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Characterization of Municipal Solid Waste in the United States: 1990 Update

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CHARACTERIZATION OF MUNICIPAL SOLID WASTE IN THE UNITED STATES, 1960 TO 2010

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EXECUTIVE SUMMARY

Many areas of the United States currently face serious problems in safely and effectively managing the garbage they generate. As a nation, we are generating more trash than ever before. At the same time, we are finding that there are limits to traditional trash management practices. As the generation of municipal solid waste (MSW) continues to increase, the capacity to handle it is decreasing. Many landfills and combustors have closed, and new disposal facilities are often difficult to site. As a result, many communities face hard choices when weighing trash management options. Some communities end up paying premium prices to transport their garbage long distances to available facilities. Others try to site facilities nearby and encounter intense public conflict. Of course, not all communities face such problems; numerous communities have found creative solutions through source reduction and recycling programs. Still, for much of the nation, the generation and management of garbage presents problems that require our focused attention.

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

Features of This Report

This report is the most recent in a series of reports released by the U.S. Environmental Protection Agency (EPA) to characterize MSW in the United States. It characterizes the national waste stream based on data through 1988 and includes:

- Information on MSW generation from 1960 to 1988.
- Information on recovery for recycling, composting, and combustion from 1960 to 1988.
- Information characterizing MSW by volume as well as by weight.
- Projections for MSW generation to the year 2010.
- Projections for MSW combustion through 2000.
- Projections (presented as a range) for recovery and recycling through 1995.

Unlike previous EPA characterization reports, this report does not include long-range projections for materials recovery. This is due to the significant uncertainties in making those projections. For example, rapid changes are now taking place at the federal, state, and local level that may have profound effects on such projections. In addition, shifts in consumer attitudes and behaviors, industry practices and efforts, and technological advances will greatly influence recovery and recycling. The potential impact of all of these changes is very difficult to predict.

Readers should note that this report characterizes the municipal solid waste stream of *the nation as a whole.* The information presented here may not, therefore, correlate with individual state or local estimates of waste generation and management.

Methodology

There are two primary methods for conducting a waste characterization study. The first is a site-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

DEFINITIONS

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

Generation refers to the amount (weight, volume, or percentage of the overall waste stream) of materials and products as they enter the waste stream and before materials recovery, composting, or combustion (incineration) takes place.

Recovery refers to materials removed from the waste stream for the purpose of recycling and/or composting. Recovery does not automatically equal recycling and composting, however. For example, if markets for recovered materials are not available, the materials that were separated from the waste stream for recycling may simply be stored or, in some cases, sent to a landfill or incinerator.

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

for a nationwide characterization of waste. Any errors in the sample or atypical circumstances encountered during sampling would be greatly magnified when expanded to represent the nation's entire waste stream.

The second method, used in this report to estimate the waste stream on a nationwide basis, 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.

Report Highlights

This report underscores the problems we face in municipal solid waste management: the generation of MSW continues to increase steadily, both in overall tonnage and in pounds per capita. In addition, the report indicates that materials recovery for recycling and the combustion of MSW have increased in recent years, while discards to landfills have decreased. Major findings include the following:

- **In 1988, 180 million tons, or 4.0 pounds per person per day of MSW were generated.** After materials recovery for recycling, discards were 3.5 pounds per person per day. Virtually all of these discards were combusted or sent to a landfill.

- **Without source reduction, the amount of waste generated in 1995 is expected to reach 200 million tons, or 4.2 pounds per person per day. By 2000, generation is projected to reach 216 million tons, or 4.4 pounds per person per day. The per capita figure for the year 2000 is a 10 percent increase over 1988 levels.**[1]

- **Based on current trends and information, EPA projects that 20 to 28 percent of MSW will be recovered annually by 1995.** Exceeding this projected range will require fundamental changes in government programs, technology, and corporate and consumer behavior.

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[1] This report updates generation projections and estimates from previous reports. The projected per capita generation estimate for the year 2000 has been increased from just under 4 pounds to 4.4 pounds. This report also increases the 1986 per capita generation estimate by 6 percent—from 3.6 to 3.8 pounds. These projections and estimates have been adjusted because the 1990 report includes additional items in the data base, such as automotive batteries and disposable diapers, corrections for imported packaging materials, and changes in the detail available in the data base, e.g., natural rubber in tires and additional plastic items.

- **Recovery of MSW materials for recycling was 13 percent in 1988. Combustion was 14 percent of total generation, and the remaining 73 percent of the municipal solid waste stream was sent to landfills or otherwise disposed of.[2]**

- **For the first time in this series of characterization reports, MSW is also characterized by *volume*.** The results indicate which materials in MSW occupy the greatest proportion of volume in landfills, and compare these percentages to those by weight. For example, paper and paperboard products make up 34 percent of the discards (after recovery) by weight and 34 percent by volume; plastics account for 9 percent by weight and 20 percent by volume; and yard wastes make up 20 percent by weight and 10 percent by volume.

Municipal Solid Waste in 1988

In 1988, generation of municipal solid waste totaled 179.6 million tons. Figure ES-1 provides a breakdown by weight of the *materials* generated in MSW in 1988. It shows that paper and paperboard products are the largest component of municipal solid waste by weight (40 percent of generation) and yard wastes are the second largest component (roughly 18 percent of generation). Four of the remaining materials in MSW—glass, metals, plastics, and food wastes—range between 7 and 9 percent each by weight of total MSW generated. Other materials in MSW include rubber, leather, textiles, wood, and small amounts of miscellaneous wastes, which each made up less than 4 percent of MSW in 1988.

The breakdown of how much waste went to recycling, combustion, and landfills is shown in Figure ES-2. *Recovery of materials* for recycling and composting was an estimated 13 percent in 1988. That amount varied significantly according to the type of waste (Table ES-1). For example, nearly 26 percent of waste paper was recovered in 1988, while less than 2 percent of plastic wastes were recovered.

The broad categories of materials in MSW are made up of many individual *products*. The products are grouped into major product categories as shown in Figure ES-3. In 1988, containers and packaging were the largest single product category generated in MSW by weight, at roughly 32 percent of the total. Nondurable goods (such as newspapers and disposable food service items) were the second largest category, at 28 percent of the total. Yard wastes were approximately 18 percent and durable goods (such as furniture and tires) were 14 percent of total generation in 1988.

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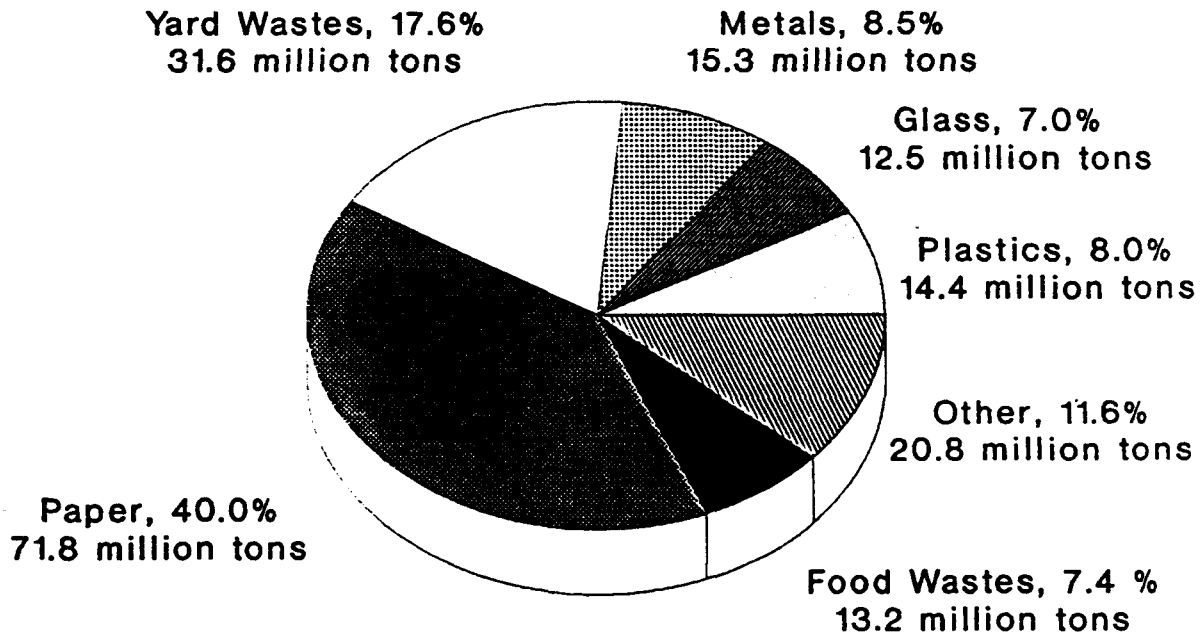
[2] While essentially all of the 73 percent of the waste stream was sent to landfills, it should be recognized that some waste may be littered, stored, or disposed of at the site of generation.

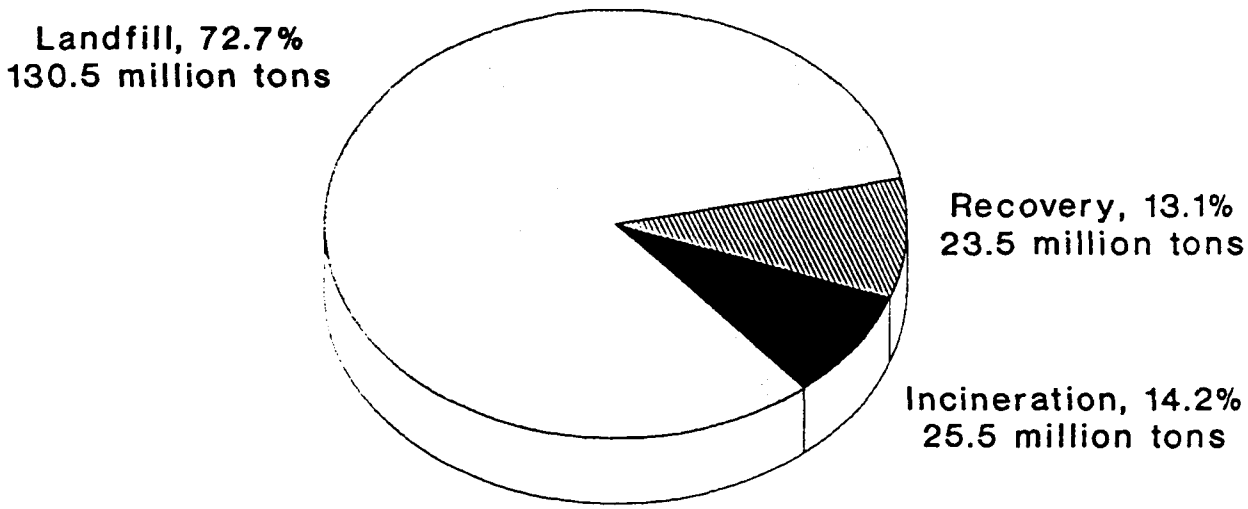
MATERIALS GENERATED IN MSW BY WEIGHT, 1988



TOTAL WEIGHT = 179.6 million tons

FIGURE ES-1

MANAGEMENT OF MSW IN U.S., 1988



TOTAL WEIGHT = 179.6 million tons

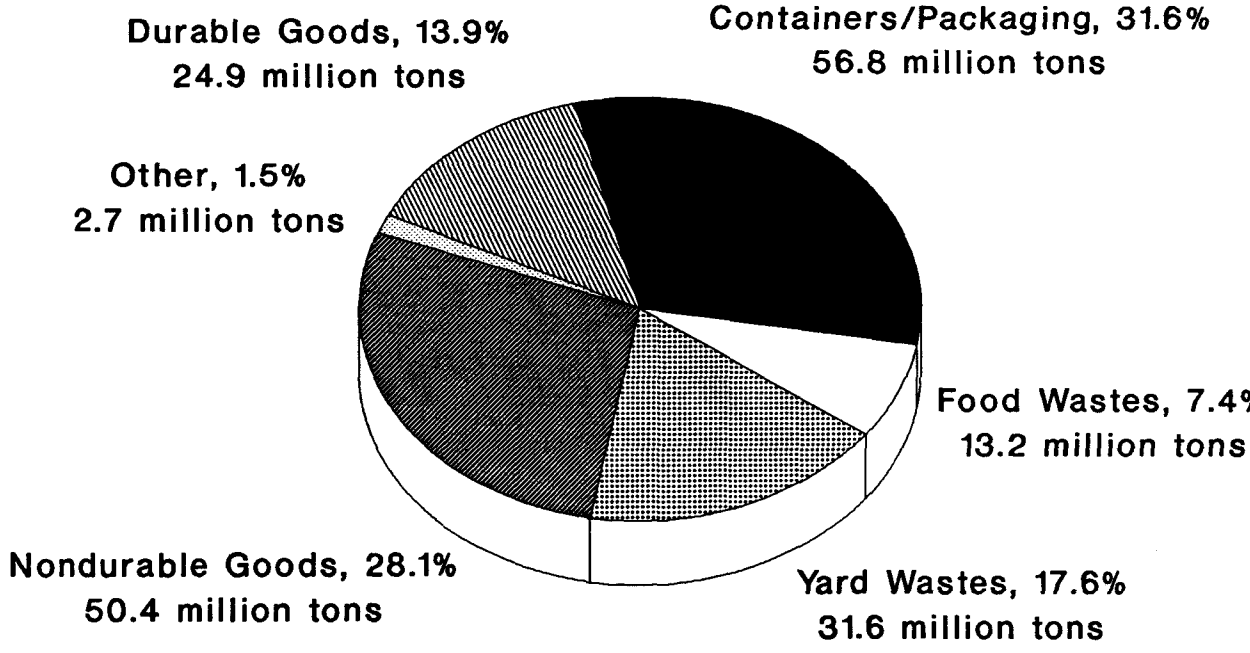
FIGURE ES-2

TABLE ES-1

Generation of MSW, Recovery of Materials and Composting of Food and Yard Waste, 1988

	Weight Generated (in Millions of Tons)	Weight Recovered (in Millions of Tons)	Percent of Generation of Each Material
Paper and Paperboard	71.8	18.4	25.6
Glass	12.5	1.5	12.0
Metals			
Ferrous	11.6	0.7	5.8
Aluminum	2.5	0.8	31.7
Other Nonferrous	1.1	0.7	65.1
Total Metals	15.3	2.2	14.6
Plastics	14.4	0.2	1.1
Rubber and Leather	4.6	0.1	2.3
Textiles	3.9	0.0	0.6
Wood	6.5	0.0	0.0
Other	3.1	0.7	21.7
Total Nonfood Product Wastes	132.1	23.1	17.5
Other Wastes			
Food Wastes	13.2	0.0	0.0
Yard Wastes	31.6	0.5	1.6
Miscellaneous Inorganic Wastes	2.7	0.0	0.0
Total Other Wastes	47.5	0.5	1.1
Total MSW	179.6	23.5	13.1

PRODUCTS GENERATED IN MSW BY WEIGHT, 1988



TOTAL WEIGHT = 179.6 million tons

FIGURE ES-3

MSW Volume Estimates

Although solid waste is usually characterized by weight, information about volume is important for such issues as determining how quickly landfill capacity is being filled and identifying the rate at which the volumes of various materials in the waste stream are changing.

Volume estimates of solid waste, however, are far more difficult to make than weight estimates. A pound of paper is a pound of paper whether it is in flat sheets, crumpled into a wad, or compacted into a bale, but the volume occupied in each case will be very different. The figures in this report are estimations of the volume of materials as they would typically be found in a landfill (a significant amount of compaction occurs in a landfill). These estimates are based largely on empirical data that are then used to estimate density factors (pounds per cubic yard) for components of solid waste under simulated landfill conditions, with corroboration from actual landfill studies.

Figure ES-4 shows the materials in MSW by volume as a percent of total MSW discards in 1988. The paper and paperboard category ranks first in volume of MSW discarded (34 percent). Plastics rank second in volume, at 20 percent of the total, and yard wastes are third, at 10 percent. Paper and plastics combined account for over one-half of the volume of MSW discarded in 1988.

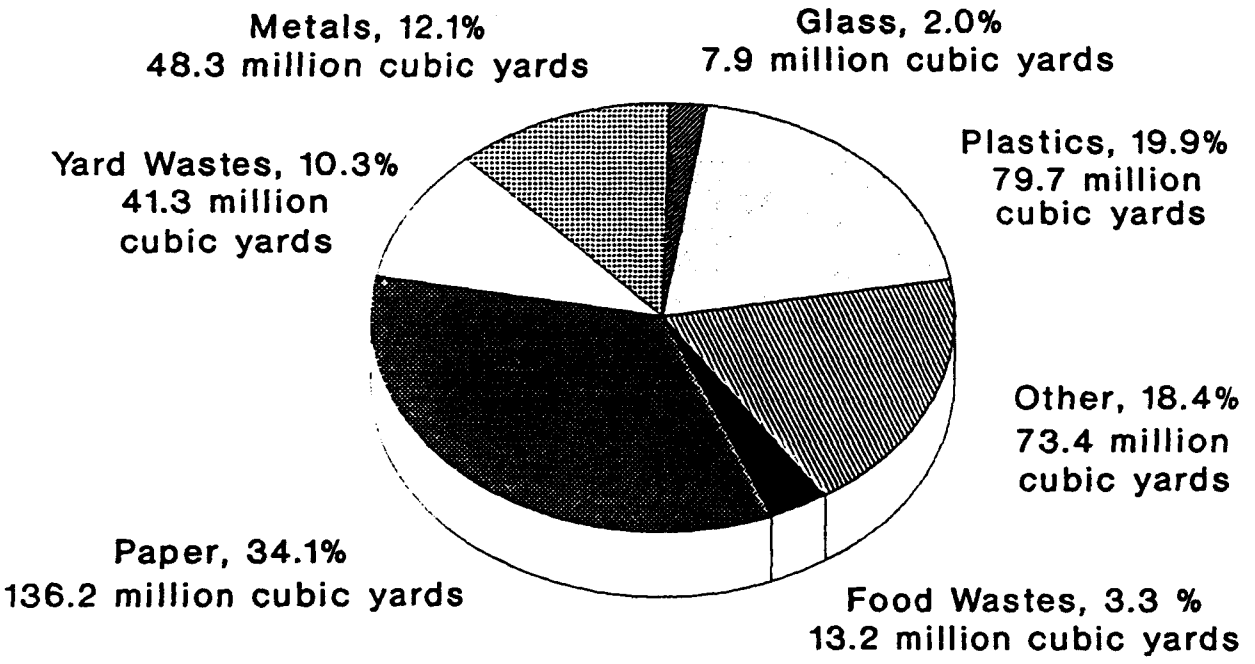
Table ES-2 compares 1988 volume and weight estimates for materials in MSW contained in the report. The right-hand column shows the ratio of volume to weight for each material. A ratio of 1.0 means that the material occupies the same proportion by volume as by weight. Values greater than 1.0 mean that the material occupies a larger proportion of volume than weight. Four materials have ratios greater than 2.0: plastics, rubber and leather, textiles, and aluminum. By contrast, yard wastes, food, and glass each have ratios of 0.5 or less, indicating that these materials are quite dense and occupy proportionately less volume in landfills.

Figure ES-5 shows the product categories that make up MSW by volume of total discards in 1988. Nondurable goods rank first in volume percentage at 34 percent. Containers and packaging are second in volume (roughly 30 percent), and durable goods are third (approximately 22 percent).

Trends in MSW Generation, Recovery, and Discards

Generation of municipal solid waste grew steadily between 1960 and 1988, from 88 million to nearly 180 million tons per year. Per capita generation of MSW increased from 2.7 pounds per person per day in 1960 to 4.0 pounds per person per day in 1988. Between 1986 and 1988, generation increased from 3.8 to 4.0 pounds per person per day (167 million to 180 million tons per year). By 2000, projected per capita MSW generation is 4.4

LANDFILL VOLUME OF DISCARDS IN MSW, 1988



TOTAL VOLUME = 400 million cubic yards

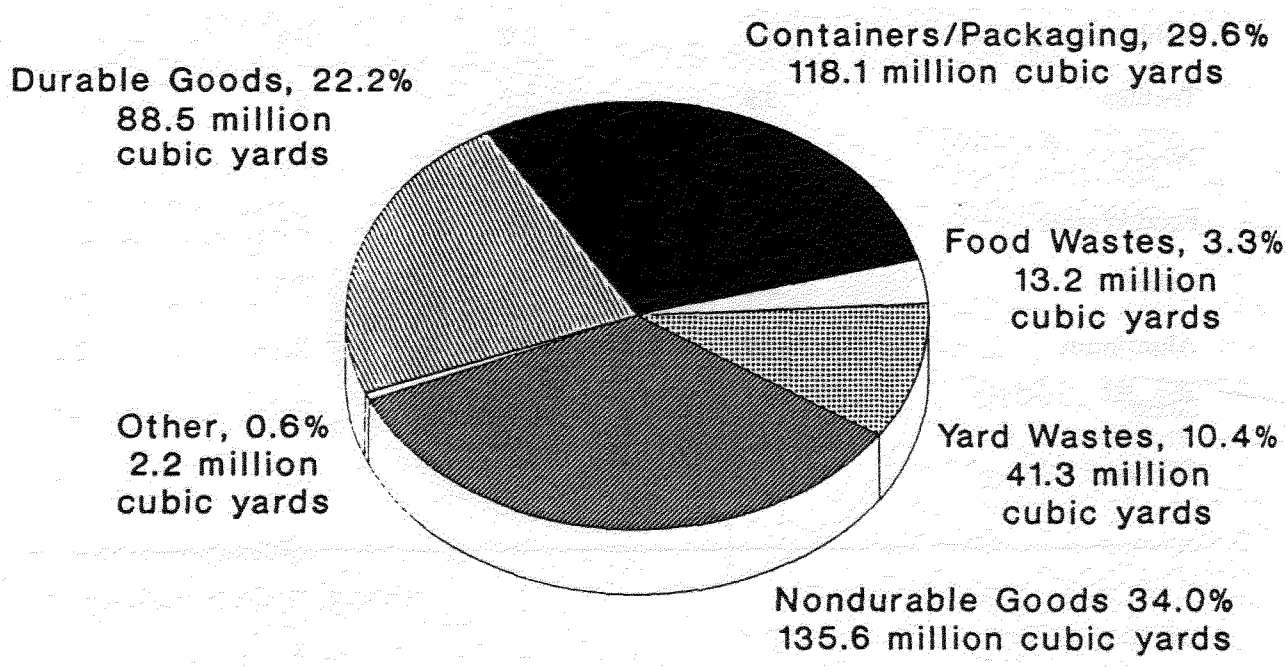
FIGURE ES-4

TABLE ES-2

Volume of Materials Discarded in MSW, 1988

	1988 Discards (mil tons)	Weight (% of MSW total)	Volume (% of MSW total)	Ratio (vol %/ wt %)
Paper and Paperboard	53.4	34.2	34.1	1.0
Plastics	14.3	9.2	19.9	2.2
Yard Wastes	31.0	19.9	10.3	0.5
Ferrous Metals	10.9	7.0	9.8	1.4
Rubber and Leather	4.4	2.9	6.4	2.3
Textiles	3.8	2.5	5.3	2.1
Wood	6.5	4.2	4.1	1.0
Food Wastes	13.2	8.5	3.3	0.4
Other	5.6	3.6	2.5	0.7
Aluminum	1.7	1.1	2.3	2.1
Glass	11.1	7.1	2.0	0.3
TOTALS	156	100	100	1.0

PRODUCTS DISCARDED IN MSW BY VOLUME, 1988



TOTAL VOLUME = 400 million cubic yards

FIGURE ES-5

pounds per person per day (216 million tons). Projected MSW generation in the year 2010 is over 250 million tons, or 4.9 pounds per person per day. Figure ES-6 shows the generation (in millions of tons) of materials in MSW between 1960 and 1988 with projections to 2010.

Recovery has increased gradually from about 7 percent of the waste generated in 1960 to 13 percent in 1988. Recovery is projected to reach between 20 percent and 28 percent of MSW generated in 1995. These projections are presented as a range because of the many unpredictable factors that might influence the growth of recovery and recycling over the next 5 years. These factors include possible changes in the Resource Conservation and Recovery Act (RCRA), which regulates the treatment, storage, and disposal of the nation's solid waste; other federal and state legislative proposals; deposit bills; bans; regional and local efforts; municipal waste combustion and landfill source separation proposals; municipal source reduction and recycling programs; industry efforts and recycling technology. While specific predictions about recycling might be misleading, EPA believes that with fundamental changes in activities and programs related to recycling, we can achieve even higher recycling rates than those projected.

Combustors handled an estimated 30 percent of MSW generated in 1960, most of them with no energy recovery and no air pollution controls. In the 1960s and 1970s, combustion dropped steadily as the old incinerators were closed, reaching a low of less than 10 percent of MSW generated by 1980. More recently, combustion of MSW has been increasing again (to 25.5 million tons, or roughly 14 percent of generation, in 1988). All major new facilities have energy recovery and are designed to meet air pollution standards.

The report projects that more than 45 million tons of MSW will be combusted in 1995, and 55 million tons will be combusted in 2000. It should be noted that because of the long lead time in planning, permitting, and constructing incineration facilities, projections for combustion are easier to make than projections for recovery. Estimates of combustion projections are based on assumptions that assume the facilities will operate at 80 percent of capacity.

Landfill use fluctuates with changes in the use of alternative solid waste management methods. For example, when the use of incineration for MSW management declines and recovery rates are low, the MSW percentage sent to landfills increases. Alternatively, when recovery and combustion of MSW increase, the percentage of MSW discarded to landfills declines. In 1960, approximately 62 percent of MSW was sent to landfills. This increased to 81 percent in 1980, then decreased to 73 percent in 1988 due to changing trends in municipal solid waste management.

U.S. MSW GENERATION, 1960-2010

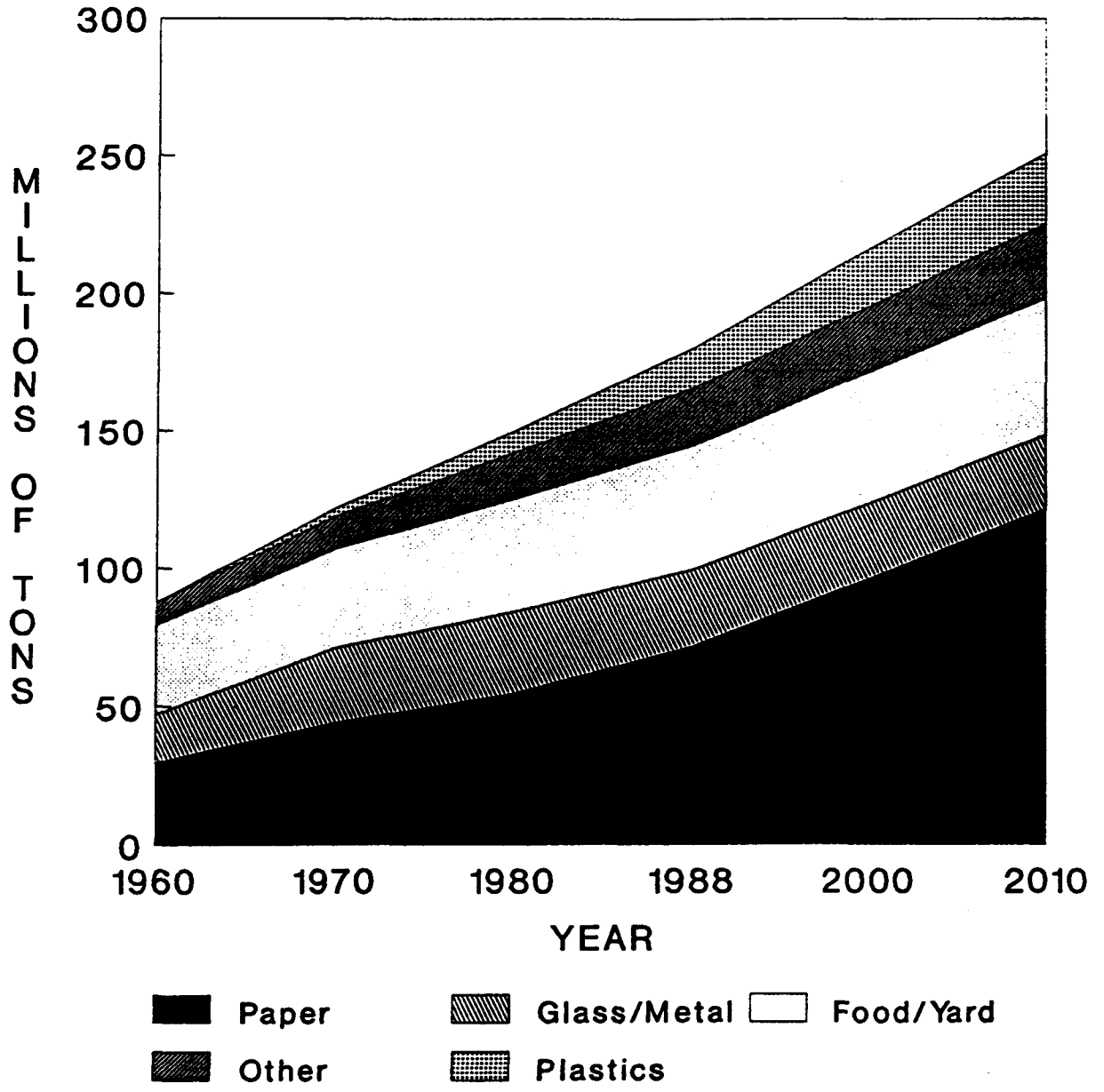


FIGURE ES-6

As we approach the twenty-first century, integrated waste management is clearly the solution to our growing waste needs. Through source reduction and recycling, we can reduce generation and increase recovery, and, in turn, reduce our reliance on combustors and landfills.

Chapter 1

INTRODUCTION AND METHODOLOGY

BACKGROUND

This report is the most recent in a 20-year series of reports sponsored by the U.S. Environmental Protection Agency to characterize municipal solid waste (MSW) in the United States. Together with the previous reports (References 1 through 13), this report provides an updated database for a 50-year characterization (by weight) of the materials and products in MSW.

EPA has used these reports for planning purposes over the years. As an additional benefit, many other individuals and organizations have used the data for their own purposes. This updated version of the MSW characterization report includes many new features, outlined below.

NEW FEATURES OF THIS REPORT

In addition to the data series that have been previously published by EPA in these MSW characterization reports, the following information and features have been added:

- While earlier reports focused primarily on discards of MSW after materials recovery, this report includes detailed tables on MSW generation and materials recovery.
- Estimates of waste recovery for composting have been included for the first time.
- Estimates of MSW combustion without energy recovery have been included for the first time.
- More categories of wastes have been accounted for. Lead-acid batteries (automotive) and disposable diapers have been added as line items. Some products that in the past have been included in "Miscellaneous Nondurables" also have been broken out as line items; these include paper and plastic plates and cups. Paper and plastics containers and packaging have been accounted for in more detail going back to 1980.
- New information permitted more plastic items in MSW to be accounted for.
- Projections of MSW generation have been extended to the year 2010.

- A chapter characterizing MSW by volume (cubic yards) has been included in addition to the traditional characterization by weight (tons).

As an overall result of these additions, the historical and projected estimates of MSW generation and discards are higher than those made in earlier versions of this characterization report. (This is explained in more detail in Chapter 6.)

MUNICIPAL SOLID WASTE IN PERSPECTIVE

Municipal Solid Waste Defined

EPA's 1989 Agenda for Action report states that municipal solid wastes come from residential, commercial, institutional, and industrial sources (Reference 14). (The Agenda for Action drew from the MSW characterization study completed in 1988, which characterized the waste stream through 1986.) As shown in Figure 1, municipal solid waste includes durable goods, nondurable goods, containers and packaging, food and yard wastes, and miscellaneous inorganic wastes.

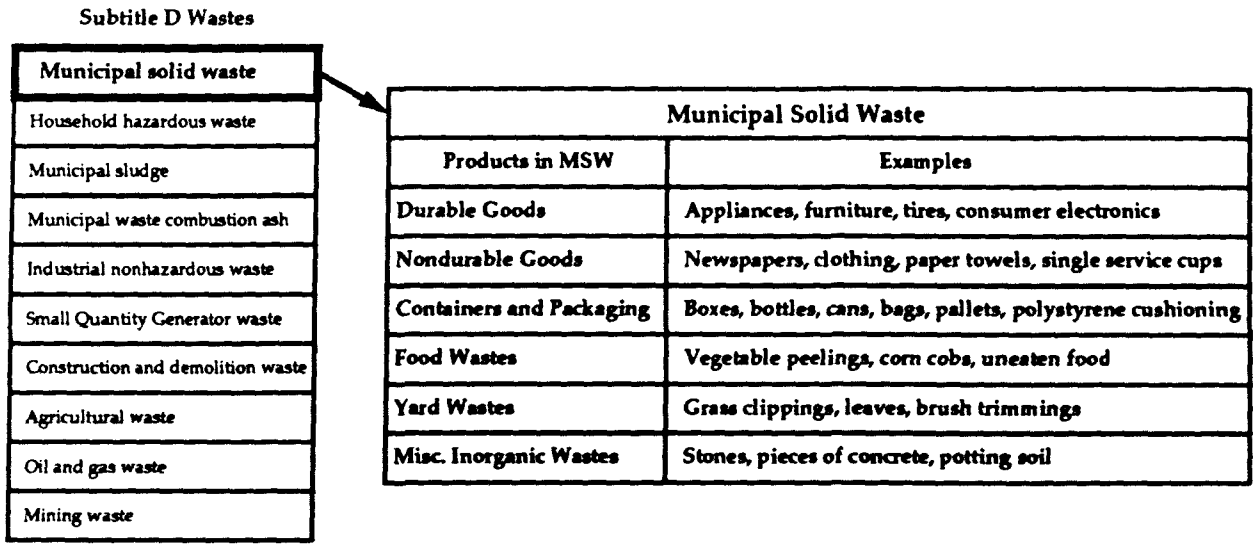


Figure 1. Municipal solid waste in the universe of Subtitle D wastes.

Some examples of the types of MSW that come from each of the broad categories of sources are:

Source	Example Products
Residential	Appliances, newspapers, clothing, disposable tableware, cereal boxes, microwavable and frozen food packaging, cans and bottles, food scraps, yard wastes, some household hazardous wastes (batteries)
Commercial	Corrugated boxes, food wastes, office papers, disposable tableware, paper napkins, yard wastes
Institutional	Cafeteria and restroom trash can wastes, office papers, classroom wastes, yard wastes
Industrial	Corrugated boxes, plastic film, wood pallets, lunchroom wastes, office papers.

The material flows methodology used in this report does not permit 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 from factories. The methodology estimates only the total quantity of such boxes disposed, not their places of discard 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, many kinds of wastes are included under Subtitle D (Reference 15). It has been common practice to landfill wastes such as municipal sludge, ash from combustion of municipal solid waste, nonhazardous industrial wastes, fluff 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. In the past, some solid waste management planners have used earlier reports in this series to estimate the total waste stream in a locality, with the result that they seriously underestimate the amounts of waste to be managed.

The Solid Waste Management Hierarchy

EPA's Agenda for Action endorsed the concept of integrated waste management, by which municipal solid waste is managed through several different practices, which can be tailored to fit a particular community's needs (Reference 14). The components of the hierarchy, in order of preference, are:

- Source reduction (including reuse of products and backyard composting of yard wastes)
- 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. (Source reduction is being addressed in other projects sponsored by EPA and others.) Estimates of composting and combustion without energy recovery are being included for the first time.

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 wastes can only be estimated through sampling and weighing studies.

On the "down side," sampling studies based on a very limited number of samples 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.

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, and this report represents the latest version of this database that has been evolving for 20 years.

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

A detailed description of the material flows methodology is included as Appendix A.

Definition of Terms

The material flows methodology produces an estimate of the 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 stream from residential, commercial, and institutional sources and before materials recovery, composting, or combustion takes place. (In earlier reports in this series and the work sheets for this report, the term "gross discards" is the same as generation.)

"Recovery of materials" as estimated in this report includes materials removed from the waste stream for the purpose of recycling, although recovery does not automatically equal recycling. Recycling processes generally leave some residues (e.g., sludges from deinking paper), but estimation of these residues was beyond the scope of this study.

Recovery of materials for composting was estimated for the first time in this series of reports. Yard wastes and food wastes were treated separately. As in the case of materials recovery, some residues may be left in the composting process, but these were not estimated.

Combustion (incineration) of MSW was estimated with and without energy recovery. Estimates of combustion without energy recovery were not previously included in these reports, but this was an important form of MSW management in the 1960s and early 1970s. Combustion with energy recovery is often called "waste-to-energy" or incineration with heat recovery.

"Discards" include the MSW remaining after recovery for recycling and composting. These discards would presumably be combusted or landfilled,

although some MSW is littered, stored or disposed on-site, or burned on-site, particularly in rural areas. No good estimates of these other disposal practices are available, but they are presumed to be small.

MATERIALS AND PRODUCTS NOT INCLUDED IN THESE ESTIMATES

As noted earlier, the 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).

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 included among these product residues.

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

In past reports in this series, some packaging of imported goods was included, others were not. While there is no precise methodology or data series available for determining the packaging of imported goods, additional estimates based on the best data available were added for this current report.

PROJECTIONS

The projections of MSW generation to the year 2010 were not based on total quantities, but were built up from projections for each product and material separately. Thus, while most products are projected to grow in tonnage, this is not universally true, and some are projected to decline.

The projections are based on trend analysis of the 28-year historical database developed for each product, government sources such as the **Industrial Outlook** published by the Department of Commerce, and, in some cases, best professional judgment.

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

Additional discussions of projection assumptions are included in Chapter 3.

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 summarizing 1988 generation, recovery, and discards of products in each material category are included.

Estimates of MSW combustion with and without energy recovery follow. A final table in this series presents a summary of MSW generation, recovery for recycling and composting, combustion, and discards to landfill or other disposal.

In Chapter 3 of the report, projections of MSW generation, materials recovery, and combustion are presented.

Chapter 4 of the report provides some additional perspectives on the MSW characterization. Summary tables showing more detail for MSW management in 1988 are presented. A table showing discards on a per person basis is provided. In addition, a table categorizing the materials in MSW into combustible and noncombustible fractions is included.

In Chapter 5, a characterization of MSW discards in 1988 by volume (cubic yards) is presented.

The final chapter of this report provides an overview comparison of the results of MSW characterization by the material flows methodology with the results of a number of field sampling studies. Also, the differences between the current update and previous material flows reports are explained.

Chapter 2

CHARACTERIZATION OF MUNICIPAL SOLID WASTE BY WEIGHT

INTRODUCTION

The tables and figures in this chapter present the results of the 1990 update of EPA's municipal solid waste characterization study through 1988. The findings are presented in two ways: a breakdown of MSW by material, and a breakdown by product (both by weight and percentage). While some products, e.g., newspapers, are made up of a single material—paper—other products, e.g., 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 the generation of each material and product, and the recovery for recycling and composting (if any). Tables and figures displaying discards of materials and products after recovery for recycling and composting follow. Recovery means the materials have been removed from the waste stream. Recovery does not automatically mean recycling, and some residues may result from the recycling, although these are not accounted for in this report.

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.

Another set of tables and figures in this chapter presents estimates of combustion of MSW and its effect on discards. Finally, a summary table and figure provide an overview of municipal solid waste management in the United States.

MATERIALS IN MUNICIPAL SOLID WASTE

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

Paper and Paperboard

By any measure, the many products made of paper and paperboard, taken collectively, are the largest component of MSW. The wide variety of products that comprise the paper and paperboard materials total is illustrated in Table 4 and Figure 2. In this report, these products are classified as either

Table 1

MATERIALS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1988
(In millions of tons and percent of total generation)

Materials	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Paper and Paperboard	29.9	38.0	44.2	43.0	54.7	61.5	71.8
Glass	6.7	8.7	12.7	13.5	15.0	13.2	12.5
Metals							
Ferrous	9.9	10.1	12.6	12.3	11.6	10.9	11.6
Aluminum	0.4	0.5	0.8	1.1	1.8	2.3	2.5
Other Nonferrous	0.2	0.5	0.7	0.9	1.1	1.0	1.1
Total Metals	10.5	11.1	14.1	14.3	14.5	14.2	15.3
Plastics	0.4	1.4	3.1	4.5	7.8	11.6	14.4
Rubber and Leather	2.0	2.6	3.2	3.9	4.3	3.8	4.6
Textiles	1.7	1.9	2.0	2.2	2.6	2.8	3.9
Wood	3.0	3.5	4.0	4.4	4.9	5.4	6.5
Other	0.1	0.3	0.8	1.7	2.9	3.4	3.1
Total Nonfood Product Wastes	54.3	67.5	84.1	87.5	106.7	115.9	132.1
Other Wastes							
Food Wastes	12.2	12.7	12.8	13.4	13.2	13.2	13.2
Yard Wastes	20.0	21.6	23.2	25.2	27.5	30.0	31.6
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.5	2.7
Total Other Wastes	33.5	35.9	37.8	40.6	42.9	45.7	47.5
Total MSW Generated - Weight	87.8	103.4	121.9	128.1	149.6	161.6	179.6

Materials	Percent of Total Generation						
	1960	1965	1970	1975	1980	1985	1988
Paper and Paperboard	34.1	36.8	36.3	33.6	36.6	38.1	40.0
Glass	7.6	8.4	10.4	10.5	10.0	8.2	7.0
Metals							
Ferrous	11.3	9.8	10.3	9.6	7.8	6.7	6.5
Aluminum	0.5	0.5	0.7	0.9	1.2	1.4	1.4
Other Nonferrous	0.2	0.5	0.6	0.7	0.7	0.6	0.6
Total Metals	12.0	10.7	11.6	11.2	9.7	8.8	8.5
Plastics	0.5	1.4	2.5	3.5	5.2	7.2	8.0
Rubber and Leather	2.3	2.5	2.6	3.0	2.9	2.4	2.5
Textiles	1.9	1.8	1.6	1.7	1.7	1.7	2.1
Wood	3.4	3.4	3.3	3.4	3.3	3.3	3.6
Other	0.1	0.3	0.7	1.3	1.9	2.1	1.7
Total Nonfood Product Wastes	61.8	65.3	69.0	68.3	71.3	71.7	73.5
Other Wastes							
Food Wastes	13.9	12.3	10.5	10.5	8.8	8.2	7.4
Yard Wastes	22.8	20.9	19.0	19.7	18.4	18.6	17.6
Miscellaneous Inorganic Wastes	1.5	1.5	1.5	1.6	1.5	1.5	1.5
Total Other Wastes	38.2	34.7	31.0	31.7	28.7	28.3	26.5
Total MSW Generated - Percent	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.

Source: Franklin Associates, Ltd.

Table 2

RECOVERY* OF MATERIALS AND COMPOSTING OF FOOD AND YARD WASTE, 1960 TO 1988
(In millions of tons and percent of generation of each material)

Materials	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Paper and Paperboard	5.4	5.7	7.4	8.2	11.9	13.1	18.4
Glass	0.1	0.1	0.2	0.4	0.8	1.0	1.5
Metals							
Ferrous	0.1	0.1	0.1	0.2	0.4	0.4	0.7
Aluminum	0.0	0.0	0.0	0.1	0.3	0.6	0.8
Other Nonferrous	0.0	0.3	0.3	0.4	0.5	0.5	0.7
Total Metals	0.1	0.4	0.4	0.7	1.2	1.5	2.2
Plastics	0.0	0.0	0.0	0.0	0.0	0.1	0.2
Rubber and Leather	0.3	0.3	0.3	0.2	0.1	0.2	0.1
Textiles	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wood	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other**	0.0	0.3	0.3	0.4	0.5	0.5	0.7
Total Nonfood Product Wastes	5.9	6.8	8.6	9.9	14.5	16.4	23.1
Other Wastes							
Food Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yard Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Miscellaneous Inorganic Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Total MSW Recovered - Weight	5.9	6.8	8.6	9.9	14.5	16.4	23.5

Materials	Percent of Generation of Each Material						
	1960	1965	1970	1975	1980	1985	1988
Paper and Paperboard	18.1	15.0	16.7	19.1	21.8	21.3	25.6
Glass	1.5	1.1	1.6	3.0	5.3	7.6	12.0
Metals							
Ferrous	1.0	1.0	0.8	1.6	3.4	3.7	5.8
Aluminum	0.0	0.0	0.0	9.1	16.7	26.1	31.7
Other Nonferrous	0.0	60.0	42.9	44.4	45.5	50.0	65.1
Total Metals	1.0	3.6	2.8	4.9	8.3	10.6	14.6
Plastics	0.0	0.0	0.0	0.0	0.0	0.9	1.1
Rubber and Leather	15.0	11.5	9.4	5.1	2.3	5.3	2.3
Textiles	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Wood	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	80.4	36.8	21.5	17.4	14.0	21.7
Total Nonfood Product Wastes	10.9	10.1	10.2	11.3	13.6	14.2	17.5
Other Wastes							
Food Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yard Wastes	0.0	0.0	0.0	0.0	0.0	0.0	1.6
Miscellaneous Inorganic Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Wastes	0.0	0.0	0.0	0.0	0.0	0.0	1.1
Total MSW Recovered - Percent	6.7	6.6	7.1	7.7	9.7	10.1	13.1

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
** Recovery of electrolytes in batteries; probably not recycled.
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

Table 3

MATERIALS DISCARDED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1988
(In millions of tons and percent of total discards)

Materials	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Paper and Paperboard	24.5	32.3	36.8	34.8	42.8	48.4	53.4
Glass	6.6	8.6	12.5	13.1	14.2	12.2	11.0
Metals							
Ferrous	9.8	10.0	12.5	12.1	11.2	10.5	10.9
Aluminum	0.4	0.5	0.8	1.0	1.5	1.7	1.7
Other Nonferrous	0.2	0.2	0.4	0.5	0.6	0.5	0.4
Total Metals	10.4	10.7	13.7	13.6	13.3	12.7	13.1
Plastics	0.4	1.4	3.1	4.5	7.8	11.5	14.3
Rubber and Leather	1.7	2.3	2.9	3.7	4.2	3.6	4.4
Textiles	1.7	1.9	2.0	2.2	2.6	2.8	3.8
Wood	3.0	3.5	4.0	4.4	4.9	5.4	6.5
Other	0.1	0.0	0.5	1.3	2.4	2.9	2.4
Total Nonfood Product Wastes	48.4	60.7	75.5	77.6	92.2	99.5	109.0
Other Wastes							
Food Wastes	12.2	12.7	12.8	13.4	13.2	13.2	13.2
Yard Wastes	20.0	21.6	23.2	25.2	27.5	30.0	31.1
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.5	2.7
Total Other Wastes	33.5	35.9	37.8	40.6	42.9	45.7	47.0
Total MSW Discarded - Weight	81.9	96.6	113.3	118.2	135.1	145.2	156.0

Materials	Percent of Total Discards						
	1960	1965	1970	1975	1980	1985	1988
Paper and Paperboard	29.9	33.4	32.5	29.4	31.7	33.3	34.2
Glass	8.1	8.9	11.0	11.1	10.5	8.4	7.1
Metals							
Ferrous	12.0	10.4	11.0	10.2	8.3	7.2	7.0
Aluminum	0.5	0.5	0.7	0.8	1.1	1.2	1.1
Other Nonferrous	0.2	0.2	0.4	0.4	0.4	0.3	0.3
Total Metals	12.7	11.1	12.1	11.5	9.8	8.7	8.4
Plastics	0.5	1.4	2.7	3.8	5.8	7.9	9.1
Rubber and Leather	2.1	2.4	2.6	3.1	3.1	2.5	2.9
Textiles	2.1	2.0	1.8	1.9	1.9	1.9	2.5
Wood	3.7	3.6	3.5	3.7	3.6	3.7	4.2
Other	0.1	0.0	0.4	1.1	1.8	2.0	1.6
Total Nonfood Product Wastes	59.1	62.8	66.6	65.7	68.2	68.5	69.9
Other Wastes							
Food Wastes	14.9	13.1	11.3	11.3	9.8	9.1	8.5
Yard Wastes	24.4	22.4	20.5	21.3	20.4	20.7	20.0
Miscellaneous Inorganic Wastes	1.6	1.7	1.6	1.7	1.6	1.7	1.7
Total Other Wastes	40.9	37.2	33.4	34.3	31.8	31.5	30.1
Total MSW Discarded - Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Discards after materials and compost recovery.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 4

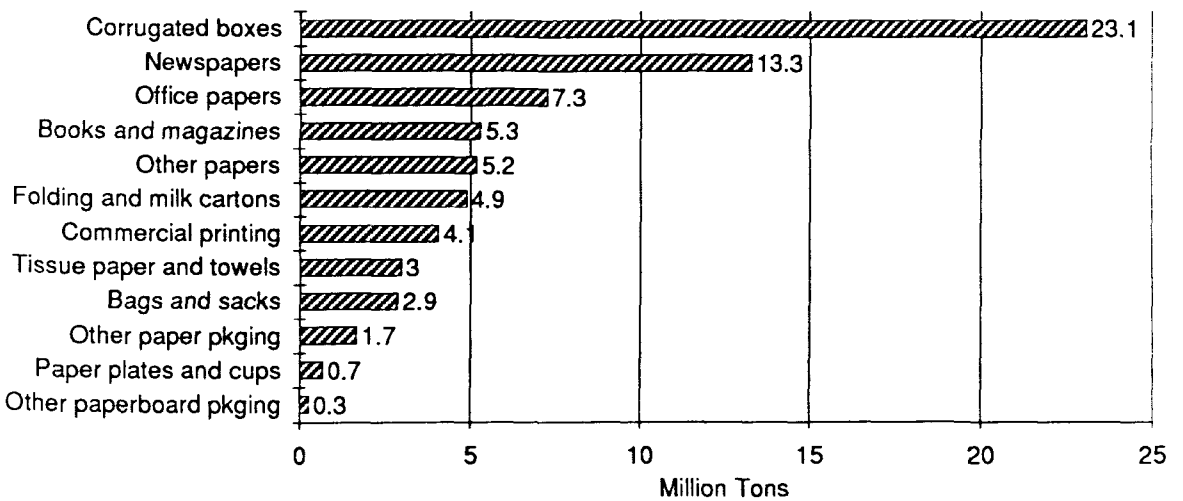
PAPER AND PAPERBOARD PRODUCTS IN MSW, 1988
(In millions of tons and percent of generation)

Product Category	Generation (Million tons)	Recovery (Million tons)	Recovery (Percent of generation)	Discards (Million tons)
Nondurable Goods				
Newspapers	13.3	4.4	33.3	8.9
Books and Magazines	5.3	0.7	13.2	4.6
Office Papers	7.3	1.6	22.5	5.7
Commercial Printing	4.1	0.6	14.6	3.5
Tissue Paper and Towels	3.0	Neg.	Neg.	3.0
Paper Plates and Cups	0.7	Neg.	Neg.	0.7
Other Nonpackaging Paper*	5.2	Neg.	Neg.	5.2
Total Paper and Paperboard Nondurable Goods	38.9	7.4	18.9	31.5
Containers and Packaging				
Corrugated Boxes	23.1	10.5	45.4	12.6
Milk Cartons	0.5	Neg.	Neg.	0.5
Folding Cartons	4.4	0.3	7.7	4.1
Other Paperboard Packaging	0.3	Neg.	Neg.	0.3
Bags and Sacks	2.9	0.2	7.0	2.7
Wrapping Papers	0.1	Neg.	Neg.	0.1
Other Paper Packaging	1.6	Neg.	Neg.	1.6
Total Paper and Paperboard Containers and Packaging	32.9	11.0	33.5	21.9
Total Paper and Paperboard	71.8	18.4	25.6	53.4

* Includes tissue in disposable diapers, paper in games and novelties, posters, tags, cards, etc.
Neg. = Negligible.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Figure 2. Paper and paperboard products generated in MSW, 1988



nondurable goods or as containers and packaging, with nondurable goods being the larger category.

The nondurable paper products include newspapers, books and magazines, office papers, commercial printing, tissue paper and towels, paper plates and cups, and other nonpackaging paper such as that used in cards, games, posters and other pictures, etc. Paper and paperboard are used in containers and packaging in the form of corrugated boxes, milk cartons, other folding cartons (e.g., cereal boxes), bags and sacks, wrapping papers, and other paper and paperboard packaging. (These products are discussed in more detail under the report section on products in MSW.)

Generation. Total generation of paper and paperboard in MSW has grown steadily from nearly 30 million tons in 1960 to nearly 72 million tons in 1988 (Table 1). As a percentage of total MSW generation, paper represented about 34 percent in 1960 (Table 1). The percentage has varied over time, but has generally increased, to 40 percent of generation in 1988.

(The sensitivity of paper products to economic conditions can be observed in Table 1. 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.)

Recovery. Recovery of paper and paperboard for recycling is at the highest rate overall compared to all other materials in MSW. As Table 4 shows, an estimated 45 percent of all corrugated boxes were recovered for recycling in 1988. Newspapers were recovered at a rate of over 33 percent and office papers at over 22 percent, with lesser percentages of other papers being recovered also. Over 18 million tons of postconsumer waste paper were recovered in 1988, over 25 percent of total generation.

Discards after Recovery. After recovery of paper and paperboard for recycling, discards were over 53 million tons in 1988, or 34 percent of total MSW discards.

Glass

Glass is found in MSW primarily in the form of containers (Table 5 and Figure 3), 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 millions tons of MSW in 1960, or over 7 percent of total generation. Generation of glass continued to grow

Table 5

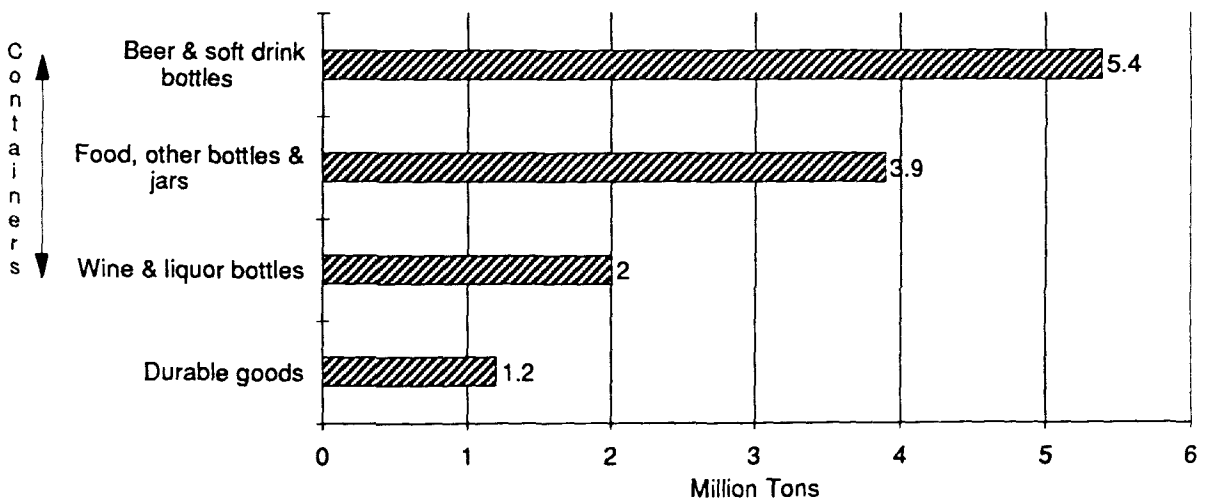
GLASS PRODUCTS IN MSW, 1988
(In millions of tons and percent of generation)

Product Category	Generation (Million tons)	Recovery (Million tons)	Recovery (Percent of generation)	Discards (Million tons)
Durable Goods*	1.2	Neg.	Neg.	1.2
Containers and Packaging				
Beer and Soft Drink Bottles	5.4	1.1	20.0	4.3
Wine and Liquor Bottles	2.0	0.1	5.0	1.9
Food and Other Bottles and Jars	3.9	0.3	8.1	3.6
Total Glass Containers	11.4	1.5	13.3	9.9
Total Glass	12.5	1.5	12.0	11.0

* Glass as a component of appliances, furniture, consumer electronics, etc.
Neg. = Negligible.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Figure 3. Glass products generated in MSW, 1988



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 15 million tons in 1980 to 12.5 million tons in 1988. Glass was 10.0 percent of MSW generation in 1980, declining to 7 percent in 1988.

Recovery. In 1988 an estimated 13 percent of glass containers were recovered for recycling, a 12 percent recovery rate for all glass in MSW.

Discards after Recovery. Recovery for recycling lowers discards of glass to 11 million tons in 1988 (7 percent of total MSW discards).

Ferrous Metals

By weight, ferrous metals are the largest category of metals in MSW (Table 6 and Figure 4). 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.

Generation. About 10 million tons of ferrous metals were generated in 1960. Like glass, the tonnages grew during the Sixties and Seventies, but began to drop as steel cans were displaced by aluminum and plastics. The percentage of ferrous metal generation in MSW has declined from over 11 percent in 1960 to 6.5 percent in 1988.

Figure 4. Metal products generated in MSW, 1988

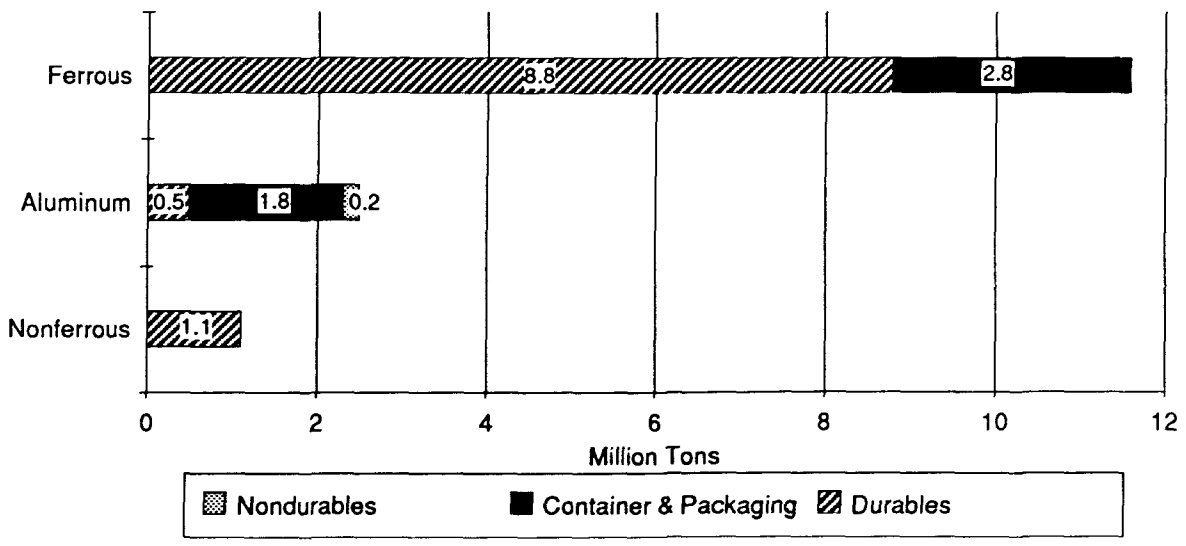


Table 6

METAL PRODUCTS IN MSW, 1988
(In millions of tons and percent of generation)

Product Category	Generation (Million tons)	Recovery (Million tons)	Recovery (Percent of generation)	Discards (Million tons)
Durable Goods				
Ferrous Metals*	8.8	0.3	3.4	8.5
Aluminum**	0.5	Neg.	Neg.	0.5
Batteries (Lead)	0.8	0.7	89.9	0.1
Other Nonferrous Metals***	0.3	Neg.	Neg.	0.3
Total Metals in Durable Goods	10.4	1.0	9.9	9.4
Nondurable Goods				
Aluminum	0.2	Neg.	Neg.	0.2
Containers and Packaging				
Steel				
Beer and Soft Drink Cans	0.1	Neg.	Neg.	0.1
Food and Other Cans	2.5	0.4	15.0	2.1
Other Steel Packaging	0.2	Neg.	Neg.	0.2
Total Steel Packaging	2.8	0.4	13.8	2.4
Aluminum				
Beer and Soft Drink Cans	1.4	0.8	55.0	0.6
Other Cans	0.1	Neg.	Neg.	0.1
Foil and Closures	0.3	Neg.	Neg.	0.3
Total Aluminum Packaging	1.8	0.8	44.1	1.0
Total Metals in Containers and Packaging	4.7	1.2	25.7	3.5
Total Metals	15.3	2.2	14.6	13.1

* Ferrous metals in appliances, furniture, tires, and miscellaneous durables.
** Aluminum in appliances, furniture, and miscellaneous durables.
*** Other nonferrous metals in appliances, lead-acid batteries, and miscellaneous durables.
Neg. = Negligible.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Recovery. Recovery of ferrous metals from MSW is not large at the present time, although good data are difficult to obtain. It is estimated that about 2 percent of ferrous metals in durable goods was recovered in 1988 (Table 6). This was mainly from appliances (white goods) shredded and magnetically separated by the same facilities that shred and recover metals from automobiles. In addition, an estimated 15 percent of steel cans (mostly food cans) were recovered for recycling in 1988. About 700,000 tons of ferrous metals were estimated to have been recovered in 1988.

Discards after Recovery. Discards of ferrous metals after recovery were about 11 million tons in 1988—7 percent of total discards.

Aluminum

The largest source of aluminum in MSW is aluminum cans and other packaging (Table 6 and Figure 4). Relatively small amounts of aluminum are also found in durable and nondurable goods.

Generation. In 1988, 1.8 million tons of aluminum were generated as containers and packaging, while a total of about 700,000 tons was found in durable and nondurable goods. The total—2.5 million tons—represented only 1.4 percent of total MSW generation in 1988. Aluminum generation was only about 400,000 tons (0.5 percent) in 1960.

Recovery. About 44 percent of all aluminum containers and packaging was recovered for recycling in 1988. Nearly all of this recovery was beer and soft drink cans; they were estimated to be recovered at a 55 percent rate in 1988.

Discards after Recovery. In 1988, 1.7 million tons of aluminum were discarded in MSW after recovery, which was 1.1 percent of total discards.

Other Nonferrous Metals

Other nonferrous metals (e.g., lead, copper, zinc) are found in durable products such as appliances, consumer electronics, etc. For the first time in this series of reports, estimates of generation of lead-acid automotive batteries have been added. These batteries are an important source of lead in MSW.

Generation. Generation of other nonferrous metals in MSW totalled 1.1 million tons in 1988. Lead in batteries accounted for 800,000 tons of this amount. Generation of these metals has increased slowly, from about 200,000 tons in 1960. As a percentage of total generation, nonferrous metals have never exceeded one percent.

Recovery. Recovery of the other nonferrous metals was over 700,000 tons in 1988, with most of this being lead recovered from batteries. While accurate statistics are difficult to find, it is estimated that about 90 percent of battery lead is recovered.

Discards after Recovery. As estimated 400,000 tons of nonferrous metals were discarded in MSW in 1988. Percentages of total remain less than one percent over the entire period.

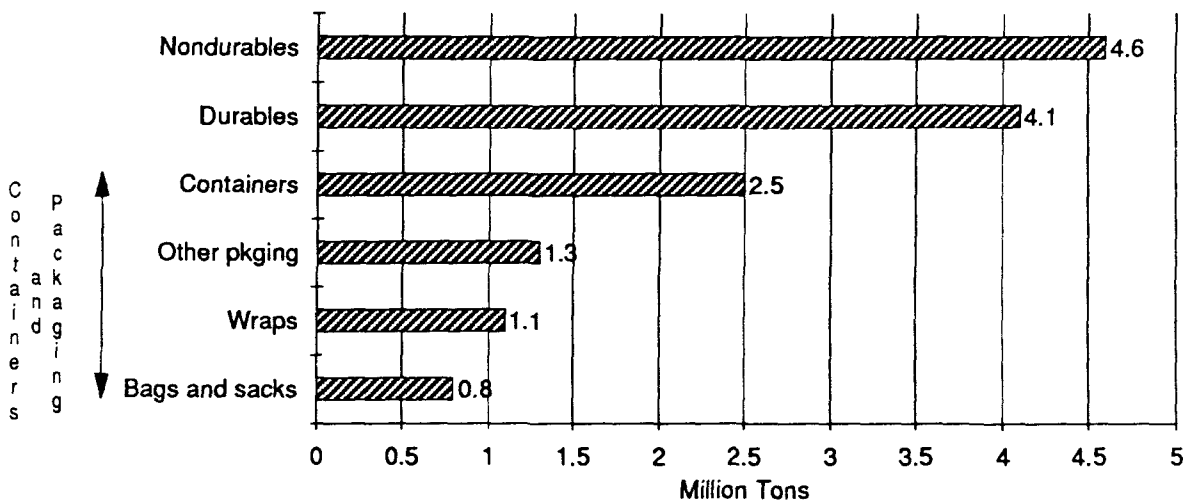
Plastics

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 5). In durable goods, plastics are found in appliances, furniture, casings of lead-acid batteries, and other products. Plastics are found in such nondurable products as disposable diapers, trash bags, cups, eating utensils, shower curtains, etc. Plastics are also used in a variety of container and packaging products, e.g., condiment and beverage containers, bags, protection for electronic equipment and computers, etc.

Generation. Plastics comprised an estimated 400,000 tons in MSW generation in 1960. The quantity grew steadily to over 14 million tons in 1988. As a percentage of MSW generation, plastics were less than one percent in 1960, increasing to 8 percent in 1988.

Recovery for Recycling. While overall recovery of plastics for recycling is small—200,000 tons, or about one percent of generation in 1988—an estimated 21 percent of plastic (polyethylene terephthalate) soft drink bottles and their base cups were recovered that year. Some recovery of plastics from lead-acid battery casings and other containers was also reported.

Figure 5. Plastic products generated in MSW, 1988



Discards after Recovery. Discards of plastics in MSW after recovery were nearly equal to generation in 1988, since the rate of recycling was only one percent.

Other Materials

Rubber and Leather. The predominant source of rubber in MSW is rubber tires (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.

Table 7

PLASTICS PRODUCTS IN MSW, 1988
(In millions of tons and percent of generation)

Product Category	Generation (Million tons)	Recovery (Million tons)	Recovery (Percent of generation)	Discards (Million tons)
Durable Goods*	4.1	<0.1	1.5	4.1
Nondurable Goods				
Plastic Plates and Cups	0.4	Neg.	Neg.	0.4
Clothing and Footwear	0.2	Neg.	Neg.	0.2
Disposable Diapers**	0.3	Neg.	Neg.	0.3
Other Misc. Nondurables***	3.8	Neg.	Neg.	3.8
Total Plastics Nondurable Goods	4.6	Neg.	Neg.	4.6
Containers and Packaging				
Soft Drink Bottles+	0.4	0.1	21.0	0.3
Milk Bottles	0.4	Neg.	<1.0	0.4
Other Containers	1.7	Neg.	Neg.	1.7
Bags and Sacks	0.8	Neg.	Neg.	0.8
Wraps	1.1	Neg.	Neg.	1.1
Other Plastic Packaging	1.2	Neg.	Neg.	1.2
Total Plastics Containers and Packaging	5.6	0.1	1.6	5.5
Total Plastics	14.4	0.2	1.1	14.3

* Plastics as a component of appliances, furniture, lead-acid batteries and miscellaneous durables.
** Does not include other materials in diapers.
*** Trash bags, eating utensils and straws, shower curtains, etc.
\+ Includes bottles and base cups.
Neg. = Negligible.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Generation. Generation of rubber and leather in MSW has shown slow growth over the years, increasing from 2 million tons in 1960 to over 4 million tons in 1988. One reason for the relatively slow rate of growth is that tires have been made smaller and longer-wearing than in past years.

As a percentage of total MSW generation, rubber and leather have ranged between 2 and 3 percent of the total over the historical period.

Recovery for Recycling. The only recovery identified in this category is rubber from tires, and that was estimated to be about 100,000 tons (5 percent of rubber in tires in 1988) (Table 8). This means that only about 2 percent of all rubber and leather in MSW was recovered in 1988.

Discards after Recovery. Discards of rubber and leather after recovery were over 4 million tons in 1988 (2.9 percent of total discards).

Table 8

RUBBER AND LEATHER PRODUCTS IN MSW, 1988
(In millions of tons and percent of generation)

Product Category	Generation (Million tons)	Recovery (Million tons)	Recovery (Percent of generation)	Discards (Million tons)
Durable Goods				
Rubber Tires*	1.9	0.1	5.6	1.8
Other Durables	1.2	Neg.	Neg.	1.2
Total Rubber & Leather Durable Goods	3.0	0.1	3.4	2.9
Nondurable Goods				
Clothing and Footwear	1.1	Neg.	Neg.	1.1
Other Nondurables	0.4	Neg.	Neg.	0.4
Total Rubber & Leather Nondurable Goods	1.5	Neg.	Neg.	1.5
Total Rubber & Leather	4.6	0.1	2.3	4.4

* Does not include other materials in tires.
Neg. = Negligible.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Textiles. Textiles in MSW are found mainly in discarded clothing, although other sources were identified to be furniture, tires, footwear, and other miscellaneous nondurables.

Generation. An estimated 3.9 million tons of textiles were generated in 1988. These products have exhibited slow growth over the study period.

Recovery for Recycling and Discards. Some small amounts of textiles are recovered, but these were not identified to be significant quantities. Therefore, discards after recovery are approximately the same as generation for textiles.

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. About 6.5 million tons of wood were generated in 1988. These products have been generated in increasing amounts over the years, but the increase is not rapid. (A 10-year time lag is built into the estimates of furniture discards.)

Recovery for Recycling and Discards. Some wood pallets are recovered from MSW, but overall recovery was not documented to be significant enough to affect quantities discarded in 1988.

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 and not classified as plastics or nonferrous metal.

Food Wastes

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

Generation. As noted earlier, the only source of data on food wastes is on-site sampling studies. As many studies as possible representing as long a time frame as possible were scrutinized. The results of these studies are expressed in percentages, so food waste estimates were based on percentages of discards (after recycling) in order to be comparable to sampling studies performed at landfills or transfer stations. In addition, an adjustment was

made for the moisture transfer that occurs when wastes are mixed prior to sampling. As a check on the sampling methodology, per capita generation of food wastes over the historical period was also calculated.

The sampling studies over a long time frame show food wastes to be a declining percentage of the waste stream, down from almost 15 percent of discards after recycling in 1960 to 8.5 percent in 1988. Generation of food wastes was estimated to be 13.2 million tons in 1988. On a per capita basis, discards of food wastes are declining. This can be attributed to more use of garbage disposals, which send food wastes to the sewer systems rather than MSW, and increasing use of prepared foods both at home and in food service establishments. (When foods are prepared and packaged off-site, the food preparation wastes are categorized as industrial wastes rather than MSW.)

Recovery and Discards. While recovery of food wastes for composting or animal feed has been discussed and practiced in some locations, no significant recovery of food wastes was identified in 1988.

Yard Wastes

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

Generation. Generation of yard wastes was estimated in exactly the same manner as food wastes, based on sampling studies. As a percentage of the waste stream, yard wastes have been exhibiting a slow decline, although in terms of per capita generation, they have been increasing slightly. An estimated 31.6 million tons of yard wastes were generated in MSW in 1988.

Recovery for Composting and Discards. For the first time in this series of reports, estimates were made for removal of yard wastes from MSW for composting projects. Composting has been identified by EPA and others as an important tool for reducing the amounts of MSW that must be landfilled or otherwise managed. Quantitative national information on composting is difficult to obtain, but estimates were based on a literature search and telephone contacts with state agencies to determine state policies on removal of yard wastes from MSW (e.g., by banning leaves from landfills), and estimates of the amounts of waste that might be affected. Removal of yard wastes for composting was estimated to be less than 2 percent of generation in 1988 (474,000 tons), leaving about 31 million tons of yard wastes to be discarded.

(It should be noted that these estimates do not account for backyard composting by individuals or practices such as less bagging of grass wastes; since the yard waste estimates are based on sampling studies at the landfill or transfer station, they are based on the quantities received there.)

Miscellaneous Inorganic Wastes

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

Generation. This category contributed an estimated 2.7 million tons of MSW in 1988.

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

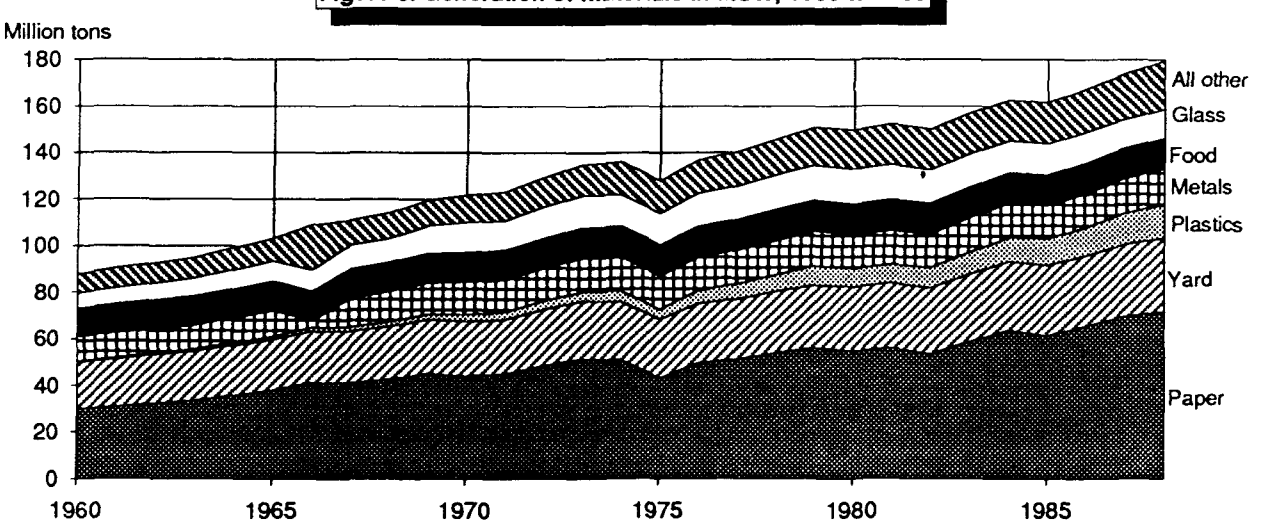
Summary of Materials in Municipal Solid Waste

Generation. Changing quantities and composition of municipal solid waste generation are illustrated in Figure 6.

Generation of MSW has grown steadily, from 87.8 million tons in 1960 to 179.6 million tons in 1988. Over the years, paper and paperboard has been the dominant material generated in MSW. Yard wastes have been the second largest component of MSW. Metals have remained fairly constant as a source of MSW, while glass increased until the 1980s and has since declined. Food wastes have remained fairly constant in terms of MSW tonnage.

Plastics have been a rapidly growing component of MSW, but in terms of tonnage contributed, they ranked fourth in 1988 (behind metals and ahead of glass).

Figure 6. Generation of materials in MSW, 1960 to 1988



Additional information on percentage increases or decreases in generation of individual materials in MSW is provided in the section "Changing Rates of MSW Generation" later in this chapter.

Recovery and Discards. The effect of recovery and composting on MSW discards is illustrated in Figure 7. Recovery of materials for recycling grew at a rather slow pace during most of the historical period covered by this data series, increasing from only 9.7 percent of generation in 1980 to 10.1 percent in 1985. Renewed interest in recycling and composting as solid waste management alternatives has taken place in the late 1980s, and the recovery rate in 1988 was estimated at 13.1 percent of generation.

Estimated recovery and composting of materials are shown in Figure 8. At the present time, recovery of paper and paperboard dominates materials recovery at 78 percent of total tonnage recovered. Recovery of other materials, while generally increasing, contributes much less tonnage.

Figure 9 illustrates the effect of recovery of materials for recycling and composting on the composition of the waste stream. For example, paper and paperboard were 40 percent of MSW generated in 1988, but after recovery, paper and paperboard were 34.2 percent of discards. Materials that have no recovery or very little exhibit a larger percentage of MSW discards compared to generation. For instance, food wastes were 7.4 percent of MSW generation in 1988, but 8.5 percent of 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 life of three years or more, although there are some exceptions. In this report, durable goods include major appliances, furniture and furnishings, rubber tires, lead-

Figure 7. Materials recovery and discards of MSW, 1960 to 1988

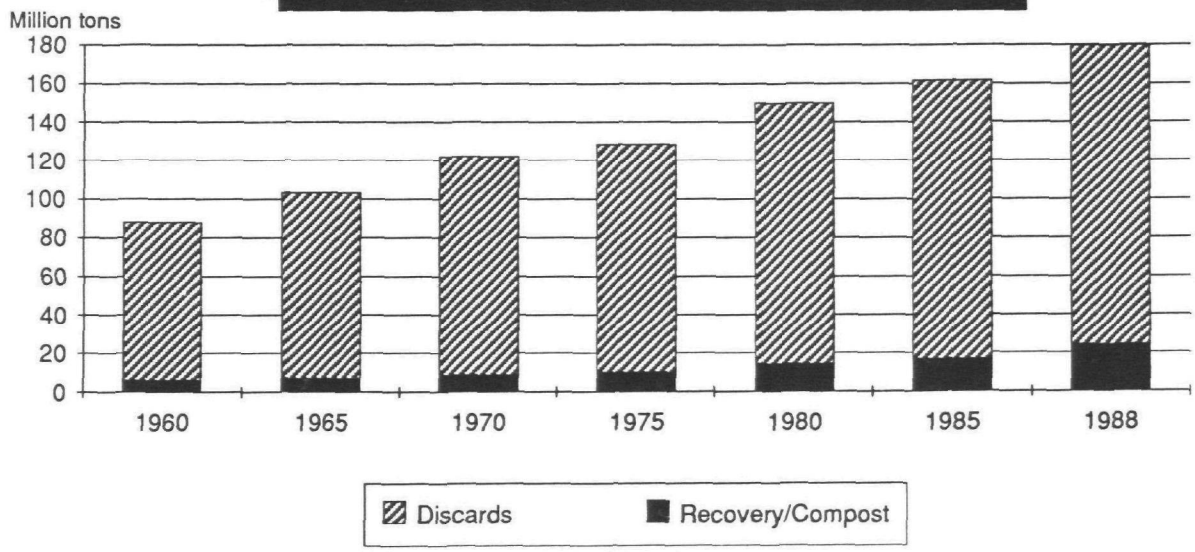


Figure 8. Materials recovery, 1988

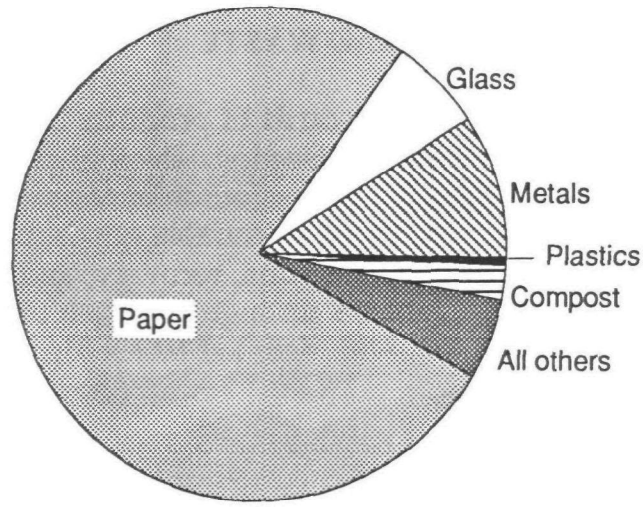


Figure 9. Materials generated and discarded in MSW, 1988

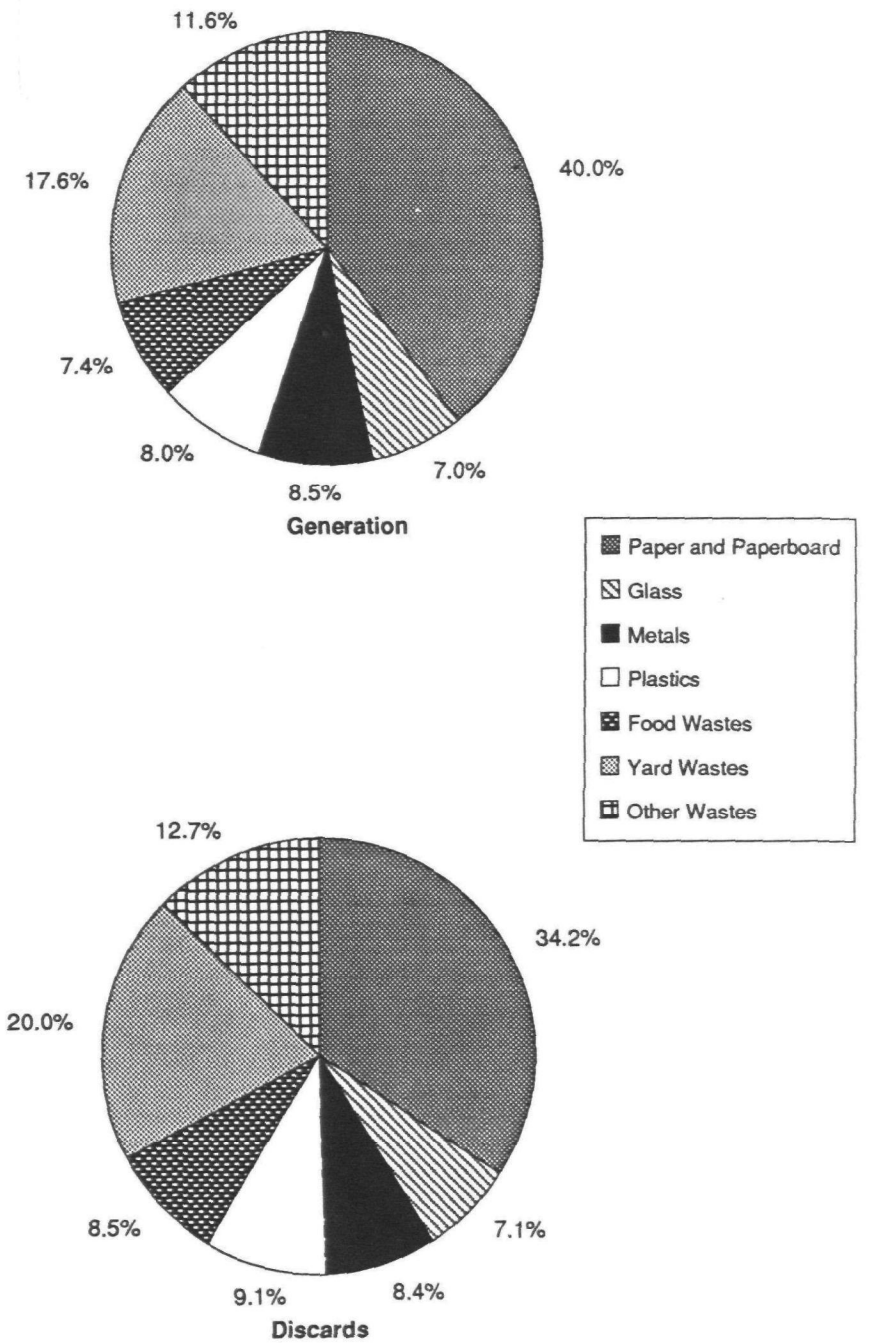


Table 9

CATEGORIES OF PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1988
(In millions of tons and percent of total generation)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 12)	9.4	11.1	15.1	17.5	19.7	21.5	24.9
Nondurable Goods (Detail in Table 15)	17.6	22.2	25.5	25.6	36.5	42.6	50.4
Containers and Packaging (Detail in Table 18)	27.3	34.2	43.5	44.4	50.5	51.8	56.8
Total Nonfood Product Wastes	54.3	67.5	84.1	87.5	106.7	115.9	132.1
Other Wastes							
Food Wastes	12.2	12.7	12.8	13.4	13.2	13.2	13.2
Yard Wastes	20.0	21.6	23.2	25.2	27.5	30.0	31.6
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.5	2.7
Total Other Wastes	33.5	35.9	37.8	40.6	42.9	45.7	47.5
Total MSW Generated - Weight	87.8	103.4	121.9	128.1	149.6	161.6	179.6

Products	Percent of Total Generation						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 12)	10.7	10.7	12.4	13.7	13.2	13.3	13.9
Nondurable Goods (Detail in Table 15)	20.0	21.5	20.9	20.0	24.4	26.4	28.1
Containers and Packaging (Detail in Table 19)	31.1	33.1	35.7	34.7	33.8	32.1	31.6
Total Nonfood Product Wastes	61.8	65.3	69.0	68.3	71.3	71.7	73.5
Other Wastes							
Food Wastes	13.9	12.3	10.5	10.5	8.8	8.2	7.4
Yard Wastes	22.8	20.9	19.0	19.7	18.4	18.6	17.6
Miscellaneous Inorganic Wastes	1.5	1.5	1.5	1.6	1.5	1.5	1.5
Total Other Wastes	38.2	34.7	31.0	31.7	28.7	28.3	26.5
Total MSW Generated - Percent	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.

Source: Franklin Associates, Ltd.

Table 10

RECOVERY* OF PRODUCTS AND COMPOSTING OF FOOD AND YARD WASTE, 1960 TO 1988
(In millions of tons and percent of generation of each product)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 13)	0.4	0.9	0.9	1.0	1.3	1.4	1.9
Nondurable Goods (Detail in Table 16)	2.4	2.8	3.8	3.8	4.8	5.6	7.4
Containers and Packaging (Detail in Table 20)	3.1	3.1	3.9	5.1	8.4	9.4	13.8
Total Nonfood Product Wastes	5.9	6.8	8.6	9.9	14.5	16.4	23.1
Other Wastes							
Food Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yard Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Miscellaneous Inorganic Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Total MSW Recovered - Weight	5.9	6.8	8.6	9.9	14.5	16.4	23.5

Products	Percent of Generation of Each Product						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 13)	4.3	8.1	6.0	5.7	6.6	6.5	7.5
Nondurable Goods (Detail in Table 16)	13.6	12.6	14.9	14.8	13.2	13.1	14.6
Containers and Packaging (Detail in Table 21)	11.4	9.1	9.0	11.5	16.6	18.1	24.3
Total Nonfood Product Wastes	10.9	10.1	10.2	11.3	13.6	14.2	17.5
Other Wastes							
Food Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yard Wastes	0.0	0.0	0.0	0.0	0.0	0.0	1.6
Miscellaneous Inorganic Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Wastes	0.0	0.0	0.0	0.0	0.0	0.0	1.1
Total MSW Recovered - Percent	6.7	6.6	7.1	7.7	9.7	10.1	13.1

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
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 1988
(In millions of tons and percent of total discards)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 14)	9.0	10.2	14.2	16.5	18.4	20.1	23.0
Nondurable Goods (Detail in Table 17)	15.2	19.4	21.7	21.8	31.7	37.0	43.0
Containers and Packaging (Detail in Table 22)	24.2	31.1	39.6	39.3	42.1	42.4	43.0
Total Nonfood Product Wastes	48.4	60.7	75.5	77.6	92.2	99.5	109.0
Other Wastes							
Food Wastes	12.2	12.7	12.8	13.4	13.2	13.2	13.2
Yard Wastes	20.0	21.6	23.2	25.2	27.5	30.0	31.1
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.5	2.7
Total Other Wastes	33.5	35.9	37.8	40.6	42.9	45.7	47.0
Total MSW Discarded - Weight	81.9	96.6	113.3	118.2	135.1	145.2	156.0

Products	Percent of Total Discards						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 14)	11.0	10.6	12.5	14.0	13.6	13.8	14.7
Nondurable Goods (Detail in Table 17)	18.6	20.1	19.2	18.4	23.5	25.5	27.6
Containers and Packaging (Detail in Table 23)	29.5	32.2	35.0	33.2	31.2	29.2	27.6
Total Nonfood Product Waste	59.1	62.8	66.6	65.7	68.2	68.5	69.9
Other Wastes							
Food Wastes	14.9	13.1	11.3	11.3	9.8	9.1	8.5
Yard Wastes	24.4	22.4	20.5	21.3	20.4	20.7	20.0
Miscellaneous Inorganic Wastes	1.6	1.7	1.6	1.7	1.6	1.7	1.7
Total Other Wastes	40.9	37.2	33.4	34.3	31.8	31.5	30.1
Total MSW Discarded - Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Discards after materials and compost recovery.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

acid automotive batteries, and miscellaneous durables (e.g., small appliances, 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 1988, these include: ferrous metals, wood, plastics, rubber and leather, glass, other nonferrrous metals (e.g., lead, copper), textiles, and aluminum.

Generation of durable goods in MSW totalled 24.9 million tons in 1988 (almost 14 percent of total MSW generation). After recovery for recycling, 23 million tons of durable goods remained as discards in 1988.

Major Appliances. Major appliances in MSW include refrigerators, washing machines, water heaters, etc. They are often called "white goods" in the trade. Generation of these products in MSW has increased very slowly; it was estimated to be 3 million tons in 1988 (less than 2 percent of total). In general, appliances have increased in quantity but not in average weight over the years.

Some ferrous metals are recovered from shredded appliances, although this quantity is not well documented. Recovery was estimated to be 200,000 tons in 1988, leaving 2.8 million tons of appliances to be discarded.

Ferrous metals are the predominant materials in major appliances, but other metals, plastics, glass, and other materials are also found.

Furniture and Furnishings. Generation of furniture and furnishings in MSW has increased from 2.1 million tons in 1960 to 7.5 million tons in 1988 (about 4 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.

Rubber Tires. About 70 percent of the rubber used in the United States is used in the manufacture of rubber tires. Generation of rubber tires increased from about one million tons in 1960 to 2.2 million tons in 1988 (about one percent of total MSW). Generation was higher in the 1970s and early 1980s, but the trend to smaller and longer-wearing tires has lowered their quantities. Small amounts of rubber are recovered for recycling (an estimated 5 percent in 1988).

Table 12

PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1988
(WITH DETAIL ON DURABLE GOODS)
(In millions of tons and percent of total generation)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods							
Major Appliances	1.5	1.0	2.7	2.6	2.8	2.7	3.0
Furniture and Furnishings	2.1	2.7	3.4	4.1	5.1	5.8	7.5
Rubber Tires	1.1	1.4	1.9	2.5	2.6	1.9	2.2
Batteries, lead acid	0.0	0.7	0.8	1.2	1.5	1.5	1.6
Miscellaneous Durables	4.7	5.4	6.3	7.1	7.7	9.6	10.6
Total Durable Goods	9.4	11.1	15.1	17.5	19.7	21.5	24.9
Nondurable Goods (Detail in Table 15)	17.6	22.2	25.5	25.6	36.5	42.6	50.4
Containers and Packaging (Detail in Table 18)	27.3	34.2	43.5	44.4	50.5	51.8	56.8
Total Nonfood Product Wastes	54.3	67.5	84.1	87.5	106.7	115.9	132.1
Other Wastes							
Food Wastes	12.2	12.7	12.8	13.4	13.2	13.2	13.2
Yard Wastes	20.0	21.6	23.2	25.2	27.5	30.0	31.6
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.5	2.7
Total Other Wastes	33.5	35.9	37.8	40.6	42.9	45.7	47.5
Total MSW Generated - Weight	87.8	103.4	121.9	128.1	149.6	161.6	179.6

Products	Percent of Total Generation						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods							
Major Appliances	1.7	1.0	2.2	2.0	1.9	1.7	1.7
Furniture and Furnishings	2.4	2.6	2.8	3.2	3.4	3.6	4.2
Rubber Tires	1.3	1.3	1.6	2.0	1.7	1.2	1.2
Batteries, Lead-Acid	0.0	0.6	0.7	0.9	1.0	0.9	0.9
Miscellaneous Durables	5.4	5.2	5.2	5.5	5.1	5.9	5.9
Total Durable Goods	10.7	10.7	12.4	13.7	13.2	13.3	13.9
Nondurable Goods (Detail in Table 15)	20.0	21.5	20.9	20.0	24.4	26.4	28.1
Containers and Packaging (Detail in Table 19)	31.1	33.1	35.7	34.7	33.8	32.1	31.6
Total Nonfood Product Wastes	61.8	65.3	69.0	68.3	71.3	71.7	73.5
Other Wastes							
Food Wastes	13.9	12.3	10.5	10.5	8.8	8.2	7.4
Yard Wastes	22.8	20.9	19.0	19.7	18.4	18.6	17.6
Miscellaneous Inorganic Wastes	1.5	1.5	1.5	1.6	1.5	1.5	1.5
Total Other Wastes	38.2	34.7	31.0	31.7	28.7	28.3	26.5
Total MSW Generated - Percent	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.

Source: Franklin Associates, Ltd.

Table 13

RECOVERY* OF PRODUCTS AND COMPOSTING OF FOOD AND YARD WASTE, 1960 TO 1988 (WITH DETAIL ON DURABLE GOODS)
(In millions of tons and percent of generation of each product)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods							
Major Appliances	0.0	0.0	0.0	0.0	0.1	0.2	0.2
Furniture and Furnishings	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rubber Tires	0.4	0.3	0.3	0.2	0.1	0.1	0.1
Batteries, lead acid	0.0	0.6	0.6	0.8	1.0	1.0	1.5
Miscellaneous Durables	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Total Durable Goods	0.4	0.9	0.9	1.0	1.3	1.4	1.9
Nondurable Goods (Detail in Table 16)	2.4	2.8	3.8	3.8	4.8	5.6	7.4
Containers and Packaging (Detail in Table 20)	3.1	3.1	3.9	5.1	8.4	9.4	13.8
Total Nonfood Product Wastes	5.9	6.8	8.6	9.9	14.5	16.4	23.1
Other Wastes							
Food Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yard Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Miscellaneous Inorganic Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Total MSW Recovered - Weight	5.9	6.8	8.6	9.9	14.5	16.4	23.5

Products	Percent of Generation of Each Product						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods							
Major Appliances	0.0	0.0	0.0	0.0	3.6	7.4	7.0
Furniture and Furnishings	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rubber Tires	36.4	21.8	15.8	8.0	3.8	5.3	4.8
Batteries, Lead-Acid	0.0	88.6	75.0	66.7	66.7	66.7	90.0
Miscellaneous Durables	0.0	0.0	0.0	0.0	1.3	1.0	0.7
Total Durable Goods	4.3	7.9	6.0	5.7	6.6	6.5	7.5
Nondurable Goods (Detail in Table 16)	13.6	12.6	14.9	14.8	13.2	13.1	14.6
Containers and Packaging (Detail in Table 21)	11.4	9.1	9.0	11.5	16.6	18.1	24.3
Total Nonfood Product Wastes	10.9	10.0	10.2	11.3	13.6	14.2	17.5
Other Wastes							
Food Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yard Wastes	0.0	0.0	0.0	0.0	0.0	0.0	1.6
Miscellaneous Inorganic Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Wastes	0.0	0.0	0.0	0.0	0.0	0.0	1.1
Total MSW Recovered - Percent	6.7	6.6	7.1	7.7	9.7	10.1	13.1

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 14

PRODUCTS DISCARDED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1988
(WITH DETAIL ON DURABLE GOODS)
(In millions of tons and percent of total generation)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods							
Major Appliances	1.5	1.0	2.7	2.6	2.7	2.5	2.8
Furniture and Furnishings	2.1	2.7	3.4	4.1	5.1	5.8	7.5
Rubber Tires	0.7	1.1	1.6	2.3	2.5	1.8	2.1
Batteries, lead acid	0.0	0.1	0.2	0.4	0.5	0.5	0.2
Miscellaneous Durables	4.7	5.4	6.3	7.1	7.6	9.5	10.5
Total Durable Goods	9.0	10.2	14.2	16.5	18.4	20.1	23.0
Nondurable Goods (Detail in Table 17)	15.2	19.4	21.7	21.8	31.7	37.0	43.0
Containers and Packaging (Detail in Table 22)	24.2	31.1	39.6	39.3	42.1	42.4	43.0
Total Nonfood Product Wastes	48.4	60.7	75.5	77.6	92.2	99.5	109.0
Other Wastes							
Food Wastes	12.2	12.7	12.8	13.4	13.2	13.2	13.2
Yard Wastes	20.0	21.6	23.2	25.2	27.5	30.0	31.1
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.5	2.7
Total Other Wastes	33.5	35.9	37.8	40.6	42.9	45.7	47.0
Total MSW Discarded - Weight	81.9	96.6	113.3	118.2	135.1	145.2	156.0

Products	Percent of Total Discards						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods							
Major Appliances	1.8	1.0	2.4	2.2	2.0	1.7	1.8
Furniture and Furnishings	2.6	2.8	3.0	3.5	3.8	4.0	4.8
Rubber Tires	0.9	1.1	1.4	1.9	1.9	1.2	1.3
Batteries, Lead-Acid	0.0	0.1	0.2	0.3	0.4	0.3	0.1
Miscellaneous Durables	5.7	5.6	5.6	6.0	5.6	6.5	6.7
Total Durable Goods	11.0	10.6	12.5	14.0	13.6	13.8	14.7
Nondurable Goods (Detail in Table 17)	18.6	20.1	19.2	18.4	23.5	25.5	27.6
Containers and Packaging (Detail in Table 23)	29.5	32.2	35.0	33.2	31.2	29.2	27.6
Total Nonfood Product Waste	59.1	62.8	66.6	65.7	68.2	68.5	69.9
Other Wastes							
Food Wastes	14.9	13.1	11.3	11.3	9.8	9.1	8.5
Yard Wastes	24.4	22.3	20.5	21.3	20.4	20.7	20.0
Miscellaneous Inorganic Wastes	1.6	1.7	1.6	1.7	1.6	1.7	1.7
Total Other Wastes	40.9	37.2	33.4	34.3	31.8	31.5	30.1
Total MSW Discarded - Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Discards after materials and compost recovery.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

In addition to rubber, tires include relatively small amounts of textiles and ferrous metals.

Lead-Acid Batteries. For the first time, generation of lead-acid automotive batteries has been included in this MSW report. This was made possible by extensive research for an EPA report on sources of lead and cadmium in MSW (Reference 17). Generation of these batteries amounted to 1.6 million tons in 1988.

Recovery of batteries for recycling fluctuates between 60 percent and 90 percent or higher. In 1988 an estimated 90 percent of the lead in these batteries was recovered for recycling as well as substantial quantities of the polypropylene battery casings, so discards after recycling of these batteries were decreased to about 200,000 tons in 1988. (Some electrolytes and other materials are also removed from MSW when the batteries are recycled, but it is thought that these materials are not recycled.) Lead-acid batteries comprised less than one percent of MSW generation in 1988.

Miscellaneous Durables. Miscellaneous durable goods include small appliances, consumer electronics such as television sets and video cassette recorders, and the like. An estimated 10.6 million tons of these goods were generated in 1988, amounting to almost 6 percent of MSW generated. Small amounts of ferrous metals are estimated to be recovered from this category, but not enough to affect discards significantly.

In addition to ferrous metals, this category includes plastics, glass, rubber, wood, and other metals.

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; and other miscellaneous products. (See Tables 15 through 17.)

Generation of nondurable goods in MSW was over 50 million tons in 1988 (28 percent of total generation). Recovery of paper products in this category is quite significant, resulting in over 7 million tons of recovery in 1988 (almost 15 percent of generation). This meant that 43 million tons of nondurable goods were discarded in 1988 (27.6 percent of discards).

Table 15

PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1988
(WITH DETAIL ON NONDURABLE GOODS)
(In millions of tons and percent of total generation)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 12)	9.4	11.1	15.1	17.5	19.7	21.5	24.9
Nondurable Goods							
Newspapers	7.1	8.3	9.5	8.8	11.0	12.5	13.3
Books and Magazines	1.9	2.2	2.5	2.3	3.4	4.7	5.3
Office Papers	1.5	2.2	2.7	2.6	4.0	5.7	7.3
Commercial Printing	1.3	1.8	2.1	2.1	3.1	3.2	4.1
Tissue Paper and Towels	1.1	1.5	2.1	2.1	2.3	2.7	3.0
Paper Plates and Cups	0.3	0.3	0.4	0.4	0.6	0.6	0.7
Plastic Plates and Cups	0.0	0.0	0.0	0.0	0.2	0.3	0.4
Disposable Diapers	0.0	0.0	0.3	1.2	2.3	2.9	2.7
Other Nonpackaging Paper	2.7	3.9	3.6	3.5	4.2	3.5	5.2
Clothing and Footwear	1.3	1.5	1.5	1.7	2.3	2.7	4.0
Other Miscellaneous Nondurables	0.4	0.5	0.8	0.9	3.1	3.8	4.6
Total Nondurable Goods	17.6	22.2	25.5	25.6	36.5	42.6	50.4
Containers and Packaging (Detail in Table 18)	27.3	34.2	43.5	44.4	50.5	51.8	56.8
Total Nonfood Product Wastes	54.3	67.5	84.1	87.5	106.7	115.9	132.1
Other Wastes							
Food Wastes	12.2	12.7	12.8	13.4	13.2	13.2	13.2
Yard Wastes	20.0	21.6	23.2	25.2	27.5	30.0	31.6
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.5	2.7
Total Other Wastes	33.5	35.9	37.8	40.6	42.9	45.7	47.5
Total MSW Generated - Weight	87.8	103.4	121.9	128.1	149.6	161.6	179.6

Products	Percent of Total Generation						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 12)	10.7	10.7	12.4	13.7	13.2	13.3	13.9
Nondurable Goods							
Newspapers	8.1	8.0	7.8	6.9	7.4	7.7	7.4
Books and Magazines	2.2	2.1	2.1	1.8	2.3	2.9	3.0
Office Papers	1.7	2.1	2.2	2.0	2.7	3.5	4.1
Commercial Printing	1.5	1.7	1.7	1.6	2.1	2.0	2.3
Tissue Paper and Towels	1.3	1.5	1.7	1.6	1.5	1.7	1.7
Paper Plates and Cups	0.3	0.3	0.3	0.3	0.4	0.4	0.4
Plastic Plates and Cups	0.0	0.0	0.0	0.0	0.1	0.2	0.2
Disposable Diapers	0.0	0.0	0.2	0.9	1.5	1.8	1.5
Other Nonpackaging Paper	3.1	3.8	3.0	2.7	2.8	2.2	2.9
Clothing and Footwear	1.5	1.5	1.2	1.3	1.5	1.7	2.2
Other Miscellaneous Nondurables	0.5	0.5	0.7	0.7	2.1	2.4	2.5
Total Nondurables	20.0	21.5	20.9	20.0	24.4	26.4	28.1
Containers and Packaging (Detail in Table 19)	31.1	33.1	35.7	34.7	33.8	32.1	31.6
Total Nonfood Product Wastes	61.8	65.3	69.0	68.3	71.3	71.7	73.5
Other Wastes							
Food Wastes	13.9	12.3	10.5	10.5	8.8	8.2	7.4
Yard Wastes	22.8	20.9	19.0	19.7	18.4	18.6	17.6
Miscellaneous Inorganic Wastes	1.5	1.5	1.5	1.6	1.5	1.5	1.5
Total Other Wastes	38.2	34.7	31.0	31.7	28.7	28.3	26.5
Total MSW Generated - Percent	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.
Source: Franklin Associates, Ltd.

Table 16

RECOVERY* OF PRODUCTS AND COMPOSTING OF FOOD AND YARD WASTE, 1960 TO 1988 (WITH DETAIL ON NONDURABLE GOODS)
(In millions of tons and percent of generation of each product)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 13)	0.4	0.9	0.9	1.0	1.3	1.4	1.9
Nondurable Goods							
Newspapers	1.8	2.0	2.3	2.4	3.0	3.5	4.4
Books and Magazines	0.1	0.1	0.3	0.2	0.4	0.5	0.7
Office Papers	0.3	0.4	0.7	0.7	1.0	1.1	1.6
Commercial Printing	0.1	0.2	0.3	0.3	0.4	0.5	0.6
Tissue Paper and Towels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paper Plates and Cups	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plastic Plates and Cups	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Disposable Diapers	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Nonpackaging Paper	0.1	0.1	0.2	0.2	0.0	0.0	0.0
Clothing and Footwear	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Miscellaneous Nondurables	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Nondurable Goods	2.4	2.8	3.8	3.8	4.8	5.6	7.4
Containers and Packaging (Detail in Table 20)	3.1	3.1	3.9	5.1	8.4	9.4	13.8
Total Nonfood Product Wastes	5.9	6.8	8.6	9.9	14.5	16.4	23.1
Other Wastes							
Food Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yard Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Miscellaneous Inorganic Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Total MSW Recovered - Weight	5.9	6.8	8.6	9.9	14.5	16.4	23.5

Products	Percent of Generation of Each Product						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 13)	4.3	8.1	6.0	5.7	6.6	6.5	7.5
Nondurable Goods							
Newspapers	25.4	24.1	24.2	27.3	27.3	28.0	33.3
Books and Magazines	5.3	4.5	12.0	8.7	11.8	10.6	13.2
Office Papers	20.0	18.2	25.9	26.9	25.0	19.3	22.5
Commercial Printing	7.7	11.1	14.3	14.3	12.9	15.6	14.6
Tissue Paper and Towels	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paper Plates and Cups	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plastic Plates and Cups	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Disposable Diapers	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Nonpackaging Paper	3.7	2.6	5.6	5.7	0.0	0.0	0.0
Clothing and Footwear	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Other Miscellaneous Nondurables	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Nondurables	13.6	12.6	14.9	14.8	13.2	13.1	14.6
Containers and Packaging (Detail in Table 21)	11.4	9.1	9.0	11.5	16.6	18.1	24.3
Total Nonfood Product Wastes	10.9	10.1	10.2	11.3	13.6	14.2	17.5
Other Wastes							
Food Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yard Wastes	0.0	0.0	0.0	0.0	0.0	0.0	1.6
Miscellaneous Inorganic Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Wastes	0.0	0.0	0.0	0.0	0.0	0.0	1.1
Total MSW Recovered- Percent	6.7	6.6	7.1	7.7	9.7	10.1	13.1

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

Table 17

PRODUCTS DISCARDED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1988
(WITH DETAIL ON NONDURABLE GOODS)
(In millions of tons and percent of total generation)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 14)	9.0	10.2	14.2	16.5	18.4	20.1	23.0
Nondurable Goods							
Newspapers	5.3	6.3	7.2	6.4	8.0	9.0	8.9
Books and Magazines	1.8	2.1	2.2	2.1	3.0	4.2	4.6
Office Papers	1.2	1.8	2.0	1.9	3.0	4.6	5.7
Commercial Printing	1.2	1.6	1.8	1.8	2.7	2.7	3.5
Tissue Paper and Towels	1.1	1.5	2.1	2.1	2.3	2.7	3.0
Paper Plates and Cups	0.3	0.3	0.4	0.4	0.6	0.6	0.7
Plastic Plates and Cups	0.0	0.0	0.0	0.0	0.2	0.3	0.4
Disposable Diapers	0.0	0.0	0.3	1.2	2.3	2.9	2.7
Other Nonpackaging Paper	2.6	3.8	3.4	3.3	4.2	3.5	5.2
Clothing and Footwear	1.3	1.5	1.5	1.7	2.3	2.7	3.9
Other Miscellaneous Nondurables	0.4	0.5	0.8	0.9	3.1	3.8	4.6
Total Nondurable Goods	15.2	19.4	21.7	21.8	31.7	37.0	43.0
Containers and Packaging (Detail in Table 22)	24.2	31.1	39.6	39.3	42.1	42.4	43.0
Total Nonfood Product Wastes	48.4	60.7	75.5	77.6	92.2	99.5	109.0
Other Wastes							
Food Wastes	12.2	12.7	12.8	13.4	13.2	13.2	13.2
Yard Wastes	20.0	21.6	23.2	25.2	27.5	30.0	31.1
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.5	2.7
Total Other Wastes	33.5	35.9	37.8	40.6	42.9	45.7	47.0
Total MSW Discarded - Weight	81.9	96.6	113.3	118.2	135.1	145.2	156.0

Products	Percent of Total Discards						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 14)	11.0	10.6	12.5	14.0	13.6	13.8	14.7
Nondurable Goods							
Newspapers	6.5	6.5	6.4	5.4	5.9	6.2	5.7
Books and Magazines	2.2	2.2	1.9	1.8	2.2	2.9	2.9
Office Papers	1.5	1.9	1.8	1.6	2.2	3.2	3.6
Commercial Printing	1.5	1.7	1.6	1.5	2.0	1.9	2.2
Tissue Paper and Towels	1.3	1.6	1.9	1.8	1.7	1.9	1.9
Paper Plates and Cups	0.4	0.3	0.4	0.3	0.4	0.4	0.4
Plastic Plates and Cups	0.0	0.0	0.0	0.0	0.1	0.2	0.2
Disposable Diapers	0.0	0.0	0.3	1.0	1.7	2.0	1.7
Other Nonpackaging Paper	3.2	3.9	3.0	2.8	3.1	2.4	3.3
Clothing and Footwear	1.6	1.6	1.3	1.4	1.7	1.9	2.5
Other Miscellaneous Nondurables	0.5	0.5	0.7	0.8	2.3	2.6	2.9
Total Nondurables	18.6	20.1	19.2	18.4	23.5	25.5	27.6
Containers and Packaging (Detail in Table 23)	29.5	32.2	35.0	33.2	31.2	29.2	27.6
Total Nonfood Product Wastes	59.1	62.8	66.6	65.7	68.2	68.5	69.9
Other Wastes							
Food Wastes	14.9	13.1	11.3	11.3	9.8	9.1	8.5
Yard Wastes	24.4	22.4	20.5	21.3	20.4	20.7	20.0
Miscellaneous Inorganic Wastes	1.6	1.7	1.6	1.7	1.6	1.7	1.7
Total Other Wastes	40.9	37.2	33.4	34.3	31.8	31.5	30.1
Total MSW Discarded - Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Discards after materials and compost recovery.
Details may not add to totals due to rounding.
Source: Franklin Associates, Ltd.

Paper and Paperboard Products. Paper and paperboard products in nondurable goods are summarized in Tables 15 through 17. A summary for 1988 was shown earlier in Table 4 and Figure 2.

Newspapers are the largest single component of this category, at 13.3 million tons generated in 1988 (7.4 percent of total MSW). Over 33 percent of newspapers generated were recovered for recycling in 1988, leaving about 9 million tons discarded (5.7 percent of MSW discarded).

Other paper products in nondurable goods include:

- Books and magazines (about 3 percent of total MSW generation in 1988)
- Office papers—copier paper, computer printout, stationery, etc. (about 4 percent of total MSW generation in 1988)
- Commercial printing—direct mail advertising, catalogs, newspaper inserts, etc. (2.3 percent of total MSW generation in 1988)
- Tissue paper and towels—facial and sanitary tissues, napkins, but not toilet tissue (less than 2 percent of total MSW generation in 1988)
- Paper plates and cups—paper plates, cups, glasses, bowls, and other food service products used in homes, commercial establishments like restaurants, and in institutional settings such as schools (about 0.4 percent of total MSW generation in 1988)
- Other nonpackaging papers—including posters, photographic papers, cards and games, etc. (about 3 percent of total MSW generation in 1988).

Overall generation of paper and paperboard products in nondurable goods was nearly 39 million tons in 1988 (about 22 percent of total MSW generation). While newspapers were recovered at the highest rate, other paper products were also recovered for recycling, and the overall recovery rate for paper in nondurables was about 19 percent in 1988 (Table 4). Thus 32 million tons of paper in nondurables were discarded in 1988.

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. Less than 400,000 tons of these products were generated in 1988, or about 0.2 percent of total MSW (see Tables 15 through 17).

Disposable Diapers. This category (which includes estimates of both infant diapers and adult incontinent products) is included as a line item for the first time in this report. An estimated 2.7 million tons of disposable diapers were generated in 1988, or 1.5 percent of total MSW generation. (Of this tonnage, 1.7 million tons is an adjustment for the urine and feces contained with the discarded diapers.) The materials portion of the diapers includes wood pulp, plastics (including the superabsorbent materials now present in most diapers), and tissue paper.

There has been some investigation of recycling/composting of disposable diapers, but no significant recovery was identified for 1988.

Clothing and Footwear. Generation of clothing and footwear was estimated to be 4 million tons in 1988 (about 2 percent of total MSW). This category has shown a gradual increase in tonnage over the years.

Textiles, rubber, and leather are the major materials components of this category, with some plastics present as well.

Some recovery of these products occurs, but the amounts are not believed to be significant enough to affect the estimates of discards. There is considerable reuse of clothing and footwear (e.g., through donation of these items to charitable organizations), but estimates of the amounts involved were not available. It is assumed that the reused clothing and footwear items eventually enter the waste stream, perhaps as rags.

Other Miscellaneous Nondurables. Generation of other miscellaneous nondurables was estimated to be 4.6 million tons in 1988 (2.5 percent of MSW). This category has been showing a fairly rapid rate of increase over the years.

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.

Containers and Packaging

Containers and packaging are a major portion of MSW, amounting to 56.8 millions tons of generation in 1988 (nearly 32 percent of total generation). Generation, recovery, and discards of containers and packaging are shown in detail in Tables 18 through 23.

While the weight of containers and packaging generated has increased steadily over the study period, the percentage by weight has actually declined since the early 1970s (Table 19). Substitution of relatively light packaging materials—plastics and aluminum—for heavier glass and steel has accounted for this trend.

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

Paper and Paperboard Containers and Packaging. Corrugated boxes are the largest single product category of MSW at 23 million tons generated, or 13 percent of total generation in 1988. Corrugated boxes also represent the largest single category of product recovery, at over 10 millions tons of recovery in 1988 (over 45 percent of boxes generated were recovered). After recovery, nearly 13 million tons of corrugated boxes were discarded, or 8 percent of MSW discards in 1988.

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 totalled nearly 33 million tons of MSW generation in 1988, or over 18 percent of total generation.

While recovery of corrugated boxes is by far the largest component of paper packaging recovery, small amounts of other paper packaging products are recovered (about 0.5 million tons in 1988). The overall recovery rate for paper and paperboard packaging in 1988 was 33.5 percent. Recovery of other paper packaging like folding boxes and sacks is mostly in the form of mixed papers, a low grade of waste paper.

Glass Containers. Glass containers and packaging include beer and soft drink bottles, wine and liquor bottles, and bottles and jars for food, cosmetics, and other products. Generation of these glass containers was over

Table 18

PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1988
(WITH DETAIL ON CONTAINERS AND PACKAGING)
(In millions of tons)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 12)	9.4	11.1	15.1	17.5	19.7	21.5	24.9
Nondurable Goods (Detail in Table 15)	17.6	22.2	25.5	25.6	36.5	42.6	50.4
Containers and Packaging							
Glass Packaging							
Beer and Soft Drink Bottles	1.4	2.6	5.6	6.3	6.7	5.7	5.4
Wine and Liquor Bottles	1.1	1.4	1.9	2.0	2.5	2.2	2.0
Food and Other Bottles & Jars	3.7	4.1	4.4	4.4	4.8	4.2	3.9
Total Glass Packaging	6.2	8.1	11.9	12.7	14.0	12.1	11.4
Steel Packaging							
Beer and Soft Drink Cans	0.6	0.9	1.6	1.3	0.5	0.1	0.1
Food and Other Cans	3.8	3.6	3.5	3.4	2.9	2.6	2.5
Other Steel Packaging	0.2	0.3	0.3	0.2	0.2	0.2	0.2
Total Steel Packaging	4.6	4.8	5.4	4.9	3.6	2.9	2.8
Aluminum Packaging							
Beer and Soft Drink Cans	0.1	0.1	0.3	0.5	0.9	1.3	1.4
Other Cans	0.0	0.0	0.1	0.0	0.0	0.0	0.1
Foil and Closures	0.1	0.2	0.2	0.3	0.3	0.3	0.3
Total Aluminum Pkg	0.2	0.3	0.6	0.8	1.2	1.6	1.8
Paper & Paperboard Pkg							
Corrugated Boxes	7.3	10.0	12.7	13.5	17.0	19.0	23.1
Milk Cartons	0.0	0.0	0.0	0.0	0.6	0.5	0.5
Folding Cartons	0.0	0.0	0.0	0.0	3.7	4.0	4.4
Other Paperboard Packaging	3.8	4.5	4.8	4.4	0.3	0.4	0.3
Bags and Sacks	0.0	0.0	0.0	0.0	3.4	3.1	2.9
Wrapping Papers	0.0	0.0	0.0	0.0	0.2	0.1	0.1
Other Paper Packaging	2.9	3.3	3.8	3.3	0.8	1.3	1.6
Total Paper & Board Pkg	14.0	17.8	21.3	21.2	26.0	28.4	32.9
Plastics Packaging							
Soft Drink Bottles	0.0	0.0	0.0	0.0	0.3	0.4	0.4
Milk Bottles	0.0	0.0	0.0	0.0	0.2	0.3	0.4
Other Containers	0.1	0.3	0.9	1.3	0.9	1.2	1.7
Bags and Sacks	0.0	0.0	0.0	0.0	0.4	0.6	0.8
Wraps	0.0	0.0	0.0	0.0	0.8	1.0	1.1
Other Plastics Packaging	0.1	0.7	1.2	1.4	0.8	1.0	1.2
Total Plastics Packaging	0.2	1.0	2.1	2.7	3.4	4.5	5.6
Wood Packaging	2.0	2.1	2.1	2.0	2.1	2.1	2.1
Other Misc. Packaging	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Total Containers & Pkg	27.3	34.2	43.5	44.4	50.5	51.8	56.8
Total Nonfood Product Wastes	54.3	67.5	84.1	87.5	106.7	115.9	132.1
Other Wastes							
Food Wastes	12.2	12.7	12.8	13.4	13.2	13.2	13.2
Yard Wastes	20.0	21.6	23.2	25.2	27.5	30.0	31.6
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.5	2.7
Total Other Wastes	33.5	35.9	37.8	40.6	42.9	45.7	47.5
Total MSW Generated - Weight	87.8	103.4	121.9	128.1	149.6	161.6	179.6

* Generation before materials recovery or combustion.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 19

PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1988
(WITH DETAIL ON CONTAINERS AND PACKAGING)
(In percent of total generation)

Products	Percent of Total Generation						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 12)	10.7	10.7	12.4	13.7	13.2	13.3	13.9
Nondurable Goods (Detail in Table 15)	20.0	21.5	20.9	20.0	24.4	26.4	28.1
Containers and Packaging							
Glass Packaging							
Beer and Soft Drink Bottles	1.6	2.5	4.6	4.9	4.5	3.5	3.0
Wine and Liquor Bottles	1.3	1.4	1.6	1.6	1.7	1.4	1.1
Food and Other Bottles & Jars	4.2	4.0	3.6	3.4	3.2	2.6	2.2
Total Glass Pkg	7.1	7.8	9.8	9.9	9.4	7.5	6.3
Steel Packaging							
Beer and Soft Drink Cans	0.7	0.9	1.3	1.0	0.3	0.1	0.1
Food and Other Cans	4.3	3.5	2.9	2.7	1.9	1.6	1.4
Other Steel Packaging	0.2	0.3	0.2	0.2	0.1	0.1	0.1
Total Steel Pkg	5.2	4.6	4.4	3.8	2.4	1.8	1.6
Aluminum Packaging							
Beer and Soft Drink Cans	0.1	0.1	0.2	0.4	0.6	0.8	0.8
Other Cans	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Foil and Closures	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Total Aluminum Pkg	0.2	0.3	0.5	0.6	0.8	1.0	1.0
Paper & Paperboard Pkg							
Corrugated Boxes	8.3	9.7	10.4	10.5	11.4	11.8	12.9
Milk Cartons	0.0	0.0	0.0	0.0	0.4	0.3	0.3
Folding Cartons	0.0	0.0	0.0	0.0	2.5	2.5	2.4
Other Paperboard Packaging	4.3	4.4	3.9	3.4	0.2	0.2	0.2
Bags and Sacks	0.0	0.0	0.0	0.0	2.3	1.9	1.6
Wrapping Papers	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Other Paper Packaging	3.3	3.2	3.1	2.6	0.5	0.8	0.9
Total Paper & Board Pkg	15.9	17.2	17.5	16.5	17.4	17.6	18.3
Plastics Packaging							
Soft Drink Bottles	0.0	0.0	0.0	0.0	0.2	0.2	0.2
Milk Bottles	0.0	0.0	0.0	0.0	0.1	0.2	0.2
Other Containers	0.1	0.3	0.7	1.0	0.6	0.7	1.0
Bags and Sacks	0.0	0.0	0.0	0.0	0.3	0.4	0.4
Wraps	0.0	0.0	0.0	0.0	0.5	0.6	0.6
Other Plastics Packaging	0.1	0.7	1.0	1.1	0.5	0.6	0.7
Total Plastics Pkg	0.2	1.0	1.7	2.1	2.3	2.8	3.1
Wood Packaging	2.3	2.0	1.7	1.6	1.4	1.3	1.2
Other Misc. Packaging	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Containers & Pkg	31.1	33.1	35.7	34.7	33.8	32.1	31.6
Total Nonfood Product Wastes	61.8	65.3	69.0	68.3	71.3	71.7	73.5
Other Wastes							
Food Wastes	13.9	12.3	10.5	10.5	8.8	8.2	7.4
Yard Wastes	22.8	20.9	19.0	19.7	18.4	18.6	17.6
Miscellaneous Inorganic Wastes	1.5	1.5	1.5	1.6	1.5	1.5	1.5
Total Other Wastes	38.2	34.7	31.0	31.7	28.7	28.3	26.5
Total MSW Generated - Percent	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.

Source: Franklin Associates, Ltd.

Table 20

RECOVERY* OF PRODUCTS AND COMPOSTING OF FOOD AND YARD WASTES, 1960 TO 1988 (WITH DETAIL ON CONTAINERS AND PACKAGING) (In millions of tons)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 13)	0.4	0.9	0.9	1.0	1.3	1.4	1.9
Nondurable Goods (Detail in Table 16)	2.4	2.8	3.8	3.8	4.8	5.6	7.4
Containers and Packaging							
Glass Packaging							
Beer and Soft Drink Bottles	0.1	0.1	0.1	0.4	0.8	1.0	1.1
Wine and Liquor Bottles	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Food and Other Bottles & Jars	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Total Glass Packaging	0.1	0.1	0.2	0.4	0.8	1.1	1.5
Steel Packaging							
Beer and Soft Drink Cans	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Food and Other Cans	0.0	0.1	0.1	0.1	0.1	0.1	0.4
Other Steel Packaging	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Steel Packaging	0.0	0.1	0.1	0.1	0.2	0.1	0.4
Aluminum Packaging							
Beer and Soft Drink Cans	0.0	0.0	0.0	0.1	0.3	0.6	0.8
Other Cans	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Foil and Closures	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Aluminum Pkg	0.0	0.0	0.0	0.1	0.3	0.6	0.8
Paper & Paperboard Pkg							
Corrugated Boxes	2.5	2.2	2.7	3.6	6.3	7.2	10.5
Milk Cartons	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Folding Cartons	0.0	0.0	0.0	0.0	0.5	0.2	0.3
Other Paperboard Packaging	0.3	0.4	0.5	0.5	0.0	0.0	0.0
Bags and Sacks	0.0	0.0	0.0	0.0	0.3	0.1	0.2
Wrapping Papers	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Paper Packaging	0.2	0.3	0.4	0.4	0.0	0.0	0.0
Total Paper & Board Pkg	3.0	2.9	3.6	4.5	7.1	7.5	11.0
Plastics Packaging							
Soft Drink Bottles	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Milk Bottles	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Containers	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bags and Sacks	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wraps	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Plastics Packaging	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Plastics Packaging	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Wood Packaging	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Misc. Packaging	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Containers & Pkg	3.1	3.1	3.9	5.1	8.4	9.4	13.8
Total Nonfood Product Wastes	5.9	6.8	8.6	9.9	14.5	16.4	23.1
Other Wastes							
Food Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yard Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Miscellaneous Inorganic Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Total MSW Recovered - Weight	5.9	6.8	8.6	9.9	14.5	16.4	23.5

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 21

RECOVERY* OF PRODUCTS AND COMPOSTING OF FOOD AND YARD WASTES, 1960 TO 1988 (WITH DETAIL ON CONTAINERS AND PACKAGING)

(In percent of generation of each product)

Products	Percent of Generation of Each Product						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 13)	4.3	8.1	6.0	5.7	6.6	6.5	7.5
Nondurable Goods (Detail in Table 16)	13.6	12.6	14.9	14.8	13.2	13.1	14.6
Containers and Packaging							
Glass Packaging							
Beer and Soft Drink Bottles	7.1	3.8	2.6	6.3	11.9	17.5	20.0
Wine and Liquor Bottles	0.0	0.0	0.5	0.0	0.0	4.5	5.0
Food and Other Bottles & Jars	0.0	0.0	0.5	0.0	0.0	0.0	8.1
Total Glass Pkg	1.6	1.2	1.5	3.1	5.7	9.1	13.3
Steel Packaging							
Beer and Soft Drink Cans	1.6	1.7	1.3	3.9	9.7	7.5	15.2
Food and Other Cans	0.5	1.2	1.8	2.7	5.2	4.3	15.0
Other Steel Packaging	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Steel Pkg	0.6	1.3	1.6	2.9	5.5	4.2	13.8
Aluminum Packaging							
Beer and Soft Drink Cans	0.0	0.0	5.1	27.0	37.0	51.0	55.0
Other Cans	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Foil and Closures	0.0	0.0	0.0	0.0	0.0	0.0	4.9
Total Aluminum Pkg	0.0	0.0	0.0	17.3	27.1	37.5	44.1
Paper & Paperboard Pkg							
Corrugated Boxes	34.2	22.0	21.3	26.7	37.1	37.9	45.4
Milk Cartons	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Folding Cartons	0.0	0.0	0.0	0.0	13.5	5.0	7.7
Other Paperboard Packaging	7.9	8.9	10.4	11.4	0.0	0.0	0.0
Bags and Sacks	0.0	0.0	0.0	0.0	8.8	3.2	7.0
Wrapping Papers	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Paper Packaging	6.9	9.1	10.5	12.1	0.0	0.0	0.0
Total Paper & Board Pkg	21.4	16.3	16.9	21.2	27.3	26.4	33.5
Plastics Packaging							
Soft Drink Bottles	0.0	0.0	0.0	0.0	4.6	18.7	21.0
Milk Bottles	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Other Containers	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bags and Sacks	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wraps	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Plastics Packaging	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Plastics Pkg	0.0	0.0	0.0	0.0	0.3	1.5	1.6
Wood Packaging	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Misc. Packaging	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Containers & Pkg	11.4	9.1	8.9	11.5	16.6	18.1	24.3
Total Nonfood Product Wastes	10.9	10.1	10.2	11.3	13.6	14.2	17.5
Other Wastes							
Food Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yard Wastes	0.0	0.0	0.0	0.0	0.0	0.0	1.6
Miscellaneous Inorganic Wastes	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Other Wastes	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Total MSW Recovered - Percent	6.7	6.6	7.0	7.7	9.7	10.1	13.1

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 22

PRODUCTS DISCARDED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1988
(WITH DETAIL ON CONTAINERS AND PACKAGING)
(In millions of tons)

Products	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 14)	9.0	10.2	14.2	16.5	18.4	20.1	23.0
Nondurable Goods (Detail in Table 17)	15.2	19.4	21.7	21.8	31.7	37.0	43.0
Containers and Packaging							
Glass Packaging							
Beer and Soft Drink Bottles	1.3	2.5	5.5	5.9	5.9	4.7	4.3
Wine and Liquor Bottles	1.1	1.4	1.9	2.0	2.5	2.1	1.9
Food and Other Bottles & Jars	3.7	4.1	4.4	4.4	4.8	4.2	3.6
Total Glass Packaging	6.1	8.0	11.7	12.3	13.2	11.0	9.9
Steel Packaging							
Beer and Soft Drink Cans	0.6	0.9	1.6	1.3	0.4	0.1	0.1
Food and Other Cans	3.8	3.5	3.4	3.3	2.8	2.5	2.1
Other Steel Packaging	0.2	0.3	0.3	0.2	0.2	0.2	0.2
Total Steel Packaging	4.6	4.7	5.3	4.8	3.4	2.8	2.4
Aluminum Packaging							
Beer and Soft Drink Cans	0.1	0.1	0.3	0.4	0.6	0.7	0.6
Other Cans	0.0	0.0	0.1	0.0	0.0	0.0	0.1
Foil and Closures	0.1	0.2	0.2	0.3	0.3	0.3	0.3
Total Aluminum Pkg	0.2	0.3	0.6	0.7	0.9	1.0	1.0
Paper & Paperboard Pkg							
Corrugated Boxes	4.8	7.8	10.0	9.9	10.7	11.8	12.6
Milk Cartons	0.0	0.0	0.0	0.0	0.6	0.5	0.5
Folding Cartons	0.0	0.0	0.0	0.0	3.2	3.8	4.1
Other Paperboard Packaging	3.5	4.1	4.3	3.9	0.3	0.4	0.3
Bags and Sacks	0.0	0.0	0.0	0.0	3.1	3.0	2.7
Wrapping Papers	0.0	0.0	0.0	0.0	0.2	0.1	0.1
Other Paper Packaging	2.7	3.0	3.4	2.9	0.8	1.3	1.6
Total Paper & Board Pkg	11.0	14.9	17.7	16.7	18.9	20.9	21.9
Plastics Packaging							
Soft Drink Bottles	0.0	0.0	0.0	0.0	0.3	0.3	0.3
Milk Bottles	0.0	0.0	0.0	0.0	0.2	0.3	0.4
Other Containers	0.1	0.3	0.9	1.3	0.9	1.2	1.7
Bags and Sacks	0.0	0.0	0.0	0.0	0.4	0.6	0.8
Wraps	0.0	0.0	0.0	0.0	0.8	1.0	1.1
Other Plastics Packaging	0.1	0.7	1.2	1.4	0.8	1.0	1.2
Total Plastics Packaging	0.2	1.0	2.1	2.7	3.4	4.4	5.5
Wood Packaging	2.0	2.1	2.1	2.0	2.1	2.1	2.1
Other Misc. Packaging	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Total Containers & Pkg	24.2	31.1	39.6	39.3	42.1	42.4	43.0
Total Nonfood Product Wastes	48.4	60.7	75.5	77.6	92.2	99.5	109.0
Other Wastes							
Food Wastes	12.2	12.7	12.8	13.4	13.2	13.2	13.2
Yard Wastes	20.0	21.6	23.2	25.2	27.5	30.0	31.1
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.5	2.7
Total Other Wastes	33.5	35.9	37.8	40.6	42.9	45.7	47.0
Total MSW Discarded - Weight	81.9	96.6	113.3	118.2	135.1	145.2	156.0

* Discards after materials and compost recovery.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 23

PRODUCTS DISCARDED* IN THE MUNICIPAL WASTE STREAM, 1960 TO 1988
(WITH DETAIL ON CONTAINERS AND PACKAGING)
(In percent of total discards)

Products	Percent of Total Discards						
	1960	1965	1970	1975	1980	1985	1988
Durable Goods (Detail in Table 14)	11.0	10.6	12.5	14.0	13.6	13.8	14.7
Nondurable Goods (Detail in Table 17)	18.6	20.1	19.2	18.4	23.5	25.5	27.6
Containers and Packaging							
Glass Packaging							
Beer and Soft Drink Bottles	1.6	2.6	4.8	5.0	4.4	3.2	2.8
Wine and Liquor Bottles	1.3	1.4	1.7	1.7	1.9	1.4	1.2
Food and Other Bottles & Jars	4.5	4.2	3.9	3.7	3.6	2.9	2.3
Total Glass Pkg	7.4	8.3	10.3	10.4	9.8	7.6	6.3
Steel Packaging							
Beer and Soft Drink Cans	0.7	0.9	1.4	1.1	0.3	0.1	0.1
Food and Other Cans	4.6	3.6	3.0	2.8	2.1	1.7	1.4
Other Steel Packaging	0.2	0.3	0.3	0.2	0.1	0.1	0.1
Total Steel Pkg	5.6	4.9	4.7	4.1	2.5	1.9	1.6
Aluminum Packaging							
Beer and Soft Drink Cans	0.1	0.1	0.3	0.3	0.4	0.5	0.4
Other Cans	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Foil and Closures	0.1	0.2	0.2	0.3	0.2	0.2	0.2
Total Aluminum Pkg	0.2	0.3	0.5	0.6	0.7	0.7	0.7
Paper & Paperboard Pkg							
Corrugated Boxes	5.9	8.1	8.8	8.4	7.9	8.1	8.1
Milk Cartons	0.0	0.0	0.0	0.0	0.4	0.3	0.3
Folding Cartons	0.0	0.0	0.0	0.0	2.4	2.6	2.6
Other Paperboard Packaging	4.3	4.2	3.8	3.3	0.2	0.3	0.2
Bags and Sacks	0.0	0.0	0.0	0.0	2.3	2.1	1.7
Wrapping Papers	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Other Paper Packaging	3.3	3.1	3.0	2.5	0.6	0.9	1.0
Total Paper & Board Pkg	13.4	15.4	15.6	14.1	14.0	14.4	14.0
Plastics Packaging							
Soft Drink Bottles	0.0	0.0	0.0	0.0	0.2	0.2	0.2
Milk Bottles	0.0	0.0	0.0	0.0	0.1	0.2	0.2
Other Containers	0.1	0.3	0.8	1.1	0.7	0.8	1.1
Bags and Sacks	0.0	0.0	0.0	0.0	0.3	0.4	0.5
Wraps	0.0	0.0	0.0	0.0	0.6	0.7	0.7
Other Plastics Packaging	0.1	0.7	1.1	1.2	0.6	0.7	0.8
Total Plastics Pkg	0.2	1.0	1.9	2.3	2.5	3.0	3.5
Wood Packaging	2.4	2.2	1.9	1.7	1.6	1.4	1.3
Other Misc. Packaging	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Containers & Pkg	29.5	32.2	35.0	33.2	31.2	29.2	27.6
Total Nonfood Product Wastes	59.1	62.8	66.6	65.7	68.2	68.5	69.9
Other Wastes							
Food Wastes	14.9	13.1	11.3	11.3	9.8	9.1	8.5
Yard Wastes	24.4	22.4	20.5	21.3	20.4	20.7	20.0
Miscellaneous Inorganic Wastes	1.6	1.7	1.6	1.7	1.6	1.7	1.7
Total Other Wastes	40.9	37.2	33.4	34.3	31.8	31.5	30.1
Total MSW Discarded - Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Discards after materials and compost recovery.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

11 million tons in 1988, or 6.3 percent of MSW generation (Tables 18 and 19). Production of glass containers has been declining in recent years.

An estimated 1.5 million tons of glass containers were recovered for recycling in 1988, or 13.2 percent of total generation. Glass beer and soft drink containers were estimated to be recovered at a 20 percent rate in 1988. After recovery for recycling, glass container discards were 10 million tons in 1988, or 6.4 percent of discards.

Steel Containers and Packaging. Steel beer and soft drink cans, food and other cans, and other steel packaging (e.g., strapping), totalled 2.8 million tons in 1988 (less than 2 percent of total generation), with most of that amount being "tin" cans for food (Tables 18 and 19). Relatively small amounts of steel cans are recovered for recycling—an estimated 400,000 tons in 1988, or 14 percent of generation in 1988. Generation of steel containers and packaging has been declining steadily.

Aluminum Containers and Packaging. Aluminum containers and packaging, a growth segment of MSW, include beer and soft drink cans, other cans, and foil and closures. Total aluminum container and packaging generation in 1988 was 1.8 million tons, or one percent of total generation.

Aluminum beer and soft drink cans were recovered at an estimated 55 percent rate in 1988. Recovery of all aluminum packaging was estimated to be 44 percent of total generation in 1988. After recovery for recycling, about one million tons of aluminum packaging were discarded in 1988. This represented less than one percent of MSW discards.

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

Plastic containers and packaging have exhibited rapid growth in MSW, with generation increasing from about 200,000 tons in 1960 (less than one percent of generation) to 5.6 million tons in 1988 (over 3 percent of generation). (Note: plastic packaging does not include the single service plates and cups classified as nondurables and discussed earlier.)

With the exception of soft drink bottles (about 21 percent estimated to have been recovered in 1988), recovery of postconsumer plastic containers and packaging has been at a very low rate in the past.

Other Packaging. Estimates are included for wood packaging and some other miscellaneous packaging like bags made of textiles, small amounts of leather, and the like. These quantities are not well documented.

Wood packaging includes wood crates and pallets. It was estimated that about 2 million tons of wood packaging were generated in 1988. This number has been held about constant over the years. Wood packaging was thus about one percent of total generation in 1988. It is known that some recovery of wood pallets takes place, but it is not considered to be significant enough to affect product discards in 1988.

Summary of Products in Municipal Solid Waste

Changing quantities and composition of municipal solid waste generation by product category are illustrated in Figure 10. 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 1988 is shown in Figure 11. Paper and paperboard made up 77 percent of nondurables in MSW generation, with plastics contributing over 9 percent. Other materials contributed lesser percentages. After recovery for recycling, paper and paperboard were 73 percent of nondurable discards, with plastics being almost 11 percent.

Figure 10. Generation of products in MSW, 1960 to 1988

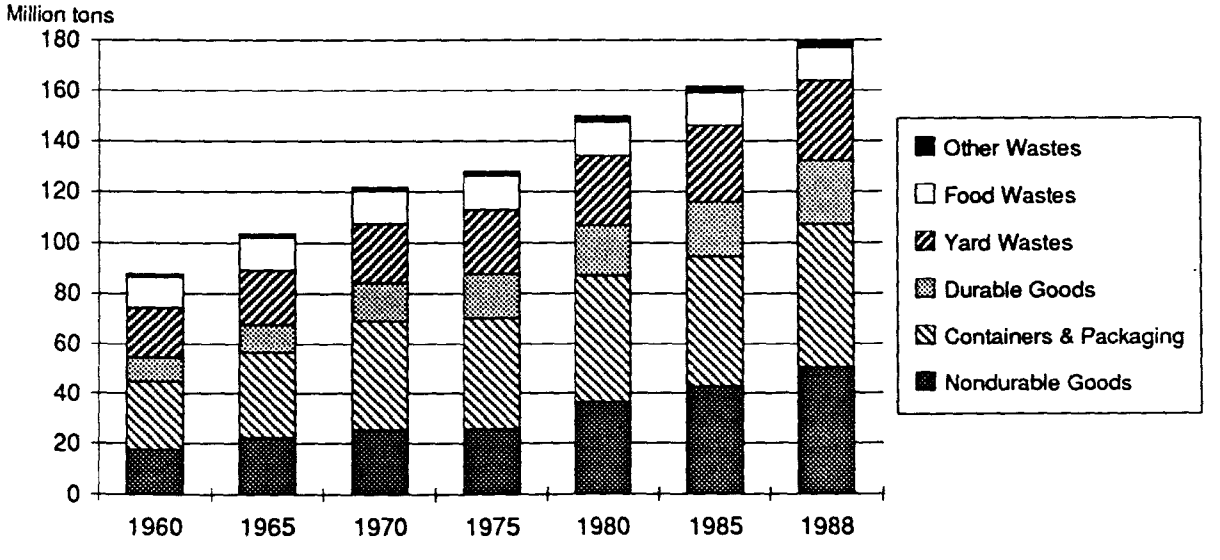
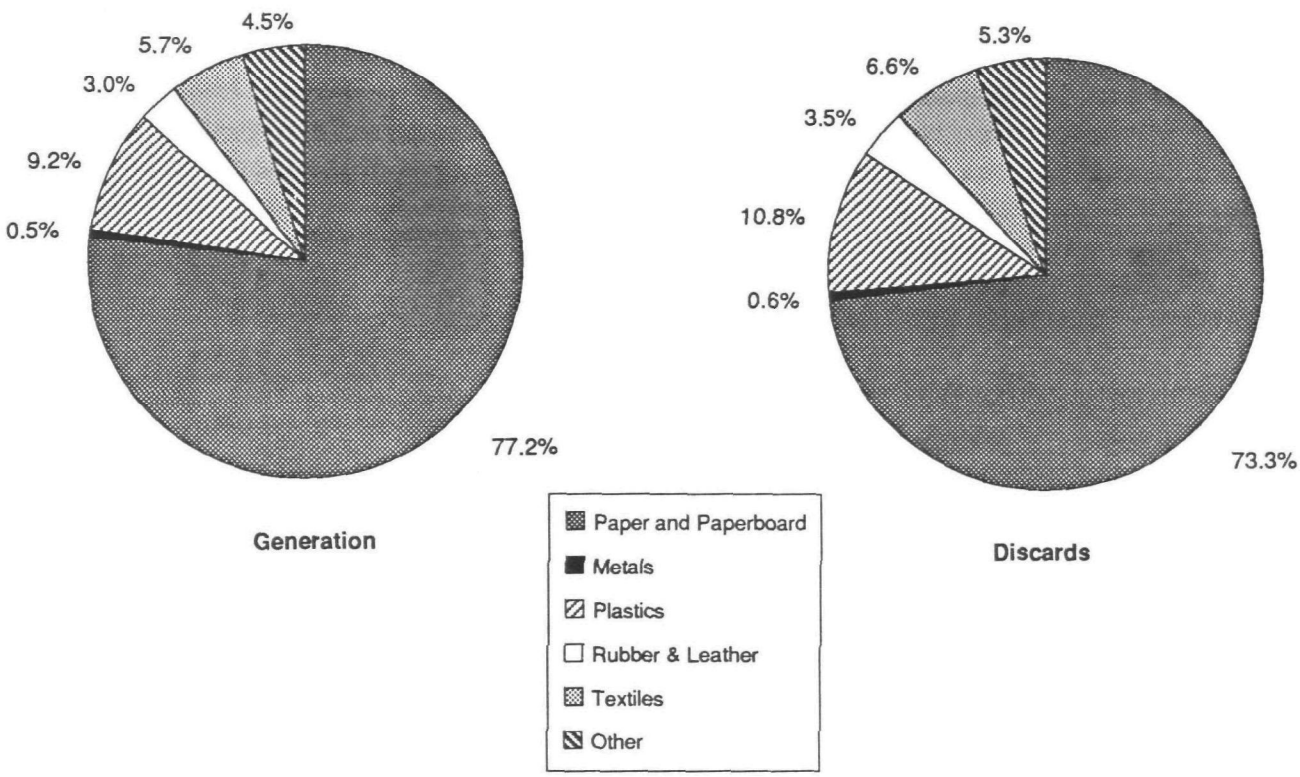


Figure 11. Generation and discards of nondurable goods, 1988



The materials composition of containers and packaging in MSW in 1988 is shown in Figure 12. Paper and paperboard products make up 58 percent of containers and packaging generation, with glass second at 20 percent of containers and packaging generation by weight. Recovery for recycling makes a significant change, with paper and paperboard being 51 percent of discards of containers and packaging discards after recovery takes place. Glass then become 23 percent of discards of containers and packaging, with other materials making up lesser amounts.

COMBUSTION OF MUNICIPAL SOLID WASTE

As described in Chapter 1, combustion of municipal solid waste ranks behind recycling and composting in the solid waste management hierarchy. Estimates of MSW combustion were made for this report. Most of the municipal solid waste combustion currently practiced in this country incorporates recovery of an energy product (generally steam or electricity); 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; recovery of energy started to become more prevalent in the 1970s.

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 no longer classified as MSW and it is not counted as MSW in this report. 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.

Combustion with Energy Recovery

Previous estimates of combustion with energy recovery were updated and expressed as a percent of MSW generation and MSW discards after recovery (Table 24). Surveys by EPA and the National Solid Wastes Management Association (References 18 and 19) were used as references. In addition, Franklin Associates conducted a limited literature search to update lists of facilities operational, under construction, or in planning.

Figure 12. Generation and discards of containers and packaging, 1988

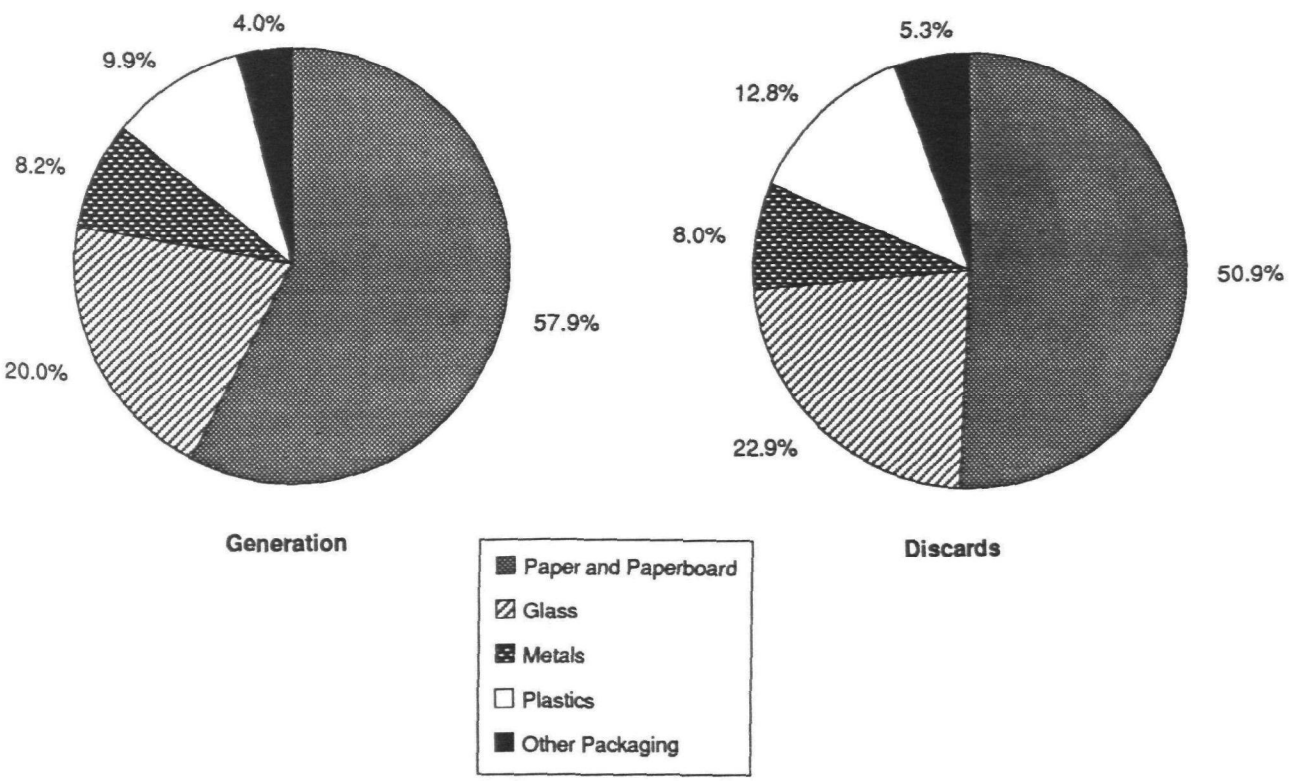


Table 24

COMBUSTION OF MUNICIPAL SOLID WASTE, 1960 TO 1988
(In millions of tons and percent)

	1960	1965	1970	1975	1980	1985	1988
Generation of MSW	87.8	103.4	121.9	128.1	149.6	161.6	179.6
Combustion with energy recovery							
Million tons	-	0.2	0.4	0.7	2.7	7.6	24.5
Percent of total generation	-	0.2	0.3	0.5	1.8	4.7	13.6
Combustion without energy recovery							
Million tons	27.0	26.8	24.7	17.8	11.0	4.1	1.0
Percent of total generation	30.8	25.9	20.3	13.9	7.4	2.5	0.6

Note: Residues from combustion of MSW are not classified as MSW in this report.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 25

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

	1960-1970	1970-1980	1980-1988	1986-1988	1987-1988
Paper & Paperboard	4.0	2.2	3.5	4.6	3.0
Glass	7.0	1.7	-2.2	-1.9	1.6
Metals	3.1	0.2	0.7	2.6	3.1
Plastics	22.8	9.8	7.9	8.6	7.8
All Other Materials*	3.5	3.4	2.6	5.9	5.5
Food Wastes	0.5	0.3	0.0	0.0	0.0
Yard Wastes	1.5	1.7	1.8	2.3	1.9
Total MSW	3.3	2.1	2.3	3.5	3.1
Population	1.2	1.1	1.0	1.0	1.0

* Rubber and leather, textiles, wood, batteries (partial) disposable diapers (partial), miscellaneous inorganics.

In most cases the facilities have a stated daily capacity, but they normally operate at less than capacity over the course of a year. When information on actual throughputs of MSW was unavailable for a facility, it was assumed for this report that throughput over a year of operation is 80 percent of rated capacity. While this is a more conservative assumption than those often used, it has proven to be reasonably accurate over the years. (While new facilities are reporting operation at very high utilization rates, other facilities do not meet the same standards for annual throughput as compared to rated capacity.)

The surveys revealed that combustion of MSW has increased rapidly since 1985, with numerous new facilities coming into operation. It was estimated that 24.5 million tons of MSW were combusted with energy recovery in 1988.

Combustion without Energy Recovery

Estimates of combustion without energy recovery have never been a part of this series of reports. To provide a more complete picture of historical MSW management, these estimates were added for this update (Table 24), although good sources of historical information are scarce.

Two sources were used to make these estimates: a 1979 survey of incineration facilities conducted by a committee of the American Society of Mechanical Engineers (Reference 20) and an EPA combustion study (Reference 21), which provided more recent information. The ASME survey provided information on the large numbers of MSW incinerators that were closed down during the 1960s and 1970s because of more stringent pollution control requirements imposed during that period. Using a very conservative estimate that throughput of MSW in these old incinerators was 60 percent of stated capacity, it was calculated that 27 million tons of MSW (30 percent of generation) were incinerated in 1960. The number may well have been higher based on the information available.

The estimates indicate that MSW combustion without energy recovery dropped steadily throughout the entire study period, to about 1.0 million tons in 1988. This trend is projected to continue. Some of these facilities have been shut down; others have been converted to energy recovery facilities.

CHANGING RATES OF MSW GENERATION

While generation of MSW is increasing overall, the individual components of the waste stream do not increase at the same rate, and in some instances, components actually decline. Some insight into this phenomenon can be gained from Table 25, which presents average annual percentage rates of increase or decrease for the major material categories in MSW.

Paper and paperboard, the largest component of MSW, increased at an average annual rate of 3.3 percent during the historical period 1960-1988. Growth was rapid in the 1960s, but average growth in the 1970s was damped by the severe recession in mid-decade. Growth resumed in the 1980s.

Glass generation in MSW grew at an overall average annual rate of 2.5 percent from 1960 to 1988. Most of the growth, however, occurred in the 1960s, when use of glass containers for beverages and other products increased rapidly. Since then, glass showed only a small annual increase in the 1970s, then decreasing annual percentages of growth.

Metals exhibit a similar pattern, although the rate of increase in the 1960s was not as pronounced. It should be noted that aluminum containers have continued to increase, while the heavier steel cans have declined.

Plastics in MSW have increased by an annual percentage of over 14 percent in the 1960 to 1988 historical period. Percentage growth was very rapid in the 1960s, when plastics generation started from a low base. Rapid growth has continued, although at a declining average annual rate.

Growth rates of the other materials in MSW have not been particularly remarkable. Total generation of MSW increased at an average annual rate of 2.6 percent in the 1960 to 1988 historical period. Growth was more rapid in the 1960s for the reasons outlined above.

SUMMARY OF HISTORICAL AND PROJECTED MSW MANAGEMENT

The series of tables and figures presented in this chapter make possible a comprehensive summary of historical municipal solid waste management. The study results are summarized in Table 26 and Figure 13. Municipal solid waste generation has grown steadily (except for occasional decreases during recession years) from 87.8 million tons in 1960 to almost 180 million tons in 1988.

Recovery for recycling and composting had little effect on the waste stream until the 1980s. Recovery was about 7 percent of generation in the 1960s and 1970s, then increased gradually to 13.1 percent (23.5 million tons) in 1988.

Adding estimates of combustion without energy recovery to the previously estimated combustion with energy recovery brings some interesting insights. It appears that over 30 percent of MSW generation was burned in 1960. This percentage declined steadily as the old incinerators were closed down due to air pollution regulations. Combustion with energy

recovery grew very slowly until the 1980s, with about 14 percent of MSW being combusted in 1988.

As Figure 13 graphically shows, discards of MSW to landfill or other disposal after materials recovery and combustion take place apparently peaked in the 1986-1987 period.

Table 26

GENERATION, MATERIALS RECOVERY, COMPOSTING, COMBUSTION, AND DISCARDS OF MUNICIPAL SOLID WASTE, 1960 TO 1988
(In millions of tons and percent of total generation)

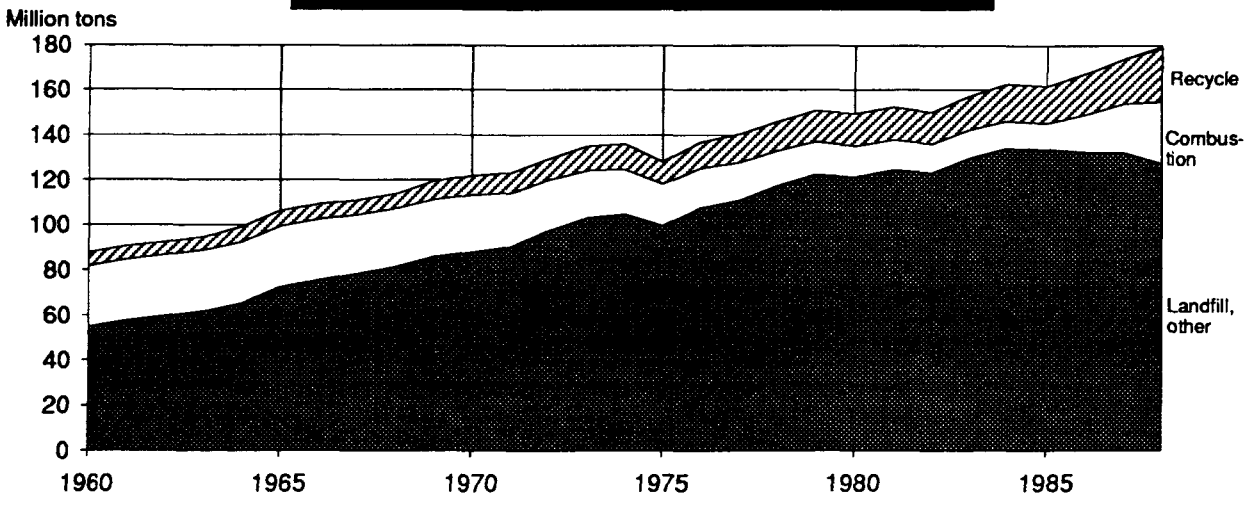
	Millions of Tons						
	1960	1965	1970	1975	1980	1985	1988
Generation	87.8	103.4	121.9	128.1	149.6	161.6	179.6
Recovery for Recycling	5.9	6.8	8.6	9.9	14.5	16.4	23.1
Recovery for Composting	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Total Materials Recovery	5.9	6.8	8.6	9.9	14.5	16.4	23.5
Discards after Recovery*	81.9	96.6	113.3	118.2	135.1	145.2	156.0
Combustion with Energy Recovery	0.0	0.2	0.4	0.7	2.7	7.6	24.5
Combustion without Energy Recovery	27.0	26.8	24.7	17.8	11.0	4.1	1.0
Total Combustion	27.0	27.0	25.1	18.5	13.7	11.7	25.5
Discards to Landfill, Other Disposal	54.9	69.6	88.2	99.7	121.4	133.5	130.5

	Percent of Total Generation						
	1960	1965	1970	1975	1980	1985	1988
Generation	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Recovery for Recycling	6.7	6.6	7.1	7.7	9.7	10.1	12.9
Recovery for Composting	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Total Materials Recovery	6.7	6.6	7.1	7.7	9.7	10.1	13.1
Discards after Recovery*	93.3	93.4	92.9	92.3	90.3	89.9	86.9
Combustion with Energy Recovery	0.0	0.2	0.3	0.5	1.8	4.7	13.6
Combustion without Energy Recovery	30.8	25.9	20.3	13.9	7.4	2.5	1.5
Total Combustion	30.8	26.1	20.6	14.4	9.2	7.2	14.2
Discards to Landfill, Other Disposal	62.5	67.3	72.4	77.8	81.1	82.6	72.7

* Does not include residues from recycling/composting processes.
** Does not include residues from recycling, composting, or combustion processes.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Figure 13. Municipal solid waste management, 1960 to 1988



This summary provides some perspective on why a landfill crisis developed in the 1980s. In the 1960s and early 1970s a large portion of MSW generation was burned. The remainder was not usually landfilled as we define landfill in the 1980s; that is, it was not compacted and buried in cells with cover material added daily. In fact, much of this waste was "dumped" and often it was burned at the dump to reduce its volume.

As the old incinerators were closed down and landfill requirements also became more stringent, while at the same time materials recovery rates were increasing very slowly, the burden on the nation's landfills grew dramatically. If, however, communities continue to increase the use of materials recovery, composting, and combustion as MSW management alternatives, the amount of MSW landfilled annually could decline substantially in the future.

Chapter 3

PROJECTIONS OF MSW GENERATION AND MANAGEMENT

INTRODUCTION

One of the useful features of this series of reports characterizing municipal solid waste in the United States is the projections of historical data into the future. For example, local officials planning for a new landfill must look at MSW disposal requirements in the future, typically over a 20-year time frame. While the data presented here should not be used as a substitute for site-specific data, the trends reflected in the national average data can provide some useful guidelines for local and regional planners.

It should be reemphasized that projections are not predictions. No one can foresee with accuracy changes in the economy (e.g., booms and recessions), which affect the municipal waste stream. In addition, it is difficult to predict new innovations and products that affect the amounts and types of MSW discards. For example, there have long been predictions of the "paperless office" due to improvements in electronic communications, but in fact, facsimile machines, high-speed copiers, and personal computers have generated unexpectedly large amounts of office papers.

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

OVERVIEW OF THIS CHAPTER

In this chapter, detailed projections of MSW generation, by material and by product, are presented through the year 2010 in the same format as the tables of historical MSW generation in Chapter 2. Projections of materials recovery and composting for the year 1995 are then presented. Finally, projections of combustion of MSW through the year 2000 are presented.

A summary table showing MSW generation, recovery, and discards of MSW in 1995 is included at the end of the chapter.

PROJECTIONS OF MSW GENERATION

Materials in Municipal Solid Waste

Projections of materials generated in MSW (by weight) are summarized in Table 27 and Figure 14, with a discussion of each material category following.

Paper and Paperboard. Projections of paper and paperboard generation in 1995 were based on a recent study sponsored by the American Paper Institute (Reference 34), with projections to later years assumed to maintain much the same patterns of growth.

Paper and paperboard is projected to continue to be the dominant material in MSW, reaching a generation of over 121 million tons in 2010. While paper and paperboard comprised 40 percent of MSW generation in 1988, it is projected to be 48 percent of generation in 2010.

Glass. As shown in Chapter 2, glass is a declining component of MSW, both in tonnage and in percentage of total generation. The decrease is mainly due to declining production of glass containers, which account for most of the glass in MSW. The decline is projected to continue. Thus glass generation is projected to decline from 12.5 million tons in 1988 to 9.5 million tons in 2010. Glass is projected to be less than 4 percent of MSW generation in 2010.

Ferrous Metals. Like glass containers, cans made of steel have been declining as a component of MSW. Unlike glass, however, more ferrous metals enter MSW as a component of durable goods than as containers. Since durable goods are an increasing component of MSW, ferrous metals in MSW were projected to increase very slightly, from 11.6 million tons in 1988 to 12 million tons in 2010. (Lighter materials like aluminum and plastics do replace heavier materials like steel in durable goods, but there is a long time lag before they are thrown away.)

It was projected than steel will comprise slightly less than 5 percent of MSW generation in 2010.

Aluminum. Containers and packaging represent the primary source of aluminum in MSW, although some aluminum is present in durables and nondurables. Aluminum in MSW has grown rapidly, and the growth is projected to continue, to 3.8 million tons in 2010. Because of its light weight, aluminum represents a small percentage of MSW generation—1.4 percent in 1988 and 1.5 percent in 2010.

Other Nonferrous Metals. Other nonferrous metals (e.g., lead, copper, and zinc) are found in durable goods like appliances, furniture, and batteries.

Table 27

PROJECTIONS OF MATERIALS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1995 TO 2010

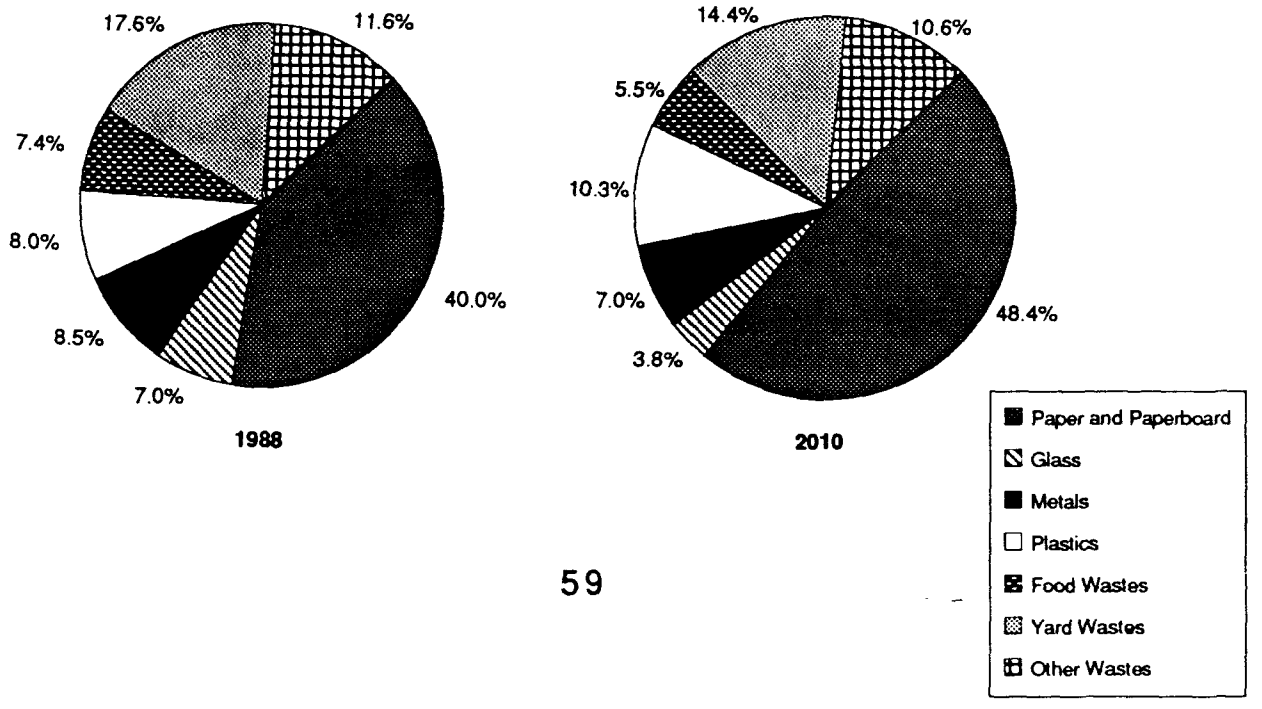
(In millions of tons and percent of total generation)

Materials	Millions of Tons			% of Total Generation		
	1995	2000	2010	1995	2000	2010
Paper and Paperboard	85.5	96.1	121.2	42.8	44.5	48.4
Glass	11.1	10.3	9.5	5.6	4.8	3.8
Metals						
Ferrous	11.7	12.0	12.0	5.9	5.5	4.8
Aluminum	3.1	3.5	3.8	1.6	1.6	1.5
Other Nonferrous	1.4	1.5	1.7	0.7	0.7	0.7
Total Metals	16.2	16.9	17.5	8.1	7.8	7.0
Plastics	18.6	21.1	25.7	9.3	9.8	10.3
Rubber and Leather	4.9	5.3	5.8	2.4	2.5	2.3
Textiles	4.1	4.3	4.6	2.0	2.0	1.8
Wood	7.4	8.4	10.2	3.7	3.9	4.1
Other	3.0	3.0	3.3	1.5	1.4	1.3
Total Nonfood Product Wastes	150.9	165.4	197.8	75.5	76.6	78.9
Other Wastes						
Food Wastes	13.2	13.3	13.7	6.6	6.2	5.5
Yard Wastes	33.0	34.4	36.0	16.5	15.9	14.4
Miscellaneous Inorganic Wastes	2.7	2.9	3.1	1.4	1.3	1.2
Total Other Wastes	48.9	50.6	52.8	24.5	23.4	21.1
Total MSW Generated	199.8	216.0	250.6	100.0	100.0	100.0

* Generation before materials recovery or combustion.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Figure 14. Materials generated in MSW, 1988 and 2010



Since lead-acid (automotive) batteries were added for this updated report, they represent the majority of this category. Generation of lead-acid batteries is projected to continue to increase, along with small increases in other nonferrous metals. Other nonferrous metals were estimated to be 1.1 million tons in 1988 and are projected to be 1.7 million tons in 2010. These metals are expected to continue to be less than one percent of MSW generation.

Plastics. Generation of plastics in MSW has grown very rapidly in the past three decades, but the rate of increase has been slowing, which is typical of products that achieve sizeable market penetration. Plastics in MSW are projected to continue to increase both in tonnage (from 14.4 million tons in 1988 to 25.7 million tons in 2010) and in percentage of total generation (from 8 percent of total in 1988 to over 10 percent in 2010).

Other Materials. Other materials in MSW--rubber, leather, textiles, and wood--are projected to have modest growth in tonnage and nearly "flat" percentages of total generation.

Food Wastes. Sampling studies over a long period of time show food wastes to be a declining percentage of the waste stream. Per capita discards of food wastes have also been declining over time, which can be explained by the increased use of preprocessed food in homes, institutions, and restaurants, and by the increased use of garbage disposers, which put food wastes into sewer systems rather than MSW. In making the projections of food wastes, it was assumed that per capita discards will decline slightly until the year 2000, then stay flat. This means that the tonnage of food wastes increases slightly, and their percentage of total MSW continues to decline, to 5.5 percent in 2010 compared to 7.4 percent in 1988.

Yard Wastes. Based on sampling studies, yard wastes have been declining as a percentage of MSW, although they have been increasing slightly on a per capita basis. In making projections, it was assumed that per capita discards of yard wastes would remain constant after 1988. As population increases, this means that yard wastes are projected to continue to increase, from over 31.6 million tons in 1988 to 36 million tons in 2010. As a percentage of MSW generation, yard wastes are projected to decline from 17.6 percent in 1988 to 14.4 percent in 2010.

Projected Growth Rates for Materials in MSW. Projected growth rates for the various materials generated in MSW are shown in Table 28. Projected population growth rates (from the Bureau of the Census) are included as well, and it is important to note that the rates of population increase are projected to decline to only one-half of one percent annually between 2000 and 2010. Two materials categories--paper and paperboard and plastics--are projected to increase at annual rates greater than population growth, although at rates lower than experienced in the past.

Table 28

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

	1960-1970	1970-1980	1980-1988	1988-2000	2000-2010
Paper & Paperboard	4.0	2.2	3.5	2.5	2.4
Glass	7.0	1.7	-2.2	-1.6	-0.8
Metals	3.1	0.2	0.7	0.8	0.3
Plastics	22.8	9.8	7.9	3.2	2.0
All Other Materials*	3.5	3.4	2.6	0.7	0.7
Food Wastes	0.5	0.3	0.0	0.1	0.3
Yard Wastes	1.5	1.7	1.8	0.7	0.5
Total MSW	3.3	2.1	2.3	1.6	1.5
Population	1.2	1.1	1.0	0.7	0.5

* Rubber and leather, textiles, wood, batteries (partial) disposable diapers (partial), miscellaneous inorganics.

Table 29

PROJECTED PER CAPITA GENERATION OF MSW, BY MATERIAL, 1988 TO 2010 (In pounds per person per day)

Materials	**1988**	**1995**	**2000**	**2010**
Paper and Paperboard	1.60	1.80	1.96	2.35
Glass	0.28	0.23	0.21	0.18
Metals	0.34	0.34	0.35	0.34
Plastics	0.32	0.39	0.43	0.50
Rubber and Leather	0.10	0.10	0.11	0.11
Textiles	0.09	0.09	0.09	0.09
Wood	0.14	0.16	0.17	0.20
Other	0.07	0.06	0.06	0.06
Total Nonfood Products	2.94	3.18	3.38	3.84
Food Wastes	0.29	0.28	0.27	0.27
Yard Wastes	0.70	0.70	0.70	0.70
Miscellaneous Inorganic Wastes	0.06	0.06	0.06	0.06
Total MSW Generated	4.00	4.21	4.41	4.86

* 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.

Generation of other materials categories is projected to continue to decline (glass) or to increase at rates of less than one percent per year.

Overall, municipal solid waste generation is projected to increase at a rate of 1.6 percent annually between 1988 and 2000 and 1.5 percent annually between 2000 and 2010.

Projected Generation of MSW Per Person. Some further insight into projected generation of materials in MSW can be gained from Table 29, which presents projected per capita generation by material category. Paper and paperboard and plastics, which are projected to grow at a faster annual rate than population, will grow in per capita generation. Other materials will decline in per capita generation or will increase only slightly. Overall, it is projected that per capita MSW generation will increase from 4 pounds per person per day in 1988 to 4.86 pounds per person per day in 2010.

Products in Municipal Solid Waste

Projected generation of the products in municipal solid waste is summarized in Table 30 and Figure 15. It is no surprise that all categories are projected to grow in tonnage. Some interesting observations can, however, be made on the relative percentage rankings of the product categories. In 1988, containers and packaging ranked first, at over 31 percent of total generation, with nondurables second at 28 percent. By the year 2000, it is projected that nondurables will surpass containers and packaging as the largest category (by weight). In 2010, nondurable goods will comprise over 34 percent of total generation, while containers and packaging will be about 30 percent.

More detailed observations on the projected growth in the individual product categories follow.

Durable Goods. Overall, durable goods are projected to increase in MSW generation, although not as a percentage of total generation (Table 31). The trends in generation of major appliances and furniture and furnishings are well established by production numbers, since lifetimes of up to 20 years are assumed. Generation of rubber tires, lead-acid batteries, and miscellaneous durables are projected based on historical trends, which are generally "flat" or exhibit low rates of growth.

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

Table 30

PROJECTIONS OF CATEGORIES OF PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1995 TO 2010

(In millions of tons and percent of total generation)

Products	Millions of Tons			% of Total Generation		
	1995	2000	2010	1995	2000	2010
Durable Goods (Detail in Table 31)	28.6	31.3	35.7	14.3	14.5	14.3
Nondurable Goods (Detail in Table 32)	60.5	68.3	86.3	30.3	31.6	34.4
Containers and Packaging (Detail in Table 33)	61.9	65.7	75.8	31.0	30.4	30.2
Total Nonfood Product Wastes	150.9	165.4	197.8	75.5	76.6	78.9
Other Wastes						
Food Wastes	13.2	13.3	13.7	6.6	6.2	5.5
Yard Wastes	33.0	34.4	36.0	16.5	15.9	14.4
Miscellaneous Inorganic Wastes	2.7	2.9	3.1	1.4	1.3	1.2
Total Other Wastes	48.9	50.6	52.8	24.5	23.4	21.1
Total MSW Generated	199.8	216.0	250.6	100.0	100.0	100.0

* Generation before materials recovery or combustion.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Figure 15. Products generated in MSW, 1988 and 2010

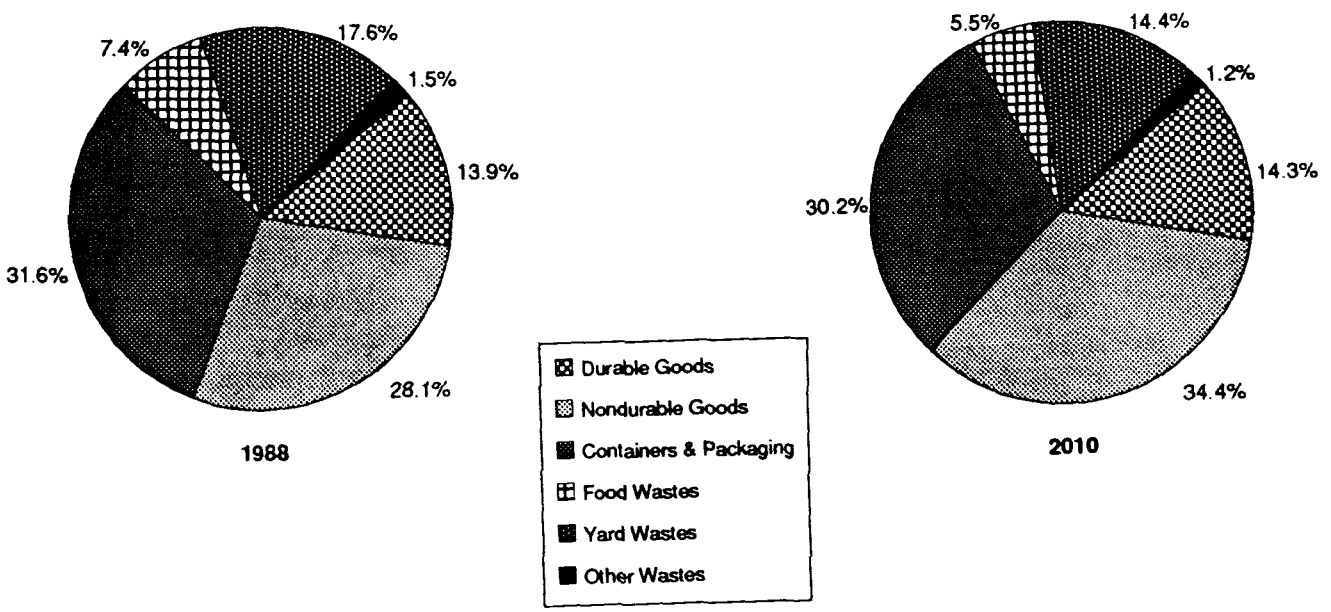


Table 31

PROJECTIONS OF PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1995 TO 2010 (WITH DETAIL ON DURABLE GOODS)

(In millions of tons and percent of total generation)

Products	Millions of Tons			% of Total Generation		
	1995	2000	2010	1995	2000	2010
Durable Goods						
Major Appliances	3.2	3.3	3.1	1.6	1.5	1.2
Furniture and Furnishings	8.8	10.0	12.3	4.4	4.6	4.9
Rubber Tires	2.0	2.1	2.2	1.0	1.0	0.9
Batteries, Lead-Acid	2.0	2.2	2.6	1.0	1.0	1.0
Miscellaneous Durables	12.6	13.8	15.6	6.3	6.4	6.2
Total Durable Goods	28.6	31.3	35.7	14.3	14.5	14.3
Nondurable Goods (Detail in Table 32)	60.5	68.3	86.3	30.3	31.6	34.4
Containers and Packaging (Detail in Table 33)	61.9	65.7	75.8	31.0	30.4	30.2
Total Nonfood Product Wastes	150.9	165.4	197.8	75.5	76.6	78.9
Other Wastes						
Food Wastes	13.2	13.3	13.7	6.6	6.2	5.5
Yard Wastes	33.0	34.4	36.0	16.5	15.9	14.4
Miscellaneous Inorganic Wastes	2.7	2.9	3.1	1.4	1.3	1.2
Total Other Wastes	48.9	50.6	52.8	24.5	23.4	21.1
Total MSW Generated	199.8	216.0	250.6	100.0	100.0	100.0

* Generation before materials recovery or combustion.
Details may not add to totals due to rounding.

Table 32

PROJECTIONS OF PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1995 TO 2010 (WITH DETAIL ON NONDURABLE GOODS)

(In millions of tons and percent of total generation)

Products	Millions of Tons			% of Total Generation		
	1995	2000	2010	1995	2000	2010
Durable Goods (Detail in Table 31)	28.6	31.3	35.7	14.3	14.5	14.3
Nondurable Goods						
Newspapers	15.0	16.4	19.4	7.5	7.6	7.7
Books and Magazines	6.8	8.1	12.0	3.4	3.8	4.8
Office Papers	9.8	11.8	16.0	4.9	5.5	6.4
Commercial Printing	5.7	6.8	9.0	2.8	3.1	3.6
Tissue Paper and Towels	3.6	4.1	5.1	1.8	1.9	2.0
Paper Plates and Cups	0.7	0.7	0.7	0.3	0.3	0.3
Plastic Plates and Cups	0.5	0.6	0.7	0.3	0.3	0.3
Disposable Diapers	2.4	2.3	2.4	1.2	1.1	1.0
Other Nonpackaging Paper	5.9	6.6	8.2	2.9	3.0	3.3
Clothing and Footwear	4.5	4.9	5.3	2.3	2.3	2.1
Other Miscellaneous Nondurables	5.5	6.1	7.3	2.8	2.8	2.9
Total Nondurable Goods	60.5	68.3	86.3	30.3	31.6	34.4
Containers and Packaging (Detail in Table 33)	61.9	65.7	75.8	31.0	30.4	30.2
Total Nonfood Product Wastes	150.9	165.4	197.8	75.5	76.6	78.9
Other Wastes						
Food Wastes	13.2	13.3	13.7	6.6	6.2	5.5
Yard Wastes	33.0	34.4	36.0	16.5	15.9	14.4
Miscellaneous Inorganic Wastes	2.7	2.9	3.1	1.4	1.3	1.2
Total Other Wastes	48.9	50.6	52.8	24.5	23.4	21.1
Total MSW Generated	199.8	216.0	250.6	100.0	100.0	100.0

* Generation before materials recovery or combustion.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Nondurable Goods. As noted above, generation of nondurable goods has been increasing rapidly, and this trend is projected to continue (Table 32). Over 86 million tons of nondurable goods are projected to be generated in 2010, or over 34 percent of total generation.

In 1988, paper products were over 77 percent of nondurables generated; it is projected that paper products will be over 81 percent of nondurables generated in 2010. These projections are based on trends developed in a study for the American Paper Institute (Reference 34). Books and magazines, office papers, and commercial printing are projected to increase their share of total generation more rapidly than other products. Newspapers, tissue papers, and other nonpackaging papers also are projected to increase, but not so rapidly.

Based on historical trends, paper plates and cups were projected to show no increase in tonnage or percentage; plastic plates and cups were projected to show growth in tonnnage, although not in percentage of total generation. (The plates and cups categories include hinged containers and other foodservice items, and it was assumed that there will be no widespread bans of disposable foodservice items.)

Because of declining birth rates and processes that make individual diapers smaller and lighter, disposable diapers began to shown a decline in weight generated after 1985, and generation of disposable diapers was projected to remain rather "flat," which means that they decline as a percentage of total generation. (It was assumed that there will be no widespread bans of disposable diapers.)

Clothing and footwear were projected to continue to experience the same slow growth exhibited in the past; these items thus will be a declining percentage of total generation.

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

Containers and Packaging. As discussed earlier, historically containers and packaging have been the largest single category of MSW generation. This is projected to change, however, as nondurables are projected to exceed containers and packaging by the year 2000 (Table 33).

Tonnage of glass packaging generated has been in decline since the early 1980s as glass was displaced by lighter materials like aluminum and plastics. These trends were projected to continue; glass containers are projected to be a declining percentage of MSW generation (just over 3 percent of total generation in 2010).

Table 33

PROJECTIONS OF PRODUCTS GENERATED* IN THE MUNICIPAL WASTE STREAM, 1995 TO 2010 (WITH DETAIL ON CONTAINERS AND PACKAGING)

(In millions of tons and percent of total generation)

Products	Millions of Tons			% of Total Generation		
	1995	2000	2010	1995	2000	2010
Durable Goods (Detail in Table 31)	28.6	31.3	35.7	14.3	14.5	14.3
Nondurable Goods (Detail in Table 32)	60.5	68.3	86.3	30.3	31.6	34.4
Containers and Packaging						
Glass Packaging						
Beer and Soft Drink Bottles	3.8	2.8	2.0	1.9	1.3	0.8
Wine and Liquor Bottles	2.0	2.0	2.0	1.0	0.9	0.8
Food and Other Bottles & Jars	4.0	4.1	4.0	2.0	1.9	1.6
Total Glass Packaging	9.8	8.9	8.0	4.9	4.1	3.2
Steel Packaging						
Beer and Soft Drink Cans	0.1	0.1	0.2	0.1	0.1	0.1
Food and Other Cans	2.2	2.0	1.6	1.1	0.9	0.6
Other Steel Packaging	0.2	0.2	0.3	0.1	0.1	0.1
Total Steel Packaging	2.5	2.3	2.0	1.3	1.1	0.8
Aluminum Packaging						
Beer and Soft Drink Cans	1.8	2.1	2.2	0.9	0.9	0.9
Other Cans	0.1	0.1	0.1	0.0	0.0	0.0
Foil and Closures	0.3	0.4	0.4	0.2	0.2	0.2
Total Aluminum Pkg	2.2	2.5	2.7	1.1	1.2	1.1
Paper & Paperboard Pkg						
Corrugated Boxes	27.6	31.2	39.9	13.8	14.5	15.9
Milk Cartons	0.5	0.4	0.4	0.2	0.2	0.2
Folding Cartons	5.0	5.1	5.1	2.5	2.3	2.0
Other Paperboard Packaging	0.3	0.3	0.3	0.2	0.1	0.1
Bags and Sacks	2.5	2.2	2.0	1.2	1.0	0.8
Wrapping Papers	0.1	0.1	0.1	0.0	0.0	0.0
Other Paper Packaging	2.0	2.3	2.9	1.0	1.0	1.2
Total Paper & Board Pkg	38.0	41.6	50.7	19.0	19.3	20.2
Plastics Packaging						
Soft Drink Bottles	0.6	0.7	0.9	0.3	0.3	0.3
Milk Bottles	0.5	0.5	0.6	0.2	0.2	0.2
Other Containers	2.4	2.7	3.5	1.2	1.3	1.4
Bags and Sacks	1.0	1.2	1.6	0.5	0.6	0.6
Wraps	1.3	1.4	1.6	0.7	0.6	0.6
Other Plastics Packaging	1.4	1.6	1.9	0.7	0.7	0.8
Total Plastics Packaging	7.1	8.1	10.1	3.6	3.8	4.0
Wood Packaging	2.1	2.1	2.1	1.0	1.0	0.8
Other Misc. Packaging	0.2	0.2	0.3	0.1	0.1	0.1
Total Containers & Pkg	61.9	65.7	75.8	31.0	30.4	30.2
Total Nonfood Product Wastes	150.9	165.4	197.8	75.5	76.6	78.9
Other Wastes						
Food Wastes	13.2	13.3	13.7	6.6	6.2	5.5
Yard Wastes	33.0	34.4	36.0	16.5	15.9	14.4
Miscellaneous Inorganic Wastes	2.7	2.9	3.1	1.4	1.3	1.2
Total Other Wastes	48.9	50.6	52.8	24.5	23.4	21.1
Total MSW Generated	199.8	216.0	250.6	100.0	100.0	100.0

* Generation before materials recovery or combustion.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Steel packaging generation has also been declining for much the same reasons as glass, and steel packaging is also projected to be a declining percentage of MSW generation (less than one percent of total generation in 2010).

Tonnage of aluminum packaging has been increasing steadily over the historical period, and this trend is projected to continue. Because of its light weight, however, aluminum stays at just over one percent of total generation in the projections.

Like other paper and paperboard products, overall generation of paper and paperboard packaging has been increasing rapidly. The increase is almost all in corrugated boxes, which are mainly used for shipping other products. Continued increases in generation of corrugated boxes are projected; tonnage of these boxes is projected to be 40 million tons in 2010, or 16 percent of total MSW generation. All paper and paperboard packaging is projected to be 20 percent of total generation in 2010.

Generation of other paper and paperboard packaging has not exhibited the same growth, generally due to displacement by plastic packaging. Thus generation of milk cartons, other folding cartons, and other paperboard packaging is projected to be almost "flat," while generation of paper bags and sacks is projected to decline, following historical trends.

Plastics packaging has exhibited rapid historical growth, and the trends are projected to continue. Soft drink bottles, milk bottles, other containers, bags and sacks, wraps, and other packaging are all projected to follow the increasing trends. Generation of all plastics packaging is projected to be 10 million tons in 2010, or 4 percent of total generation.

PROJECTIONS OF MSW RECOVERY

In past reports in this series, recovery of municipal solid waste for recycling has been projected along with projections of MSW generation. As demonstrated in Chapter 2, these projections were relatively easy to make because recovery rates tended to change slowly, if at all. The situation, however, changed dramatically in the late 1980s. A high level of interest in municipal solid waste management in general, and in recycling and composting in particular, has developed. Government agencies at all levels are seeking ways to stimulate materials recovery. Local communities are adding materials recovery and recycling programs so rapidly that there is no accurate nationwide accounting system. In response to the demand for more recovery and more markets for recovered products, industry associations and individual companies have invested large amounts of money and effort in developing new recycling programs and products containing recovered materials.

Because the situation is so fluid, and because accurate current (1990) data on recycling and composting programs are difficult to obtain, EPA has chosen to make projections of MSW recovery in a range, and to limit the projections to 1995.

Discussion of Assumptions

Some general assumptions and principles were used in making the recovery estimates for 1995:

- Recovery includes both recovery for recycling and for composting. Recovery does not always equal recycling, however, and residues left after composting or recycling are not accounted for.

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

- It was assumed that there will not be a nationwide deposit law for beverage containers, but that the present state deposit laws will remain in place.

- It was assumed that affected industries will continue to emphasize recovery and recycling programs, and will make the necessary investments to meet their goals.

- It was assumed that the current trend toward banning certain yard wastes in landfills will continue, providing stimulus for composting programs.

- Based on the preceding assumptions, most U.S. citizens will have access to recovery options in 1995, which will often, in fact, be mandated. These options will include curbside collection, dropoff and buyback centers, and, in some instances, mixed waste processing facilities.

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

Table 34

ESTIMATED RANGES OF RECOVERY AND COMPOSTING OF SELECTED PRODUCTS, 1995
(In millions of tons and percent of generation of each material)

Products	Million tons		% of generation	
	Low	High	Low	High
Paper and Paperboard				
Newspapers	6.8	8.3	45.0	55.0
Books and magazines	1.0	1.7	15.0	25.0
Office papers	2.0	2.9	20.0	30.0
Commercial printing	0.9	1.4	15.0	25.0
Corrugated boxes	15.2	17.4	55.0	63.0
Other paper and paperboard	0.6	0.9	2.9	4.4
Total Paper & Paperboard	26.5	32.6	31.0	38.0
Glass Containers				
Beer and soft drink bottles	1.3	1.7	35.0	45.0
Other glass containers	0.8	1.4	13.0	17.5
Total Glass Containers	2.1	3.1	22.0	32.0
Ferrous Metals				
Beer and soft drink cans	<0.1	<0.1	45.0	55.0
Other steel containers	1.0	1.2	45.0	55.0
Ferrous in durables	0.5	1.1	6.8	16.8
Total Ferrous Metals	1.5	2.4	12.8	20.5
Aluminum				
Beer and soft drink cans	1.1	1.4	60.0	75.0
Other aluminum packaging	<0.1	<0.1	6.5	17.5
Total Aluminum Packaging	1.1	1.4	50.0	64.0
Plastics				
Soft drink bottles	0.1	0.2	25.0	40.0
Milk/water bottles	<0.1	0.1	10.0	25.0
Other plastic packaging	0.2	0.7	3.8	11.5
Total Plastics Packaging	0.4	1.1	6.0	15.0
Batteries (lead only)	0.8	0.9	85.0	95.0
Composting				
Food wastes	0.0	1.0	0.0	7.6
Yard wastes	6.6	11.0	20.0	33.3
Other materials*	1.2	2.2	--	--
Total Recovery	40.1	55.3	20.0	27.7

* Plastic and other materials in batteries; rubber; wood; textiles.

Source: Franklin Associates, Ltd.

Assumptions and Projections for Specific Products and Materials

For the reasons stated above, assumptions as to the projected recovery rates for specific products and materials were made in ranges. While it is certainly possible that any given product will be recovered at higher or lower rates than those given here, it should be noted that no one material alone can affect the "bottom line" significantly.* The ranges of recovery assumptions for specific products are shown in Table 34.

* If, for example, yard wastes in the "Low" range of recovery (Table 34) were recovered at a rate of 33.3 percent instead of 20 percent (and all other recovery rates were held equal), then the overall recovery rate would be 22.3 percent instead of 20 percent. Materials comprising less tonnage in MSW will affect the overall recovery rates even less.

Paper and paperboard product recovery rate ranges were built around the industry goal of 35 percent postconsumer recovery in 1995 (Reference 34). To reach the high range projected (38 percent postconsumer recovery), 55 percent of newspapers and 63 percent of corrugated boxes would be recovered. Office papers, books and magazines, and commercial printing (direct mail, advertising inserts) would be recovered at rates of up to 30 percent. It was assumed that there would be some recycling of other paper products like paper towels and napkins, posters and cards, other paper packaging, etc. Reaching these high recovery rates will require that new markets for recovered papers be developed over and above those the industry has commited to. Since paper is the dominant material in MSW, both in generation and in current recovery, these assumptions are particularly important.

Of all **glass** products, beer and soft drink bottles are recovered at the highest rate (20 percent in 1988). It was projected that these bottles will be recovered at rates between 35 and 45 percent in 1995. This assumes that current beverage container deposit laws will stay in place and that the collection rate will be doubled through other recycling programs. Also, there will be additional recovery of other glass containers (mostly food bottles and jars) under the projected scenarios.

Ferrous metals are recovered from durable goods (appliances) and from containers (cans). It was assumed that 45 to 55 percent of steel beverage cans will be recovered in 1995 (partly through collection programs and partly through magnetic separation at processing facilities). It was assumed that 45 to 55 percent of other steel cans will be similarly collected, and that up to 17 percent of the ferrous metals in appliances will be recovered at shredding facilities.

According to industry sources, **aluminum** beverage cans are currently recovered at rates exceeding 60 percent, and it was projected that they will be recovered at a 60 to 75 percent rate in 1995. Some additional recovery of other aluminum packaging was also projected. (While recovery rates for aluminum cans are high, the tonnage is relatively small and does not affect total recovery rates very much.)

Plastic soft drink bottles were recovered at a rate of 21 percent in 1988, and a 25 to 40 percent recovery rate was projected for 1995. This assumes that current collection in beverage container deposit states continues, and that additional recovery is achieved through collection programs. In addition, it was projected that these programs will recover 10 to 25 percent of plastic milk/water bottles and up to 12 percent of other plastic packaging. Since overall recovery of plastics in MSW is currently at very low rates, achievement of the projected recovery rates will require development of new collection infrastructure and markets for recovered plastics.

It was projected that the lead in automotive **batteries** will be recovered at an 85 to 95 percent rate in 1995, which is not a significant increase over the rates that have already been achieved.

Since yard wastes are the second-largest component in MSW, programs to recover these wastes are an important part of the projections. There is new emphasis on **compost** programs, and it was projected that these programs will remove 20 to 33 percent of yard wastes from MSW by 1995. In addition, it was assumed that enough food waste composting programs will be in place to remove up to 8 percent of food wastes from MSW in 1995. Since recovery of food and yard wastes for compost was estimated to be at very low levels in 1988, achieving these projections will require some fundamental changes in waste management practices at many locations.

Some recovery of other materials (e.g., rubber, wood, and textiles) was projected for 1995, but the quantities are not large enough to affect the overall recovery rate significantly.

Summary of Recovery Projections

The range of projected recovery and composting of materials in 1995 is shown in Table 35 and Figure 16. Projected composite recovery rates range

Figure 16. Materials recovery and composting projections, 1995

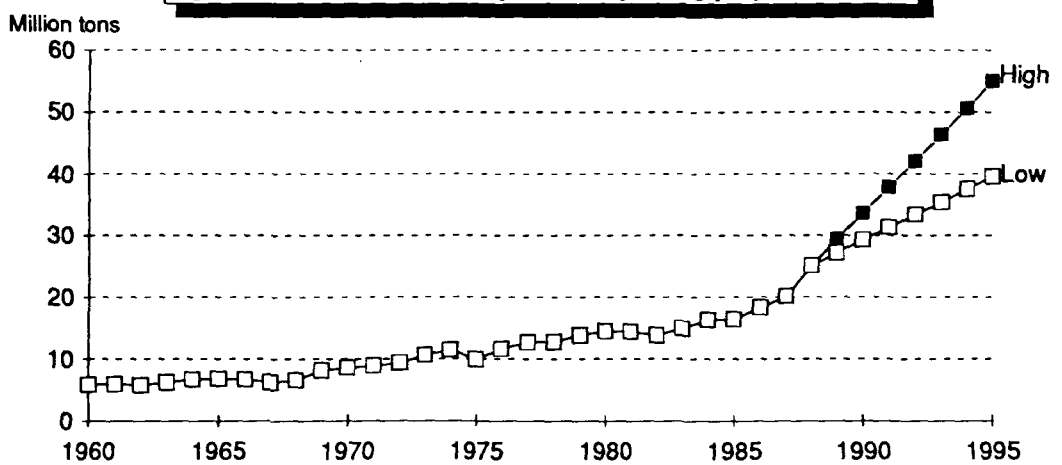


Table 35

PROJECTED GENERATION AND ESTIMATED RANGES OF RECOVERY* AND COMPOSTING, 1995
(In millions of tons and percent of generation of each material)

Materials	Generation	Recovery Million tons Low	Recovery Million tons High	Recovery % of generation Low	Recovery % of generation High
Paper and Paperboard	85.5	26.3	32.6	30.8	38.1
Glass	11.1	2.1	3.1	18.9	27.9
Metals					
Ferrous	11.7	1.5	2.4	12.8	20.4
Aluminum	3.1	1.1	1.4	35.4	45.1
Other Nonferrous	1.4	0.8	0.9	58.4	65.7
Total Metals	16.2	3.4	4.7	21.0	29.0
Plastics	18.6	0.5	1.3	2.7	6.7
Rubber	4.9	0.1	0.3	2.0	5.4
Food Wastes	13.2	0.0	1.0	0.0	7.6
Yard Wastes	33.0	6.6	11.0	20.0	33.3
Other Materials**	17.2	1.1	1.3	6.4	7.3
	199.8	40.1	55.3	20.0	27.7

* Recovery of postconsumer wastes; does not include converting/fabrication scrap.
** Includes electrolytes and other materials removed with recycled batteries. May not be recycled.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

from 20 to 27.7 percent of MSW generation in 1995. Paper and paperboard products account for the largest tonnage recovery at either end of the range, with yard wastes contributing the second largest tonnage. Metals and glass will also contribute significant tonnage, with other materials making lesser contributions.

Recovered tonnage of materials made a significant increase between 1987 and 1988 (Figure 16). At the high end of the recovery projections, it is assumed that materials collection can be increased and materials markets can be found to sustain this growth. At the lower end of the recovery projections, recovery would grow in the more moderate pattern of previous years. Increasing recovery beyond the high end projections means that some fundamental changes will have to be made in the ways our wastes are managed.

PROJECTIONS OF MSW DISCARDS

Projected ranges of 1995 discards of materials in MSW after recovery for recycling and composting are summarized in Table 36. This table is derived simply by subtracting the projected 1995 materials recovery ranges from the

Table 36

PROJECTED RANGE OF DISCARDS OF MATERIALS IN THE MUNICIPAL WASTE STREAM, 1995
(In millions of tons and percent of total discards)

Materials	Million tons		% of discards	
	High	Low	High	Low
Paper and Paperboard	59.2	52.9	36.6	37.0
Glass	9.0	8.0	5.5	5.6
Metals				
Ferrous	10.2	9.3	6.4	6.4
Aluminum	2.0	1.7	1.2	1.3
Other Nonferrous	0.6	0.5	0.3	0.4
Total Metals	12.8	11.5	8.0	8.0
Plastics	18.1	17.3	12.0	11.3
Rubber and Leather	4.8	4.6	3.2	3.0
Food Wastes	13.2	12.2	8.4	8.3
Yard Wastes	26.4	22.0	15.2	16.5
Other Materials**	16.1	15.9	11.0	10.1
	159.8	144.5	100.0	100.0

Note: High estimates of discards correspond to low estimates of recovery.
* Discards after materials and compost recovery.
** Textiles, wood, other.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

projected MSW generation in 1995. The table illustrates the obvious fact that higher recovery of materials results in lower quantities of MSW to be discarded to landfills, combustion, or other disposal. The percentage of total discards calculated for each material in MSW also changes depending upon the recovery range, since both the total quantity of discards and the discards in each product category change, and the recovery and discards of the various materials change at different rates.

PROJECTIONS OF MSW COMBUSTION

As described in Chapter 2, surveys of municipal solid waste combustion facilities were used to develop historical combustion estimates. These same surveys were used to identify facilities that are under construction or in the planning stages. The surveys indicate that numerous new facilities are scheduled to come into operation in the 1990s. Using this information, it was projected that 45.5 million tons of MSW will be combusted in 1995 and about 55 million tons in the year 2000 (Table 37). This amounts to nearly 23 percent of MSW generation in 1995 and over 25 percent in 2000.

Table 37

PROJECTIONS OF COMBUSTION OF MUNICIPAL SOLID WASTE, 1988 TO 2000 (In millions of tons and percent)

	1988	1995	2000
Generation of MSW	179.6	199.8	216.0
Combustion with energy recovery	24.5	45.0	55.0
Combustion without energy recovery	1.0	0.5	0.1
Total Combustion	25.5	45.5	55.1
Percent of Generation	14.2	22.8	25.5

Note: Residues from combustion of MSW are not classified as MSW in this report.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Table 38

GENERATION, RECOVERY, COMBUSTION, AND DISPOSAL OF MUNICIPAL SOLID WASTE, 1988 AND 1995 (In millions of tons and percent of total generation)

	Millions of Tons		% of Generation	
	1988	1995	1988	1995
Generation	179.6	199.8	100.0	100.0
Recovery for Recycling	23.1	38.8	12.9	19.4
Recovery for Composting	0.5	9.5	0.3	4.8
*Total Materials Recovery**	23.5	48.3	13.1	24.2
Discards after Recovery**	156.0	151.5	86.9	75.8
Combustion with Energy Recovery	24.5	45.0	13.6	22.5
Combustion without Energy Recovery	1.0	0.5	1.5	0.3
Total Combustion	25.5	45.5	14.2	22.8
Landfill, Other Disposal***	130.5	106.0	72.7	53.1

* Mid-range recovery estimates.
** Does not include residues from recycling/composting processes.
*** Does not include residues from recycling, composting, or combustion processes.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

While substantial amounts of MSW were burned without energy recovery in past years, most of these older facilities have been closed due to air pollution requirements. It is projected that all major facilities for combustion of MSW will have energy recovery in the future.

SUMMARY OF MSW MANAGEMENT IN 1995

Table 38 presents a summary of the 1995 projections presented in this chapter, with similar figures for 1988 included for contrast. From 1988 to 1995, generation of MSW is projected to increase by 1.5 percent per year compared to 2.3 percent per year between 1980 and 1988. Using mid-range projections, recovery for recycling and composting increases significantly, and combustion also is projected to increase significantly. The remaining discards to landfill and other disposal are thus projected to decrease between 1988 and 1995. In 1988, an estimated 73 percent of MSW generated was sent to landfill or other disposal. If mid-range projections of recovery are used, 53 percent of MSW generation will be landfilled in 1995. This does not mean, however, that landfill capacity will not be a problem, since landfill capacity may continue to decline more repidly than discards requiring management by landfilling.

Chapter 4

ADDITIONAL PERSPECTIVES ON MUNICIPAL SOLID WASTE

INTRODUCTION

This chapter provides some additional perspectives on characterization of municipal solid waste. The first section presents an analysis, by material, of MSW generation, materials recovery, and discards in 1988, the most recent year for which historical data are available. The second section presents the data series in terms of pounds per person per day. Finally, MSW is characterized in terms of the fractions that are combustible and noncombustible.

MUNICIPAL SOLID WASTE IN 1988

Generation, recovery for recycling and composting, and discards of the materials in MSW are summarized in Table 39. This table illustrates again the effect of recovery on MSW. Paper and paperboard, for instance, amounted to 40 percent of MSW generation in 1988. Over 18 million tons of paper and paperboard were recovered for recycling in 1988, leaving discards of these products at about 34 percent of MSW. To cite another example, plastics were 8 percent of MSW generation in 1988. Plastics were recycled at a low rate--slightly over one percent--and therefore the percentage of plastics in MSW discards after recycling increased to over 9 percent.

DISCARDS BY INDIVIDUALS

Municipal solid waste planners often think in terms of generation and discards on a per capita basis. Tables 40 and 41 present the data series developed in Chapter 2 of this report on the basis of pounds per person per day. In Table 40, generation, recovery, combustion, and landfill or other disposal are all summarized. The top line shows a steady increase in per capita generation of MSW, from 2.66 pounds per person per day in 1960 to 4.0 pounds per person per day in 1988.

After recovery for recycling and composting takes place, discards are lowered to 3.48 pounds per person per day in 1988. Of these discards, an estimated 0.61 pounds per person per day were combusted and 2.87 pounds per person per day were disposed by landfilling or some other method.

In Table 41, per capita generation of each material category characterized in this study is shown.

COMBUSTIBLES/NONCOMBUSTIBLES

The composition of MSW in terms of combustible and noncombustible fractions is of interest to planners of combustion facilities and others working with MSW. This information is shown in Table 42. The combustible fraction of MSW has been increasing steadily since 1975, from 76 percent combustibles in 1975 to 83 percent in 1988.

These changes are readily explained by the changing composition of MSW. The percentages of paper and plastics have been increasing steadily, while use of glass and steel, particularly in containers and packaging, has been decreasing.

Table 39

GENERATION, MATERIALS RECOVERY AND COMPOSTING, AND DISCARDS OF MATERIALS IN MUNICIPAL SOLID WASTE, 1988
(In millions of tons and percent)

	Generation		Recovery for Recycling & Composting		Discards*	
Materials	Million Tons	% of Total Generation	Million Tons	% of Material Generation	Million Tons	% of Total Discards
Paper and Paperboard	71.8	40.0	18.4	25.6	53.4	34.2
Glass	12.5	7.0	1.5	12.0	11.0	7.1
Ferrous Metals	11.6	6.5	0.7	5.8	10.9	7.0
Aluminum	2.5	1.4	0.8	31.7	1.7	1.1
Other Nonferrous Metals	1.1	0.6	0.7	65.1	0.4	0.3
Total Metals	*15.3*	*8.5*	*2.2*	*14.6*	*13.1*	*8.4*
Plastics	14.4	8.0	0.2	1.1	14.3	9.1
Rubber and Leather	4.6	2.5	0.1	2.3	4.4	2.9
Textiles	3.9	2.1	Neg.	0.6	3.8	2.5
Wood	6.5	3.6	Neg.	Neg.	6.5	4.2
Other	3.1	1.7	0.7	21.7	2.4	1.6
Total Nonfood Product Wastes	132.1	73.5	23.1	17.5	109.0	69.9
Other Wastes						
Food Wastes	13.2	7.4	Neg.	Neg.	13.2	8.5
Yard Wastes	31.6	17.6	0.5	1.6	31.1	20.0
Misc. Inorganic Wastes	2.7	1.5	Neg.	Neg.	2.7	1.7
Total Wastes	179.6	100.0	23.5	13.1	156.0	100.0

* Discards after recovery for recycling and composting, but before combustion.
Neg. = Negligible
Details may not add to totals due to rounding.

Source: Tables 1 through 3.

Table 40

PER CAPITA GENERATION, MATERIALS RECOVERY, COMBUSTION, AND NET DISCARDS OF MUNICIPAL SOLID WASTE, 1960 TO 1988
(In pounds per person per day; population in thousands)

	1960	1970	1980	1988
Generation	2.66	3.27	3.61	4.00
Recovery for Recycling and Composting	0.18	0.23	0.35	0.52
Discards after Recovery*	2.48	3.04	3.26	3.48
Combustion	0.82	0.67	0.33	0.61
Discards to Landfill, Other Disposal**	1.67	2.37	2.93	2.87
Population (thousands)	180,671	203,984	227,255	245,807

* Does not include residues from recycling/composting processes.
** Does not include residues from recycling, composting, or combustion processes.
Details may not add to totals due to rounding.
Population figures from Bureau of the Census, Current Population Reports.

Table 41

PER CAPITA GENERATION OF MUNICIPAL SOLID WASTE, BY MATERIAL, 1960 TO 1988
(In pounds per person per day)

Materials	1960	1970	1980	1988
Paper and Paperboard	0.91	1.19	1.32	1.60
Glass	0.20	0.34	0.36	0.28
Metals	0.32	0.38	0.35	0.34
Plastics	0.01	0.08	0.19	0.32
Rubber and Leather	0.06	0.09	0.10	0.10
Textiles	0.05	0.05	0.06	0.09
Wood	0.09	0.11	0.12	0.14
Other	0.00	0.02	0.07	0.07
Total Nonfood Products	1.65	2.26	2.57	2.94
Food Wastes	0.37	0.34	0.32	0.29
Yard Wastes	0.61	0.62	0.66	0.70
Miscellaneous Inorganic Wastes	0.04	0.05	0.05	0.06
Total MSW Generated	2.66	3.27	3.61	4.00

* 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.

Table 42

COMPOSITION OF MUNICIPAL SOLID WASTE DISCARDS* BY COMBUSTIBLE AND NONCOMBUSTIBLE FRACTIONS, 1960 TO 1988
(In percent of total discards)

Year	Combustibles	Noncombustibles**
1960	77.9	22.2
1965	78.5	21.5
1970	75.3	24.7
1975	75.7	24.3
1980	78.0	22.0
1985	81.1	18.9
1988	82.8	17.2

* Discards after materials recovery has taken place, and before combustion.
** Includes glass, metals, and miscellaneous inorganics.
Details may not add to totals due to rounding.

Source: Table 3.

Chapter 5

CHARACTERIZATION OF MUNICIPAL SOLID WASTE BY VOLUME

INTRODUCTION

Solid waste is generally characterized by weight, either in pounds or tons. Most statistics are compiled by weight, landfill operators generally charge fees by weight, estimates of quantities are stated in tons, and the remainder of this report uses tons or millions of tons to specify the quantity of MSW.

However, it has been realized for many years that the space occupied by waste is also important. Landfills do not get overweight. Their space fills up. It would be useful to quantify MSW by cubic yards of space occupied, than by tons of weight. However, volume measurements are far more complex to make than weight measurements. Volume measurements are very contextual. A pound of paper is a pound of paper no matter whether it is in flat sheets, crumpled into a wad, or compacted into a bale. However, the volume occupied will be very different in each case. Perhaps the one-pound wad of paper will occupy as much as ten times the volume of a pound of baled paper.

Another problem with volume measurement of MSW is the difficulty in establishing a typical set of environmental conditions to serve as a basis for comparison. We may agree that volumes of MSW in landfills are of most interest right now, but the difficulty arises as to how to define typical landfill conditions. Every waste management system treats waste differently, and achieves different levels of compaction and therefore different volumes for different materials. The waste also degrades with time. As waste remains in a landfill, the surroundings may become more acidic, and the gases in the landfill convert from air to other chemicals, perhaps changing the strength and other physical characteristics of materials. The moisture conditions will also change with time. This makes it extremely difficult to devise a set of standard environmental conditions to serve as a basis for volume measures.

In addition, weight can be readily and rapidly measured with a set of scales. People agree that properly calibrated scales will accurately measure weight. But, there is no agreed upon method for measuring volume.

Many people are beginning to make judgements about the rate at which various materials are filling up landfills. Their decisions are not based on a realistic database, because there has never been a consistent set of measurements taken. Thus, it becomes important to try to develop a set of volume factors for MSW to initiate the process of determining a scientific

basis for decision-making. While it is difficult to attain a high degree of accuracy in volume measurements because of the complexity of the problem, a reasonable approach can shed light on these issues.

Because of the desirability of establishing a national consensus on solid waste volumes, a series of measurements was taken in 1989 to present for the first time a methodology for measuring volumes and to generate a preliminary set of data (Reference 22). This chapter is based in part on the results reported in that document. A comparison of the results published in that report to the results reported here is presented later.

METHODOLOGY

The Garbage Project at the University of Arizona, where the experimental work was done, has published landfill volume data on a variety of MSW components as a result of a series of landfill sampling projects. Those results were used where possible. Many components are permanently deformed during the collection, compaction and landfilling processes. These include glass, metals, and wood. However, other materials are resilient and change their volume quite easily. These include paper and plastics, and to a lesser extent, textiles, rubber, food and yard wastes. It was concluded that additional work was needed on these components. Paper and plastics comprise more than 43 percent of MSW discards, so the focus in this work was on those two components.

Occasional historical data for volumes of paper and plastics as MSW components have been published in the past, but no systematic approach has been used to set out specific formats for volume measures. The context chosen for the measurements was average or typical conditions in a modern landfill, which is properly licensed and operating under standards of good practice. To understand the role of various MSW components, data were sought for separate components. Finally, these measures were extended to a composite waste stream to model national average or typical landfill composition.

The basic approach was to develop an experimental program to measure a set of density factors for solid waste components, measured in pounds per cubic yard. The MSW weight data reported in millions of tons (from Chapter 2) were converted to millions of pounds, and the MSW volume in millions of cubic yards was calculated by dividing the weight values by the density (in pounds per cubic yards).

EXPERIMENTAL PROGRAM

The experimental program was developed in cooperation with The Garbage Project, administered as a part of the Department of Anthropology,

Bureau of Applied Research in Anthropology, The University of Arizona, located in Tucson. They are experienced in landfill sampling and in volume measurement. They use a specially constructed machine, which can compact MSW samples so as to replicate landfill conditions.

For purposes of conducting experiments, paper was separated into four broad categories based on similarities of compaction behavior. Plastics were also separated into four categories, with another category for composite mixtures of paper and plastics. The nine categories are listed below:

- Nonpackaging paper (paper plates, tissues, towels, mail, newspapers, magazines, books, forms, greeting cards, etc.)
- Corrugated boxes
- Paperboard boxes (food boxes, detergent boxes, milk cartons, six-pack wraps, etc.)
- Other paper and paperboard packaging (bags, wrapping paper, towel rolls, molded pulp egg cartons, cups, hinged fast food containers, cigarette wrappers, etc.)
- Plastic film packaging (bags, wrappers, food wrap films, wet-wipes packs, bubble packaging, condiment packs, etc.)
- Plastic rigid containers (bottles, jars, tubs and lids, microwave trays, hard cosmetic cases, bottle basecups, etc.)
- Other plastic packaging (cookie trays, six-pack ring holders, flexible tubes, polystyrene foam packaging, etc.)
- Nonpackaging plastic (cups, tumblers, eating utensils, pens, razors, toys, food serving trays, hangers, Easter grass, sponges, etc.)
- Composite mixtures of paper and plastic (blister packs, juice concentrate containers, spiral wound dough containers, diapers, etc.)

Because of the complexities attendant with measuring volumes of landfilled materials, it was decided that no laboratory approach could suitably replicate the compaction history of wastes through the disposal, hauling, and landfill compaction steps. Nor could any laboratory conditions suitably replicate the variety and sequence of environmental conditions experienced by waste deposited in a landfill. A central part of the methodology was to retrieve materials from landfills after they have experienced the actual conditions of the solid waste system.

In June of 1989 an excavation was undertaken at the Los Reales landfill in Tucson for the purpose of retrieving landfilled material. With a backhoe, trenches were made at several locations. MSW from several time horizons (1983 to 1985) was retrieved, bagged, and marked. The samples were then taken to The Garbage Project's processing area located at the University of Arizona. The samples were dumped onto sorting tables and hand sorted into the nine paper and plastic categories described above. A total of 56 samples of approximately 30 gallons each was obtained.

The process of removing the samples from their landfill resting places for hand sorting removes them from their landfill context. The primary effect is to introduce a "fluffing" of the samples. In order to remove this extra air introduced by handling, and to reapply the pressure of layers of waste piled on top of landfilled materials, the samples were placed in a special compression machine. The machine accepts approximately 30 gallon samples and applies pressure with a hydraulic ram in a fashion reminiscent of a baler. The pressures achieved by the machine are 8 to 9 pounds per square inch, which is a typical pressure experienced by waste residing in a landfill.

The results of these experiments and analysis of the data resulted in a set of density factors for the paper and plastic products.

DENSITY FACTORS FOR LANDFILLED MATERIALS

To facilitate calculating MSW volume, Table 43 was prepared. It summarizes best estimates of the density of 24 important categories of waste, reported in pounds per cubic yard as compacted into landfills. The paper and plastic densities are the result of the experimental efforts described above. The values for other materials are based on prior work by The Garbage Project, other literature sources, and other experiments performed at Franklin Associates. In some cases, estimates were made based on behavior of similar materials. References for the origins of each density value are included in Table 43.

Densities of durable goods present a particular problem, since no experimental values are available. Where it was necessary to include densities of durable products, they were assigned the average density of other wastes. A composite density is shown in Table 43.

Plastic coatings applied to packaging and other products present another special case. These coatings do not act as materials in their own right, but take on the characteristics of the products on which they are applied. Their density was also assumed to be the same as the average density of other products.

Table 43

SUMMARY OF DENSITY FACTORS FOR LANDFILLED MATERIALS

	Density (lb/cuyd)	References*
DURABLE GOODS**	520	32
NONDURABLE GOODS		
Nondurable Paper	800	23
Nondurable Plastic	315	23
Diapers	400	24
Rubber	345	25
Textiles	435	26
Misc. Nondurables (mostly plastics)	390	31
PACKAGING		
Glass Containers		
Beer & soft drink	2,800	25, 29
Other containers	2,800	25, 29
Steel Containers		
Beer & soft drink	560	25
Food cans	560	25
Other packaging	560	25
Aluminum		
Beer & soft drink	250	29, 30
Other packaging	550	29
Paper and Paperboard		
Corrugated	750	23
Other paperboard	820	23
Paper packaging	740	23
Plastics		
Film	670	23
Rigid containers	355	23
Other packaging	185	23, 31
Wood Packaging	800	26
Other Misc. Packaging	1,015	23
Food Wastes	2,000	25
Yard Wastes	1,500	27, 28

* References are listed at the end of this report.
** No measurements were taken for durable goods or plastic coatings.

VOLUME OF PRODUCTS DISCARDED

Table 44, which shows the volume of product discards in cubic yards, was derived from Chapter 2 and Table 43. (It is necessary to characterize the volume of MSW discards rather than generation because the weight discard estimates most closely match the wastes received at a landfill, where the experimental data are derived. Discards include the waste left after materials recovery and composting and before combustion, landfilling, or other disposal.) The weight values from Tables 14, 17, and 22 are shown in the first column of Table 44, with the volumes being calculated by taking the weight values, converting to pounds, and dividing by the density (in pounds per cubic yard) from Table 43. The results are reported in Table 44 as volume in millions of cubic yards of waste on a landfill volume basis. The totals show that in 1988, the 156 million tons of discards occupied nearly 400 million cubic yards of space.

Table 45 and Figure 17 were abstracted from Table 44 to summarize some of the detail. As shown in the table, the three categories of nondurable goods, containers and packaging, and durable goods account for 86 percent of the waste. The largest volume is occupied by nondurable goods, followed by containers and packaging and durable goods. These same three categories account for 70 percent of MSW by weight.

VOLUME OF MATERIALS DISCARDED

Table 46 reports these same data by material rather than by product. The values are ranked by landfill volume occupied, with the most voluminous products listed first. Paper occupies the most volume, representing about one-third of the total. This is followed by plastics, at about one-fifth of the total. Those two product categories account for just over one-half of the volume occupied by solid waste.

The right-hand column of Table 46 presents the ratio of volume percent to weight percent for each material category. A ratio of 1.0 would mean that the material occupies the same proportion of volume as weight. Values greater than 1.0 mean that a larger proportion of volume is occupied than weight. Four materials stand out as having ratios greater than 2.0: plastics, rubber and leather, textiles, and aluminum. On the other hand, yard wastes, food, and glass each have ratios of 0.5 or less, illustrating that these materials are quite dense and occupy proportionately little volume in landfills.

VALIDITY OF RESULTS

These volume data should not be interpreted as highly accurate. The results reported here are a first attempt to use this method for analyzing solid

Table 44

VOLUME OF PRODUCTS DISCARDED IN MSW, 1988

	1988 Discards* (mil tons)	Weight (% of total)	Landfill Density** (lb/cu yd)	Landfill Volume*** (mil cu yd)	Volume (% of total)
DURABLE GOODS	23.0	14.7	520	88.5	22.2
NONDURABLE GOODS					
Newspapers	8.9	5.7	800	22.1	5.5
Books and magazines	4.6	2.9	800	11.5	2.9
Office papers	5.7	3.6	800	14.2	3.5
Commercial printing	3.5	2.2	800	8.8	2.2
Tissue paper and towels	3.0	1.9	800	7.6	1.9
Paper plates and cups	0.7	0.4	800	1.6	0.4
Plastic plates and cups	0.4	0.2	355	2.1	0.5
Disposable diapers	2.7	1.7	400	13.3	3.3
Other nonpackaging paper	5.2	3.3	800	12.9	3.2
Clothing and footwear	3.9	2.5	435	18.1	4.5
Other misc. nondurables	4.6	2.9	390	23.4	5.9
Total Nondurable Goods	43.0	27.6	634	135.6	34.0
CONTAINERS AND PACKAGING					
Glass Packaging					
Beer and soft drink	4.3	2.8	2,800	3.1	0.8
Wine and liquor	1.9	1.2	2,800	1.4	0.3
Food and other bottles & jars	3.6	2.3	2,800	2.6	0.6
Total Glass Packaging	9.8	6.3	2,800	7.0	1.8
Steel Packaging					
Beer and soft drink cans	0.1	0.1	560	0.3	0.1
Food and other cans	2.1	1.4	560	7.6	1.9
Other steel packaging	0.2	0.1	560	0.8	0.2
Total Steel Packaging	2.4	1.6	560	8.7	2.2
Aluminum Packaging					
Beer and soft drink cans	0.6	0.4	250	4.8	1.2
Other cans	0.1	<0.1	250	0.8	0.2
Foil and closures	0.3	0.2	550	1.1	0.3
Total Aluminum Pkg	1.0	0.7	299	6.7	1.7
Paper & Paperboard Pkg					
Corrugated boxes	12.6	8.1	750	33.6	8.4
Milk cartons	0.5	0.3	820	1.2	0.3
Folding cartons	4.1	2.6	820	10.0	2.5
Other paperboard packaging	0.3	0.2	820	0.8	0.2
Bags and sacks	2.7	1.7	740	7.3	1.8
Wrapping paper	0.1	0.1	800	0.3	0.1
Other paper packaging	1.6	1.0	740	4.3	1.1
Total Paper & Board Pkg	21.9	14.0	763	57.5	14.4

(continued on next page)

Table 44 (continued)

VOLUME OF PRODUCTS DISCARDED IN MSW - 1988

	1988 Discards* (mil tons)	Weight (% of total)	Landfill Density** (lb/cu yd)	Landfill Volume*** (mil cu yd)	Volume (% of total)
Plastics Packaging					
Soft drink bottles	0.3	0.2	355	1.7	0.4
Milk bottles	0.4	0.3	355	2.3	0.6
Other containers	1.7	1.1	355	9.7	2.4
Bags and sacks	0.8	0.5	670	2.4	0.6
Wraps	1.1	0.7	670	3.3	0.8
Other plastics packaging	1.2	0.8	185	13.2	3.3
Total Plastic Packaging	5.5	3.5	341	32.4	8.1
Wood packaging	2.1	1.3	800	5.3	1.3
Other misc. packaging	0.2	0.1	1,015	0.4	0.1
Total Containers & Packaging	43.0	27.6	729	118.0	29.6
Total Nonfood Product Waste	109	69.9	637	342	85.8
Other Wastes					
Food	13.2	8.5	2,000	13.2	3.3
Yard	31.1	20.0	1,500	41.3	10.4
Misc. Inorganics	2.7	1.7	2,500	2.2	0.5
Total Other Wastes	47.0	30.1	1,659	56.7	14.2
TOTAL MSW DISCARDED	156	100.0	783	399	100.0

* From Tables 14, 17, and 22. Discards after materials recovery and composting, before combustion and landfilling.

** From Table 43.

*** This assumes that all waste is landfilled, but some is combusted and otherwise disposed.

Source: Franklin Associates, Ltd.

Figure 17. Volume of major MSW categories, as a percent of total

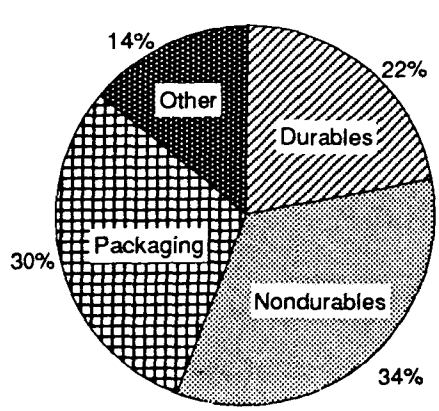


Table 45

SUMMARY OF VOLUME OF PRODUCTS DISCARDED* IN MSW, 1988

	Percent by Weight*	Percent by Volume**
Durable Goods	14.7	22.2
Nondurable Goods	27.6	34.0
Containers and Packaging	27.6	29.6
Food Wastes	8.5	3.3
Yard Wastes	20.0	10.4
Other	1.7	0.5
Total Discards	100.0	100.0

* Discards after materials recovery and composting, before combustion and landfilling.
** From Table 44.

waste. While bringing an important perspective to solid waste, the results should be viewed as approximate and not definitive. As discussed before, volume measurements of solid waste are quite complex at best, and will never accurately represent particular situations. However, the results do show in a general way which components of waste are the most voluminous, and which occupy less volume than average. It is clear that this perspective needs to be used in solid waste policy decisions.

Additional work which could extend the validity of these measures includes a more comprehensive sampling program and development of a methodology for better addressing the moisture content of materials in landfills. In addition, density factors for durables need to be measured.

COMPARISONS TO EARLIER WORK

The earlier work on MSW volume (Reference 22) was carried using EPA's previous MSW characterization report, which presented a weight database as the most recent historical data. The results presented here, therefore, differ in some minor ways from the results presented in Reference 22. The primary differences are caused by the fact that since 1986 the total amount of materials in solid waste has grown significantly, with some components growing faster than others.

Some new plastics categories that were not reported in the 1986 database have been identified, and a number of refinements in the methodology have resulted in new weight estimates for some existing products. (See Chapter 6.) The result is that although the same density factors reported in Reference 22 were used for the 1986 data, changes in the weight data as reported in the 1988 data result in greater volume differences than can be accounted for simply by growth. For example, Reference 22 reports a volume percent to weight percent ratio of 2.5 for plastics, while Table 46 reports a ratio of 2.2. This decrease in the ratio is caused by several factors, including strong growth in dense plastic products (such as film), and also because of reclassification or identification of greater quantities of dense plastic products for the 1988 weight database.

Another area for further investigation is the effect on density of mixing various MSW components. The density values in Table 43 are based on sorted MSW categories, but recent tests conducted by The Garbage Project indicate that mixing wastes results in a higher than expected density. For example, if you mix one cubic yard of paper with one cubic yard of plastic, you get less than two cubic yards of material. This is because the intermingling of two or more different materials with different characteristics results in a filling of more air spaces than occurs with a single material. This effect is apparently enhanced when materials are compacted into landfills because of the shaking or vibration created by the movement of heavy equipment on the MSW.

Table 46

VOLUME OF MATERIALS DISCARDED IN MSW, 1988

	1988 Discards* (mil tons)	Weight* (% of MSW total)	Landfill Density** (lb/cu yd)	Landfill Volume*** (mil cu yd)	Volume (% of MSW total)	Ratio (vol %/ wt%)
Paper & Paperboard	53.4	34.2	784	136.2	34.1	1.0
Plastics	14.3	9.2	359	79.7	19.9	2.2
Yard Wastes	31.0	19.9	1,500	41.3	10.4	0.5
Ferrous Metals	10.9	7.0	560	39.0	9.8	1.4
Rubber & Leather	4.4	2.9	346	25.7	6.4	2.3
Textiles	3.8	2.5	400	21.1	5.3	2.1
Wood	6.5	4.2	840	16.3	4.1	1.0
Food Wastes	13.2	8.5	2,000	13.2	3.3	0.4
Other+	5.6	3.6	1,120	10.0	2.5	0.7
Aluminum	1.7	1.1	366	9.3	2.3	2.1
Glass	11.0	7.1	2,268	7.9	2.0	0.3
Totals	156	100	858	400	100	1.0

* From Table 3. Discards after materials recovery and landfilling, before combustion and landfilling.
** Composite factors derived by Franklin Associates, Ltd.
*** This assumes that all waste is landfilled, but some is combusted and otherwise disposed.
\+ Found by difference to obtain total to match products table.

The observations above suggest that the total volume of all wastes in Tables 44 and 46 mixed together may actually be less than shown. However, there is no suggestion that this effect would significantly change the relative measures recorded in the tables, such as the various percentages and ratios calculated.

Chapter 6

COMPARISON OF MSW ESTIMATES

INTRODUCTION

As explained in Chapter 1, there are two basic methodologies for estimating quantities and composition of MSW:

- The material flows approach used in this report
- Sampling, sorting, and weighing of waste on-site.

Both methodologies have validity; both must be used with care if they are to be effective for solid waste management purposes.

This chapter compares the MSW estimates in this report with other estimates from two perspectives. First, the estimates in the current report are compared with previous material flows estimates. Second, the estimates in the current report are compared with some of the estimates made by on-site sampling studies.

COMPARISON WITH PREVIOUS MATERIAL FLOWS STUDIES

The material flows methodology has been evolving for nearly 20 years now. Over the years increasing levels of detail have been added as new data became available and as new funding from public and private sources allowed more complete analyses of the materials and products in MSW. For example, the current report includes line items for some products--e.g., disposable diapers and plastic soft drink bottles--that were insignificant in the early 1970s when the methodology was first being developed. Many new types of packaging have come into common use in the past two decades, and the current estimates include more detailed information on paper and plastic packaging starting with 1980. (It should be noted that there are no good government sources on the production of products like disposable diapers and plastic packaging; these data were provided voluntarily by industrial sources.)

When changes were made in the database for the current update, e.g., to account for additional products, the changes were--to the extent data were available--carried backward in the data series as well as being added to the recent years. This was done to preserve the integrity of the data series by avoiding discontinuities in the database. (There are, however, some discontinuities introduced by the information sources.) In addition, two

additional years of historical data plus the addition of more products led to a reevaluation of the previous projections of future waste generation.

Comparison of Current and Previous Estimates Based on Historical Data

The last year for which MSW was characterized in the 1988 study update (Reference 13) was 1986. To highlight the changes that have been made in this 1990 update, Table 47 was prepared. Overall, the estimate of generation of MSW in 1986 has been increased by about 6 percent, or from about 158 million tons of MSW to over 167 million tons. A material-by-material discussion of the changes follows.

(A word of caution: In some categories very large percentage increases are shown. These do not necessarily mean that large tonnage increases occurred; rather they are caused by the addition of certain products as line items that were not accounted for separately before. The weight columns and the overall percentage increases are more significant from a solid waste management standpoint.)

The discussion in this chapter is aimed mostly at explaining technical changes in the database. For a better understanding of long term changes in the municipal solid waste stream, Chapter 2 is recommended.

Paper and Paperboard. The most significant change made in this category was the addition of a correction factor to corrugated boxes to account for the large amount of goods in imported packaging, e.g., electronic equipment imported already boxed. Some small changes were made in other paper and paperboard categories to correspond to updates in the source database.

Glass. A small upward adjustment was made in the amount of glass shown under Miscellaneous Durables.

Ferrous Metals. A small upward adjustment was made in the amount of ferrous metals shown under Miscellaneous Durables.

Aluminum. No changes were made in the aluminum discards estimates.

Other Nonferrous Metals. The large percentage increase (although relatively small tonnage increase) in other nonferrous metals is caused by the addition of lead-acid automotive batteries to the data series.

Plastics. Some significant changes were made in the estimates of plastics discards. The consultants had access to a much more detailed database made available by industry (Reference 33). Certain product categories that

Table 47

COMPARISON OF THE 1988 AND THE 1990 ESTIMATES FOR 1986 MATERIALS GENERATION* (In millions of tons and percent)

Materials	Previous Estimate**	Current Estimate***	Percent Difference	Comments
Paper and paperboard	64.7	65.6	+1.4	Correction for imported boxes.
Glass	12.9	13.0	+0.5	Slight increase in Misc. Durables.
Metals				
Ferrous	11.0	11.1	+1.1	Slight increase in Misc. Durables.
Aluminum	2.4	2.4	0.0	
Other nonferrous	0.3	1.0	+263.8	Lead-acid batteries added to data.
Plastics	10.3	12.2	+18.2	Additional plastics accounted for.
Rubber and leather	4.0	4.3	+7.1	Additional rubber accounted for.
Textiles	2.8	2.8	-2.1	Minor changes in data source.
Wood	5.8	5.8	0.0	
Other+	0.1	3.2	+3,434	Diapers and batteries added.
Total Nonfood Product Waste	114.3	121.5	+6.2	
Food wastes	12.5	13.2	+5.6	Calculated estimate.
Yard wastes	28.3	30.2	+6.7	Calculated estimate.
Miscellaneous inorganic wastes	2.6	2.6	0.0	
Total MSW Generated	157.7	167.4	+6.2	
Pounds per Person per Day	3.58	3.80	+6.1	

* Generation before recovery for recycling and composting.
** From Table 7 of the March 1988 EPA MSW characterization report (Reference 13).
*** From the work sheets prepared for this report.
\+ Includes part of materials in disposable diapers and lead-acid batteries.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

had been ambiguous in databases available earlier (e.g., many products were grouped together as "Other") were "broken out" in more detail, permitting a clearer understanding of which components could reasonably be assigned to disposal as municipal solid waste. As a result, the amounts of plastics resins assigned to packaging were lowered, but the amounts assigned to durables and nondurables were increased. Overall, estimated generation of plastics in MSW in 1986 increased by 18 percent. Stated another way, the amount of plastics products generated in 1986 did not increase, but the consultants' ability to identify which products should be classified as MSW did.

A correction factor was also added to account for plastics packaging of imported products, e.g., polystyrene foam cushioning of consumer electronics.

Rubber and Leather. It was learned that the Department of Commerce data series used as a source for these estimates omitted natural rubber starting in 1980. Therefore a correction was made to account for this past omission.

Textiles. *Some minor changes in the manner in which data were* reported in the Department of Commerce data sources are reflected in the textiles estimates.

Other. The large change in this category is the result of the addition of disposable diapers and lead-acid batteries to the list of products included.

Disposable diapers are made of wood pulp, tissue paper, and various plastics. The tissue paper and part of the plastic in these diapers were previously accounted for under "Miscellaneous Nondurables." The wood pulp and some additional plastics were added to the estimates of diaper generation. Also, an estimate was made of the urine and feces discarded with the diapers. Since the wood pulp and moisture did not fit under any existing material category, they were accounted for under "Other," which previously was a very small category. Disposable diapers account for an additional 2.5 million tons of "Other" MSW generation in 1986. (The tissue paper and plastics in diapers are still added into the paper and plastics material categories.)

About half of the material in lead-acid automotive batteries is said to be lead (Reference 17), which is accounted for under Other Nonferrrous Metals. The batteries also contain plastics, which are accounted for under that materials category. The remainder of the batteries' weight is electrolytes and some other miscellaneous materials, which were included for the first time under "Other." This addition accounted for over 600,000 tons of MSW generation in 1986. (It should be noted that, since batteries are recovered at a high rate, most of this generation is not shown later as discards.)

Food and Yard Wastes. As discussed in the earlier chapters of this report, estimates of food and yard wastes discarded in MSW must be based on sampling studies, which report them in terms of percentage of total MSW discarded. Since the adjustments discussed above resulted in a larger total of nonfood product wastes discarded, the estimates of food and yard wastes discarded were adjusted upward to keep the percentages in line with previous estimates. No estimates of food or yard waste composting were made for 1986, so discards of food and yard wastes are the same as generation.

Comparison of Current and Previous Projections of MSW Generation

As discussed in earlier chapters of this report, projections of MSW generation are done on a material by material and product by product basis. The projections are made using trend analysis, available reports from

government (Department of Commerce) sources, industry sources, and in some instances, best professional judgement on the industries involved. Projections were updated for this 1990 report based on the additional two years of historical data available for the update. They were also based on the revisions of the 1980 to 1988 database made possible by new sources of information, which in some cases resulted in additional products being added to the database.

The overall result of these revisions is that projections of MSW materials generation were increased in most instances. For comparison purposes, previous and current projections for the year 2000 were used, since that was the last year projected in the 1988 report (Reference 13). The material by material comparisons are shown in Table 48 and significant changes are discussed below.

Table 48

COMPARISON OF THE 1988 AND THE 1990 PROJECTIONS OF MATERIALS GENERATION IN 2000*
(In millions of tons and percent)

Materials	Previous Estimate**	Current Estimate***	Percent Difference	Comments
Paper and paperboard	86.6	96.1	+11.0	Reevaluated historical trends.
Glass	13.4	10.3	-23.2	Reevaluated historical trends.
Metals				
Ferrous	12.0	12.0	0.0	
Aluminum	3.6	3.5	-3.5	Small decrease in durables.
Other nonferrous	0.4	1.5	320.4	Lead-acid batteries added to data.
Plastics	15.7	21.1	+34.2	Additional plastics accounted for.
Rubber and leather	3.9	5.3	+34.8	Additional rubber accounted for.
Textiles	3.4	4.3	+26.3	Revised furniture, clothing.
Wood	6.1	8.4	+38.1	Furniture discards revised upward.
Other+	0.1	3.0	+2,495	Diapers and batteries added.
Total Nonfood Product Waste	145.2	165.4	+13.9	
Food wastes	12.3	13.3	+8.1	Calculated estimate.
Yard wastes	32.0	34.4	+7.5	Calculated estimate.
Miscellaneous inorganic wastes	3.2	2.9	-9.4	Reevaluated historical trends.
Total MSW Generated	192.7	216.0	+12.1	
Pounds per Person per Day	3.94	4.41	+11.9	

* Generation (gross discards) before any materials recovery.
** From the work sheets prepared for this report.
*** From Table 27 of this report.
\+ Includes part of materials in disposable diapers and lead-acid batteries.
Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

Paper and Paperboard. Historical generation of paper and paperboard products continued to grow between 1986 and 1988, and this was taken into account. In addition, the consultants had access to an extensive analysis done for the paper industry (Reference 34), which projected paper and paperboard production, net imports, and recovery to the year 1995. This report was used as the basis to project increased generation of paper and paperboard to the years 2000 and 2010 (an increase of 11 percent over the previous projection for 2000).

Glass. Generation of glass has continued to decline from 1986 to 1988. In fact, glass containers would disappear from the waste stream if a trend line analysis were followed. The consultants elected not to use that projection, but to assume that glass containers will continue to be made. The projected generation for 2000 was, however, lowered by 23 percent based on the historical data.

Other Nonferrous Metals. The large projected increase in generation of other nonferrous metals in 2000 is entirely due to the addition of lead-acid batteries as a line item.

Plastics. The accounting for additional plastic items in the historical database was discussed earlier. These additions, plus projected continued growth, account for the increased projection of plastics generation in 2000.

Rubber and Leather. As discussed earlier, additional estimates of rubber in tires were added to the historical database. As a result, the projections of rubber in tires were increased upward also.

Textiles. As discussed earlier, the historical data source for clothing was revised upward; therefore the projections of textiles generation were revised upward also. In addition, some revisions were made in the projections of furniture discards, which include textiles.

Wood. Increased projections of furniture discards caused the projected generation of wood in 2000 to be revised upward.

Other. The addition of some materials in disposable diapers and lead-acid batteries to the database was reflected in the MSW projections for 2000.

Food and Yard Wastes, Miscellaneous Inorganic Wastes. As discussed previously, these wastes are estimated based on sampling studies. Since the projections of nonfood product wastes generated were revised upward, it was necessary to reevaluate the generation of the other wastes also. This resulted in an increased projection of total food and yard wastes generated (although not an increase in per capita generation). Miscellaneous inorganic wastes were adjusted slightly downward (with no change in per capita generation).

COMPARISON WITH ESTIMATES MADE BY SAMPLING STUDIES

Comparison of estimates made by the material flows methodology with estimates made by sampling and weighing MSW are of interest, but must be approached with caution. For one thing, the waste stream sampled in any particular study may not be comparable to the mix of products included in the material flows methodology. For example, industrial waste is often included in waste received and sampled at a landfill or transfer station. Seasonal variations in the waste stream may also affect the results of a sampling study.

Another important factor to consider when comparing results is moisture transfer among materials in wastes as they are collected. The material flows methodology characterizes wastes in their as-generated condition. That is, moisture in disposable diapers is accounted for, and estimates of food and yard wastes have been adjusted to include the moisture

Table 49

COMPARISON OF MSW DISCARDS BY MATERIAL FLOWS AND SAMPLING METHODOLOGIES
(In percent of total by weight)

Material	1988 Material Flows Estimate*	Range of 16 Sampling Studies**	Range of 9 Sampling Studies***
Paper and paperboard	34.2	14.4 - 54.2	29.9 - 45.9
Glass	7.1	2.8 - 19.9	3.6 - 12.9
Metals	8.4	4.3 - 11.5	1.5 - 9.4
Plastics	9.1	4.9 - 9.7	5.3 - 12.6
Rubber, leather, textiles	5.4	1.9 - 5.9	1.1 - 7.2
Wood	4.2	0.8 - 12.9	0.7 - 8.2
Food wastes	8.5	5.1 - 19.3	1.3 - 28.8
Yard wastes	20.0	3.5 - 30.9	0.0 - 39.7
Other	3.3	NA NA	3.8 - 16.6

* Discards after recovery for recycling and composting.
** Compiled by Franklin Associates from a variety of sources. 1984-1988 time frame.
*** Reference 22 (OTA).
NA-Not available.

inherent in the discards. Wastes as sampled, however, have been mixed together prior to sampling, and the moisture in the wastes has been transferred among products. For example, paper products in MSW absorb large quantities of moisture from food and yard wastes, and the latter wastes thus contain less moisture than they did in their as-generated condition. This moisture transfer may significantly affect the relative percentages of the materials in MSW.

Municipal solid waste composition estimated by the material flows methodology is compared with composition estimated by sampling studies in Table 49. The sampling study results are presented in ranges; the first set represents the results of 16 studies as compiled by Franklin Associates, and the second set is taken from a recent Office of Technology Assessment report on MSW (Reference 35). For each material category, the percentage estimated by the material flows methodology falls within the range found in the sampling studies. (The sole exception is an "other" category, which is not well defined.)

Another interesting comparison of the material flows and sampling methodologies was made Dr. Edwin Korzun and others at Florida Institute of Technology (Reference 36). As part of a study for the State of Florida, they did a careful analysis of waste received at landfills in Brevard County, Florida. They were particularly careful to sort out wastes that are not classified as MSW, e.g., construction, demolition, and industrial wastes. As a result of their research, they concluded that:

> "The comparison of the broad categories indicates that the sum of the subcategories from Franklin and those obtained locally, known to be site specific for a particular Florida county, do not vary widely. Since no major differences were observed it was concluded that the Franklin subcategories of the percentage of materials in the United States municipal solid waste stream could be utilized to estimate those same components in the state of Florida with reasonable accuracy."

It seems clear that both the material flows and sampling methodologies have valid uses in estimating municipal solid waste generation and discards. Whatever methodology is used, it is most important to be very clear as to what wastes are being measured and at what point in the solid waste management system the measurements are being taken.

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to be approximately 90 percent of the density of textile products.

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Appendix A

MATERIAL FLOWS METHODOLOGY

The material flows methodology is illustrated in Figures A-1and 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 are compiled for 1960 through 1988, using published data series. U.S. Department of Commerce sources are 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 are 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 <u>not</u> counted as part of the postconsumer recovery of waste reported later in this report.

ADJUSTMENTS FOR IMPORTS/EXPORTS

In some instances imports and exports of products are a significant part of MSW, and adjustments are made to account for this. For example, up to 60 percent of the newsprint used in the United States is imported from Canada. Examples of other products where imports are significant include appliances, tires, clothing, and footwear.

DIVERSION

Some consumer products are diverted from the municipal waste stream because of the way they are used. For example, the statistics on tissue paper production include items such as toilet paper, which is assumed to be disposed into the sewer rather than MSW, and cigarette papers, which are assumed to be mostly consumed in use. Paper and paperboard production figures also include building materials and board used in automobiles, for

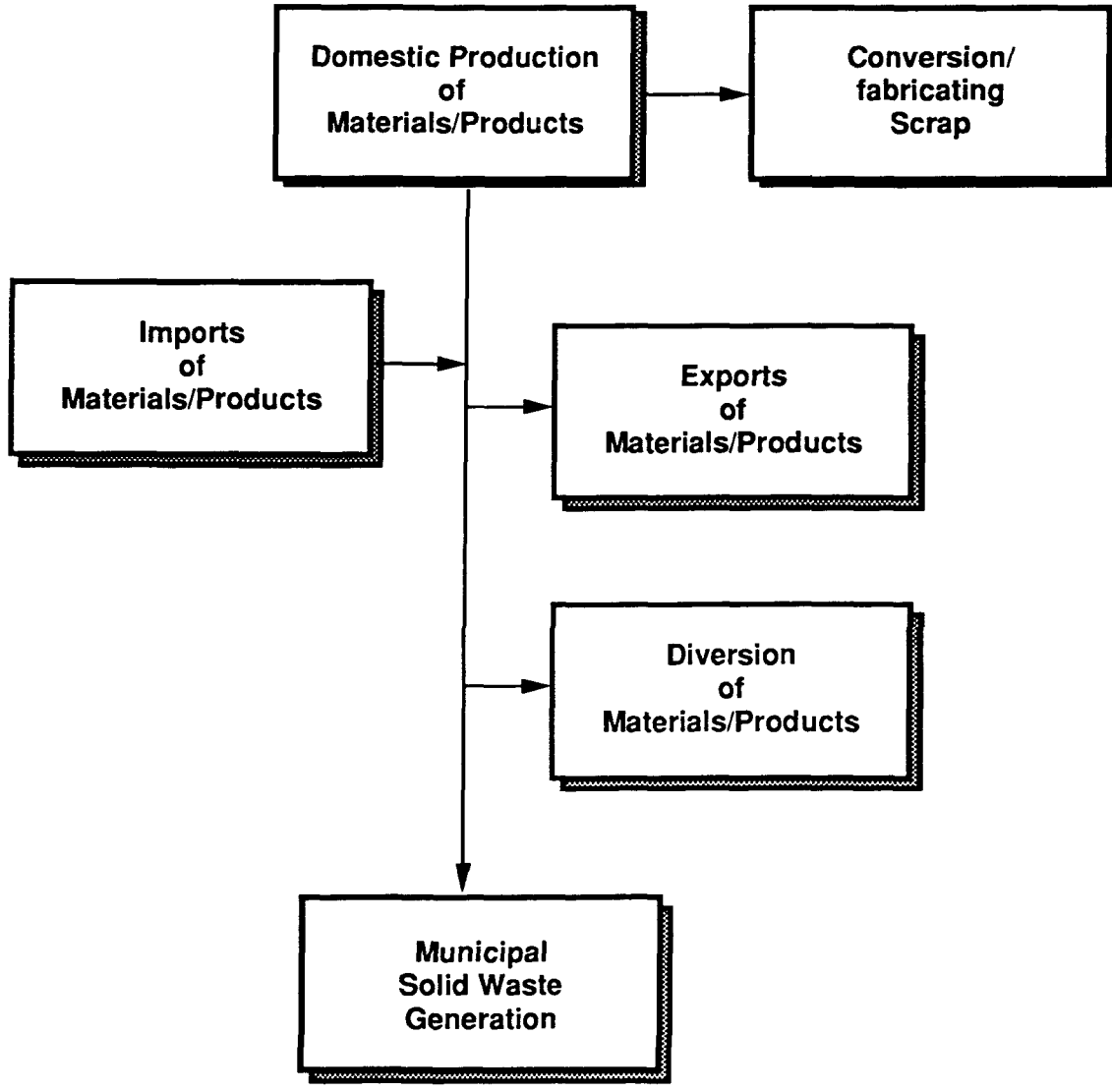

Figure A-1. Material flows methodology for estimating generation of products and materials in municipal solid waste.

example. Adjustments are made to the data where appropriate to account for these kinds of uses.

ADJUSTMENTS FOR PRODUCT LIFETIME

Some products, such as 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, durable goods like appliances and tires have relatively long lifetimes. Data on average product lifetimes are used to adjust the data series to account for this. For example, water heaters are estimated to have a 10-year lifetime. Thus, water heaters produced in 1978 were added to product discards in 1988.

MUNICIPAL SOLID WASTE GENERATION

The result of these estimates and calculations is a material-by-material and product-by-product estimate of municipal solid waste generation for each year in the series (Figure A-1). The term "generation" as used in this report thus refers to the weight of materials and products as they enter the municipal waste stream, before any recovery for recycling or composting takes place, and before any combustion takes place.

ESTIMATING MSW MANAGEMENT ALTERNATIVES

The municipal solid waste stream as defined at various points in Figure A-2 can be related to the MSW management hierarchy. MSW generation represents the point before which source reduction efforts can be applied in an attempt to reduce the amounts of waste generated. Information on materials and product generation also provides data as to the amounts of waste available for recycling, composting, or other management alternatives and opportunities.

Recovery for Recycling

Recovery of materials for recycling comes near the top of the MSW management hierarchy. Good data on recycling of materials are available from several trade associations, although the data vary in reliability and consistency of the historical data series. In some instances estimates were made by Franklin Associates.

It should be noted that these estimates are for recovery of materials for recycling. Estimation of residues left after the recycling process (e.g., sludges from deinking paper or unprocessible materials) was beyond the scope of this study.

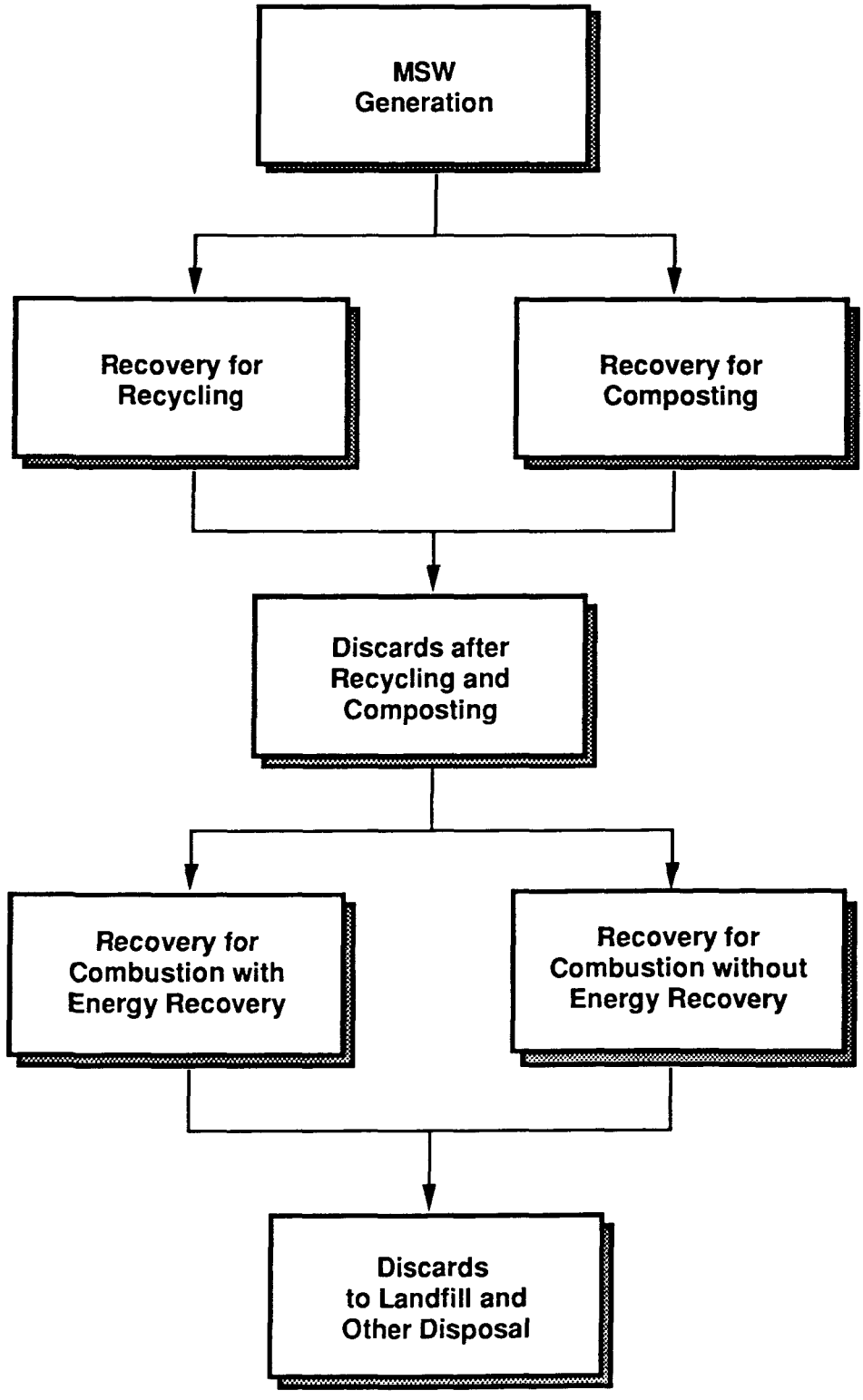

Figure A-2. Material flows methodology for estimating recovery and discards of municipal solid waste.

Recovery for Composting

Widespread emphasis on composting of materials in MSW (primarily yard wastes), is a comparatively recent development, but one that stands with recycling near the top of the hierarchy. For the first time, estimates of composting were made for this report, although no really good records are available as yet. The methodology used was to contact states that are requiring that yard wastes be kept out of landfills, now or in the future, and to estimate the future impact of these new regulations. Thus, these estimates of composting activity consist primarily of projections into the future.

As in the case of recycling, no estimates of unusable residues left after composting were made. In addition, only large-scale composting was included; backyard composting by individuals was considered to be a source reduction measure.

Discards After Recycling and Composting

The estimates of recovery for recycling and composting permit the preparation of tables summarizing the materials and products discarded into the waste stream after those activities are completed. The composition of the waste stream on a percentage basis was recalculated, so that the effect of the removal of various materials for recycling and composting can be determined.

The waste stream thus characterized would, on average, be the waste stream available for combustion processes, or for landfill if no combustion is done.

Combustion with Energy Recovery

As in previous reports, estimates of historical and projected municipal waste combustion with energy recovery were made. Energy recovery from MSW was estimated by compiling published data from several sources on current facilities, those under construction, and those in various stages of planning. Throughput in combustion facilities is normally less than design capacities. Where published data on facility throughputs were not available, Franklin Associates made estimates.

As was the case for recycling and composting, no estimates of the amounts of residues from MSW combustion were included, since these residues are not classified as MSW in the list of Subtitle D wastes.

Combustion without Energy Recovery

Previous reports in this series have not included estimates of combustion without energy recovery, but to complete the estimates of all MSW management alternatives in the hierarchy, these estimates were made for the current report. The methodology was similar to that for combustion with energy recovery.

DISCARDS OF MUNICIPAL SOLID WASTE

Completion of all the steps above permits calculation of the remaining quantities of MSW after materials are removed for recycling, composting, and combustion. These discards of MSW are generally assumed to be landfilled. It should be noted, however, that some MSW becomes litter, and some is still self-disposed, stored on-site, or burned, particularly in rural areas. No good estimates of these quantities are available, but they are presumed to be relatively quite small.

CHARACTERIZING FOOD, YARD, AND OTHER WASTES

The material flows methodology works quite well for products in MSW, because production numbers are available from published sources for the products. Food wastes, yard wastes, and some miscellaneous inorganic wastes are, however, also present in municipal solid waste. Estimates of the quantities of these wastes are made based on sampling data from as wide a range of sources as possible. These sources present food, yard, and other wastes as percentages of the waste streams sampled. A composite of these sampling percentages over the historical period covered by the study was used, along with the total quantities of product wastes developed by the material flows methodology, to estimate the food, yard, and miscellaneous inorganic wastes.

Moisture is transferred from food and yard wastes to other materials in MSW before sampling studies are performed. Adjustments were made to account for this fact, so that weights of all materials and products in MSW are presented in the "as generated" condition rather than after moisture transfer has taken place during the collection and disposal process.