0.2%	0.5%	0.8%	0.9%	0.9%	1.0%	0.9%	0.9%
Paper & Paperboard Pkg								
Corrugated Boxes	8.3%	10.5%	11.3%	11.7%	12.2%	13.1%	13.6%	13.8%
Milk Cartons**			0.5%	0.2%	0.2%	0.2%	0.2%	0.2%
Folding Cartons**			2.5%	2.1%	2.2%	2.4%	2.5%	2.6%
Other Paperboard Packaging	4.4%	4.0%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%
Bags and Sacks**			2.2%	1.2%	1.1%	1.1%	0.9%	0.9%
Wrapping Papers**			0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
Other Paper Packaging	3.3%	3.1%	0.6%	0.5%	0.5%	0.5%	0.5%	0.6%
Total Paper & Board Pkg	16.0%	17.7%	17.4%	15.9%	16.4%	17.5%	18.0%	18.4%
Plastics Packaging								
Soft Drink Bottles**			0.2%	0.2%	0.2%	0.3%	0.3%	0.3%
Milk Bottles**			0.2%	0.3%	0.2%	0.3%	0.3%	0.3%
Other Containers	0.1%	0.8%	0.6%	0.7%	0.7%	0.6%	0.6%	0.6%
Bags and Sacks**			0.3%	0.5%	0.5%	0.6%	0.6%	0.6%
Wraps**			0.6%	0.7%	0.9%	0.8%	0.8%	0.9%
Other Plastics Packaging	0.1%	1.0%	0.5%	1.0%	1.0%	1.1%	1.0%	1.1%
Total Plastics Packaging	0.1%	1.7%	2.2%	3.4%	3.6%	3.7%	3.6%	3.9%
Wood Packaging	2.3%	1.7%	2.6%	4.0%	3.9%	3.3%	2.9%	3.1%
Other Misc. Packaging	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Total Containers & Pkg	31.1%	36.0%	34.7%	31.4%	31.9%	32.7%	32.3%	33.0%
Total Product Wastes†	62.0%	68.8%	71.8%	71.4%	71.8%	73.8%	74.1%	74.7%
Other Wastes								
Food Wastes	13.8%	10.6%	8.6%	10.1%	10.1%	10.0%	10.3%	10.4%
Yard Trimmings	22.7%	19.2%	18.1%	17.1%	16.8%	14.7%	14.1%	13.4%
Miscellaneous Inorganic Wastes	1.5%	1.5%	1.5%	1.4%	1.4%	1.4%	1.5%	1.5%
Total Other Wastes	38.0%	31.2%	28.2%	28.6%	28.2%	26.2%	25.9%	25.3%
Total MSW Generated - %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* Generation before materials recovery or combustion.
Details may not add to totals due to rounding.
** Not estimated separately prior to 1980.
† Other than food products.
Neg. = Less than 5,000 tons or 0.05 percent.
Source: Franklin Associates, Ltd.

Table 20

RECOVERY* OF PRODUCTS IN MUNICIPAL SOLID WASTE, 1960 TO 1996
(WITH DETAIL ON CONTAINERS AND PACKAGING)
(In thousands of tons)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 13)*	350	940	1,360	3,810	4,140	5,230	5,110	5,410
Nondurable Goods *(Detail in Table 16)*	2,390	3,730	4,670	8,790	11,070	12,610	13,610	12,860
Containers and Packaging								
Glass Packaging								
Beer and Soft Drink Bottles	90	140	730	1,890	1,530	1,650	1,670	1,680
Wine and Liquor Bottles	10	10	20	210	430	470	470	480
Food and Other Bottles & Jars	Neg.	Neg.	Neg.	520	930	990	1,000	1,010
Total Glass Packaging	100	150	750	2,620	2,890	3,110	3,140	3,170
Steel Packaging								
Beer and Soft Drink Cans	10	20	50	40	40	Neg.	Neg.	Neg.
Food and Other Cans	20	60	150	590	1,090	1,550	1,510	1,640
Other Steel Packaging	Neg.	Neg.	Neg.	60	50	60	50	50
Total Steel Packaging	30	80	200	690	1,180	1,610	1,560	1,690
Aluminum Packaging								
Beer and Soft Drink Cans	Neg.	10	310	990	1,080	1,120	990	990
Other Cans	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Foil and Closures	Neg.	Neg.	Neg.	20	30	30	30	30
Total Aluminum Pkg	Neg.	10	310	1,010	1,110	1,150	1,020	1,020
Paper & Paperboard Pkg								
Corrugated Boxes	2,520	2,760	6,390	11,530	13,310	16,210	18,480	19,340
Milk Cartons**			Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Folding Cartons**			Neg.	340	460	1,010	1,080	980
Other Paperboard Packaging			520	Neg.	Neg.	Neg.	Neg.	Neg.
Bags and Sacks**			Neg.	200	340	420	340	260
Wrapping Papers**			Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Other Paper Packaging	220	350	310	Neg.	Neg.	Neg.	Neg.	Neg.
Total Paper & Board Pkg	2,740	3,110	7,220	12,070	14,110	17,640	19,900	20,580
Plastics Packaging								
Soft Drink Bottles**			10	140	210	320	300	280
Milk Bottles**			Neg.	20	110	170	190	200
Other Containers	Neg.	Neg.	Neg.	20	80	140	150	190
Bags and Sacks**			Neg.	30	20	30	40	50
Wraps**			Neg.	30	20	30	40	50
Other Plastics Packaging	Neg.	Neg.	Neg.	20	10	20	20	30
Total Plastics Packaging	Neg.	Neg.	10	260	450	710	740	800
Wood Packaging	Neg.	Neg.	Neg.	130	200	360	450	480
Other Misc. Packaging	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Containers & Pkg	2,870	3,350	8,490	16,780	19,940	24,580	26,810	27,740
Total Product Wastes†	5,610	8,020	14,520	29,380	35,150	42,420	45,530	46,010
Other Wastes								
Food Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	480	570	520
Yard Trimmings	Neg.	Neg.	Neg.	4,200	5,400	8,000	9,000	10,800
Miscellaneous Inorganic Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Other Wastes	Neg.	Neg.	Neg.	4,200	5,400	8,480	9,570	11,320
Total MSW Recovered - Weight	5,610	8,020	14,520	33,580	40,550	50,900	55,100	57,330

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
** Not estimated separately prior to 1980.
† Other than food products.
Details may not add to totals due to rounding.
Neg. = Less than 5,000 tons or 0.05 percent.
Source: Franklin Associates, Ltd.

Table 21

RECOVERY* OF PRODUCTS IN MUNICIPAL SOLID WASTE, 1960 TO 1996
(WITH DETAIL ON CONTAINERS AND PACKAGING)
(In percent of generation of each product)

	Percent of Generation of Each Product							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 13)*	3.5%	6.4%	6.2%	12.8%	13.6%	16.8%	16.4%	17.1%
Nondurable Goods *(Detail in Table 16)*	13.8%	14.9%	13.6%	16.8%	21.0%	22.2%	23.8%	23.1%
Containers and Packaging								
Glass Packaging								
Beer and Soft Drink Bottles	6.4%	2.5%	10.8%	33.5%	27.9%	31.4%	32.6%	32.2%
Wine and Liquor Bottles	Neg.	Neg.	Neg.	10.3%	22.3%	26.1%	26.3%	24.7%
Food and Other Bottles & Jars	Neg.	Neg.	Neg.	12.5%	21.4%	19.8%	21.6%	26.0%
Total Glass Packaging	1.6%	1.3%	5.4%	22.1%	24.6%	25.8%	27.2%	28.7%
Steel Packaging								
Beer and Soft Drink Cans	1.6%	1.3%	9.6%	26.7%	50.0%	Neg.	Neg.	Neg.
Food and Other Cans	Neg.	1.7%	5.3%	23.2%	39.9%	51.8%	56.1%	58.2%
Other Steel Packaging	Neg.	Neg.	Neg.	30.0%	29.4%	27.3%	23.8%	29.4%
Total Steel Packaging	Neg.	1.5%	5.5%	23.9%	39.6%	50.0%	53.8%	56.5%
Aluminum Packaging								
Beer and Soft Drink Cans	Neg.	10.0%	36.5%	63.9%	68.4%	65.5%	62.7%	63.5%
Other Cans	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Foil and Closures	Neg.	Neg.	Neg.	6.1%	9.1%	8.8%	8.6%	8.3%
Total Aluminum Pkg	Neg.	1.8%	24.4%	53.2%	57.2%	55.0%	51.8%	52.0%
Paper & Paperboard Pkg								
Corrugated Boxes	34.4%	21.6%	37.4%	48.0%	52.4%	57.6%	64.2%	66.6%
Milk Cartons**			Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Folding Cartons**			Neg.	Neg.	10.0%	19.6%	20.3%	18.2%
Other Paperboard Packaging	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Bags and Sacks**			Neg.	Neg.	14.7%	18.3%	17.2%	13.1%
Wrapping Papers**			Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Other Paper Packaging	7.5%	9.2%	36.5%	Neg.	Neg.	Neg.	Neg.	Neg.
Total Paper & Board Pkg	19.4%	14.5%	27.4%	36.9%	41.2%	47.0%	52.3%	53.5%
Plastics Packaging								
Soft Drink Bottles**			3.8%	32.6%	41.2%	53.3%	46.2%	40.0%
Milk Bottles**			Neg.	3.8%	21.2%	29.3%	30.6%	30.8%
Other Containers	Neg.	Neg.	Neg.	1.4%	5.2%	10.1%	12.7%	14.8%
Bags and Sacks**			Neg.	3.2%	2.1%	2.3%	3.3%	3.7%
Wraps**			Neg.	2.0%	1.1%	1.7%	2.3%	2.7%
Other Plastics Packaging	Neg.	Neg.	Neg.	1.0%	0.5%	0.9%	0.9%	1.3%
Total Plastics Packaging	Neg.	Neg.	Neg.	3.8%	6.0%	9.0%	9.8%	9.8%
Wood Packaging	Neg.	Neg.	Neg.	1.6%	2.5%	5.1%	7.3%	7.4%
Other Misc. Packaging	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Containers & Pkg	10.5%	7.7%	16.1%	26.0%	29.9%	35.1%	39.2%	40.1%
Total Product Wastes†	10.3%	9.6%	13.3%	20.1%	23.4%	26.8%	29.0%	29.4%
Other Wastes								
Food Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	2.2%	2.6%	2.4%
Yard Trimmings	Neg.	Neg.	Neg.	12.0%	15.4%	25.4%	30.3%	38.6%
Miscellaneous Inorganic Wastes	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Total Other Wastes	Neg.	Neg.	Neg.	7.2%	9.2%	15.1%	17.5%	21.3%
Total MSW Recovered - %	6.4%	6.6%	9.6%	16.4%	19.4%	23.8%	26.1%	27.3%

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
** Not estimated separately prior to 1980.
† Other than food products.
Details may not add to totals due to rounding.
Neg. = Less than 5,000 tons or 0.05 percent.
Source: Franklin Associates, Ltd.

Table 22

PRODUCTS DISCARDED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996
(WITH DETAIL ON CONTAINERS AND PACKAGING)
(In thousands of tons)

	Thousands of Tons							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 14)*	9,570	13,720	20,440	26,000	26,290	25,890	26,030	26,250
Nondurable Goods *(Detail in Table 17)*	14,940	21,330	29,750	43,380	41,710	44,240	43,630	42,790
Containers and Packaging								
Glass Packaging								
Beer and Soft Drink Bottles	1,310	5,440	6,010	3,750	3,950	3,600	3,450	3,530
Wine and Liquor Bottles	1,080	1,900	2,450	1,820	1,500	1,330	1,320	1,460
Food and Other Bottles & Jars	3,710	4,440	4,780	3,640	3,420	4,010	3,620	2,880
Total Glass Packaging	6,090	11,770	13,220	9,210	8,870	8,940	8,390	7,870
Steel Packaging								
Beer and Soft Drink Cans	640	1,570	520	110	40	10	Neg.	Neg.
Food and Other Cans	3,760	3,480	2,700	1,950	1,640	1,440	1,180	1,180
Other Steel Packaging	260	270	240	140	120	160	160	120
Total Steel Packaging	4,660	5,300	3,410	2,200	1,800	1,610	1,340	1,300
Aluminum Packaging								
Beer and Soft Drink Cans	Neg.	100	540	560	500	590	590	570
Other Cans	Neg.	60	40	20	30	40	40	40
Foil and Closures	170	410	380	310	300	310	320	330
Total Aluminum Pkg	170	560	960	890	830	940	950	940
Paper & Paperboard Pkg								
Corrugated Boxes	4,810	10,000	10,690	12,480	12,090	11,930	10,320	9,680
Milk Cartons**			790	510	480	520	510	460
Folding Cartons**			3,820	3,960	4,130	4,140	4,230	4,410
Other Paperboard Packaging	3,840	4,830	230	290	280	300	260	230
Bags and Sacks**			3,380	2,240	1,980	1,880	1,640	1,720
Wrapping Papers**			200	110	80	80	70	50
Other Paper Packaging	2,720	3,460	850	1,020	1,120	1,070	1,150	1,350
Total Paper & Board Pkg	11,370	18,290	19,130	20,610	20,160	19,920	18,180	17,900
Plastics Packaging								
Soft Drink Bottles**			250	290	300	280	350	420
Milk Bottles**			230	510	410	410	430	450
Other Containers	60	910	890	1,410	1,460	1,240	1,030	1,090
Bags and Sacks**			390	910	950	1,290	1,160	1,310
Wraps**			840	1,500	1,800	1,740	1,670	1,810
Other Plastics Packaging	60	1,180	790	2,020	2,150	2,230	2,200	2,270
Total Plastics Packaging	120	2,090	3,390	6,640	7,070	7,190	6,840	7,350
Wood Packaging	2,000	2,070	3,940	8,050	7,890	6,760	5,720	6,000
Other Misc. Packaging	120	130	130	150	160	160	150	150
Total Containers & Pkg	24,500	40,210	44,180	47,750	46,780	45,520	41,570	41,510
Total Product Wastes†	49,010	75,260	94,370	117,130	114,780	115,650	111,230	110,550
Other Wastes								
Food Wastes	12,200	12,800	13,000	20,800	21,000	21,020	21,230	21,380
Yard Trimmings	20,000	23,200	27,500	30,800	29,600	23,500	20,750	17,200
Miscellaneous Inorganic Wastes	1,300	1,780	2,250	2,900	3,000	3,100	3,150	3,200
Total Other Wastes	33,500	37,780	42,750	54,500	53,600	47,620	45,130	41,780
Total MSW Discarded - Weight	82,510	113,040	137,120	171,630	168,380	163,270	156,360	152,330

* Discards after materials and compost recovery. Does not include construction & demolition debris, industrial process wastes, or certain other wastes. Details may not add to totals due to rounding.

** Not estimated separately prior to 1980.

† Other than food products.

Neg. = Less than 5,000 tons or 0.05 percent.

Source: Franklin Associates, Ltd.

Table 23

PRODUCTS DISCARDED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1996
(WITH DETAIL ON CONTAINERS AND PACKAGING)
(In percent of total discards)

	Percent of Total Discards							
Products	**1960**	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Durable Goods *(Detail in Table 14)*	11.6%	12.1%	14.9%	15.1%	15.6%	15.9%	16.6%	17.2%
Nondurable Goods *(Detail in Table 17)*	18.1%	18.9%	21.7%	25.3%	24.8%	27.1%	27.9%	28.1%
Containers and Packaging								
Glass Packaging								
Beer and Soft Drink Bottles	1.6%	4.8%	4.4%	2.2%	2.3%	2.2%	2.2%	2.3%
Wine and Liquor Bottles	1.3%	1.7%	1.8%	1.1%	0.9%	0.8%	0.8%	1.0%
Food and Other Bottles & Jars	4.5%	3.9%	3.5%	2.1%	2.0%	2.5%	2.3%	1.9%
Total Glass Packaging	7.4%	10.4%	9.6%	5.4%	5.3%	5.5%	5.4%	5.2%
Steel Packaging								
Beer and Soft Drink Cans	0.8%	1.4%	0.4%	0.1%	Neg.	Neg.	Neg.	Neg.
Food and Other Cans	4.6%	3.1%	2.0%	1.1%	1.0%	0.9%	0.8%	0.8%
Other Steel Packaging	0.3%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%
Total Steel Packaging	5.6%	4.7%	2.5%	1.3%	1.1%	1.0%	0.9%	0.9%
Aluminum Packaging								
Beer and Soft Drink Cans	Neg.	0.1%	0.4%	0.3%	0.3%	0.4%	0.4%	0.4%
Other Cans	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Foil and Closures	0.2%	0.4%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%
Total Aluminum Pkg	0.2%	0.5%	0.7%	0.5%	0.5%	0.6%	0.6%	0.6%
Paper & Paperboard Pkg								
Corrugated Boxes	5.8%	8.8%	7.8%	7.3%	7.2%	7.3%	6.6%	6.4%
Milk Cartons**			0.6%	0.3%	0.3%	0.3%	0.3%	0.3%
Folding Cartons**			2.8%	2.3%	2.5%	2.5%	2.7%	2.9%
Other Paperboard Packaging	4.7%	4.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Bags and Sacks**			2.5%	1.3%	1.2%	1.2%	1.0%	1.1%
Wrapping Papers**			0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
Other Paper Packaging	3.3%	3.1%	0.6%	0.6%	0.7%	0.7%	0.7%	0.9%
Total Paper & Board Pkg	13.8%	16.2%	14.0%	12.0%	12.0%	12.2%	11.6%	11.8%
Plastics Packaging								
Soft Drink Bottles**			0.2%	0.2%	0.2%	0.2%	0.2%	0.3%
Milk Bottles**			0.2%	0.3%	0.2%	0.3%	0.3%	0.3%
Other Containers	0.1%	0.8%	0.6%	0.8%	0.9%	0.8%	0.7%	0.7%
Bags and Sacks**			0.3%	0.5%	0.6%	0.8%	0.7%	0.9%
Wraps**			0.6%	0.9%	1.1%	1.1%	1.1%	1.2%
Other Plastics Packaging	0.1%	1.0%	0.6%	1.2%	1.3%	1.4%	1.4%	1.5%
Total Plastics Packaging	0.1%	1.8%	2.5%	3.9%	4.2%	4.4%	4.4%	4.8%
Wood Packaging	2.4%	1.8%	2.9%	4.7%	4.7%	4.1%	3.7%	3.9%
Other Misc. Packaging	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Total Containers & Pkg	29.7%	35.6%	32.2%	27.8%	27.8%	27.9%	26.6%	27.3%
Total Product Wastes†	59.4%	66.6%	68.8%	68.2%	68.2%	70.8%	71.1%	72.6%
Other Wastes								
Food Wastes	14.8%	11.3%	9.5%	12.1%	12.5%	12.9%	13.6%	14.0%
Yard Trimmings	24.2%	20.5%	20.1%	17.9%	17.6%	14.4%	13.3%	11.3%
Miscellaneous Inorganic Wastes	1.6%	1.6%	1.6%	1.7%	1.8%	1.9%	2.0%	2.1%
Total Other Wastes	40.6%	33.4%	31.2%	31.8%	31.8%	29.2%	28.9%	27.4%
Total MSW Discarded - %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

* Discards after materials and compost recovery. Does not include construction & demolition debris, industrial process wastes, or certain other wastes. Details may not add to totals due to rounding.

** Not estimated separately prior to 1980.

† Other than food products.

Neg. = Less than 5,000 tons or 0.05 percent.

Source: Franklin Associates, Ltd.

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 1996 is shown in Figure 15. Paper and paperboard made up 74.5 percent of nondurables in MSW generation, with plastics contributing 9.6 percent, and textiles 9.4 percent. Other materials contributed lesser percentages. After recovery for recycling, paper and paperboard were 68.8 percent of nondurable discards, with plastics being 12.5 percent, and textiles 10.3 percent.

The materials composition of containers and packaging in MSW in 1996 is shown in Figure 16. By weight, paper and paperboard products made up 55.6 percent of containers and packaging generation, with glass second at 15.9 percent of containers and packaging generation. Plastics accounted for 11.8 percent of containers and packaging generation, while wood pallets were 9.4 percent.

Recovery for recycling makes a significant change, with paper and paperboard being 43.1 percent of containers and packaging discards after recovery takes place. Glass containers accounted for 19.0 percent of discards of containers and packaging, plastics was 17.7 percent, and woods comprised 14.4 percent.

Some additional perspectives on products in municipal solid waste are included in Appendix B of this report.

Figure 14. Generation of products in MSW, 1960 to 1996

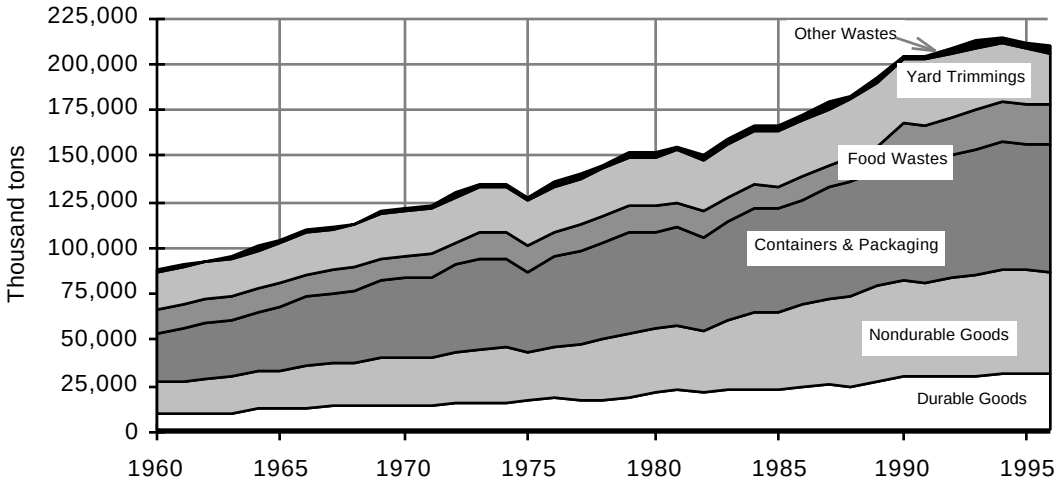
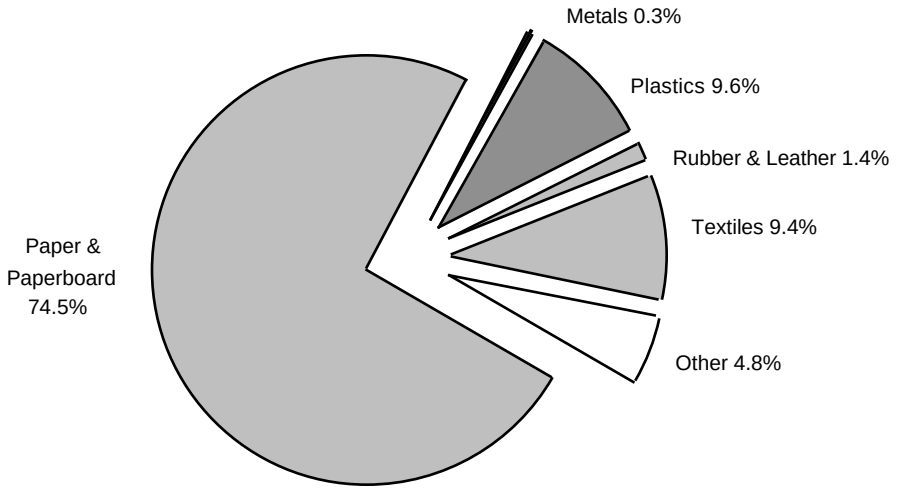
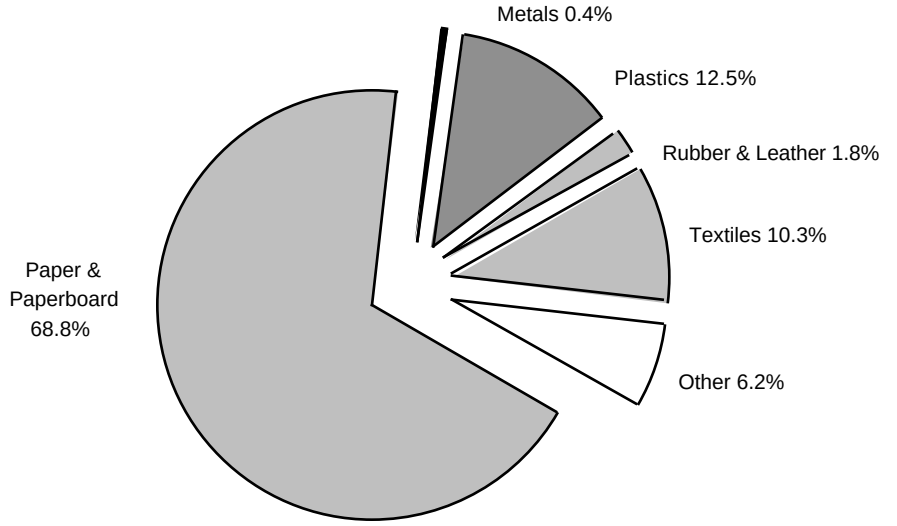


Figure 15. Nondurable goods generated and discarded in municipal solid waste, 1996
(in percent of total generation and discards)

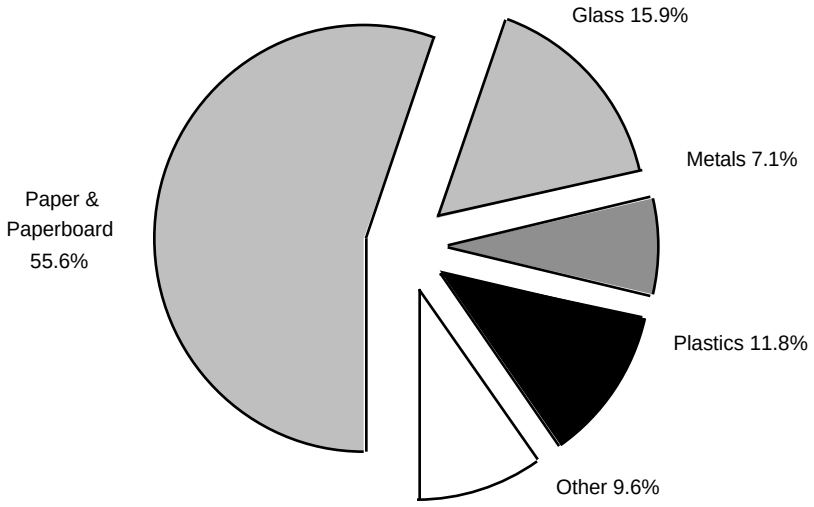


Generation

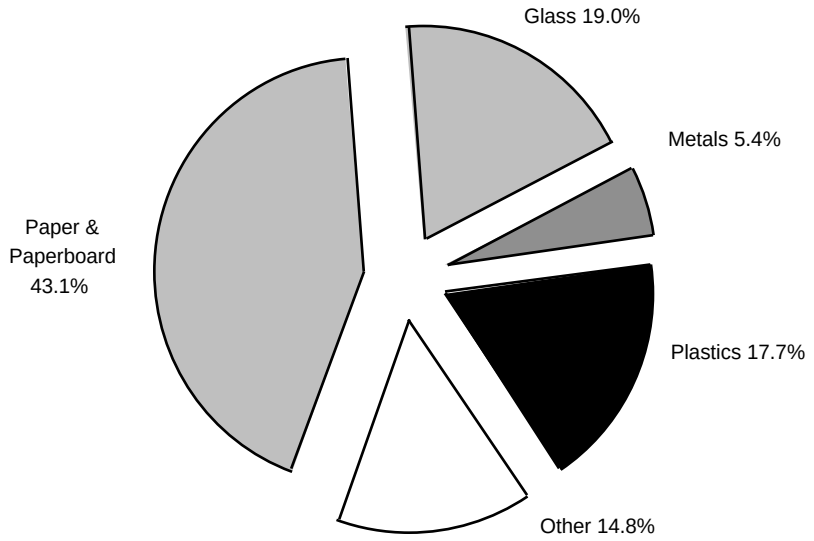


Discards

Figure 16. Containers and packaging generated and discarded in municipal solid waste, 1996
(in percent of total generation and discards)



Generation



Discards

SUMMARY

The data presented in this chapter can be summarized by the following observations:

MSW Generation

- Total generation of municipal solid waste in 1996 was 209.7 million tons, which was less than in 1995 (211.5 million tons) and 1994 (214.2 million tons).

- Paper and paperboard products made up the largest percentage of all the materials in MSW—79.9 million tons, or 38.1 percent of total generation in 1996.

- Yard trimmings comprised the second largest material category, estimated at 28.0 million tons, or 13.4 percent of total generation, in 1996. This compared to 35.0 million tons (16.8 percent of total generation) in 1992. This decline is largely due to state legislation affecting yard trimmings disposal in landfills, including source reduction measures such as backyard composting and leaving grass trimmings on the yard.

- Total materials in products declined by 200,000 tons from 1995 to 1996, and over 1.5 million tons from 1994 to 1996. Paper and paperboard products in MSW experienced the largest decline, 1.7 million tons from 1995 to 1996.

- Plastic products had the largest increase in generation for all materials, growing by nearly one million tons (18.9 versus 19.8 million tons) from 1995 to 1996. Plastics used for containers and packaging accounted for the majority of this increase.

- Between 1995 and 1996, generation of durable goods and containers and packaging increased in tonnage (1.7 and 1.3 percent, respectively), while generation of nondurable goods decreased in tonnage (-2.8 percent). In nondurables, newspapers and magazines accounted for the largest decline—1.4 million tons—from 1995 to 1996.

- Each major product category increased as a percentage of MSW generated, while generation of yard trimmings was declining in percentage.

MSW Recovery

- Recovery of materials in MSW increased from 55.1 million tons in 1995 (26.1 percent of total generation) to 57.3 million tons in 1996 (27.3 percent of generation).

- Recovery of most materials in MSW increased in both tonnage and percent of total generation. Two material categories, paper and paperboard and food wastes, experienced a slight decrease in tonnage recovered from 1995 to 1996.

- Recovery of products in MSW increased by 480,000 tons, from 29.0 percent to 29.4 percent of generation. Recovery of ferrous products accounted for most of this increase—270,000 tons. Recovery of other wastes (yard trimmings and food wastes) increased by over 1.7 million tons, from 17.5 percent to 21.3 percent of generation.

- Containers and packaging led the major product categories in tonnage and percentage recovery, increasing from 26.8 million tons (39.2 percent of generation) in 1995 to 27.7 million tons (40.1 percent of generation) in 1996. Nondurable goods had the second highest tonnage recovery in 1996—12.9 million tons, or 23.1 percent of generation.

- Measured by tonnage, the most-recovered products in 1996 were corrugated boxes (19.3 million tons), yard trimmings (10.8 million tons), newspapers (6.6 million tons), glass containers (3.2 million tons), office papers (3.2 million tons), and ferrous metal from large appliances (2.2 million tons). Collectively, these products account for nearly 80 percent of total MSW recovery.

- Measured by percentage of generation, products with the highest recovery rates in 1995 were lead-acid batteries (93.8 percent), corrugated boxes (66.6 percent), aluminum beverage cans (63.5 percent), ferrous metals in large appliances (62.5 percent), steel cans (58.2 percent), and newspapers (54.1 percent).

Long Term Trends

- Generation of MSW has increased steadily (except in recession years), from 88.1 million tons in 1960 to 209.7 million tons in 1996. However, in 1995 and 1996 both the tonnage of materials in products and total MSW has declined.

- Generation of paper and paperboard, the largest material component of MSW, has increased in almost every year. Yard trimmings, the second largest component, have been declining recently due to state legislation

affecting yard trimmings disposal in landfills and source reduction measures at residences. Generation of other materials is generally on an upward trend, although generation of glass in 1996 was lower than in 1980, and generation of metals in 1996 was about the same as in 1980.

- In percentage of total MSW generation, recovery for recycling (including composting) did not exceed 15 percent until 1990. Growth in the recovery rate to current levels (27.3 percent) reflects a rapid increase in the infrastructure for recovery starting in the late 1980s.

- Recovery (as a percent of generation) of most materials in MSW has increased dramatically over the 36 years for which statistics have been tabulated. Some examples:

	1980	**1996**
Paper and paperboard	21%	41%
Glass	5%	26%
Metals	8%	40%
Plastics	2%	5%
Yard trimmings	–	39%

Chapter 2

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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 (overview in Figure 17). Estimates of historical recovery of materials for recycling, including yard trimmings for 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 (including composting) from total MSW generation.

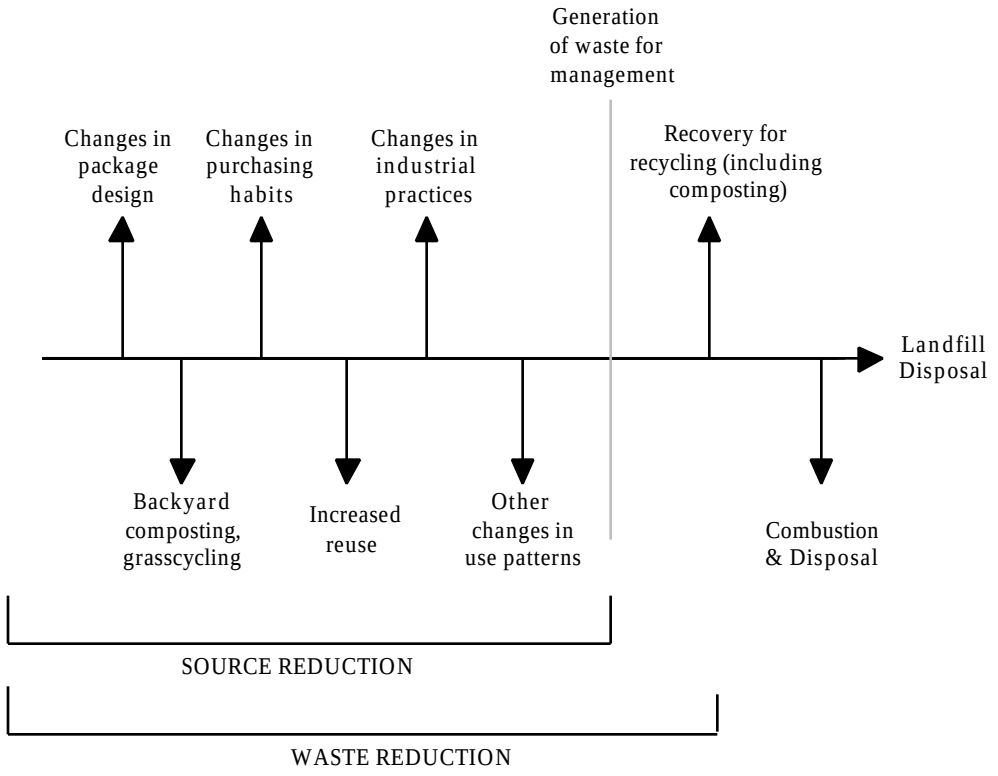
Also included in this chapter is a discussion of the current MSW management infrastructure. Current solid waste collection, processing, and disposal programs and facilities are highlighted with tables and figures.

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 other management alternatives deal with MSW once it is generated. Included in this chapter is a discussion on trends in source reduction from a national perspective, including the identification of possible factors that could explain any apparent trends in source reduction.

SOURCE REDUCTION

Source reduction is gaining more attention as an important solid waste management option. Source reduction, often called "waste prevention," is defined by EPA 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

Figure 17. Diagram of Solid Waste Management



Source: Franklin Associates, Ltd. based on EPA hierarchy.

pickup, or if it is taken by the generator to another site for disposal or other management alternative.

Source reduction measures encompass a very broad range of activities by private citizens, communities, commercial establishments, institutional agencies, and manufacturers and distributors. Example source reduction actions are shown in Table 24 and further discussed in this chapter. In general, source reduction activities include:

- Redesigning products or packages so as to reduce the quantity of materials or the toxicity of the materials used, by substituting lighter materials for heavier ones and lengthening the life of products to postpone disposal.
- Using packaging that reduces the amount of damage or spoilage to the product.
- Reducing amounts of products or packages used through modification of current practices by processors and consumers.
- Reusing products or packages already manufactured.

Table 24

SELECTED EXAMPLES OF SOURCE REDUCTION PRACTICES

Source Reduction Practice	MSW Product Categories			
	Durable Goods	**Nondurable Goods**	**Containers & Packaging**	**Organics**
Redesign				
Material reduction	• Downgauge metal in appliances	• Paperless purchase orders	• Concentrates	• Xeriscaping
Material substitution	• Use of composites in appliances and electronic circuitry		• Cereal in bags • Coffee brick • Multi-use products	
Lengthen life	• High mileage tire • Electronic components reduce moving parts	• Regular servicing • Look at warranties • Extend warranties	• Design for secondary uses	
Consumer Practices				
	• Purchase	• Repair • Duplexing • Sharing • Reduce unwanted third class mail	• Purchasing: products in bulk, concentrates	
Reuse				
By design	• Modular design	• Envelopes	• Pallets • Returnable secondary packaging	
Secondary	• Borrow or rent for temporary use • Give to charity • Buy or sell at garage sale	• Clothing • Waste paper scratch pads	• Loosefill • Grocery sacks • Dairy containers • Glass and plastic jars	
Reduce/Eliminate Toxins				
	• Eliminate PCBs	• Soy ink, waterbased • Waterbased solvents • Reduce mercury	• Replace lead foil on wine bottles	
Reduce Organics				
Food wastes				• Backyard composting • Vermi-composting
Yard trimmings				• Backyard composting • Grasscycling

Source: Franklin Associates, Ltd.

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

Source Reduction Through Redesign

Since source reduction of products and packages can save money through reducing materials and energy costs, manufacturers and packaging designers have been pursuing these activities for many years. Combined with other source reduction measures, redesign can have a significant effect on material use and eventual discards. Design for source reduction can take several approaches.

Materials substitution can make a product or package lighter. For example, 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 also involve a flexible package instead of a rigid package. A product or package can be redesigned to reduce weight or volume. 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.

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, manufacturers must be willing to invest in new product development and consumers must demand the products and be willing to pay for them to make the goal work. Consumers and manufacturers must also be willing to care for and repair products.

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). Modifying practices can be combined with other source reduction measures to reduce generation and limit material use.

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

Similar to lengthening product life, 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 (e.g., furniture, wood pallets, clothing, etc.). The recovery of products and materials for recycling (including 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 use by 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. 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 waste prevention measure is the use of washable plates, cups, napkins, towels, diapers, etc. instead of the disposable variety. (This will reduce solid waste but will have other environmental 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 easily 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 National Wooden Pallet & Container Association estimates that over 60 percent of new wood pallets produced are reusable.

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 purchased in small packages. This practice can achieve a notable 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 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.

Management of Organic Materials

Food wastes and yard trimmings combined made up over 23 percent of MSW generation in 1996, so source reduction measures aimed at these products can have an important effect on waste generation. Composting is the usual method for recovering these organic materials. As defined in this report, composting of organic materials 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.

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 discards 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. Other actions that will complement the increase in yard trimmings management include establishment of variable rates, improved technology (mulching mowers), and legislative regulations (e.g., landfill bans).

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 affecting management of yard trimmings. By 1997, nearly two dozen states (amounting to approximately 50 percent of the nation's population) were to 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.

Trends in Source Reduction

This section focuses on source reduction trends for two major product categories of MSW—nondurable papers (i.e., newspapers, telephone directories, office papers, etc.), and containers and packaging (other than corrugated boxes

and wood pallets). These two categories were chosen because of the likely presence of source reduction trends and their significant contribution to total MSW generation. Together they represent over 35 percent of total MSW generation and 50 percent of products generated as MSW.

Another component of MSW that has had success with source reduction is yard trimmings. Recent trends in source reducing yard trimmings (primarily through local and state legislation affecting yard trimmings disposal in landfills) are discussed in detail in Chapter 2 of this report.

Containers and Packaging. This discussion of trends in packaging source reduction focuses on primary packaging, which includes the packages that actually hold a product. Examples of primary packaging include cans, bottles, and boxes such as cereal boxes. Some secondary packaging is also included in the analysis (see packaging definitions box). This discussion *excludes* corrugated boxes and wood packaging (pallets), which generally are used to contain and transport products already packaged in primary or secondary packaging.

PACKAGING DEFINITIONS

Primary packaging has direct contact with the product it holds. Examples include glass and plastic bottles that contain beverages, steel and aluminum cans that contain food or beverages, bags that hold chips, and paperboard that packages food or consumer goods such as toys.

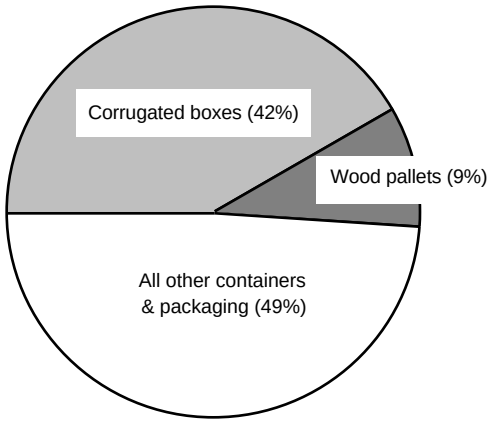
Secondary packaging allows products to be unitized for handling and distribution, but does not come into direct contact with the product. Examples include a corrugated paperboard tray that holds cans of vegetables, a plastic ring or paperboard box that unitizes beverage cans, and a sealed plastic bag that holds small boxes of candies.

Tertiary packaging unitizes products (usually already in primary and secondary packaging) for shipping or distribution. Examples include a corrugated box holding many boxes or bags of a food product, and shrink or stretch plastic unitizing boxes on a wood pallet.

Exclusion of corrugated containers and wood pallets does not imply that these packages are not being source reduced; this is occurring. However, these two packaging categories are so significant in weight that they tend to overwhelm any discussion of other packaging.

As Figure 18 shows, corrugated containers and wood pallets together made up 51 percent of all containers and packaging in 1996. The remaining 49 percent of containers and packaging is predominantly primary packaging.

Figure 18. Containers and packaging in MSW, 1996



One measure of source reduction of packaging is generation on a per capita basis (Figure 19 and Table 25).

Total generation of products and packaging in MSW typically grows as population grows, so expressing generation on a per person basis eliminates population growth as a factor and permits the focus to be on actual use of a product or package. Daily generation of packaging per person tended to increase through the 1960s and 1970s. Generation on a per-person basis tended to decrease after 1979, although most of the decline came in the early 1980s. Also, some years have seen an "uptick" in generation of packaging (Figure 19.)

Figure 19. Daily generation of packaging* per person, 1960 to 1996
(In pounds per person per day)

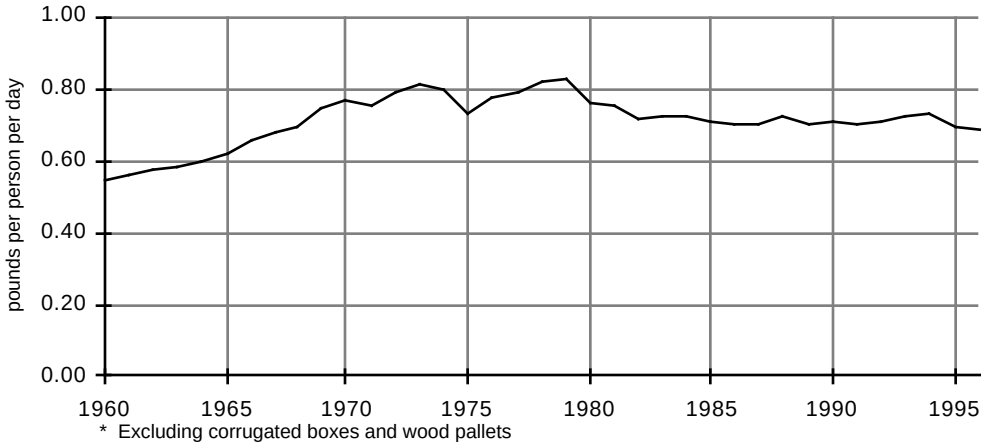


Table 25

GENERATION OF PACKAGING*, 1960 TO 1996
(Pounds per person per day)

Year	Generation (pcd)	Annual Increase or decrease (%)
1960	0.55	—
1970	0.77	3.5%
1980	0.76	-0.1%
1985	0.71	-1.4%
1996	0.70	-0.2%

* Excluding corrugated boxes and wood pallets.

Source reduction measures for packaging include:

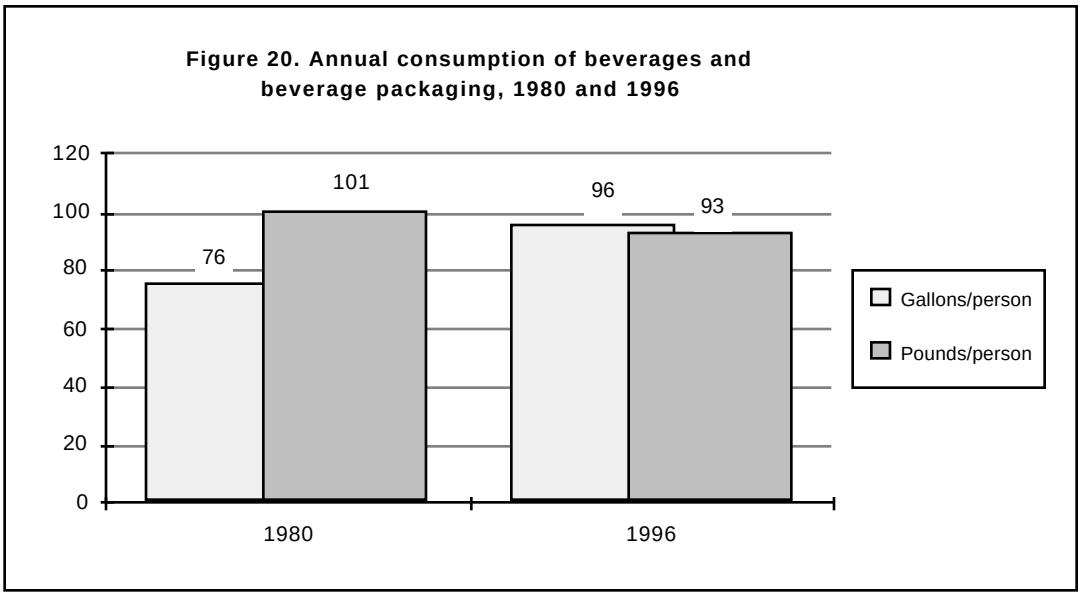
- lightweighting—reducing the material required to make a package, e.g., an aluminum can
- elimination of packaging (e.g., not putting a bottle in a box)
- product concentration—changing product formulation to permit a smaller package
- material substitution—using a lighter material to perform the same function.

While these source reduction measures are relatively easy to quantify on a product-specific basis (examples have been included in previous characterization reports), it is not practical as yet to quantify the effects of any particular measure on a national basis. Nevertheless, some interesting observations can be made based on available data. To illustrate packaging source reduction, packaging of three product categories was investigated: beverages, food, and nonfood products.

Beverage Packaging. The packaged beverages included in this analysis are soft drinks, beer, wine, liquor, fruit juice and drinks, milk, water, and other drinks not requiring additional preparation. Consumption per person of these beverages has grown from 76 gallons per year to 96 gallons per year, or 28 percent, since 1980 (Figure 20 and Table 26). In particular, consumption of packaged soft drinks and water has grown tremendously.

At the same time, packaging of beverages on a per person basis has actually decreased from 101 pounds per year to 93 pounds per year, or 7.5 percent. Pounds of packaging per gallon of beverage decreased from 1.33 in 1980 to 0.97 pounds per gallon in 1996, or 27 percent.

All beverage containers have been made lighter over the 16-year period. However, most of the source reduction has apparently come about through



materials substitution of plastics and paper for glass and metals (Figure 21). While the introduction of plastic bottles and paper cartons for milk and juice caused an apparent increase in materials use for beverage containers, the trend since 1980 has been mostly downward in pounds used per person per day.

Table 26

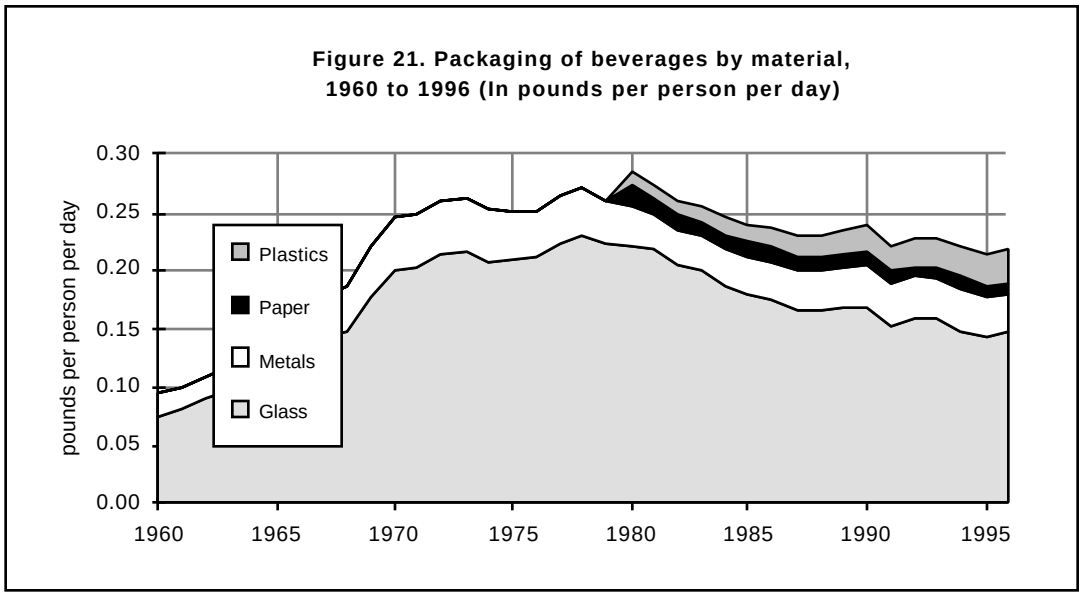
CONSUMPTION AND PACKAGING OF LIQUID FOODS, 1980 AND 1996

	1980		1996	
	Consumption (million gallons)	Packaging (thousand tons)	Consumption (million gallons)	Packaging (thousand tons)
Beer	4,847	4,678	5,795	5,540
Soft Drinks	6,315	2,162	10,295	1,722
Wine	460	985	485	1,038
Liquor	445	760	327	559
Water	630	63	2,892	346
Sport Drinks*			454	172
Ready-to-drink Tea*			621	999
Fruit Beverages	2,256	2,522	2,256	1,753
Milk	2,229	291	2,469	254
Total	17,182	11,461	25,594	12,383
Gallons / person / year	76		96	
Packaging / person / year (lb)		101		93
Pounds of packaging per gallon		1.33		0.97

* Included in other beverage categories in 1980.

References: Beverage World, Can Manufacturers Institute, Brewers Almanac, Statistical Abstract, Distilled Spirit Council, The Beer Institute.

Source: Franklin Associates, Ltd.



Food and Nonfood Packaging. Nonbeverage food consumption (in pounds per person) has been on the rise since 1980. Total food consumption increased from 948 pounds per person per year in 1980 to 1,099 pounds per person per year in 1994—almost 16 percent. Consumption of fresh fruits and vegetables and other foods (e.g., snack foods) increased more than meat, poultry, and canned goods.

Consumption of nonfood products also has been increasing. Although the weights of total purchases are not available, constant dollar expenditures for general merchandise, building materials (including hardware), apparel, drug store purchases, and other goods are available.

General merchandise expenditures increased more than 5 percent per year between 1980 and 1995. Overall expenditures increased 4.8 percent per year, after adjusting for inflation. Although this does not directly show an increase in the total weight of product purchases, it does indicate a likely increase in packaged products.

Nonbeverage food consumption, nonfood product expenditures, and nonbeverage packaging are summarized in Figure 22. Nonfood constant dollar expenditures per capita rose 47 percent from 1980 to 1994. Food consumption in pounds per person increased almost 16 percent. Packaging of these products was about the same in pounds per person per day in 1994 as in 1980 (Figure 23).

The fact that more goods are likely being purchased while packaging stays about constant (on a per-person basis) suggests that goods are being packaged more efficiently. Excluding corrugated boxes and wooden pallets, more food and other products are being packaged with less glass, steel, aluminum, and paper on a per person basis. Only plastic packaging has increased on a per person basis between 1980 and 1996.

Figure 22. Food consumption, nonfood expenditures, and packaging, 1980 to 1994

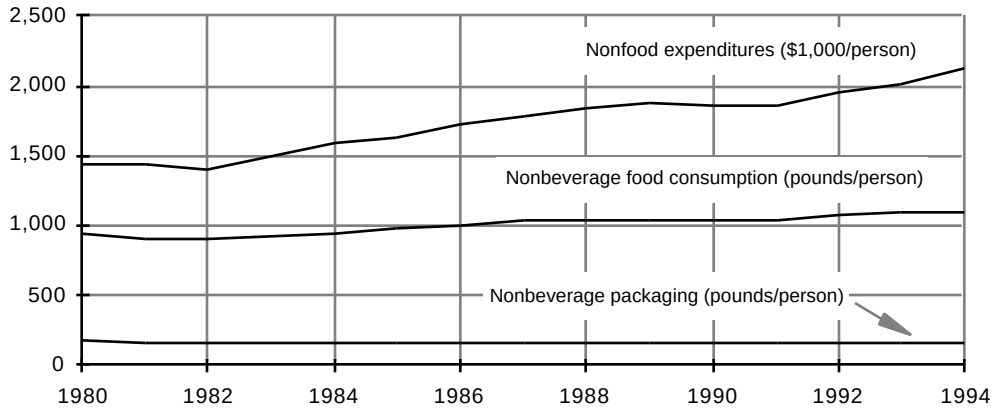
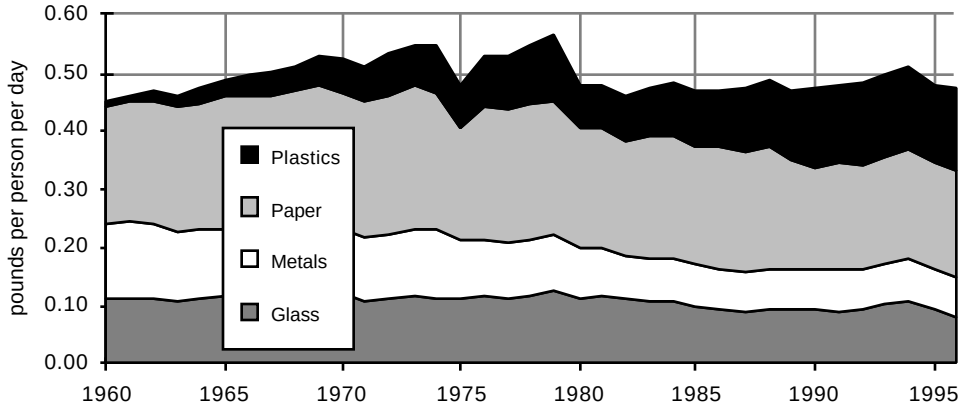


Figure 23. Packaging of food and nonfood products by material, 1960 to 1996



In summary, these data indicate that more beverage, food, and nonfood products are being packaged with less material. For non-transportation packaging, there appears to be a trend in source reduction.

Nondurable Paper. This discussion of trends in source reduction focuses on nondurable papers. Nondurable papers include newspapers, books, magazines, office paper, telephone directories, third class mail, other commercial printing, and other nonpackaging paper. Newspapers are by far the largest component of nondurable papers, with 12.3 million tons generated in 1996. There were 6.6 million tons each of office papers and commercial

printing in 1996. Other large categories of nondurable papers include 4.5 million tons of third class mail, 4.5 million tons of other nonpackaging paper, and 2.9 million tons of books and magazines. Nondurable paper totaled 41.4 million tons in 1996.

After experiencing continued growth from 1960 to 1990, per capita generation of nondurable paper has remained essentially flat over the past six years (Table 27, Figures 24 and 25).

Table 27

GENERATION OF NONDURABLE PAPERS*, 1960 TO 1996
(In pounds per person per day)

Year	Generation (pcd)	Annual Increase or Decrease (%)
1960	0.44	—
1970	0.55	2.2%
1980	0.62	1.3%
1990	0.80	2.5%
1996	0.78	-0.2%

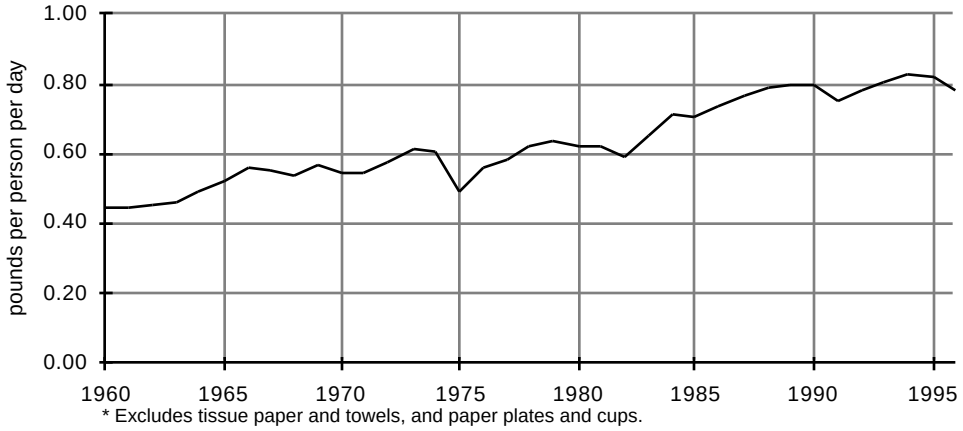
* Excludes tissue paper and towels, and paper plates and cups.

Compared to 1990, per capita generation rates of commercial printing had a slight increase, whereas newspapers have seen a decline, and other paper grades have not changed much. Nondurable papers, as a percent of total MSW generation, has also remained flat—at about 27 percent since 1990.

The majority of nondurable paper is used for information dissemination, with most nondurable paper grades created for the sole purpose of distributing information. For example, newspapers bring news and advertisements to people, while telephone directories list important numbers. Commercial printing and third class mail also deliver message. Looking at how information is distributed may give insights to source reduction trends of printed materials used for information dissemination.

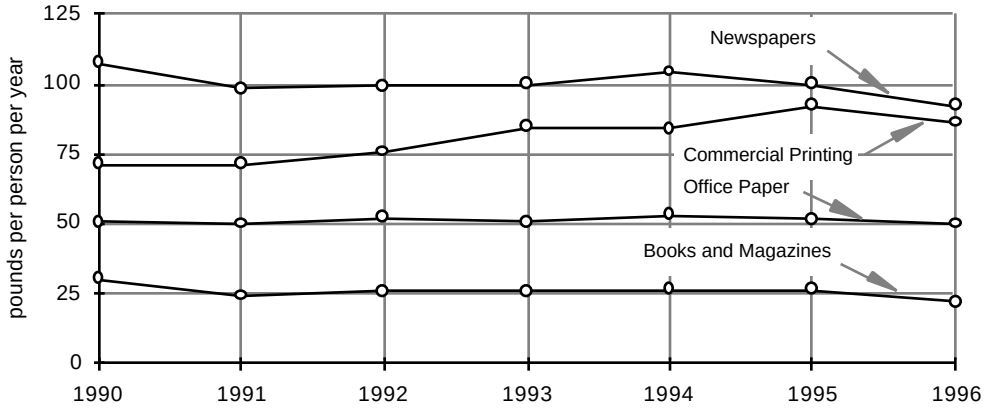
New forms of electronic (i.e., nonpaper) media, both in personal/business communication and advertising, may be affecting paper generation. The "paperless office" was a subject discussed in the 1980's with the advent of the personal computer. In general, offices did not significantly reduce paper usage. However, with little growth experienced for nondurable paper generation rates in the 1990's, the "information age" may be beginning to have an effect on nondurable paper generation.

Figure 24. Daily generation of nondurable papers* per person, 1960 to 1996 (In pounds per person per day)



* Excludes tissue paper and towels, and paper plates and cups.

Figure 25. Annual generation of nondurable papers per person, 1990 to 1996 (In pounds per person per year)



Information dissemination is difficult to measure. Therefore, it will be discussed in two general categories: personal and business communication and data exchange; and advertising for goods and services. Both of these categories have undergone dramatic changes in recent times. The changes involve computers, telecommunications, and other electronic machinery; the mix of printed versus nonprinted media; and the sheer amount of information and data being exchanged.

Personal and Business Communication. Personal and business communication and data exchange occurs through telephones, faxes, the

internet, electronic mail (e-mail), and first class mail. Trends in nondurable paper generation compared to electronic media use are shown in Table 28.

As noted earlier, nondurable paper generation has remained essentially flat during the 1990's. In contrast, the use of electronic forms of data transfer, communication, and information dissemination has experienced large growth—providing *possible* evidence of the beginnings of a trend in source reduction.

As Table 28 indicates, the annual percent change for nondurable paper generation is relatively flat (±5 percent). In contrast, the percent of households with a personal computer (PC) has increased every year, recently more than 8 percent per year. Homes with a personal computer have grown from 22 million in 1989 to 43 million in 1996. Roughly half of those homes had a communications modem and more than one-third subscribed to an internet service. The number of hours spent with on-line electronic communication is expected to grow by 36 percent annually through 1999. Internet domain sites, electronic locations where internet users can go electronically for information, grew by more than 300 percent in 1996.

Electronic mail, or e-mail, provides users the ability to send and receive letters and memos, tables and figures, and whole documents (or anything scanable) without the use of paper. E-mail has been growing rapidly in the last few years. There were 1.7 trillion e-mail messages sent in 1996, growing more than 50 percent per year. E-mail addresses have increased by more that 20 percent per year for the past six years.

Table 28

COMPARISON OF NONDURABLE PAPER GENERATION* AND MEDIA USAGE

	Nondurable Paper*		Homes with a PC		E-mail Addresses		Internet Domain Sites	
	thousand tons	annual % change	million units	annual % change	thousand addresses	annual % change	thousand sites	annual % change
1990	36,438		23		6,000			
1991	34,745	-4.6%	24	4%	13,446	124%		
1992	36,545	5.2%	29	20%	20,893	55%		
1993	38,142	4.4%	32	9%	26,196	25%		
1994	39,547	3.7%	36	13%	31,500	20%		
1995	39,648	0.3%	39	9%	39,200	24%	250	
1996	37,513	-5.4%	43	8%	51,000	30%	1,080	332%

* Excludes tissue paper and towels, and paper plates and cups.

References: Encyclopedia of American Industries, Electronic Messaging Association, Franklin Associates, Ltd, InterNIC News.

The telephone is an important tool for most homes and businesses. Approximately 94 percent of households in the U.S. have telephones. This percent is likely higher for businesses. Growth in cellular phone subscribers has been significant—from approximately 2 million users in 1988 to over 33 million users in 1995. The facsimile (fax) machine has made business and personal communications more rapid. Anything on a printed page can be faxed to any location in the world that has telephone lines and a fax machine. This can decrease the time required for exchange, but may not reduce the paper generated. In fact, sometimes letters and documents are faxed and sent through the mail. This redundancy occurs to provide a clean original of the documents faxed.

While growth in e-mail, telephone, and fax communications has significantly increased, the generation of first class mail has not noticeably declined. In fact, first class mail has increased, both in number of pieces and tonnage. In 1996, almost 100 billion pieces of mail were delivered, up from 76 billion in 1986. This is due partly to the increase in product purchases via mail. First class mail is still an integral part of business communication and data exchange, with most businesses using it to deliver letters, reports, information, products, etc. Also important are overnight services not associated with the U.S. Postal Service (e.g., Federal Express). These services operate much like first class mail, but guarantee overnight delivery.

E-mail, the internet, and other electronic media all have the potential to reduce paper generation in the future. If Americans are getting more information—news, advertising, entertainment, and other—from non-printed media, paper generation from printed media (newspapers, magazines, etc.) could be reduced. Although other forces are acting to bring about reductions in the generation of certain grades of paper, the tremendous growth of the internet will likely have an impact. Also, as the comfort level with handling electronic media increases, the 1980's vision of a "paperless office" may eventually have an effect on nondurable paper generation. (Note: it could be argued that increased electronic communication has the potential to *increase* paper generation—however, nondurable paper generation rates for the 1990's do not appear to support this.)

Advertising. In this era, consumer information is proliferating dramatically and constant dollar advertising expenditures are growing (from $54 billion in 1980 to $170 billion in 1996). This brings up the question—where and how is information transmission taking place? As was indicated, printed matter generation per capita has been relatively flat in the 1990's. Only commercial printing has experienced significant growth, increasing by over 10 percent per year.

Table 29

ADVERTISING EXPENDITURES BY MEDIUM, 1990 and 1995
(In billion dollars and percent)

	1990		1995	
	Billion $	Percent	Billion $	Percent
Printed Media				
Newspapers	$32.3	25.1%	$36.8	22.7%
Magazines	$6.8	5.3%	$8.6	5.3%
Yellow Pages	$8.9	6.9%	$10.3	6.4%
Direct Mail	$23.4	18.2%	$32.6	20.1%
Business Papers	$2.4	1.9%	$3.6	2.2%
Subtotal	$73.8	57.3%	$91.8	56.7%
Nonprinted Media				
Television	$28.4	22.1%	$36.7	22.7%
Radio	$8.7	6.8%	$11.5	7.1%
Other	$17.7	13.8%	$21.9	13.5%
Subtotal	$54.9	42.7%	$70.1	43.3%
Total	$128.6	100.0%	$161.9	100.0%

Reference: Statistical Abstract, 1996.

Advertising has been changing in the past two decades. Table 29 (see above) compares 1990 and 1995 advertising expenditures for the printed and nonprinted media markets. Printed media experienced a slight decline in the total percent of advertising expenditures (57.3 percent in 1990 compared to 56.7 percent in 1995), and an annual growth rate of about 5 percent (compared to 5.5 percent for nonprinted media) for the same period.

Other observations for each type of major advertising media are presented below.

- Direct mail has a large share of advertising dollars, accounting for over 50 percent of the growth in printed media advertising. Direct mail, both third class mail and catalogs, is a method marketers use to target their products to customers of particular demographic attributes.

- Newspaper subscriptions have been decreasing for some time. Per capita newspaper generation has steadily declined from 1986 to 1996 and per household generation declined more rapidly. Magazine generation has been following a similar trend. Per capita generation has not fallen faster because Sunday circulation and Sunday paper size have increased. As newspapers and magazines decline in popularity, other forms of media usage are increasing. (Newspapers have been studied as a source reduction case study in the 1996 MSW update.)

- Cable and satellite television companies have dramatically increased the number of television channels available to viewers. The average person spends 1,600 hours per year watching television, both for news and entertainment. Advertising expenditures for television are nearly equal to newspaper advertising.

- Advertising on radio and in telephone directories has been relatively flat in the past ten years. Advertising on radio, like television, produces negligible generation of nondurable paper. Generation of directories has been flat the past several years.

- Other advertising expenditures include e-mail and internet advertisements. This is an increasing mode of advertising. More computers are in use in homes and businesses, and modems are becoming standard equipment.

This analysis suggests that information dissemination media used in advertising *may be* shifting. More electronic communications, data transfers, and advertisements are occurring, while nondurable paper growth is flat. Although it is difficult to document the electronic industry and exactly how it affects paper generation, these trend data could be described as evidence for source reduction in nondurable papers.

RECOVERY FOR RECYCLING (INCLUDING COMPOSTING)

Recyclables Collection

Before recyclable materials can be processed and recycled into new products, they must be collected. Most residential recycling involves curbside recyclables collection, drop-off programs, buy-back operations, and/or container deposit systems. Collection of recyclables from commercial establishments is usually separate from residential recyclables collection programs.

Curbside Recyclables Collection. In 1996, there were over 8,800 curbside recyclables collection programs reported in the U.S. As shown in Table 30 and Figure 26, the extent of residential curbside recycling programs varies tremendously by geographic region, with the most extensive curbside collection occuring in the Northeast.

In 1996 slightly over one-half (51 percent) of the U.S. population, or 134 million persons, had access to curbside recyclables collection programs. The Northeast region had the largest population served, 43 million persons. In the Northeast over 80 percent of the population had access to curbside recyclables collection, while in the South only 35 percent of the population had access to curbside recycling. Most of the programs were located in the Northeast (39 percent) and Midwest (36 percent) regions of the country.

Table 30

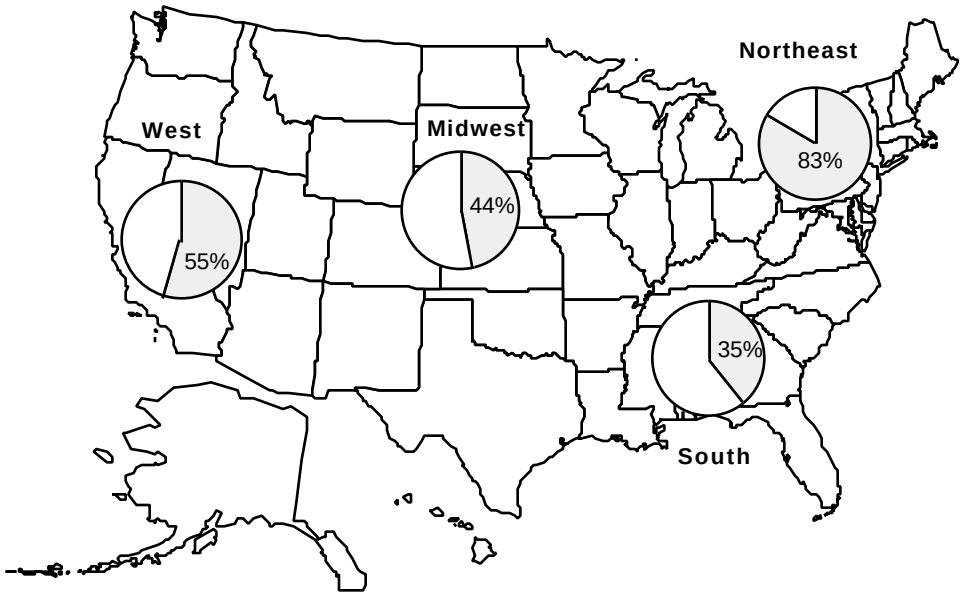
NUMBER AND POPULATION SERVED BY CURBSIDE RECYCLABLES COLLECTION PROGRAMS, 1996

Region	Number of Programs	Population (in millions)	Population Served (1) (in thousands)	Population Served (1) (%)
NORTHEAST	3,427	51,580	43,052	83%
SOUTH	1,318	93,098	32,798	35%
MIDWEST	3,198	62,082	27,454	44%
WEST	874	57,340	31,326	55%
U.S. Total	8,817	264,100	134,630	51%

(1) Percent of population served by curbside programs was calculated using population of states reporting data.

Source: Statistical Abstract 1996, Bureau of Census 1996, BioCycle 1997.

Figure 26. Population Served by Curbside Recycling, by Region



Drop-off Centers. Drop-off centers typically collect residential materials, although some accept materials from businesses. They are found in locations such as grocery stores, sheltered workshops, charitable organizations, city-sponsored sites, and apartment complexes. Types of materials collected vary greatly; however, drop-off centers can usually accept a greater variety of materials than a curbside collection program.

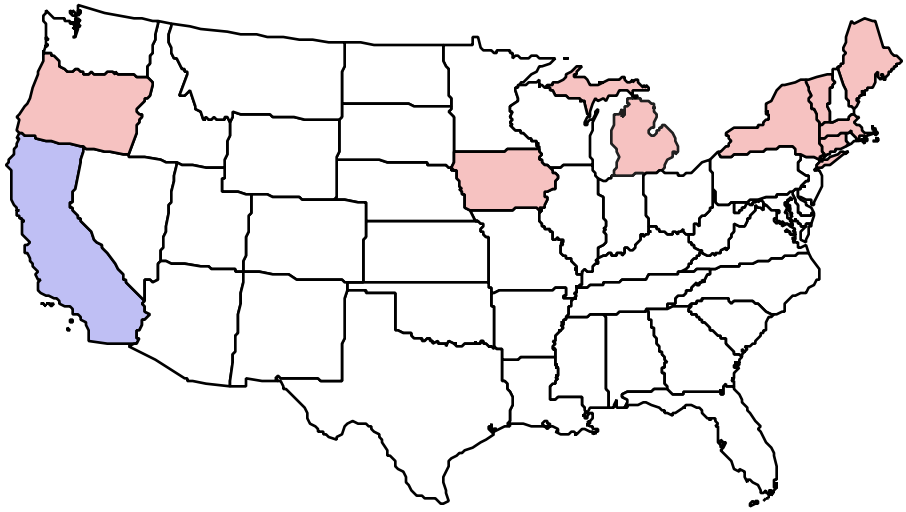
It is difficult to quantify drop-off centers in the U.S. It is estimated that there were 10,436 programs in 1996, according to the ***BioCycle*** survey (Goldstein 1997). In some areas, particularly those with sparse population, drop-off centers may be the only option for collection of recyclable materials. In other areas, they supplement other collection methods.

Buy-back Centers. A buy-back center is typically a commercial operation that pays individuals for recovered materials. This could include scrap metal dealers, aluminum can centers, waste haulers, or paper dealers. Materials are collected by individuals, small businesses, and charitable organizations.

Deposit Systems. Nine states have container deposit systems: Connecticut, Delaware, Iowa, Maine, Massachusetts, Michigan, New York, Oregon, and Vermont (Figure 27). In these programs, the consumer pays a deposit on beverage containers at the point of purchase, which is redeemed on return of the empty containers. California has a similar system where containers can be redeemed, but the consumer pays no deposit. With the exception of California, no new deposit laws have been enacted since the early 1980s, due in part to the convenience and economics of curbside recycling.

Deposit systems generally target beverage containers (primarily beer and soft drink), which account for less than 4 percent of total MSW generation. It is estimated that about 35 percent of all recovery of beverage containers comes from the 9 traditional deposit states mentioned above, and an additional 20 percent of beverage containers recovered come from California. (Note: These recovery estimates reflect not only containers redeemed by consumers for deposit, but also

Figure 27. States with Deposit/Redemption Legislation



containers recovered through existing curbside and drop-off recycling programs. Containers recovered through these programs eventually are credited to the distributor and counted towards the redemption rate.)

Commercial Recyclables Collection. The greatest quantity of recovered materials comes from the commercial sector. Old corrugated containers (OCC) and office papers are widely collected from commercial establishments. Grocery stores and other retail outlets that require corrugated packaging are part of an infrastructure that brings in the most recovered material. OCC is often baled at the retail outlet and picked up by a paper dealer.

Office paper (e.g., white, mixed color, computer, etc.) is part of another commercial recyclables collection infrastructure. Depending on the quantities generated, businesses (e.g., banks, institutions, schools, printing operations, etc.) can sort materials and have them picked up by a paper dealer, or self deliver the materials to the recycler. It should be noted that commercial operations also make recycling available for materials other than paper.

Multi-family residence recycling could be classified as either residential or commercial recyclables collection. Multi-family refuse is usually handled as a commercial account by waste haulers. It is also the same waste hauler that makes recycling available to multi-family dwellings (typically 5 or more units), which could resemble a drop-off center.

Recyclables Processing

Processing recyclable materials is performed at materials recovery facilities (MRFs), mixed waste processing facilities, and mixed waste composting facilities. Some materials are sorted at the curb and require less attention. Other materials are sorted into streams at the curb, such as a paper stream and a container stream, with additional sorting at a facility (MRF). Mixed waste can also be processed to pull out recyclable and compostable materials.

Materials Recovery Facilities. Materials recovery facilities vary widely across the U.S., depending on the incoming materials and the technology and labor used to sort the materials. There were 363 MRFs operating in the U.S in 1996, with an estimated total daily capacity of 29.4 thousand tons per day (Table 31). Like curbside collection programs, the most extensive recyclables processing capacity occurs in the Northeast (Figure 28).

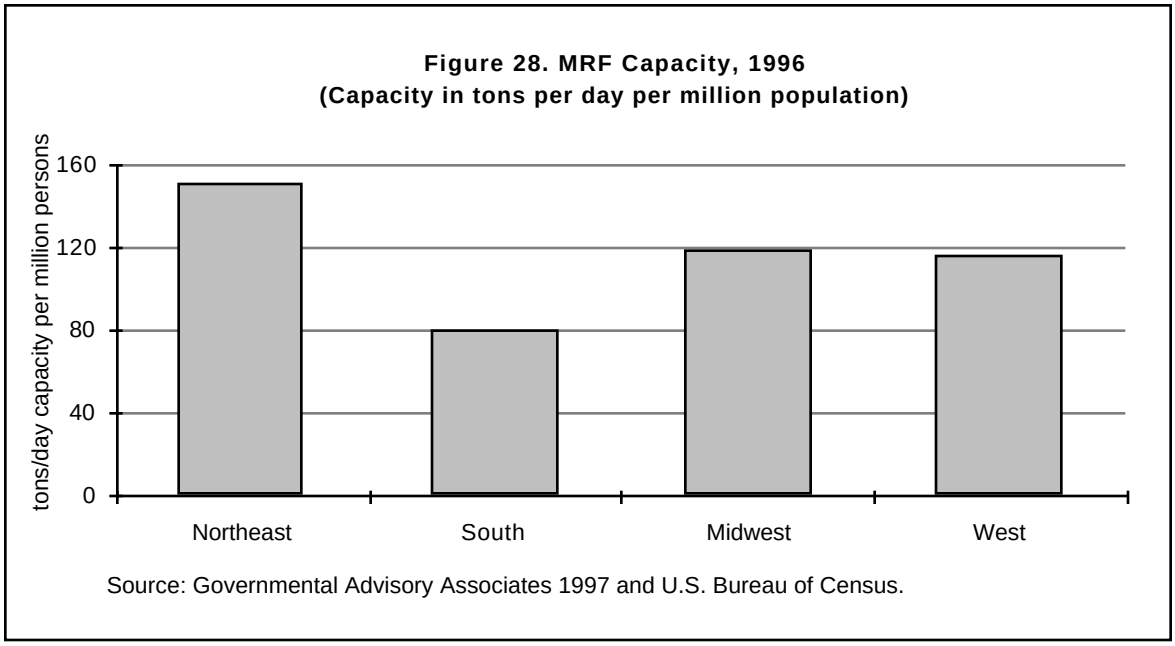
The majority of MRFs are considered low technology, meaning the materials are predominantly sorted manually. MRFs classified as high technology sort recyclables using eddy currents, magnetic pulleys, optical sensors, and air classifiers. As MRFs change and grow, many low technology MRFs add high tech features and high technology MRFs include manual sorting, making the difference between high and low technology MRFs less definitive.

Table 31

MATERIALS RECOVERY FACILITIES, 1996

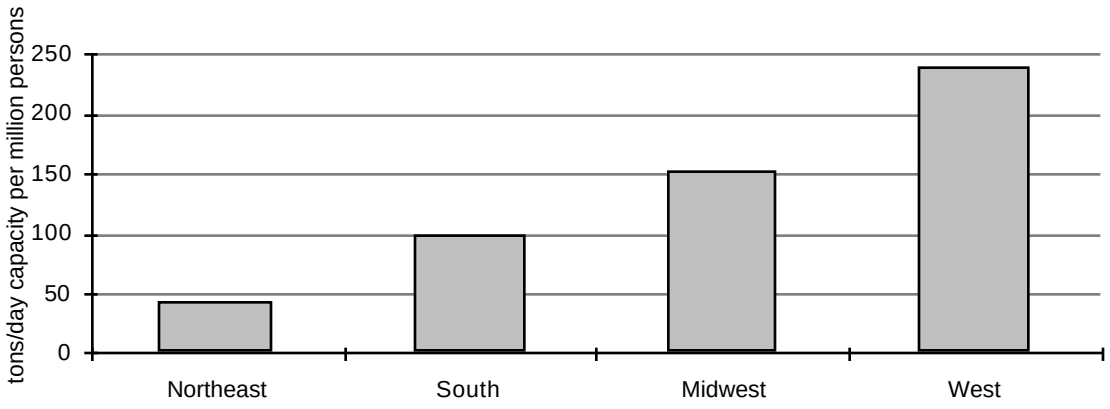
Region	Number	Capacity (tpd)
NORTHEAST	95	7,800
SOUTH	93	7,500
MIDWEST	92	7,400
WEST	83	6,700
U.S. Total	363	29,400

Source: Governmental Advisory Associates 1997.



Mixed Waste Processing. Mixed waste processing facilities are less common than conventional MRFs, but there are several facilities in operation in the U.S., as shown in Figure 29. Mixed waste processing facilities receive waste just as if it were going to a landfill. The mixed waste is loaded on conveyors and, using both mechanical and manual (high and low technology) sorting, recyclable materials are removed for further processing. In 1996, there were reported 58 mixed waste processing facilities in the U.S., handling about 34,800 tons of waste per day (Governmental 1997). The West region has the largest concentration of these processing facilities.

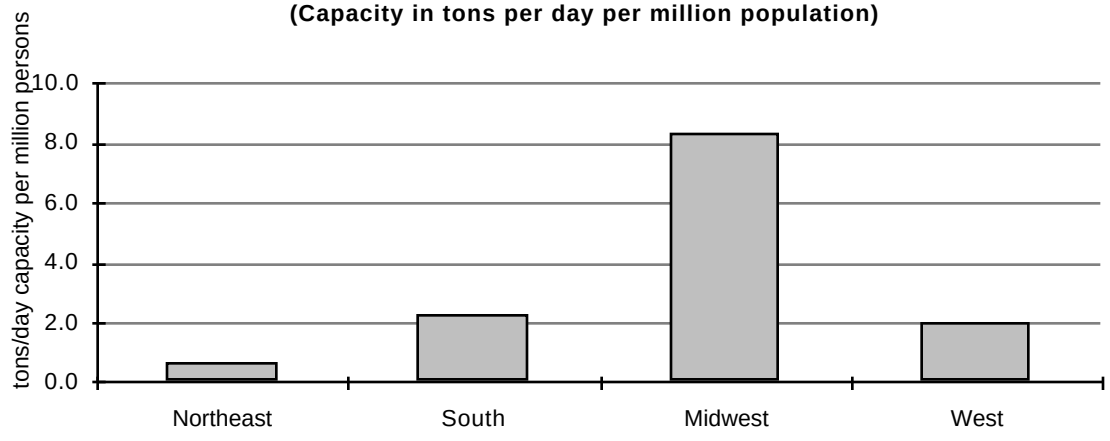
Figure 29. Mixed Waste Processing Capacity, 1996
(Capacity in tons per day per million population)



Source: Governmental Advisory Associates 1997 and U.S. Bureau of Census.

Mixed Waste Composting. Mixed waste composting starts with unsorted MSW. Large items are removed, as well as ferrous and other metals, depending on the type of operation. Mixed waste composting takes advantage of the high percentage of biologically organic components of MSW, such as paper, food wastes and yard trimmings, wood, and other materials. In 1996, there were 14 mixed waste composting facilities, predominantly in the Midwest, as shown in Figure 30. These facilities handle about 900 tons per day in total.

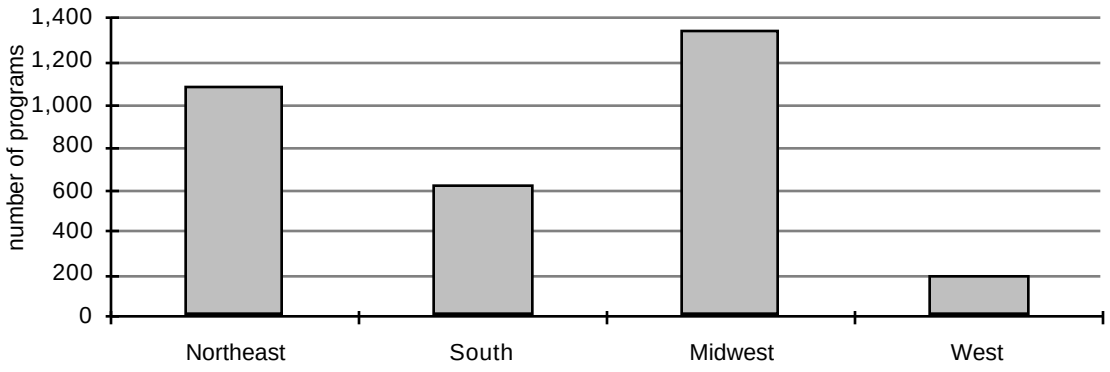
Figure 30. MSW Composting Capacity, 1996
(Capacity in tons per day per million population)



Source: BioCycle 1996 and U.S. Bureau of Census.

Yard Trimmings Composting. Yard trimmings composting is much more prevalent than mixed waste composting. On-site management of yard trimmings is not included in this section, but is discussed in the source reduction section. There were 3,260 yard trimmings composting programs reported in 1996. About 75 percent of these programs are in the Northeast and Midwest regions, as shown in Figure 31. Based on 10.8 million tons of yard trimmings recovered for composting in the United States, yard trimmings composting facilities handled approximately 25,500 tons per day in 1996.

Figure 31. Yard Trimmings Composting Programs, 1996
(In number of programs)



Source: BioCycle 1997.

COMBUSTION

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 1980s.

Total U.S. MSW combustion with energy recovery, referred to as waste-to-energy (WTE) combustion, had a 1996 design capacity of 100,000 tons per day. There were 110 WTE facilities in 1996 (Table 32). The Northeastern and Southern regions had most of the MSW combustion capacity in 1996 (Figure 32). In addition to WTE combustion, 5,400 tons per day of refuse-derived fuel (RDF) were prepared, and there was an additional 2,450 daily tons of capacity for incineration without energy recovery.

Table 32

MUNICIPAL WASTE COMBUSTORS 1996 (1)(2)

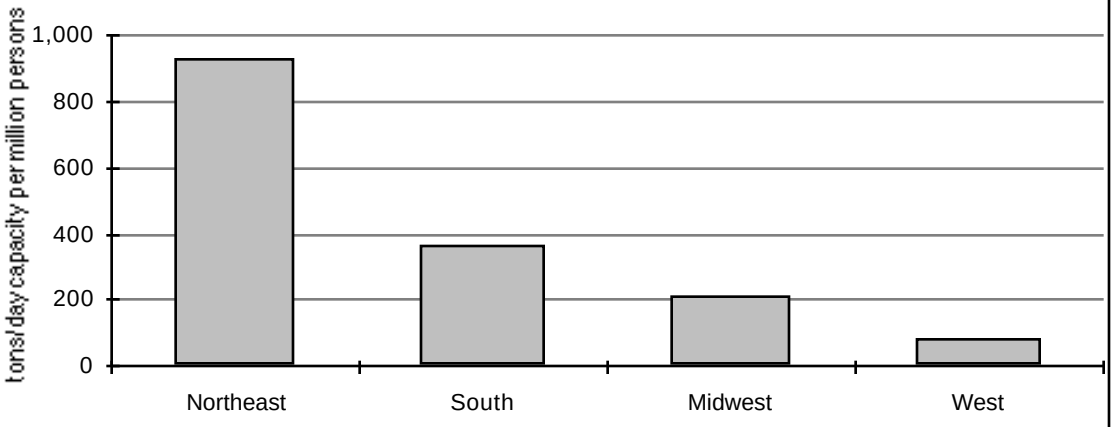
Region	WTE (2) No. existing	WTE (2) Design Capacity (tpd)	WTE (2) No. planned & under construction	WTE (2) Design Capacity (tpd)	RDF Processing (3) No.	RDF Processing (3) Design Capacity (tpd)	Incinerator (4) No.	Incinerator (4) Design Capacity (tpd)
NORTHEAST	43	48,092	4	6,740	0	0	12	434
SOUTH	36	34,145	4	3,025	3	2,115	2	95
MIDWEST	22	13,288	2	3,400	4	2,990	3	1,700
WEST	9	4,830	2	175	1	300	2	222
U.S. Total (1)	110	100,355	12	13,340	8	5,405	19	2,451

(1) Projects on hold or inactive were not included. Facilities in Hawaii and Alaska not included.
(2) WTE includes MB, MOD, RDF, RDF-Combustion.
(3) RDF processing = waste processing facility generating a prepared fuel for off-site combustion. Includes existing and planned sites.
(4) Facilities without energy recovery.

Source: Integrated Waste Services Association, 1997.

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 2.5 million tons of MSW were combusted in this manner in 1996, with tires contributing a majority of the total.

Figure 32. Municipal Waste Combustion Capacity, 1996
(Capacity in tons per day per million population)



Source: Integrated Waste Services Association 1997 and U.S. Bureau of Census.

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 total throughput of MSW through all combustion facilities was an estimated 36 million tons, or 17 percent of MSW generation, in 1996.

RESIDUES FROM WASTE MANAGEMENT FACILITIES

Whenever municipal wastes are processed, residues will remain. For the purposes of this report, it is assumed that most of these residues are landfilled.

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, 5 to 10 percent is probably typical for a MRF. Residues from a MRF or compost facility are generally landfilled. Since the recovery estimates in this report are based on recovered materials purchased by end users rather than materials entering a processing facility, the residues are counted with other disposed materials.

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. (There are a number of efforts underway to reuse ash.) 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.

LANDFILL

Although the number of landfills is decreasing, the capacity has remained relatively constant. In 1996, approximately 2,400 municipal solid waste landfills were reported in the contiguous U.S. New landfills are now much larger than in the past.

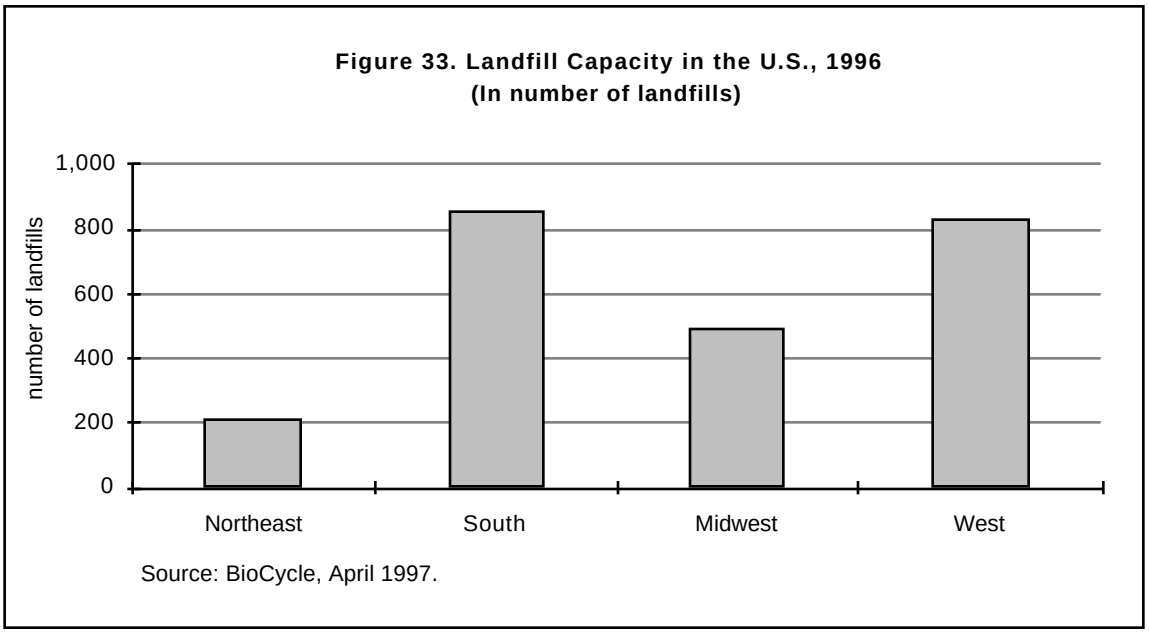
Table 33 and Figure 33 show the number of landfills in each region. The Southeast and West had the greatest number of landfills. Thirty-five states had more than 10 years of capacity left. Three states reported having less than 5 years of capacity remaining.

Table 33

LANDFILL FACILITIES, 1996

Region	Number of Landfills *	Number of States with Years Capacity Remaining		
		> 10 yr	5 to 10 yr	< 5 yr
NORTHEAST	208	5	1	3
SOUTHEAST	857	11	5	0
MIDWEST	490	8	4	0
WEST	827	11	0	0
U.S. Total *	2,382	35	10	3

* Excludes landfills reported in Alaska (700) and Hawaii (9).
Source: BioCycle, April 1997 and Waste Age May, 1996.



SUMMARY OF HISTORICAL AND CURRENT MSW MANAGEMENT

This summary provides some perspective on historical and current municipal solid waste management practices in the U.S. The study results are summarized in Table 34 and Figure 34.

Historically, municipal solid waste generation has grown relatively steadily (88 million tons in 1960 to 214 million tons in 1994). However, after peaking in 1994, MSW generation the last two years has experienced a decline (both in product and non-product waste categories). In 1996 MSW generation was less

Table 34

GENERATION, MATERIALS RECOVERY, COMPOSTING, COMBUSTION, AND DISCARDS OF MUNICIPAL SOLID WASTE, 1960 TO 1996
(In thousands of tons and percent of total generation)

	Thousands of Tons							
	1960	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Generation	88,120	121,060	151,640	205,210	208,930	214,170	211,460	209,660
Recovery for recycling	5,610	8,020	14,520	29,380	35,150	42,420	45,530	46,010
Recovery for composting*	Neg.	Neg.	Neg.	4,200	5,400	8,480	9,570	11,320
Total Materials Recovery	5,610	8,020	14,520	33,580	40,550	50,900	55,100	57,330
Discards after recovery	82,510	113,040	137,120	171,630	168,380	163,270	156,360	152,330
Combustion**	27,000	25,100	13,700	31,900	32,690	32,490	35,540	36,090
Discards to landfill, other disposal†	55,510	87,940	123,420	139,730	135,690	130,780	120,820	116,240

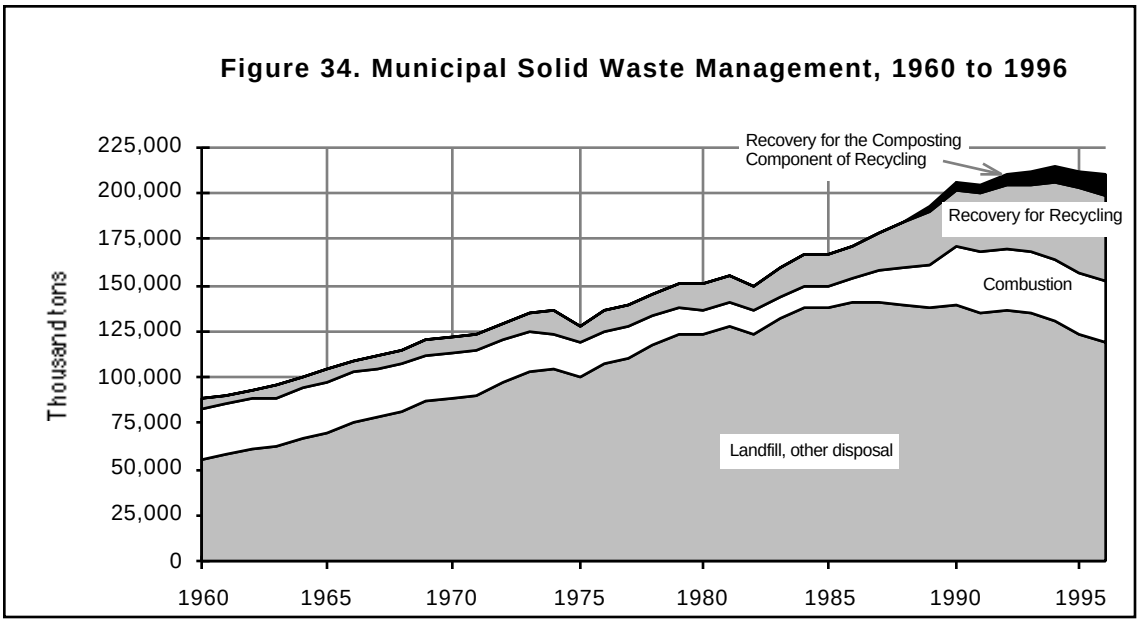
	Percent of Total Generation							
	1960	**1970**	**1980**	**1990**	**1992**	**1994**	**1995**	**1996**
Generation	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Recovery for recycling	6.4%	6.6%	9.6%	14.3%	16.8%	19.8%	21.5%	21.9%
Recovery for composting*	Neg.	Neg.	Neg.	2.0%	2.6%	4.0%	4.5%	5.4%
Total Materials Recovery	6.4%	6.6%	9.6%	16.4%	19.4%	23.8%	26.1%	27.3%
Discards after recovery	93.6%	93.4%	90.4%	83.6%	80.6%	76.2%	73.9%	72.7%
Combustion**	30.6%	20.7%	9.0%	15.5%	15.6%	15.2%	16.8%	17.2%
Discards to landfill, other disposal†	63.0%	72.6%	81.4%	68.1%	64.9%	61.1%	57.1%	55.4%

* Composting of yard trimmings and food wastes. Does not include mixed MSW composting or backyard composting. MSW composting estimated to be less than 500 thousand tons per year.
** Includes combustion of MSW in mass burn or refuse-derived fuel form, 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.

than 210 million tons, providing possible evidence of the beginnings of a trend in source reduction. (See the previous section in this chapter for a discussion on trends in source reduction.)

In the 1960s and early 1970s a large percentage of MSW was burned, with little recovery for recycling. Landfill disposal typically consisted of open dumping, often accompanied with open burning of the waste to reduce its volume. Through the mid-1980s, incineration declined considerably and landfills became difficult to site, and 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 34 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. Although there are now fewer municipal solid waste landfills, their average size has increased and capacity at the national level does not appear to be a problem. However, regional dislocation sometimes occur.

Recovery of products and yard trimmings increased steadily, while combustion has stayed relatively constant—15 to 17 percent of total MSW generation. As a result, MSW discards to landfills have decreased in the 1990's. Landfilling accounted for 116.2 million tons of MSW in 1996. As a percent of total MSW generation, landfilling has consistently decreased—from 83.2 percent of generation in 1986 to 55.4 percent in 1996.

Chapter 3

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Chapter 4

MARKETS FOR RECOVERED MATERIALS

INTRODUCTION

The past few years, markets and prices for recovered materials have fluctuated widely. There are a number of factors driving these markets changes. Some factors discussed in this chapter include:

- Economic conditions: domestic and international
- Overall demand for products
- Demand for products made partially or entirely from recovered materials
- Quality of recovered materials (contamination issues)
- Capacity to use recovered materials
- Excess capacity to produce virgin materials
- Transportation distances (costs)
- Export markets
- Discontinuities between supply and demand
- Legislation.

This chapter provides a broad overview of markets for the most commonly recovered materials in MSW; paper and paperboard, glass containers, aluminum containers, steel in cans and major appliances, HDPE and PET plastics bottles, and compost.

PAPER AND PAPERBOARD

Current Markets for Recovered Paper and Paperboard

The major markets for recovered paper and paperboard products are the domestic paper industry and exports (Table 35 and Figure 35). A small amount of recovered paper (mostly newspapers) is also used for other purposes such as insulation and animal bedding. Products made of paper and paperboard are an important component of municipal solid waste (MSW), making up 37 percent of MSW generation and 57 percent of MSW recovery in 1996. Thus, recovery of paper and paperboard products has a significant effect on the amount of MSW remaining to be managed by other alternatives.

Table 35 highlights changes that occurred between 1995 and 1996. Despite a 10 percent increase in domestic mill consumption of recovered paper, weak export demand caused a slight decline in total paper and paperboard recovery (42.3 million tons in 1996 versus 42.5 million tons in 1995).

Table 35

MARKETS FOR RECOVERED PAPER AND PAPERBOARD, 1995 AND 1996
(In thousand tons)

Markets	1995 Utilization	1995 % of Total Utilization	1996 Utilization	1996 % of Total Utilization
Paper Manufacture				
Newsprint	3,169	7%	3,198	8%
Printing-Writing, Related Papers	2,493	6%	2,541	6%
Packaging & Industrial Converting	987	2%	1,113	3%
Tissue Papers	3,396	8%	3,642	9%
Total Paper	10,045	24%	10,494	25%
Paperboard Manufacture				
Kraft Linerboard	4,019	9%	4,207	10%
Other Kraft Paperboard	306	1%	328	1%
Semichemical Paperboard	1,860	4%	2,082	5%
Recycled Containerboard	6,931	16%	8,782	21%
Other Recycled Paperboard	7,430	17%	7,602	18%
Total Paperboard	20,546	48%	23,001	54%
Construction Paper & Board Manufacture	1,070	3%	1,064	3%
Total Domestic Paper Industry	31,661	74%	34,559	82%
Net Exports*	9,898	23%	6,686	16%
Other Uses**	980	2%	1,030	2%
Total Recovered Paper and Paperboard	42,539	100%	42,275	100%

1996 domestic utilization is preliminary. Includes both preconsumer and postconsumer recovered paper and paperboard.

* Exports minus imports.

** Cellulosic insulation, animal bedding, etc.

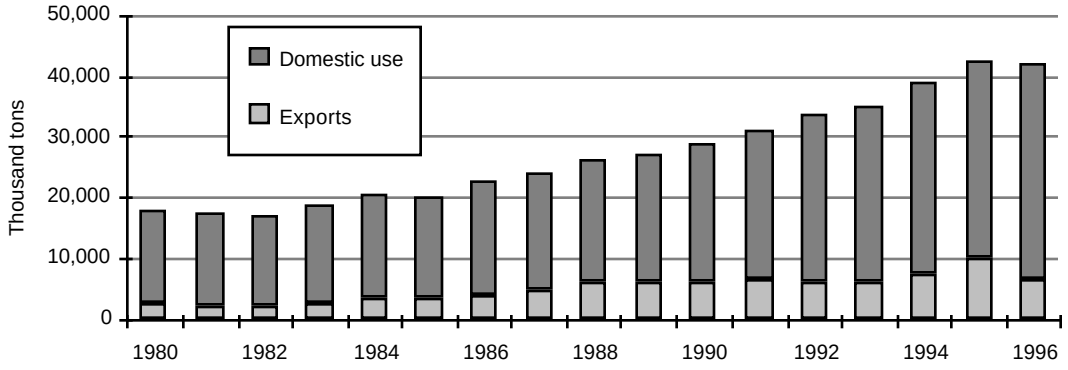
Details may not add to totals due to rounding.

Source: American Forest & Paper Association.

Utilization of recovered paper and paperboard in domestic paperboard manufacture increased by about 2.5 million tons between 1995 and 1996, with recycled containerboard and other paperboard consuming nearly 40 percent of the total used in 1996. Utilization of recovered paper and paperboard in paper manufacture increased modestly between 1995 and 1996.

As Table 35 and Figure 35 show, exports increased dramatically until mid-1995, then went into decline through 1996. As a result, total markets for recovered paper and paperboard declined slightly between 1995 and 1996, although domestic consumption was up. In this same time frame, prices for

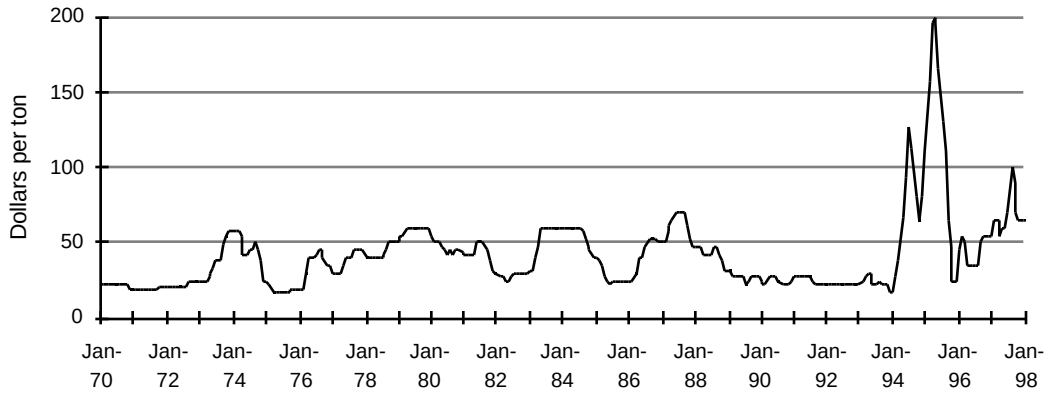
Figure 35. Recovered paper and paperboard domestic use and exports, 1980 to 1996 (In thousand tons)



Source: AF&PA

recovered papers fluctuated wildly. (See Figure 36 for an example.) While the example figure is for old corrugated containers (OCC), other recovered paper grades showed much the same pattern. Exports were not the only factor in the price decline in 1995–1996; production at domestic mills (operating rate) was well below capacity in the same period.

Figure 36. Average Chicago end user prices for OCC, 1970 to 1998 (In dollars per ton)



Source: Miller Freeman

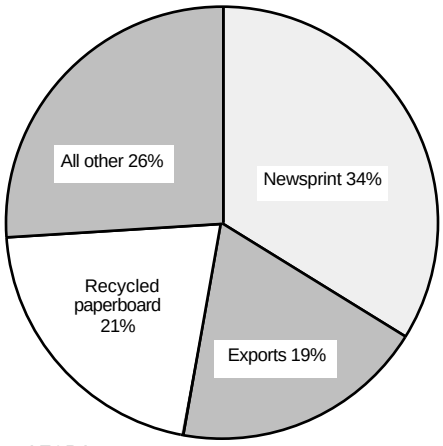
Markets for Specific Recovered Paper and Paperboard Products

The American Forest & Paper Association (AF&PA) issues an annual report of domestic use and exports of recovered paper and paperboard by grade.* Five grades are reported: old newspapers (which include printing-writing paper inserts and other papers as well as newsprint); old corrugated containers (which can include kraft paper bags); mixed papers (which can include a wide variety of recovered papers and paperboard such as office papers, telephone directories, magazines, and others); pulp substitutes (which are high grade, print free, and usually converting scrap); and high-grade deinking (which are printed office papers, converting scrap, and other high-quality papers).

Because many recovered paper products could be marketed as more than one grade of recovered paper, (e.g., office papers could be mixed papers or high-grade deinking), the discussion that follows should not be interpreted as identifying the *only* markets for a particular recovered product.

Old Newspapers. Markets for recovered old newspapers as reported by AF&PA are shown in Figure 37. Recovered newspapers go to a very wide range of products and exports. As Figure 37 illustrates, the most important single use is in the manufacture of newsprint, at 34 percent of the total recovered. In 1996 recycled paperboard, at 21 percent of total, was the second most important market for newspapers, while exports consumed about the same amount as recycled paperboard. All other uses (e.g., construction products, molded pulp products, cellulose insulation, and animal bedding) amounted to 26 percent of the total.

Figure 37. End user markets for recovered newspapers, 1996

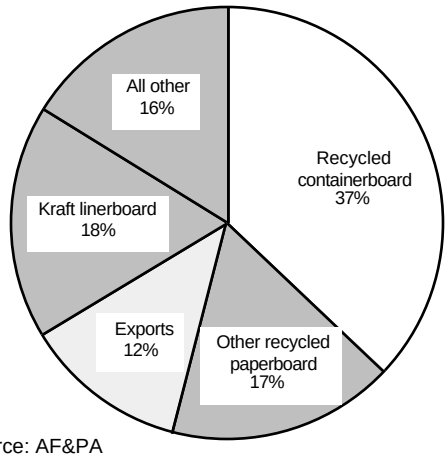


Source: AF&PA

* AF&PA data reported in this section include both preconsumer and postconsumer recovery. Recovery figures shown elsewhere in this report are for postconsumer recovery only.

Corrugated. Markets for recovered corrugated (mostly corrugated boxes) are shown in Figure 38. Recovered corrugated goes to a wide variety of end uses, although paperboard products use the majority recovered. In 1996, recycled containerboard provided 37 percent of the total market, with kraft linerboard (used to make corrugated boxes) and other recycled paperboard, at 18 percent and 17 percent, accounting for large quantities also. Exports accounted for 12 percent of the total and all other uses (e.g., packaging and industrial papers, tissue papers, and construction products) amounted to 16 percent.

Figure 38. End user markets for recovered corrugated, 1996

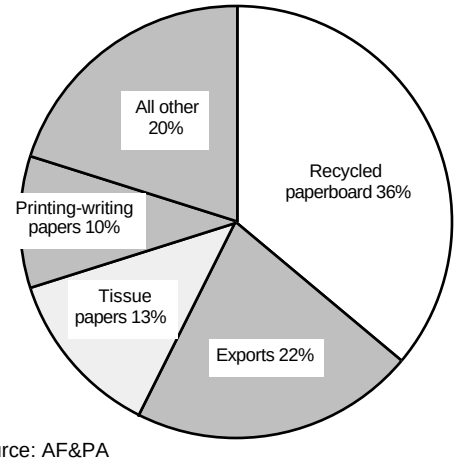


Source: AF&PA

Mixed Papers. Markets for recovered mixed papers are shown in Figure 39. The largest market for recovered mixed papers in 1996 was recycled paperboard at 36 percent of the total recovered. The mixed papers that go into recycled paperboard tend to be the "lower" grades, which could include boxboard, magazines, telephone directories, and other grades that are heavily printed. The second largest market in 1996 was exports at 22 percent. Tissue papers and printing-writing papers together accounted for 23 percent of the mixed paper market. The "higher" grades of mixed paper, e.g., office papers and preconsumer converting scrap, would tend to go to these end uses. Finally, a variety of other uses (e.g., newsprint and construction products) accounted for 20 percent of mixed papers recovered in 1996.

Pulp Substitutes and High-grade Deinking Papers. These grades of recovered paper contain higher percentages of preconsumer paper than the other grades discussed. Postconsumer recovered paper in these grades is mostly high-grade office papers. Markets for these grades in 1996 are shown in Figure 40. Tissue papers were the largest market at 31 percent of total recovered, and printing-writing papers were second, at 26 percent of total. Exports took 19

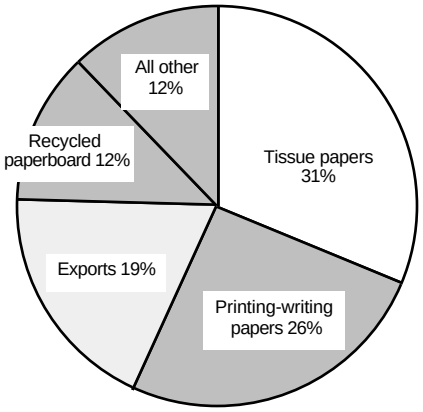
Figure 39. End user markets for recovered mixed papers, 1996



Source: AF&PA

percent of these recovered grades, while recycled paperboard and other uses (e.g., newsprint, packaging and industrial papers, and construction products) accounted for the other 24 percent.

Figure 40. End user markets for pulp substitutes and high grade deinking papers, 1996



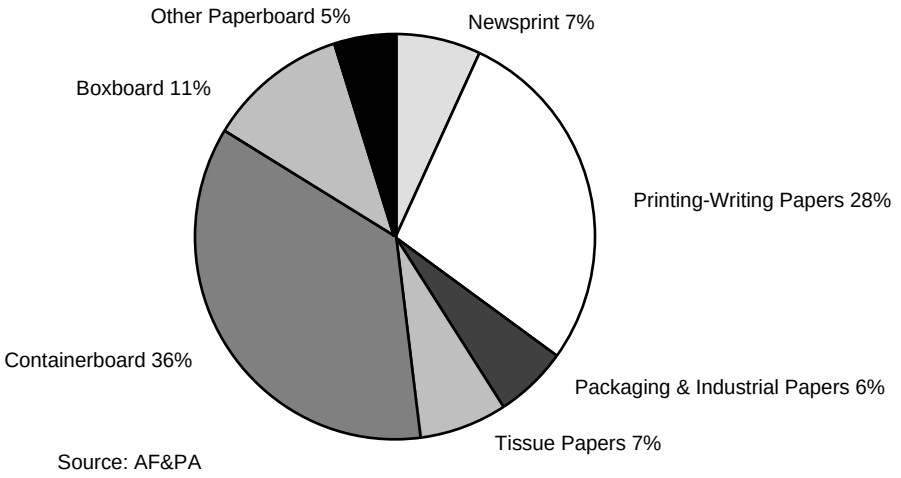
Source: AF&PA

Industry Structure for Recovered Paper and Paperboard

The pulp and paper industry* as a whole is an important part of the U.S. economy, ranking eleventh among all manufacturing industries in contribution

* The generic term "paper industry" includes manufacturers of paper, paperboard, and construction paper and paperboard products.

Figure 41. Capacity to produce paper and paperboard by product category, 1996



Source: AF&PA

to gross domestic product (GDP) (Miller Freeman 1996). Within the industry, containerboard (corrugated boxes) and the various grades of printing and writing papers are the dominant grades produced, making up 64 percent of total capacity in 1996 (AF&PA 1996). (See Figure 41 above.) Other important grades of paper and paperboard produced in the United States include newsprint, packaging and industrial converting papers, tissue papers, boxboard, and other paperboard.

In 1996, the annual domestic capacity to produce paper and paperboard products was:

Paper products	47.5 million tons
Paperboard products	51.6 million tons
Construction products*	2.1 million tons
Total paper industry	101.2 million tons

It should be noted that the industry capacity shown above includes some products (e.g., bathroom tissue, automotive board, and construction products) that are not classified as MSW. These products are, however, markets for recovered paper and paperboard products in MSW.

Papermaking capacity is not evenly distributed across the United States, as shown for 1994 in Table 36. The South Central Region, which includes Alabama, Louisiana, Mississippi, and other states, had 31 percent of all papermaking capacity in that year. Next was the South Atlantic Region at 24 percent (e.g.,

* Paper or paperboard construction products include gypsum wallboard liners, roofing felt, and panel board.

Table 36

CAPACITY TO PRODUCE PAPER AND PAPERBOARD BY CENSUS REGION, 1994
(In thousand tons)

Grades	New England	Middle Atlantic	North Central	South Atlantic	South Central	Mountain & Pacific	Total
Paper	5,109	4,148	10,856	7,756	11,889	6,182	45,940
Paperboard	1,086	1,734	6,094	14,893	16,568	6,949	47,324
Construction	53	325	502	482	749	95	2,206
Total Capacity	6,248	6,207	17,452	23,131	29,206	13,226	95,470
% of Total	7%	7%	18%	24%	31%	14%	100%
Number of mills	67	89	137	70	78	61	502
Consumption of recovered paper	2,057	2,957	8,564	6,111	5,802	5,459	30,950
% of Total	7%	10%	28%	20%	19%	18%	100%

Source: American Forest & Paper Association.

Florida, Georgia, North Carolina, and South Carolina). The North Central Region (which includes Michigan, Minnesota, Ohio, Wisconsin, and other states) and the Middle Atlantic Region (New Jersey, New York, and Pennsylvania) had more mills than the southern regions, but the mills were smaller, on average. The Mountain and Pacific Regions, which include California, Oregon, and Washington, have the fewest mills, but significant capacity (14 percent of the total).

Regional markets (consumption) for recovered paper and paperboard are also shown in Table 36. The North Central Region, which has many recycling mills, is the leader; the South Atlantic, South Central, and Mountain and Pacific Regions also consume large quantities of recovered paper and paperboard. The New England and Middle Atlantic Regions consume the lowest quantities of recovered paper and paperboard.

Factors Driving Markets for Recovered Paper and Paperboard

The paper industry is large and very diverse. The fiber content of paper and paperboard products ranges from 100 percent virgin wood fibers to 100 percent recycled fibers, with many combinations of virgin/recycled fibers in between. For many of these products, it is quite possible to vary the mix of virgin/recycled fibers depending upon the availability, quality, and price of the different fiber sources. Also, it is possible in many instances to substitute one recovered paper grade for another, again depending upon the availability and price. For these reasons, it is quite difficult to pinpoint exact reasons for demand for recovered paper. This section includes a discussion of some of the factors driving recovered paper markets.

- ***Demand for paper and paperboard products in general***. Production of paper is quite sensitive to economic conditions, and in bad economic times, demand for products such as newspapers, corrugated boxes, and some printing papers will fall. Since so many of these paper grades use at least some recovered paper in their production, this affects demand for recovered paper. (See the first part of this chapter for a discussion of some factors affecting growth of the paper industry.)

- ***Demand for products containing recycled fiber***. Consumers may resist purchasing products made with recovered paper because of real or perceived quality problems. For example, producers of deinked pulp for use in printing-writing papers have been experiencing quality and demand problems, and there have been mill shutdowns as a result.

- ***Exports***. Exports are a very important market for recovered papers, but these markets are erratic and almost impossible to predict. They are dependent upon economic and political factors in the importing countries. Some of the factors contributing to a slowdown in U.S. paper exports in the 1990s included: competitive prices for virgin woodpulp, higher levels of paper recovery in Europe and some Asian countries, a temporary shortage of containers for shipping in 1993, and a decline in the worldwide economy in 1996.

- ***Discontinuities between supply and demand***. Supply and demand for recovered paper products are often "out of synch." For example, if one or more foreign countries suddenly begin purchasing large quantities of recovered paper, supplies will become short and prices will be driven up. If the export demand drops suddenly, which is not uncommon, then prices will plunge and there will be too much supply.

  To cite another example, a rapid build-up of recycling collection and processing infrastructure, which has happened in the 1990s, can create an oversupply, again contributing to a fall in prices unless demand also increases.

- ***Virgin material capacity***. Occasionally a large amount of new capacity to produce mostly virgin fiber products will drive down the price of virgin pulp. The virgin pulp may then compete with recycled pulp at a favorable price.

- ***Quality Issues.*** The paper industry has specifications defining the permissible content of many grades of recovered paper. If recovered paper is contaminated (e.g., by the presence of other grades of paper

or other materials such as glass or plastics), the collected paper may be rejected by the buyer or reclassified as a less desirable (and less valuable) product. This can become a problem when paper is collected along with other materials, as often occurs in a curbside collection program.

- ***Legislation favoring recycled content***. Legislation favoring recycled content products (or sometimes the threat of legislation) at the state or federal level can help to create demand for recycled content papers.

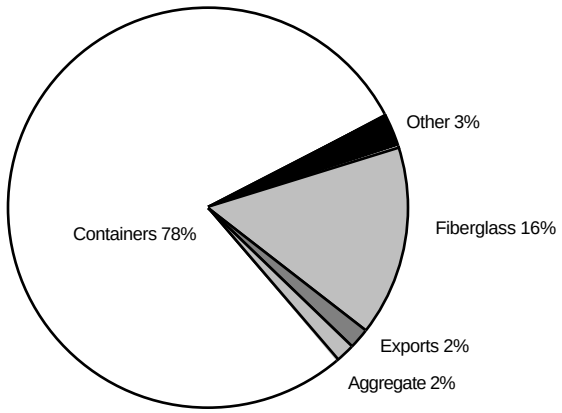
CONTAINER GLASS

Current Markets for Recovered Glass Containers

Glass container manufacturers are by far the largest users of glass cullet, as shown in Figure 42. Approximately 2.5 million tons of cullet are used by domestic glass container manufacturers, which is almost 80 percent of total recovery. Container manufacturers use cullet of the same color (color contamination allowances vary from 0 to 50 percent). Cullet use saves energy and consumption of virgin raw materials (essentially sand).

As previously shown in Chapter 2, over 11 million tons of container glass were generated in 1996 (approximately 10 million tons are produced domestically). The largest component of container glass generation is beer bottles (45 percent), followed by food containers (35 percent). Soft drink bottles, wine and liquor bottles, and containers for other products (e.g., medicine, cosmetics) are also produced.

Figure 42. End user markets for glass containers by product category



Source: Glass Packaging Institute

Approximately 61 percent of domestic glass containers are flint (clear), 31 percent are amber (brown), and the remaining 8 percent are green (Resource Recycling October 1996). The share of imported glass containers that are amber and green is much higher.

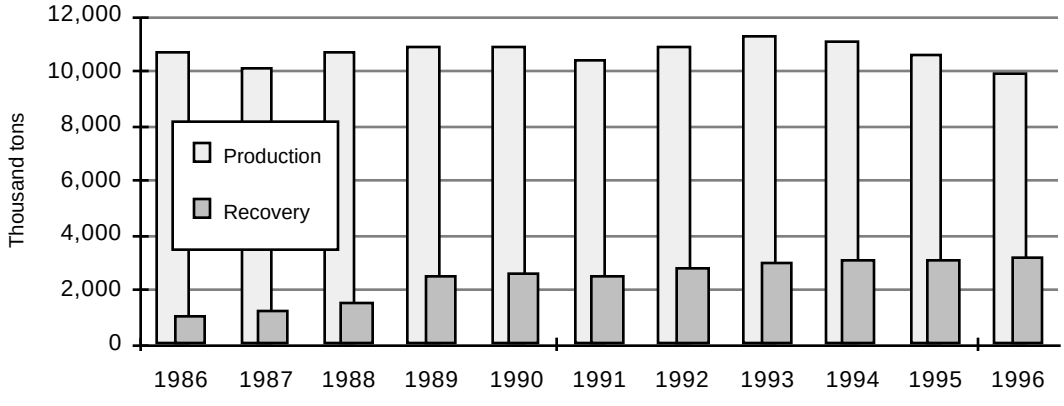
Container glass is a versatile recyclable material. Aside from color, the properties of container glass cullet (crushed glass) are common to the various glass containers. For example, color sorted cullet from a pickle jar can be used in the fabrication of a soft drink or perfume container of the same color.

Glass is recovered through most curbside collection programs, container deposit programs, and drop-off programs. Recovery of container glass has increased since 1980, but the increase has been fairly "flat" in recent years (Figure 43). Recovery has increased from 750 thousand tons in 1980 (5 percent) to 3.2 million tons in 1996 (29 percent).

Market shares for glass containers have declined in the last decade, and that trend is expected to continue in the near future. Glass containers were once the predominant container for soft drinks, but aluminum and more recently, plastics, have dramatically increased their market share in beverages as well as some other traditional glass markets (e.g., salad dressing, peanut butter, etc.). Non-refillable beer bottles are the largest market for glass, accounting for nearly one-half of domestic glass container shipments.

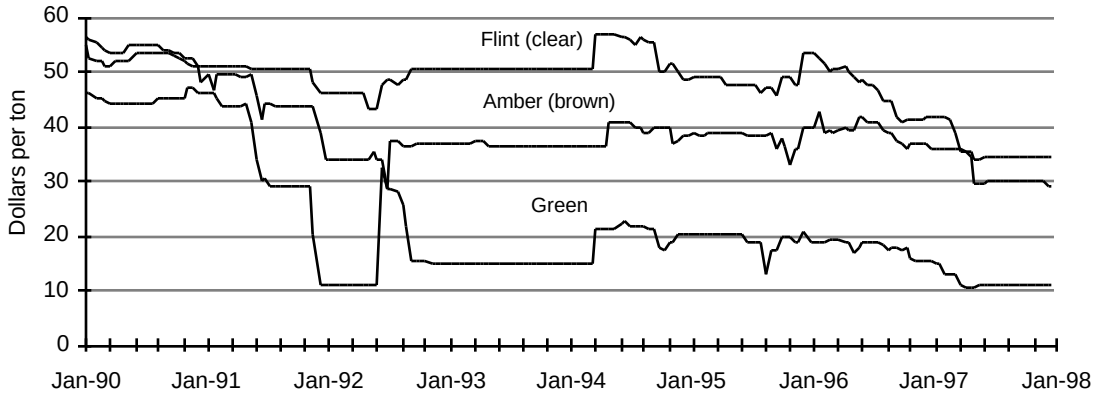
Domestic glass container manufacturers currently average about 27 percent recycled content. The glass industry has steadily increased recycled

Figure 43. Domestic glass container production and recovery, 1986 to 1996 (In thousand tons)



Source: U.S. Department of Commerce, Glass Packaging Institute, and Franklin Associates, Ltd.

Figure 44. End user prices for container glass cullet, 1990 to 1998 (In dollars per ton)



Source: Recycling Times

content over the past decade and can likely achieve higher recycled content. Some European manufacturers, as well as a few U.S. manufacturers, have recycled content over 80 percent.

There is also a considerable amount of cullet going to fiberglass fabrication. Other markets include use as aggregate in glasphalt, glascrete, and other construction materials; abrasives and filter media; and miscellaneous art and project glass. Altogether, these other markets total 640 thousand tons recovered in 1996. The U.S. exported less than 50 thousand tons of glass cullet to Great Britain, Italy, Canada, Mexico and other countries.

Market prices for glass cullet have remained relatively stable in recent years. As shown in Figure 44, currently flint and amber glass cullet ranges from $30 to $40 per ton, and green between $10 and $20 per ton.

Industry Structure for Recovered Glass Containers

There are approximately 70 glass container plants in the U.S. Glass container manufacturers are concentrated in Illinois, Indiana, New Jersey, Ohio, and Pennsylvania. There are also facilities in California, North Carolina, Oklahoma, Texas, and several other states, but in general, there are very few plants in the central U.S. and the Rocky Mountain states (Franklin Assoc. 1994).

Glass benefication (processing) facilities accept crushed glass from recyclers with substantially more processing occurring. At the benefication plant cullet is cleaned and further processed into furnace-ready quality. Glass benefication plants are found throughout the same areas as the container plants.

Fiberglass manufacturers are found throughout the northeast, southeast, midwest, and pacific coast regions. Markets for glass aggregate and abrasives are scattered throughout the U.S.

Factors Driving Markets for Recovered Glass Containers

Markets for recovered container glass cullet are dependent on the following:

- level of contamination
- level of recycled content in new glass containers
- production volume of new glass containers
- transportation distance to facility.

Acceptable glass contamination for colored glass varies from near zero percent to 50 percent. Flint glass can accept anywhere from zero to 5 percent color contamination, while amber glass can accept up to 20 percent. Green glass fabrication can accept up to 50 percent different colors. There is very low tolerance for ceramics contamination in glass manufacture. A small chip or fragment of ceramic material from a cap or mug will disintegrate in the furnace, causing problems in hundreds of new containers.

As shown earlier in Figure 43, production of new glass containers has waned in recent years, having an impact on demands for raw materials. It is expected that domestic production of glass containers will remain at about 10 million tons annually. Demand for cullet is somewhat proportional to production. However, as production of glass containers has declined, the more efficient glass plants have continued to make containers and use considerable amounts of cullet.

Recycled glass is collected in excess of traditional market needs in many areas of the country (Resource Recycling August 1997). This is an indication that new markets must be identified or the cullet must be shipped further to meet the needs of a traditional market.

The density of glass cullet is very high, making the distance to market an important issue. The further the cullet must be transported, the higher the ultimate cost of the raw materials. There is a high concentration of glass manufacturing facilities in Illinois and New Jersey and the states in between. However, about one fourth of the states have no manufacturers.

If glass container collection and processing programs continue to provide quality glass cullet, and the distance to market is acceptable, communities should be able to adequately supply the domestic glass container market. Based on expected domestic production volume and recycled cullet content use, the demand for quality color-separated cullet will continue to be sound.

ALUMINUM CONTAINERS

Current Markets for Recovered Aluminum Containers

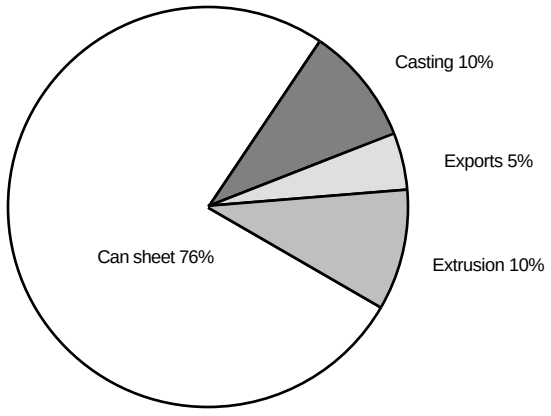
All aluminum packaging is produced from aluminum sheet, plate, and foil. Aluminum beverage cans contain just over 50 percent recycled content, so most recovered used beverage containers (UBCs) are remelted into ingot, flattened into can sheet, and made into new beverage cans, as shown in Figure 45. Some UBCs are exported, and some ingot is made from UBCs.

Aluminum containers traditionally have been the most sought after container by curbside programs, buy-back programs, scrap dealers, etc. because of their high value. Scrap aluminum is converted into new products at a substantial energy savings compared to making aluminum from raw material (bauxite).

Aluminum packaging made up a little less than one percent of MSW generation in 1996. Aluminum packaging recovery—almost exclusively used beverage containers—has been at or greater than 50 percent since 1981. Figure 46 shows generation and recovery of aluminum beverage cans since 1980. Recovery has remained at or near one million tons since 1990.

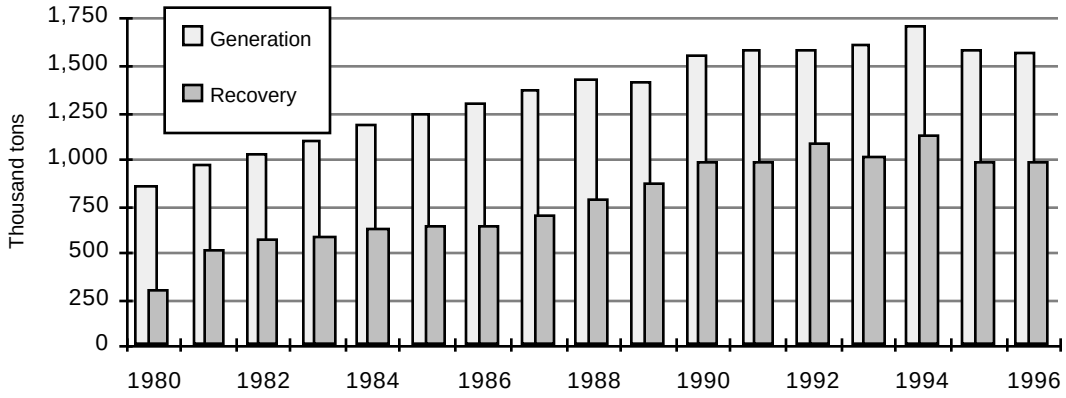
The recycled content for new aluminum containers in 1992 was 47 percent, and in 1996 it was 51.6 percent. Aluminum markets can absorb more material, either in new beverage cans by increasing the recycled content or in other markets such as aluminum casting, extrusion, or exports (Figure 46).

Figure 45. End user markets for aluminum containers by product category



Source: Container Recycling Report

Figure 46. Aluminum beverage can generation and recovery, 1980 to 1996 (In thousand tons)



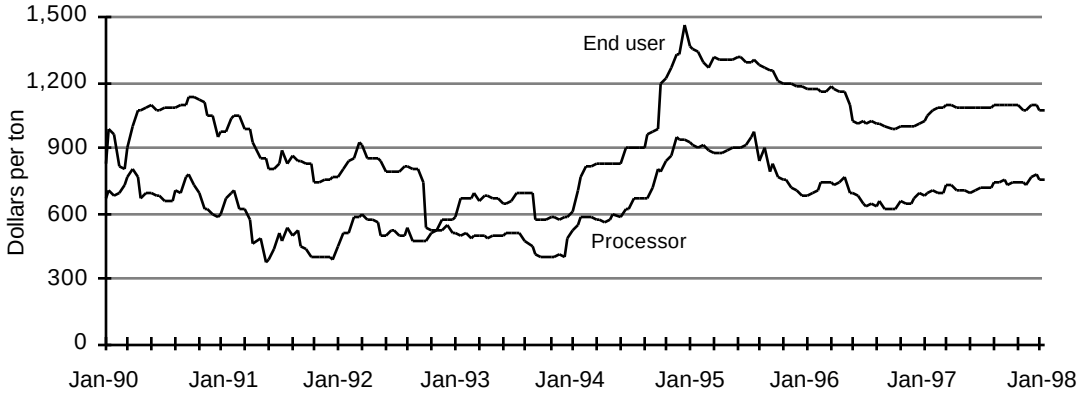
Source: Aluminum Association, Can Manufacturers Institute, Franklin Associates, Ltd.

Market prices for recovered aluminum containers have varied significantly in the past several years, as shown in Figure 47. End user prices paid by primary and secondary smelters ranged from an average of $600 per ton in 1994 to over $1,400 per ton in 1995. Recently, processor prices have been, on average, lower than end user prices by about $300 per ton.

Industry Structure for Recovered Aluminum Containers

Many secondary ingot mills have, by design, been built near sheet manufacturers. As shown previously in Figure 45, most recovered aluminum

Figure 47. End user and processor market prices for aluminum containers,1990 to 1998 (In dollars per ton)



Source: Recycling Times

containers eventually make it back into aluminum sheet, which is new can stock. A small amount of aluminum is being exported as ingot from a secondary smelter, and a smaller amount of UBCs is exported.

In 1997, there were 74 secondary ingot mills in the U.S., concentrated in the Great Lakes area, southern California, Tennessee, Georgia, and several scattered elsewhere (Aluminum Association 1997). The scrap ingot mills will be the likely destination for most recovered UBCs. There are 48 sheet and plate manufacturers with convenient access to the secondary ingot mills.

Factors Driving Markets for Recovered Aluminum Containers

Markets for recovered aluminum containers are dependent on the following:

- level of contamination
- street price for UBCs
- level of recycled content in new containers
- demand for new aluminum containers.

End users of recovered aluminum require that it meet strict specifications. UBCs must be magnetically separated to remove steel and iron, be free of foreign substances, and be baled to certain size and density requirements.

In states having a deposit on beverage containers, consumers have an additional economic incentive to return UBCs. Recovery in non-deposit states is more strongly tied to the street price for UBCs. If the street price (the price paid by buy-back centers) increases, more containers will be retrieved in the consumer market from disposal locations, parks, roadsides, commercial sites, and residences.

The industry has made gains in source reduction by reducing the thickness of aluminum beverage cans. In 1996, there were almost 32 cans per pound, compared to 31 in 1995 and 24 in 1980. Recent source reduction gains have also been realized as a result of a reduced lid size (Container Recycling Report May 1997).

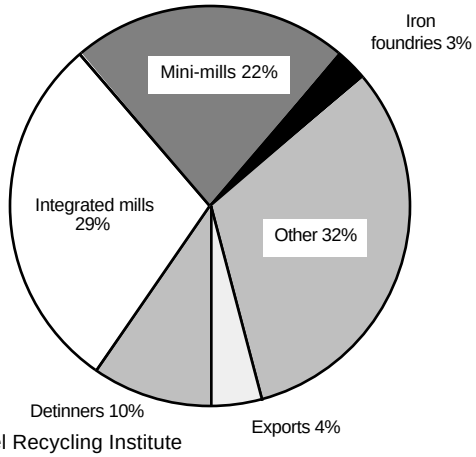
Overall, market share for new aluminum containers has been relatively flat in the past several years. Although aluminum food and other containers have increased market prominence, they are heavily outweighed by the aluminum beverage container (82 percent of aluminum packaging), which has lost some ground recently to slightly larger PET plastic bottles. The combination of source reduction and flat market share could mean that fewer UBCs would be available for recovery. However, recovered tonnage and percentage can increase if more cans are recovered.

STEEL IN CANS AND APPLIANCES

Current Markets for Recovered Steel in MSW

Integrated steel mills consumed 420 thousand tons, and mini-mills consumed 520 thousand tons of recovered steel (Figure 48). Approximately 140 thousand tons of steel cans went to detinners in 1996, where the tin was removed electrochemically. Once detinned, the cans entered other recovery markets. The market outlook for residential recovered steel appears positive. Market prices have been relatively stable, consumption has been growing, and the industry is actively promoting collection and processing.

Figure 48. End user markets for steel cans by product category



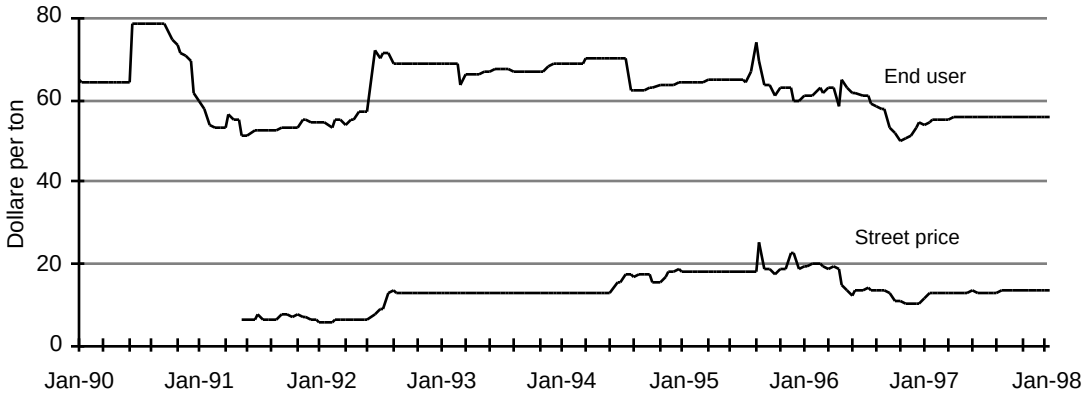
Source: Steel Recycling Institute

The market value of recovered steel is shown in Figure 49. End user prices for steel containers have been relatively flat in the 1990s, ranging from $50 to $70 per ton. The street price for steel cans was considerably lower, at about $15 per ton. Prices shown are the average of the high and low prices for all U.S. regions. Market prices for appliances (not shown) ranged from $0 to $12 per ton at processors (street prices).

Industry Structure for Recovered Steel in MSW

Production of iron and steel is an important industry in the U.S., with over 105 million tons produced in 1996 (AISI 1997). About 57 percent of the production is in basic oxygen process furnaces, which use some scrap as a raw material, and the remainder is produced in electric arc furnaces, which typically use 100 percent scrap.

Figure 49. End user and processor market prices for steel containers, 1990 to 1998 (In dollars per ton)



Source: Recycling Times

Steel mills in Indiana and Ohio rank highest in tons produced, with mills in the other Great Lakes states and southern states accounting for most of the other production. There are relatively few mills in the central and western states.

Recoverable steel in MSW comes primarily from steel cans and major appliances. From these sources, about 5.4 million tons of steel were generated in MSW in 1996 (approximately 2.8 million tons of steel cans and 2.6 million tons of appliance steel). Excluded from this discussion are steel in tires, furniture, and miscellaneous durable products (e.g., small appliances, electronics), some of which get recovered for recycling.

Steel cans are a common component of household MSW; they are collected predominantly through curbside recyclables collection programs. They are also separated from the ash of waste combustion facilities.

Recoverable steel is also generated from obsolete appliances (washers, dryers, refrigerators, dishwashers, water heaters, microwave ovens, ranges, and room air conditioners). Most of these appliances are taken to automobile shredders or other scrap processing operations, where the steel is recovered.

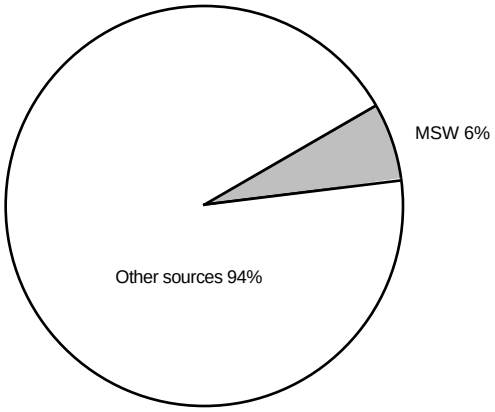
Both steel cans and steel in appliances are recovered at high rates. About 3.9 million tons of steel in MSW were recovered for recycling in 1996. About 2.2 million tons were from appliances and 1.7 million tons were from steel cans. The steel can recovery rate in 1996 was 56 percent, while steel from appliances was recovered at a rate of 83 percent.

Factors Driving Markets for Recovered Steel in MSW

Capacity to utilize recovered steel from MSW is not really an issue. Ferrous scrap accounts for more than half of the raw materials used to produce steel products and iron castings in the U.S. (Metal Statistics 1996). Further, steel recovered from MSW is a very small portion (about 6 percent) of the total recovered scrap used based on data from the American Iron and Steel Institute (Figure 50).

The only real issue, then, is the continued willingness of the domestic steel and iron industry to utilize steel products recovered from MSW. Since the industry is actively promoting recovery of steel from MSW, markets seem to be secure for the recovered products.

Figure 50. Sources of recovered steel and iron for domestic use, 1996



Source: AISI

PET AND HDPE PLASTICS

Current Markets for Recovered Plastic Bottles

Plastics make up approximately 9 percent of total MSW by weight. This discussion on markets for recovered plastics will focus on high density polyethylene (HDPE) and polyethylene terephthalate (PET) resins, as they account for about 80 percent of currently recovered plastics in MSW. (Other plastic resins are also recovered, including polypropylene, low density polyethylene, polystyrene, and others.)

HDPE Bottles. Natural (unpigmented) HDPE bottles for milk, water, and juice make up less than one percent of MSW, but are frequently collected for recycling. These natural HDPE bottles were recovered at a rate of 30 percent in 1996. Most HDPE bottles are recovered through curbside and drop-off recycling programs. Also, HDPE grocery bags are often collected at grocery stores.

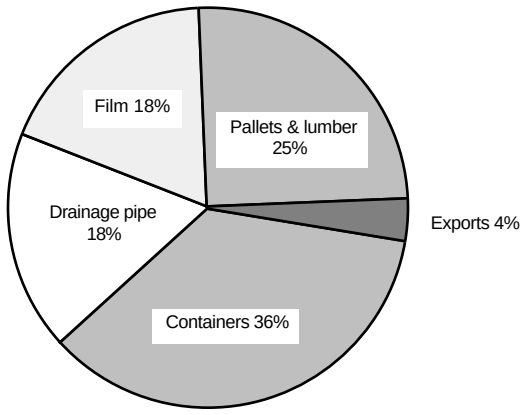
New bottles made with recycled content are the largest consumer of recovered HDPE containers, as shown in Figure 51. Drainage pipe and plastic lumber are also significant consumers of postconsumer HDPE resin. Other uses for postconsumer HDPE resin include fabrication into trash bags and grocery sacks, slip sheets used in warehouse distribution, pallets, and crates.

The market for postconsumer natural HDPE throughout the early 1990s remained steady. There appeared to be less HDPE bottle scrap available in 1996. Reclaimers believe this was due to a decline in participation and education in curbside programs. There were also a few curbside recyclables collection programs that stopped collecting plastics (Container Recycling Report Feb. 1997).

Market prices for postconsumer natural HDPE have been relatively good, as shown in Figure 52. Except for a rise and fall in 1995, the price paid for natural HDPE has been between $100 and $200 per ton in the early 1990s. From early 1996 to present, the average HDPE price has steadily risen to over $300 per ton.

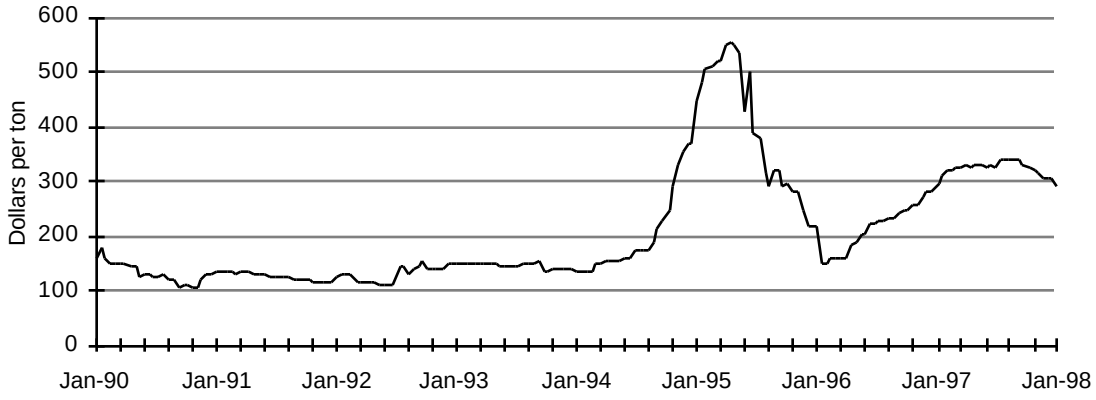
As natural HDPE commands stronger market prices, color-separated HDPE resin has become more marketable (Container Recycling Report February 1997). Many fabrication techniques can use a color separated HDPE resin, such as found in multilayer and heavily pigmented bottles and containers.

Figure 51. End user markets for HDPE bottles by product category



Source: Modern Plastics

Figure 52. Average end user prices for baled natural HDPE, 1990 to 1998 (In dollars per ton)

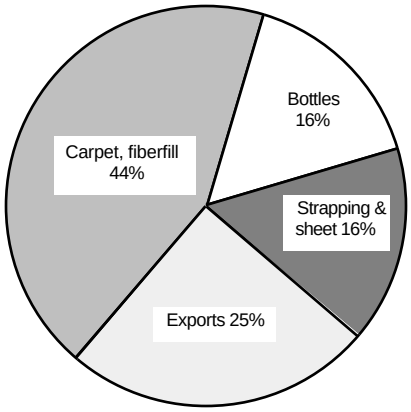


Source: Recycling Times

PET Bottles. While PET soft drink bottles make up less than one percent of all MSW, they are typically included in recovery programs. PET soft drink bottles were recovered at a rate of 39 percent in 1996. PET bottles are often collected through residential curbside collection systems. PET soft drink bottles are also collected in container deposit/redemption programs in 10 states. In addition, drop-off collection programs usually receive PET soft drink bottles.

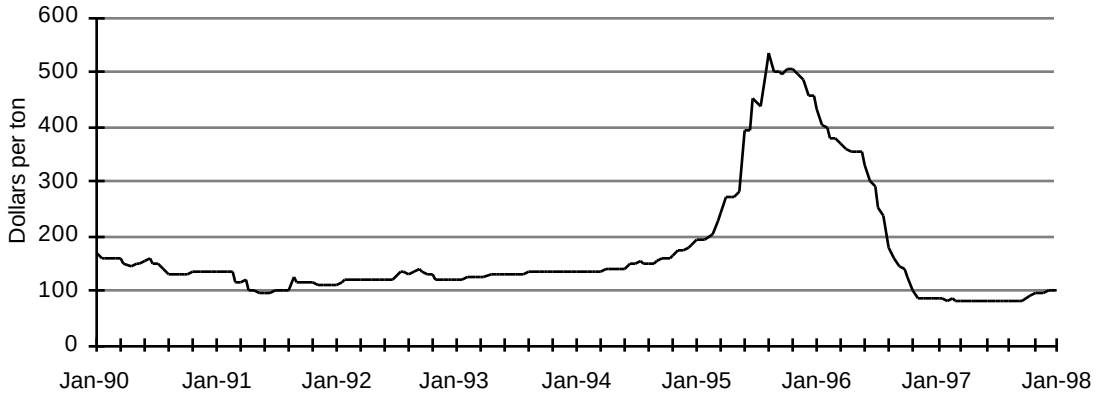
Fiber markets are the largest user of recovered PET, consuming approximately 140 thousand tons in 1996 (Figure 53). Markets for the fiber

Figure 53. End user markets for PET bottles by product category



Source: Modern Plastics

Figure 54. Average end user prices for baled PET bottles, 1990 to 1998 (In dollars per ton)



Source: Recycling Times

include carpeting and fiberfill for garments and sleeping bags. About 80 thousand tons of postconsumer PET were exported in 1996. Other uses for postconsumer PET resin include food grade and non-food grade bottles, strapping and sheet, and other applications.

Scrap prices for recovered PET have not been as favorable as HDPE prices, as shown in Figure 54. PET had the same rise and fall that most recyclable materials had in 1995; however, because of the large supply of off-class virgin resin (which competes with recycled PET), the PET price kept dropping after others stabilized or began climbing. Prices for baled PET reached a low point of about $80 per ton at the end of 1996. By the end of 1997 average prices for bales were over $100 per ton.

Industry Structure for Recovered Plastic Bottles

Like the other basic industries discussed in this chapter, production of plastic resins is an important part of the U.S. economy. With respect to recycling, however, there are important differences. Other materials producers (e.g., the paper, glass, and steel industries) can and do use recovered postconsumer materials as raw materials in their plants, with or without the addition of virgin raw materials. For technical reasons, plastic resin producers rarely do the same.

Recovered plastic products are usually sent to a reclaimer, who sorts, grinds, cleans, dries, and pelletizes the plastics. HDPE handlers and reclaimers tend to be located near metropolitan centers, because it is in the larger cities that successful curbside recyclables collection or drop-off programs supply operations with a supply of postconsumer HDPE. PET handlers and reclaimers are

concentrated in the eastern U.S. Recyclers in South Carolina and Georgia consume a considerable amount of postconsumer PET.

After processing, the pellets can be sold to a fabricator to be made into a new product. The pellets are not returned to a virgin resin plant. Therefore, capacity to make virgin resin does not provide a market for recovered resin.

Factors Driving Markets for Recovered Plastic Bottles

The factors driving the postconsumer plastics markets differ by resin. HDPE markets are currently healthy, with no oversupply of virgin HDPE resin to provide price competition.

Market factors for PET are less favorable. Due to the increased popularity of PET beverage bottles, the industry geared up for increased production. There is currently an over-capacity for virgin PET resin, reducing its price structure and providing off-class virgin which competes with recycled PET for the same markets. Not only has the U.S. developed a large capacity, but China, Korea, and Taiwan, consumers of U.S. postconsumer PET, have been increasing their virgin capacity. This further reduces demand for U.S. recovered PET.

There has also been a weakening or sunset of plastic recycling laws in some states. For example, legislation in Florida changed, reducing the demand for recovered PET.

COMPOST

Current Markets for Compost

Composters must make a product consistently high in quality to ensure long term markets. Composters have increased their markets by producing compost blends to meet the needs of specific end users. Different composts can be blended, or compost can be combined with other materials such as soil to produce custom blends. Compost has a variety of uses including erosion control, wetland mitigation, bioremediation, land reclamation, biofilters, storm water filtrates, soil amendments, low grade fertilizers, mulches and fungicides (BioCycle October 1996, July 1997). End users of compost include farms, golf courses and other sport fields, nurseries, the home products industry, parks and recreation departments, state highway departments, and land reclamation projects.

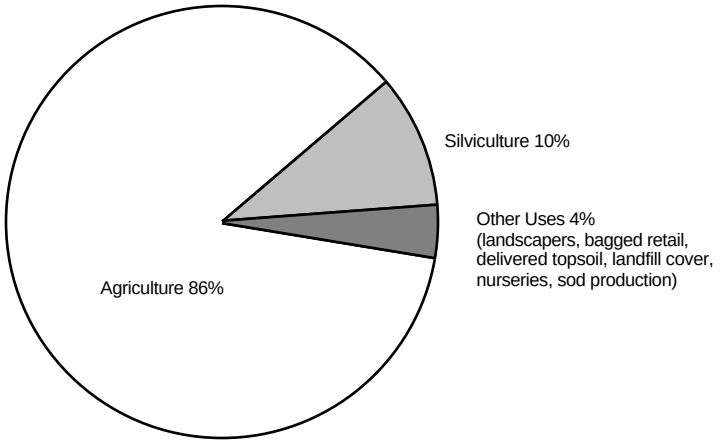
Several components of MSW can be composted, including yard trimmings, food wastes, soiled paper, and the biodegradable components in mixed MSW. Non-MSW feed stocks currently being composted include industrial food waste, agricultural by-products, biosolids (waste water treatment

sludge), and animal manure. Composting non-MSW feed stocks is increasing in popularity as a resource management technique.

It is estimated that 80 to 85 percent of compost is successfully marketed. Mixed MSW compost is more difficult to market. Only one of the MSW composting facilities reports any revenue from sale of materials (BioCycle December 1996).

A market capacity study for compost use completed for The Solid Waste Composting Council found that capacity for compost use is far greater than supply. The silviculture (development and care of forests) and agriculture industries have the greatest potential demand for compost use. Figure 55 shows the percentage demand by industry based on cubic yards.

Figure 55. Capacity to consume compost



Source: The Composting Council

This same study estimated market penetration to be the greatest for the industries included in the "other" category. The landscape industry has a penetration of approximately 20 percent, bagged/retail 80 percent, and container nurseries less than 50 percent. The silviculture and agriculture industries, estimated to have the largest capacity, have a market penetration of less than one and 2 percent respectively. Table 37 lists market penetration for all of the industries considered in the study.

A project completed in 1996 for The Composting Council Research and Education Foundation surveyed compost facilities in seven states—California, New Jersey, Ohio, Washington, Minnesota, Florida, and Massachusetts. The

Table 37

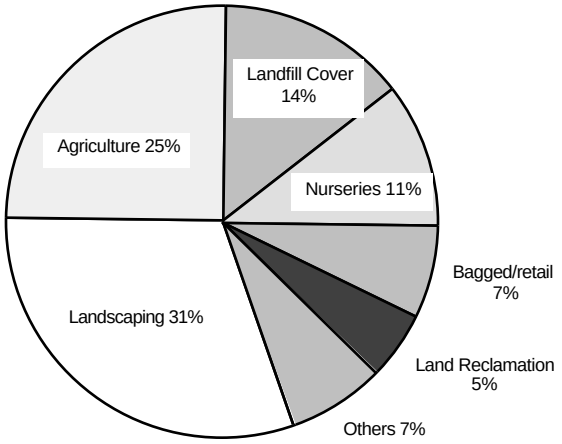
ESTIMATED MARKET PENETRATION FOR COMPOST PRODUCTS (In percent)

Application Segment	Market Penetration (%)
Landscapers	< 20
Delivered Topsoil	< 5
Bagged / Retail	80
Landfill Final Cover	< 5
Surface Mine Reclamation	< 5
Container Nurseries	< 50
Field Nurseries	< 1
Sod Production	< 1
Silviculture	< 1
Agriculture	< 2

Source: The Composting Council.

responding facilities estimated the distribution of their compost by weight. The results of this survey are illustrated above in Figure 56. The landscape and agriculture industries received over 50 percent of the compost produced by the facilities in the seven states surveyed.

Figure 56. Compost market distribution



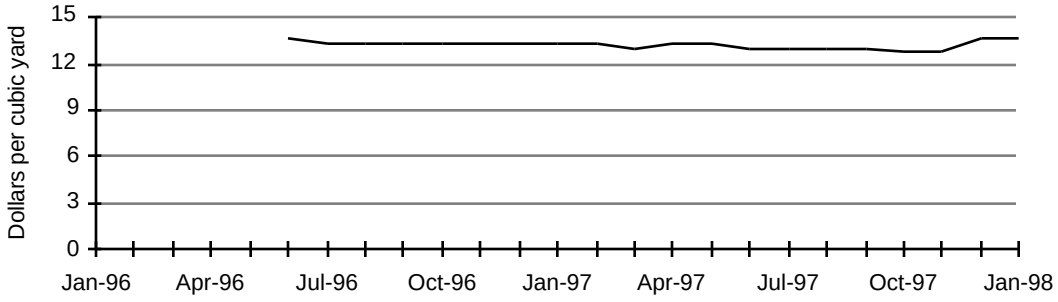
Source: The Composting Council

The facilities surveyed were also asked to estimate the percentages of various feedstocks used in the compost operation. The most common response was yard trimmings at 72 percent. Other feedstocks mentioned included wood, manure, biosolids, and brewery waste.

Figure 57 shows the average prices paid for yard trimmings compost. The price remained fairly constant over the 16-month period shown. Compost prices vary widely based on product quality, competition and customer type. The prices in Figure 57 are averages (i.e., not weighted by compost quantities sold). The reported prices paid for compost ranged from 2 dollars per cubic yard to 30 dollars per cubic yard over this period. On the *average,* compost prices are lowest in the northwest and highest in the southwest.

Compost is sold in bulk loads or bagged. Bulk sales move larger quantities of compost for most composters. Bagged compost builds product acceptance and expands markets. A consumer may be hesitant to purchase large quantities of compost but will purchase a bag, which can lead to bulk sales later (BioCycle August 1996).

Figure 57. Average end user prices for yard trimmings compost, 1996 to 1998 (In dollars per cubic yard)



Source: Compost News

Industry Structure for Compost

Compost can be produced from a source separated organics stream or combinations of the various feedstocks. ***BioCycle*** reported in 1996 over 3,200 yard trimmings composting facilities in the U.S. and 15 MSW composting facilities. The number of operational food waste composting facilities in 1997, also surveyed by ***BioCycle***, was 176. The actual number of facilities may be greater, as

not all yard trimmings facilities are required to be permitted and therefore may not be counted by state agencies. There may also be industries composting process wastes on-site that are not accounted for in any of the surveys.

Factors Driving Markets for Compost

Compost markets are dependent on the following:

- quality of compost
- consistency of product quality
- customer acceptance
- distance from supplier to customer
- meeting needs of end users.

Compost quality and consistency of quality over time lead to customer acceptance and continuing sales. Providing compost users technical compost parameters (e.g., pH, salt content, particle size, etc.) help assure successful compost use and overall satisfaction. Education on the benefits of compost also improves customer acceptance.

The distance from the supplier to the customer impacts the marketing of compost. Since compost is marketed at a comparatively low value, the transportation cost may have a larger impact on compost than most other recovered products. The markets available to a compost operator may be limited by the feedstock and/or the potential end users that are located within a marketable distance.

Understanding the needs of potential end users allows an operator to customize the end product to meets these needs. For example, the nutrient level and end product particle size needs will vary depending on the final application. To expand sales, a compost operator must realize the importance of individual differences in compost use.

Chapter 4

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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.

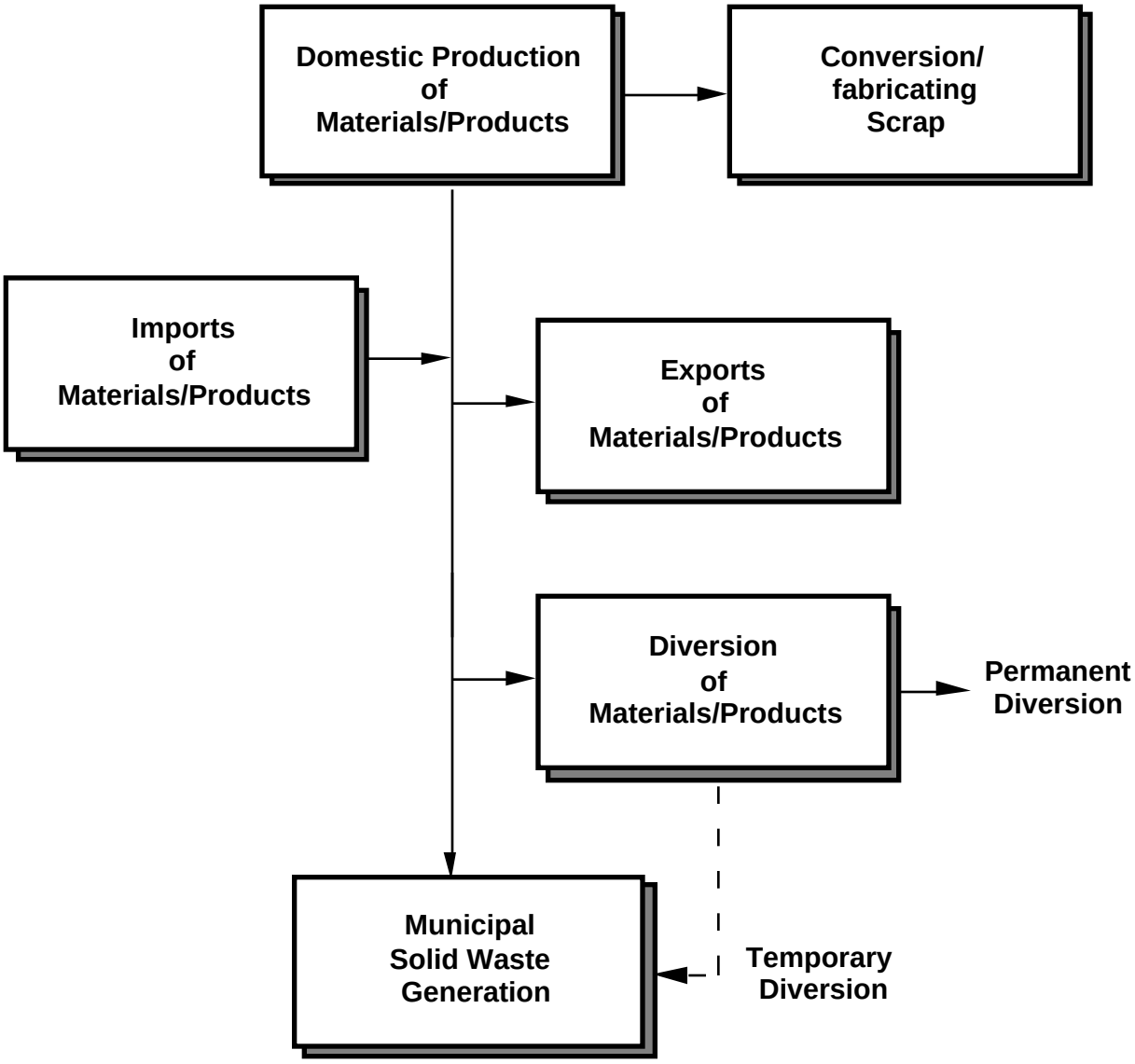

Figure A-1. Material flows methodology for estimating generation of products and materials in municipal solid waste.

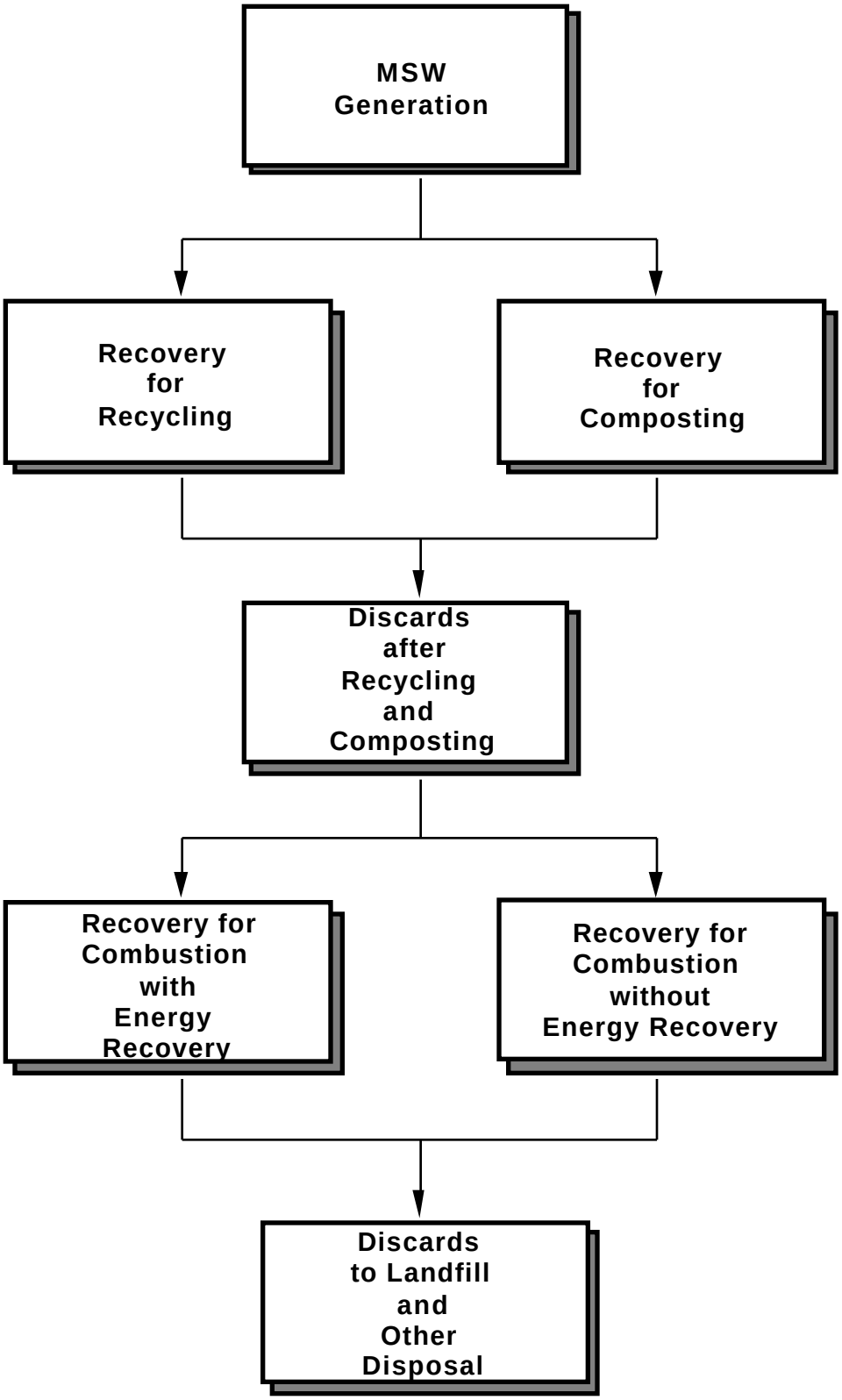

Figure A-2. Material flows methodology for estimating discards of products and materials in municipal solid waste.

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

ADDITIONAL PERSPECTIVES ON MUNICIPAL SOLID WASTE

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

- Historical and 1996 MSW generation and management on a pounds per person per day basis
- Historical and 1996 MSW generation by material on a pounds per person per day basis
- A classification of 1996 MSW generation into residential and commercial components
- Historical and 1996 discards of MSW classified into organic and inorganic fractions
- A ranking of products and materials in 1996 MSW by tonnage generated, recovered for recycling, 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 B-1. The top line shows a steady increase in per capita generation of MSW from 1960 to 1990, from 2.7 pounds per person per day in 1960 to 4.5 pounds per person per day in 1990. During the 1990s, however, the per capita generation rate has decreased to 4.3 pounds per person per day in 1996. The primary reason for the 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 (including composting). Discards after recovery for recycling grew from 2.5 pounds per person per day in 1960 to 3.8 pounds per person per day in 1990. Between 1990 and 1996, discards declined to 3.2 pounds per person per day due to increased recovery for recycling (including composting).

In 1996, an estimated 0.7 pounds per person per day of discards were managed through combustion, while the remainder—2.4 pounds per person per day—went to landfill or other disposal.

Table B-1

PER CAPITA GENERATION, MATERIALS RECOVERY, COMBUSTION, AND DISCARDS OF MUNICIPAL SOLID WASTE, 1960 TO 1996
(In pounds per person per day; population in thousands)

	1960	1970	1980	1990	1992	1994	1995	1996
Generation	2.68	3.25	3.66	4.51	4.49	4.51	4.41	4.33
Recovery for recycling & composting	0.17	0.22	0.35	0.74	0.87	1.07	1.15	1.18
Discards after recovery	2.51	3.04	3.31	3.77	3.62	3.44	3.26	3.15
Combustion	0.82	0.67	0.33	0.70	0.70	0.68	0.70	0.70
Discards to landfill, other disposal	1.69	2.36	2.98	3.07	2.92	2.75	2.56	2.44
Resident Population (thousands)	179,979	203,984	227,255	249,398	255,011	260,372	262,890	265,284

Details may not add to totals due to rounding.
Population figures from Bureau of the Census, Current Population Reports.
Source: Franklin Associates, Ltd.

In Table B-2, per capita generation of each material category characterized in this study is shown. The current per capita generation rate for paper and paperboard products has nearly doubled from 1960 (0.9 versus 1.65 pounds per person per day). However, since 1990 per capita paper generation has remained relatively steady—between 1.6 and 1.7 pounds per person per day. Plastics has experienced the largest per capita growth rate, increasing to 0.4 pounds per person per day in 1996. After experiencing growth from 1960 to 1990, per capita generation rates for glass and metal products have declined slightly. Per capita generation rates for rubber and leather and textile products have increased to 0.13 and 0.16 pounds per person per day, respectively. After growing steadily, the increasing use of reusable pallets in the 1990s has resulted in a decrease in per capita wood generation—to 0.2 pounds per person per day.

Generation of food wastes has remaining at about 0.45 pounds per person per day during the 1990s (Note: change in food waste generation methodology reflected in years 1990 through 1996). Generation of yard trimmings on a per capita basis increased over a 30-year period, but has begun to decline because of source reduction efforts. Generation of yard trimmings was 0.6 pounds per person per day in 1996.

Overall, per capita generation of MSW increased throughout the 36-year study period. However, since 1990 per capita generation of materials use in nonfood products has remained relatively steady (3.2 to 3.3 pounds per person per day) while per capita generation for yard trimmings has decreased due to source reduction efforts.

Table B-2

PER CAPITA GENERATION* OF MUNICIPAL SOLID WASTE, BY MATERIAL, 1960 TO 1996
(In pounds per person per day)

Materials	1960	1970	1980	1990	1992	1994	1995	1996
Paper and paperboard	0.91	1.19	1.33	1.60	1.60	1.70	1.70	1.65
Glass	0.20	0.34	0.36	0.29	0.28	0.28	0.27	0.26
Metals	0.33	0.37	0.37	0.36	0.35	0.34	0.33	0.33
Plastics	0.01	0.08	0.16	0.38	0.40	0.41	0.39	0.41
Rubber and leather	0.06	0.08	0.10	0.13	0.12	0.13	0.13	0.13
Textiles	0.05	0.05	0.06	0.13	0.14	0.15	0.15	0.16
Wood	0.09	0.10	0.17	0.27	0.26	0.24	0.22	0.22
Other	0.00	0.02	0.06	0.07	0.07	0.08	0.08	0.08
Total Nonfood Products	1.66	2.24	2.63	3.22	3.22	3.33	3.27	3.23
Food wastes	0.37	0.34	0.31	0.46	0.45	0.45	0.45	0.45
Yard trimmings	0.61	0.62	0.66	0.77	0.75	0.66	0.62	0.58
Miscellaneous inorganic wastes	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.07
Total MSW Generated	2.68	3.25	3.66	4.51	4.49	4.51	4.41	4.33
Resident Population (thousands)	179,979	203,984	227,255	249,398	255,011	260,372	262,890	265,284

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

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 1996 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 subsequently made 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 B-3).

Table B-3

CLASSIFICATION OF MSW GENERATION INTO RESIDENTIAL AND COMMERCIAL FRACTIONS, 1996
(In thousands of tons and percent of total)

	Thousand tons	Percent of total
Residential Wastes	115,310 – 136,280	55.0% – 65.0%
Commercial Wastes	73,380 – 94,350	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 B-4. (Discards

were used instead of generation because discards enter the solid waste management system after recovery for recycling, including composting.)

The organic fraction of MSW has been increasing steadily since 1970, from 75 percent organics in 1970 to over 85 percent in 1996. It is interesting to note, however, that the percentage of MSW that is organics began to "level off" after 1990 because of the decline in yard trimmings discarded.

Table B-4

COMPOSITION OF MSW DISCARDS* BY ORGANIC AND INORGANIC FRACTIONS, 1960 TO 1996 (In percent of total discards)

Year	Organics**	Inorganics†
1960	77.3%	22.7%
1970	75.5%	24.5%
1980	77.5%	22.5%
1990	85.1%	14.9%
1996	85.5%	14.5%

* 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: Table 3.

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 see in perspective the relative tonnages generated or discarded by the different items. Therefore, Tables B-5, B-6, and B-7 were developed to illustrate this point.

In Table B-5, the various MSW products and materials are arranged in descending order by weight generated in 1996. Subtotals in the right-hand column group components together for further illustration. For example, corrugated boxes, yard trimmings, and food wastes stand at the top of the list, with each generating over 10 percent of total MSW. Together these three items totaled 37.6 percent of MSW generated in 1996. The next six components, each comprising 3 to 10 percent of total MSW generation, accounted for 24.5 percent of generation. Together these nine components accounted for over 62 percent of total MSW generated. The 22 items at the bottom of the list each amounted to

less than one percent of generation in 1996; together they amounted to only 11.1 percent of total MSW generation.

Table B-6 ranks products in descending order by weight recovered in 1996. Three products—corrugated boxes, yard trimmings, and newspapers—each account for over 10 percent of total recovery, and collectively account for over 64 percent of MSW recovery. The next three components, each comprising 3 to 10 percent of total MSW recovery, accounted for 12.4 percent of generation. The bottom 17 items each amounted to less than one percent of generation in 1996; together they amounted to only 6.0 percent of total MSW recovery.

A different perspective is provided in Table B-7, which ranks products in MSW by weight discarded after recovery for recycling (including composting). This table illustrates how recovery alters the products' generation rankings. For example, corrugated boxes, which ranked the highest in generation, ranked fourth in discards in 1996.

Food wastes and yard trimmings accounted for over 25 percent of total MSW discards in 1996. Seven components, each representing 3 to 10 percent of total MSW discards, accounted for over 33 percent of discards. These components included; miscellaneous durables, corrugated boxes, furniture and furnishings, wood packaging, other commercial printing, newspapers, and clothing and footwear. Together these nine components made up 58.3 percent of MSW discards in 1996. Twenty categories of discards were each less than one percent of the total; together these items totaled 9.4 percent of 1996 discards.

Table B-5

GENERATION OF MUNICIPAL SOLID WASTE, 1996
ARRANGED IN DESCENDING ORDER BY WEIGHT
(In thousands of tons and percent of MSW generation)

	Thousand Tons	Percent of Total	Cummulative Percent
Corrugated boxes	29,020	13.8%	13.8%
Yard trimmings	28,000	13.4%	27.2%
Food wastes	21,900	10.4%	37.6%
Newspapers	12,290	5.9%	43.5%
Miscellaneous durables	12,000	5.7%	49.2%
Furniture and furnishings	7,320	3.5%	52.7%
Office-type papers	6,660	3.2%	55.9%
Other commercial printing	6,560	3.1%	59.0%
Wood packaging	6,480	3.1%	62.1%
Paper folding cartons	5,390	2.6%	64.7%
Clothing and footwear	5,340	2.5%	67.2%
Glass beer & soft drink bottles	5,210	2.5%	69.7%
Third class mail	4,510	2.2%	71.9%
Other nonpackaging paper	4,070	1.9%	73.8%
Rubber tires	3,910	1.9%	75.7%
Glass food & other bottles	3,890	1.9%	77.5%
Major appliances	3,520	1.7%	79.2%
Miscellaneous nondurables	3,450	1.6%	80.9%
Miscellaneous inorganic wastes	3,200	1.5%	82.4%
Disposable diapers	3,050	1.5%	83.8%
Steel cans and other packaging	2,990	1.4%	85.3%
Tissue paper and towels	2,980	1.4%	86.7%
Carpets and rugs	2,310	1.1%	87.8%
Other plastic packaging	2,300	1.1%	88.9%
Paper bags and sacks	1,980	0.9%	89.8%
Magazines	1,970	0.9%	90.8%
Aluminum cans and other packaging	1,960	0.9%	91.7%
Glass wine & liquor bottles	1,940	0.9%	92.6%
Plastic wraps	1,860	0.9%	93.5%
Lead-acid batteries	1,810	0.9%	94.4%
Plastic bags and sacks	1,360	0.6%	95.0%
Other paper packaging	1,340	0.6%	95.7%
Plastic other containers	1,280	0.6%	96.3%
Paper plates and cups	950	0.5%	96.7%
Books	940	0.4%	97.2%
Plastic trash bags	860	0.4%	97.6%
Plastic plates and cups	810	0.4%	98.0%
Small appliances	780	0.4%	98.3%
Towels, sheets, and pillowcases	750	0.4%	98.7%
Plastic soft drink bottles	700	0.3%	99.0%
Plastic milk bottles	660	0.3%	99.4%
Telephone directories	470	0.2%	99.6%
Paper milk cartons	460	0.2%	99.8%
Other paperboard packaging	230	0.1%	99.9%
Other miscellaneous packaging	150	0.1%	100.0%
Paper wraps	50	<0.1%	100.0%
Total MSW Generation	209,660	100.0%	

Source: Chapter 2.

Table B-6

RECOVERY OF MUNICIPAL SOLID WASTE, 1996
ARRANGED IN DESCENDING ORDER BY WEIGHT
(In thousands of tons and percent of MSW recovery)

	Thousand Tons	Percent of Total	Cummulative Percent
Corrugated boxes	19,340	33.7%	33.7%
Yard trimmings	10,800	18.8%	52.6%
Newspapers	6,650	11.6%	64.2%
Office-type papers	3,190	5.6%	69.7%
Major appliances	2,200	3.8%	73.6%
Lead-acid batteries	1,700	3.0%	76.5%
Glass beer & soft drink bottles	1,680	2.9%	79.5%
Steel cans and other packaging	1,680	2.9%	82.4%
Aluminum cans and other packaging	1,020	1.8%	84.2%
Glass food & other bottles	1,020	1.8%	86.0%
Paper folding cartons	980	1.7%	87.7%
Other commercial printing	810	1.4%	89.1%
Miscellaneous durables	740	1.3%	90.4%
Rubber tires	730	1.3%	91.6%
Clothing and footwear	700	1.2%	92.9%
Third class mail	670	1.2%	94.0%
Food wastes	520	0.9%	94.9%
Wood packaging	490	0.9%	95.8%
Glass wine & liquor bottles	480	0.8%	96.6%
Magazines	480	0.8%	97.5%
Plastic soft drink bottles	270	0.5%	97.9%
Paper bags and sacks	260	0.5%	98.4%
Plastic milk and other bottles	200	0.3%	98.7%
Plastic other containers	190	0.3%	99.1%
Books	170	0.3%	99.4%
Towels, sheets, and pillowcases	130	0.2%	99.6%
Telephone directories	60	0.1%	99.7%
Plastic bags and sacks	50	0.1%	99.8%
Plastic wraps	50	0.1%	99.9%
Other plastic packaging	30	0.1%	99.9%
Carpets and rugs	20	<0.1%	100.0%
Plastic plates and cups	10	<0.1%	100.0%
Small appliances	10	<0.1%	100.0%
Total MSW Recovery	57,330	100.0%	

Source: Chapter 2.

Table B-7

DISCARDS OF MUNICIPAL SOLID WASTE, 1996
ARRANGED IN DESCENDING ORDER BY WEIGHT
(In thousands of tons and percent of discards)

	Thousand Tons	Percent of Total	Cummulative Percent
Food wastes	21,380	14.0%	14.0%
Yard trimmings	17,200	11.3%	25.3%
Miscellaneous durables	11,270	7.4%	32.7%
Corrugated boxes	9,690	6.4%	39.1%
Furniture and furnishings	7,320	4.8%	43.9%
Wood packaging	5,990	3.9%	47.8%
Other commercial printing	5,750	3.8%	51.6%
Newspapers	5,640	3.7%	55.3%
Clothing and footwear	4,640	3.0%	58.3%
Paper folding cartons	4,410	2.9%	61.2%
Other nonpackaging paper	4,070	2.7%	63.9%
Third class mail	3,840	2.5%	66.4%
Glass beer & soft drink bottles	3,530	2.3%	68.8%
Office-type papers	3,470	2.3%	71.0%
Miscellaneous nondurables	3,450	2.3%	73.3%
Miscellaneous inorganic wastes	3,200	2.1%	75.4%
Rubber tires	3,180	2.1%	77.5%
Disposable diapers	3,050	2.0%	79.5%
Tissue paper and towels	2,980	2.0%	81.4%
Glass food & other bottles	2,870	1.9%	83.3%
Carpets and rugs	2,290	1.5%	84.8%
Other plastic packaging	2,270	1.5%	86.3%
Plastic wraps	1,820	1.2%	87.5%
Paper bags and sacks	1,710	1.1%	88.6%
Magazines	1,490	1.0%	89.6%
Glass wine & liquor bottles	1,470	1.0%	90.6%
Other paper packaging	1,340	0.9%	91.5%
Major appliances	1,320	0.9%	92.3%
Plastic bags and sacks	1,300	0.9%	93.2%
Steel cans and other packaging	1,300	0.9%	94.0%
Plastic other containers	1,090	0.7%	94.7%
Paper plates and cups	950	0.6%	95.4%
Aluminum cans and other packaging	940	0.6%	96.0%
Trash bags	860	0.6%	96.6%
Plastic plates and cups	800	0.5%	97.1%
Books	770	0.5%	97.6%
Small appliances	760	0.5%	98.1%
Towels, sheets, and pillowcases	620	0.4%	98.5%
Paper milk cartons	460	0.3%	98.8%
Plastic milk and other bottles	460	0.3%	99.1%
Plastic soft drink bottles	430	0.3%	99.4%
Telephone directories	410	0.3%	99.6%
Other paperboard packaging	230	0.2%	99.8%
Other miscellaneous packaging	150	0.1%	99.9%
Lead-acid batteries	110	0.1%	100.0%
Paper wraps	50	<0.1%	100.0%
Total MSW Discards	152,330	100.0%	

Source: Chapter 2.

Characterization of MSW Discards by Volume

Solid waste is generally characterized by weight, either in pounds or tons. Most statistics are compiled by weight. Landfill, combustion, and recycling facilities generally charge fees by weight, and estimates of quantities are stated in tons. Weight can be readily and accurately measured using scales. People agree that properly calibrated scales will accurately measure weight, but there is no standard methodology for measuring municipal solid waste volume. Previous work on establishing a national consensus on solid waste volumes were undertaken in 1989. Results of this, and subsequent, research are presented in detail in previous updates of this report (i.e., 1990 and 1994 updates).

This section of Appendix B presents estimates of MSW discards by volume for 1996 using density factors previously developed. Table B-8 summarizes these estimated density factors for major categories of landfilled materials.

The estimated volume of MSW discards by product (Table B-9) and material (Table B-10), in cubic yards, was derived from Chapter 2 and Table B-8. (It is necessary to characterize the volume of MSW *discards* rather than generation because discard estimates most closely match the wastes received at a landfill, where the experimental data were derived. Discards include the waste left after materials recovery and composting and before combustion, landfilling, or other disposal.)

The data in Tables B-9 and B-10 is useful in comparing relative volumes of products and materials in a landfill. However, caution is advised when using the data in these tables. The density values in Table B-8 are based on sorted MSW materials. The intermingling of different materials with different characteristics, as occurs in a landfill, results in filling more air space than if the materials were landfilled individually (or apart from each other). For example, mixing one cubic yard of paper with one cubic yard of plastic results in less than two cubic yards of material. At best, the data in the tables may provide an indication of the relative order of densities and volumes of the various waste components in a landfill.

The calculated MSW landfill densities shown in Tables B-9 and B-10 are about 750 pounds per cubic yard of, significantly less than what is typically reported. Densities achieved in landfills that accept MSW are reported to vary between 700 and 1,600 pounds per cubic yard. A minimum initial compaction density of 1,000 pounds per cubic yard is sometimes recommended in landfill operator training courses. As landfill depth increases, the density of the waste increases. Higher densities are found in other solid wastes disposed in landfills. The MSW discards density would, therefore, need to be higher than shown here in order to achieve the landfill densities generally reported today.

Table B-8

SUMMARY OF ESTIMATED DENSITY FACTORS FOR LANDFILLED MATERIALS

	Density (lb/cu yd)
Durable Goods	475
Nondurable Goods	
Nondurable paper	800
Nondurable plastic	315
Disposable diapers	
Diaper materials	795
Urine and feces	1,350
Rubber	345
Textiles	435
Miscellaneous nondurables	390
Containers and Packaging	
Glass containers	
Beer & soft drink bottles	2,800
Other containers	2,800
Steel Containers	
Beer & soft drink cans	560
Food cans	560
Other packaging	560
Aluminum	
Beer & soft drink cans	250
Other packaging	550
Paper and Paperboard	
Corrugated	750
Other paperboard	820
Paper packaging	740
Plastics	
Film	670
Rigid containers	355
Other packaging	185
Wood packaging	800
Other miscellaneous packaging	1,015
Food Wastes	2,000
Yard Trimmings	1,500

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

Table B-9

ESTIMATED VOLUME OF PRODUCTS DISCARDED IN MSW, 1996

	1996 Discards* (thousand tons)	Weight (% of total)	Landfill Density** (lb/cu yd)	Landfill Volume*** (thousand cu yd)	Volume (% of total)
DURABLE GOODS	26,250	17.2%	475	110,526	27.4%
NONDURABLE GOODS					
Newspapers	5,640	3.7%	800	14,100	3.5%
Books	770	0.5%	800	1,925	0.5%
Magazines	1,490	1.0%	800	3,725	0.9%
Office papers	3,470	2.3%	800	8,675	2.2%
Directories	410	0.3%	800	1,025	0.3%
Third class mail	3,840	2.5%	800	9,600	2.4%
Other commercial printing	5,750	3.8%	800	14,375	3.6%
Tissue paper and towels	2,980	2.0%	800	7,450	1.8%
Paper plates and cups	950	0.6%	800	2,375	0.6%
Plastic plates and cups	800	0.5%	355	4,507	1.1%
Trash bags	860	0.6%	670	2,567	0.6%
Disposable diapers	3,050	2.0%	1,150	5,303	1.3%
Other nonpackaging paper	4,070	2.7%	800	10,175	2.5%
Clothing and footwear	4,640	3.0%	435	21,333	5.3%
Towels, sheets & pillowcases	620	0.4%	435	2,851	0.7%
Other misc. nondurables	3,450	2.3%	390	17,692	4.4%
Total Nondurable Goods	42,790	28.1%	699	122,375	30.4%
CONTAINERS AND PACKAGING					
Glass Packaging					
Beer and soft drink	3,530	2.3%	2,800	2,521	0.6%
Wine and liquor	1,470	1.0%	2,800	1,050	0.3%
Food and other bottles & jars	2,870	1.9%	2,800	2,050	0.5%
Total Glass Packaging	7,870	5.2%	2,800	5,621	1.4%
Steel Packaging					
Food and other cans	1,180	0.8%	560	4,214	1.0%
Other steel packaging	120	0.1%	560	429	0.1%
Total Steel Packaging	1,300	0.9%	560	4,643	1.2%
Aluminum Packaging					
Beer and soft drink cans	570	0.4%	250	4,560	1.1%
Other cans	40	0.0%	250	320	0.1%
Foil and closures	330	0.2%	550	1,200	0.3%
Total Aluminum Pkg	940	0.6%	309	6,080	1.5%
Paper & Paperboard Pkg					
Corrugated boxes	9,690	6.4%	750	25,840	6.4%
Milk cartons	460	0.3%	820	1,122	0.3%
Folding cartons	4,420	2.9%	820	10,780	2.7%
Other paperboard packaging	230	0.2%	820	561	0.1%
Bags and sacks	1,710	1.1%	740	4,622	1.1%
Wrapping paper	50	0.0%	800	125	0.0%
Other paper packaging	1,340	0.9%	740	3,622	0.9%
Total Paper & Board Pkg	17,900	11.8%	767	46,672	11.6%

(continued on next page)

Table B-9 (continued)

ESTIMATED VOLUME OF PRODUCTS DISCARDED IN MSW, 1996

	1996 Discards* (thousand tons)	Weight (% of total)	Landfill Density** (lb/cu yd)	Landfill Volume*** (thousand cu yd)	Volume (% of total)
Plastics Packaging					
Soft drink bottles	430	0.3%	355	2,423	0.6%
Milk and other bottles	450	0.3%	355	2,535	0.6%
Other containers	1,090	0.7%	355	6,141	1.5%
Bags and sacks	1,300	0.9%	670	3,881	1.0%
Wraps	1,820	1.2%	670	5,433	1.3%
Other plastics packaging	2,270	1.5%	185	24,541	6.1%
Total Plastics Packaging	7,360	4.8%	327	44,953	11.2%
Wood packaging	5,990	3.9%	800	14,975	3.7%
Other misc. packaging	150	0.1%	1,015	296	0.1%
Total Containers & Packaging	41,510	27.3%	674	123,239	30.6%
Total Product Waste†	110,550	72.6%	621	356,141	88.4%
Other Wastes					
Food wastes	21,380	14.0%	2,000	21,380	5.3%
Yard trimmings	17,200	11.3%	1,500	22,933	5.7%
Miscellaneous inorganics	3,200	2.1%	2,500	2,560	0.6%
Total Other Wastes	41,780	27.4%	1,783	46,873	11.6%
TOTAL MSW DISCARDED	152,330	100%	756 ‡	403,014 ‡	100%

* From Chapter 2. Discards after materials recovery and composting, before combustion and landfilling.

** From Table B-8.

*** This assumes that all waste discards are landfilled, but some are combusted.

† Other than food products.

‡ This density factor and volume are derived by adding the individual factors. Actual landfill density and densities of certain products may be considerably higher than shown (see discussion in text).

Source: Franklin Associates, Ltd.

Table B-10

ESTIMATED VOLUME OF MATERIALS DISCARDED IN MSW, 1996

	1996 Discards* (thousand tons)	Weight (% of MSW total)	Landfill Density** (lb/cu yd)	Landfill Volume*** (thousand cu yd)	Volume (% of MSW total)
Paper & Paperboard	47,320	31.1	795	119,044	29.5
Plastics	18,700	12.3	370	101,081	25.1
Yard Trimmings	17,200	11.3	1,500	22,933	5.7
Ferrous Metals	7,330	4.8	570	25,719	6.4
Rubber & Leather	5,610	3.7	355	31,606	7.8
Wood	10,350	6.8	850	24,353	6.0
Textiles	6,770	4.4	410	33,024	8.2
Food Wastes	21,380	14.0	2,000	21,380	5.3
Aluminum	1,960	1.3	380	10,316	2.6
Glass	9,180	6.0	2,500	7,344	1.8
Other†	6,530	4.3	2,100	6,219	1.5
Totals	152,330	100.0	756 ‡	403,020 ‡	100.0

* From Chapter 2. Discards after materials recovery and composting, before combustion and landfilling.

** Composite material density factors developed by Franklin Associates, Ltd.

*** This assumes that all waste discards are landfilled, but some are combusted.

† Found by difference to obtain total to match products table. Note: Results in this table and Table B-9 are not identical due to rounding differences.

‡ This density factor and volume are derived by adding the individual factors. Actual landfill density and densities of certain materials may be considerably higher than shown (see discussion in text).

Source: Franklin Associates, Ltd.