Characterization of Municipal Solid Waste in the United States, 1960-2000

Final Report

PRC Engineering
Suite 600
303 East Wacker Drive
Chicago, IL 60601
312-938-0300
TWX 910-2215112
Cable CONTOWENG

prc
Planning Research Corporation

CHARACTERIZATION OF MUNICIPAL SOLID WASTE IN THE UNITED STATES 1960 - 2000

FINAL REPORT

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Waste Programs Enforcement
Washington, D.C. 20460

Work Assignment No.	:	349
EPA Region	:	Headquarters
Site No.	:	None (R)
Date Prepared	:	July 25, 1986
Contract No.	:	68-01-7037
PRC No.	:	15-3490-00
Prepared By	:	Franklin Associates, Ltd. (Marjorie Franklin)
Telephone No.	:	(913) 649-2225
EPA Primary Contact	:	Gerri Dorian
Telephone No.	:	(202) 382-4688

CHARACTERIZATION OF MUNICIPAL SOLID WASTE

IN THE UNITED STATES

1960-2000

FINAL REPORT

July 1986

Office of Solid Waste
U.S. Environmental Protection Agency
Washington, D.C. 20460

PREFACE

This report on characterization of municipal solid waste in the United States was prepared by Franklin Associates, Ltd. for the U.S. Environmental Protection Agency, Office of Solid Waste and Energy Response. Gerri Dorian was EPA's Project Manager.

Franklin Associates' Project Manager was Marjorie A. Franklin. The report's principal authors were Mrs. Franklin (Chapter 1), Nicholas S. Artz, P.E. (Chapter 2 and the energy recovery section of Chapter 3), and Robert G. Hunt (Chapter 3). Staff support for the Working Papers for this report was provided by Jacob E. Beachey, Veronica R. Sellers, Nancy J. Lappin, and Katherine L. Totten.

This work was performed under subcontract to PRC Engineering, EPA Contract No. 68-01-7037, Work Assignment No. 349. Harry Ellis was PRC's Technical Monitor.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

CHARACTERIZATION OF MUNICIPAL SOLID WASTE IN THE UNITED STATES, 1960 TO 2000

SUMMARY

Knowledge of the quantities and composition of municipal solid waste (MSW) is a necessary tool for many aspects of solid waste management. This report presents a summary of estimates of historical MSW quantities and composition from 1960 to 1984, with projections to the year 2000.

The material flows methodology developed by EPA in the early 1970s, with refinements that have been added in succeeding years, was used to make these estimates. Complete descriptions and documentation of the methodology used for each MSW component are included in Working Papers that accompany this report.

In addition to characterization of MSW, which is defined as residential, commercial, and institutional wastes, this report includes information on other wastes that are landfilled, and a discussion of the factors that influence MSW generation.

MATERIALS AND PRODUCTS IN THE MUNICIPAL WASTE STREAM

The quantities of the various materials that make up the municipal waste stream do not increase (or decrease) at the same rate. The first table on page S-2 illustrates the changing composition of MSW over time. (MSW discards in this table are those remaining after materials recovery has taken place.) Paper and plastics materials have been increasing more rapidly than the other components of the waste stream. Glass, ferrous metals, rubber, and other materials have been increasing more slowly or even declining.

Products in the municipal waste stream were characterized in detail and grouped as durable goods, nondurable goods, containers and packaging, and other wastes. The second table on page S-2 illustrates trends in product discards after materials recovery has taken place.

Durable goods, which are increasing rather slowly in the waste stream, include large appliances, furniture, tires, and other miscellaneous items. Rubber tires are actually decreasing in tonnage. Nondurable goods are growing more rapidly in the waste stream. Paper products in this category, especially office paper and printing papers, have been growing more rapidly than most other products.

MATERIALS DISCARDED INTO THE MUNICIPAL WASTE STREAM
(In millions of tons and percent)

Materials	1970 tons	1970 %	1984 tons	1984 %	2000 tons	2000 %
Paper and Paperboard	36.5	33.1	49.4	37.1	65.1	41.0
Glass	12.5	11.3	12.9	9.7	12.1	7.6
Metals	13.5	12.2	12.8	9.6	14.3	9.0
Plastics	3.0	2.7	9.6	7.2	15.5	9.8
Rubber and Leather	3.0	2.7	3.3	2.5	3.8	2.4
Textiles	2.2	2.0	2.8	2.1	3.5	2.2
Wood	4.0	3.6	5.1	3.8	6.1	3.8
Other	-	0.1	0.1	0.1	0.1	0.1
Food Wastes	12.7	11.5	10.8	8.1	10.8	6.8
Yard Wastes	21.0	19.0	23.8	17.9	24.4	15.3
Miscellaneous Inorganic Wastes	1.8	1.6	2.4	1.8	3.1	2.0
TOTAL	110.3	100.0	133.0	100.0	158.8	100.0

Source: Franklin Associates, Ltd.

PRODUCTS DISCARDED INTO THE MUNICIPAL WASTE STREAM
(In millions of tons and percent)

Products	1970 tons	1970 %	1984 tons	1984 %	2000 tons	2000 %
Durable Goods	13.9	12.6	18.6	14.0	22.9	14.4
Nondurable Goods	21.6	19.6	34.0	25.6	47.4	29.8
Containers and Packaging	39.3	35.6	43.5	32.7	50.1	31.6
Other Wastes	35.5	32.1	37.0	27.8	38.3	24.1
TOTAL	110.3	100.0	133.0	100.0	158.8	100.0

Source: Franklin Associates, Ltd.

Containers and packaging as a category of MSW have been showing a declining trend in recent years. This is caused by the relatively increasing use of lightweight aluminum and plastics and decreasing use of heavier steel and glass containers.

The "Other Wastes" category includes food wastes, yard wastes, and other miscellaneous inorganic wastes. A major revision has been made in previous estimates of food and yard wastes. Based on a survey of sampling studies, the estimated quantities of food and yard wastes have been reduced by a sizeable amount. Estimates of total discards have thus been reduced approximately 10 percent.

Other analyses show an increasing trend in the percentage of organic materials in the waste stream. Quantities of waste discarded by individuals each day (pounds per capita per day) would be increasing if it were not for energy recovery activities. With energy recovery accounted for, per capita discards are shown to be decreasing.

OTHER LANDFILL WASTES

In addition to the characterization of municipal solid wastes, other wastes that may be landfilled are described in this report and quantified to a limited extent. These wastes include:

- Demolition/construction wastes
- Water/wastewater treatment residues (sludge)
- Trees and brush
- Street refuse (sweepings, etc.)
- Car bodies
- Nonhazardous industrial process waste
- Incinerator residue
- Boiler residue (power plant ash, etc.)
- Household hazardous wastes
- Small quantity generator hazardous wastes
- Used oil

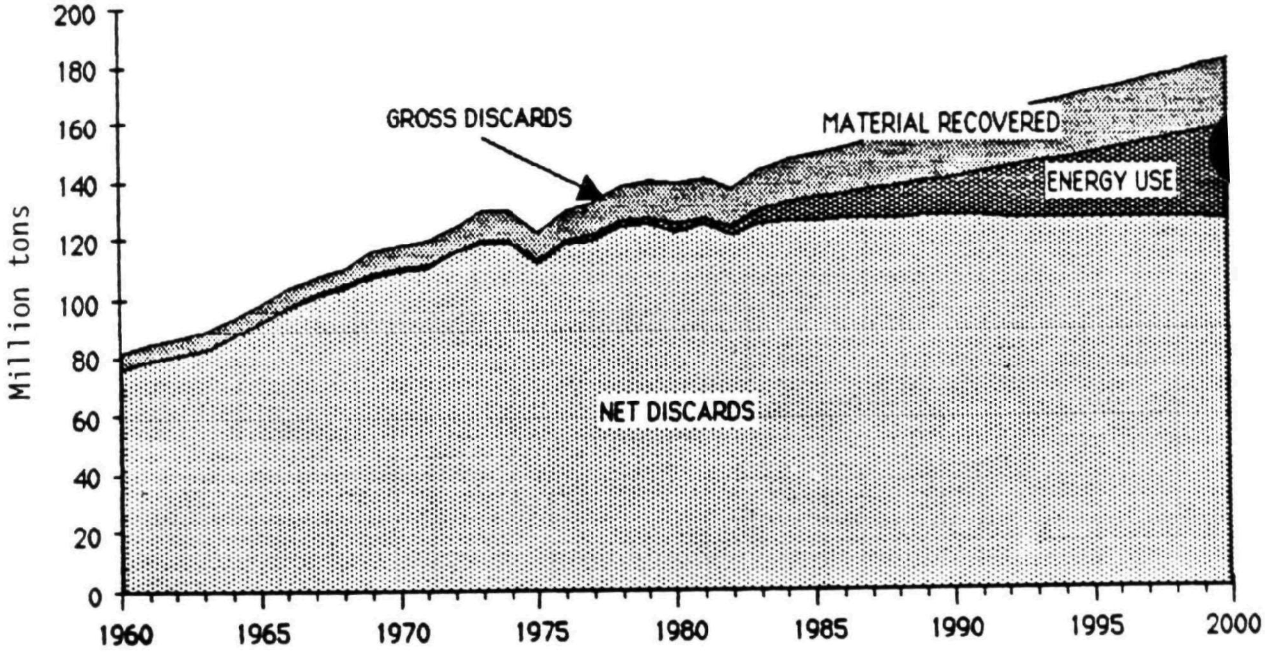
Total generation of these wastes is much larger than the MSW estimates, but the portion of these wastes going to municipal solid waste landfills is not documented.

FACTORS AFFECTING MUNICIPAL SOLID WASTE GENERATION AND DISPOSAL

A number of factors affect generation of MSW. Increasing population, increasing affluence, and social changes all affect purchases of goods and discards. The effects of these factors have not been quantified, however.

Technological changes, for example, computers with printers that generate large amounts of paper, have an effect on the waste stream. These changes are also evident in containers and packaging. Lightweight aluminum and plastics are being substituted for heavier steel and glass in beverage containers, for example.

While many of the factors affecting MSW disposal are difficult to quantify, materials recovery for recycling and energy recovery from MSW can be estimated with reasonable accuracy. The figure below illustrates the effects of these activities. Over time, gross discards (the top line) have grown steadily except for dips during recessions in 1975 and 1982. The combined effects of materials recovery and energy recovery have, however, caused a "flattening" of net discards after materials recovery and energy recovery have taken place. The estimates in this report indicate that the tonnage of municipal solid waste discards will decrease slightly in the future. These recovery estimates are conservative, so net discards could be even lower if recovery activities are increased more rapidly.



Gross discards, materials recovery, energy recovery, and net discards of municipal solid waste, 1960 to 2000.

Chapter 1

HISTORICAL AND PROJECTED MUNICIPAL SOLID WASTE DISPOSAL

BACKGROUND

Since the late 1960s there has been increasing concern about the manner in which municipal solid wastes (MSW) are collected and disposed. As a corollary, there have been many attempts to quantify and characterize the amounts of waste that must be dealt with, and the U.S. Environmental Protection Agency (EPA) has taken the lead in many of these efforts.

There are two basic approaches to estimating quantities of municipal solid waste, which is a heterogeneous and poorly-defined aggregation of materials. The first method, which is site-specific, involves weighing, sampling, and sorting a waste stream into its specific components. Some of these efforts involve a single sampling of a waste stream; others include characterization of numerous samples over a long period of time. This method is useful, but wide variations in local conditions and the range of wastes sampled make it difficult to apply this method to obtain national average figures.

The second approach to quantifying and characterizing the municipal solid waste stream--the method used for this report--uses a material flows approach. This method is much more general in application and requires considerable manipulation of the data. 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 (1)(2)(3)(4). The material flows approach to solid waste estimation was described in some detail in a 1975 EPA publication (5), and estimates of MSW made using this methodology were published in Reports to Congress in the mid-1970s (6)(7)(8). Finally, the Resource Conservation Committee used estimates of MSW generated using this method in its 1979 Report to the President and Congress (9)(10)(11). Since that time, very little information on MSW generation and disposal has been published by EPA, although some privately-sponsored work has been done (12).

OVERVIEW OF THIS CHAPTER

This chapter provides a summary of estimates of municipal solid waste disposal for the historical period 1960 to 1984, with projections to the year 2000. Quantities and composition of MSW by materials category and by product category are presented. Changing trends in the materials and products disposed, and the amounts disposed per person, are discussed.

METHODOLOGY

General Description

The methodology used to generate the MSW disposal estimates in this report is an extension of the previous work described above. Working papers that accompany this report detail the estimation procedure for each material and product category. Briefly described, the methodology relies on published data series documenting historical production (or consumption) of materials and products that enter the municipal waste stream. U.S. Department of Commerce statistics are used for many of the data series, with trade association data used in a few instances. Deductions for converting losses of materials in manufacturing processes are made.

Imports and exports significantly affect consumption of many products in the U.S. waste stream, and adjustments are made as appropriate for each product. An adjustment is also made for products that are destroyed in use (e.g., cigarette paper) or diverted from the waste stream for long periods of time (e.g., books in libraries).

After all necessary adjustments are made, discards of each product are calculated. Since there is significant recovery of many products in the waste stream, estimates of materials recovery (if any) for each product are made. After all discards are totaled, a deduction is made for the materials incinerated in energy recovery facilities. (Incinerator ash, which is discussed in Chapter 2, is not included in these estimates.) The final result, or "Net Discards," represents total discards into the municipal waste stream.

This procedure is illustrated in Figure 1-1.

The methodology described above develops estimates of nonfood product wastes based on available data series. Other materials in the municipal waste stream--food wastes, yard wastes, and some miscellaneous inorganic wastes--cannot be derived from any published data series. These estimates are based on sampling data from as wide a range of sources as possible. These sources present food and yard wastes as percentages of the total waste stream, and a composite of sampling data over a period of years was used, along with the nonfood product waste data, to estimate the food, yard, and other wastes.

Materials and Products Included in These Estimates

The municipal solid waste estimates provided by the methodology described above include residential, commercial, and institutional solid wastes. Since the estimates for each product are based on production data, the methodology cannot determine whether a corrugated box, for

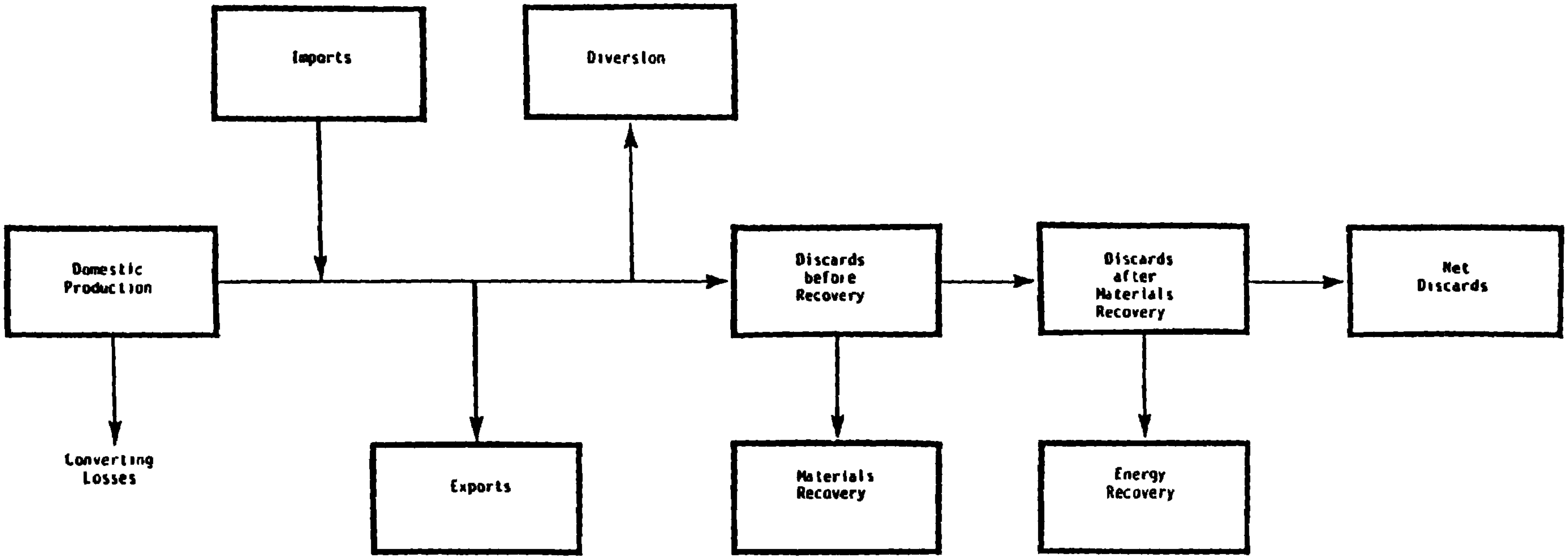


Figure 1-1. Generalized material flows for products in the municipal waste stream.

example, was emptied and discarded in a home, a retail store, a school, or a factory; all corrugated boxes are counted. For estimates of total U.S. waste, it can be presumed that all corrugated boxes collected from any source are recycled, taken to a landfill, incinerated, or otherwise disposed. For localized estimates of MSW generation, however, it is very important to know the source of the waste stream. Using the example above, relatively few corrugated boxes come from residences, but many come from stores and factories. A waste stream generated solely from residential wastes would thus be expected to have far less than the average percentage of corrugated containers.

The broad nonfood product categories included are:

- Durable goods
- Nondurable goods
- Containers and packaging

The durable goods category includes major appliances, furniture and furnishings, and rubber tires--categories that often are referred to as "oversize and bulky" wastes. This category also includes miscellaneous durable goods such as small appliances.

The nondurable goods category includes many paper products such as newspapers and paper towels. Apparel, footwear, and miscellaneous nondurables (especially many small plastic products) also are included in this category.

The containers and packaging category includes such items as cans, bottles, boxes, and wrapping materials made of glass, metals, paper, plastics, and wood.

To the nonfood product wastes described above are added food wastes, yard wastes, and miscellaneous inorganic wastes to complete the estimates of MSW.

The material flows methodology yields estimates of MSW discarded; it cannot determine whether the MSW was collected. Thus, soft drink cans are counted regardless of whether they are disposed in a city trash can, littered by a roadside, or disposed on-site in a remote rural area.

Materials and Products Not Included in These Estimates

Many wastes that may go to municipal landfills are not estimated by the material flows methodology. Examples of these wastes include demolition and construction wastes, sludges, automobile bodies, and nonfood products such as detergents or cosmetics that may be left inside containers. Many of these wastes are discussed in Chapter 2.

While the material flows methodology accounts for net imports of products, it does not account for the packaging of imported goods. Thus the containers and packaging category is understated by an unknown amount.

Projections

Historical estimates of MSW discards were made through 1984. Projections to 2000 were made using a combination of trend analysis, knowledge of the industries involved, and government sources such as Industrial Outlook (13).

MATERIALS IN THE MUNICIPAL WASTE STREAM

Historical and projected quantities of materials in the municipal waste stream are shown in Table 1-1 and Figure 1-2. Percentage of total discards for each material is shown in Table 1-2. In these tables, "Total Wastes Discarded" is discards after recovery of materials has taken place. The total discards of materials are adjusted by subtracting MSW processed for energy recovery to obtain "Net Wastes Discarded." These are the totals shown in Figure 1-2.

The relative magnitude of the various materials in the municipal waste stream is illustrated in Figure 1-3. Comments on each of the materials in MSW follow below. A more complete discussion of the factors influencing changes in the waste stream is included in Chapter 3.

Paper and Paperboard

The paper and paperboard category is the largest materials category, ranging from 24.5 million tons disposed in 1960 to almost 50 million tons disposed in 1984. Discards of paper and paperboard are projected to be 65 million tons in 2000. Paper's share of the municipal waste stream has ranged from 30 percent to 37 percent over the past quarter-century; the trend has been generally upward and this is projected to continue. As will be shown in Chapter 3, paper and paperboard would comprise a much larger share of the waste stream if materials recovery did not take place.

Glass

The tonnage of glass (mostly containers) in the waste stream increased steadily until the early 1980s, then began to fall slowly. As a percentage of the waste stream, glass comprised 8 percent in 1960, rising to over 11 percent in the early 1980s, then falling to under 10 percent in 1984. The percentage of glass in the waste stream is projected to fall to under 8 percent by 2000.

Table 1-1

MATERIALS DISCARDED INTO THE MUNICIPAL WASTE STREAM, 1960 TO 2000
(In millions of tons)

Materials	1960	1965	1970	1975	1980	1981	1982	1983	1984	1990	1995	2000
Paper and Paperboard	24.5	32.2	36.5	34.5	42.2	43.9	41.5	45.9	49.4	54.2	59.5	65.1
Glass	6.4	8.5	12.5	13.2	14.2	14.3	13.8	13.5	12.9	12.4	12.2	12.1
Metals												
Ferrous	9.9	10.0	12.4	12.0	11.2	11.1	11.0	11.1	11.0	11.0	11.1	11.2
Aluminum	0.3	0.5	0.8	1.0	1.4	1.3	1.3	1.5	1.5	2.0	2.3	2.7
Other Nonferrous	0.2	0.2	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.4
Plastics	0.4	1.4	3.0	4.4	7.6	7.8	8.4	9.1	9.6	11.8	13.7	15.5
Rubber and Leather	1.7	2.2	3.0	3.7	4.1	4.1	3.8	3.4	3.3	3.5	3.7	3.8
Textiles	2.0	2.2	2.2	2.5	2.9	3.6	3.0	3.0	2.8	3.1	3.3	3.5
Wood	3.0	3.5	4.0	4.3	4.9	4.4	5.0	5.2	5.1	5.3	5.7	6.1
Other	-	-	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
TOTAL NONFOOD PRODUCT WASTES	48.4	60.7	74.8	76.0	89.0	91.0	88.2	93.1	96.0	103.7	111.9	120.5
Food Wastes	11.2	12.1	12.7	13.4	11.6	11.3	11.0	11.1	10.8	10.9	10.9	10.8
Yard Wastes	15.5	17.7	21.0	22.1	22.9	23.1	23.3	23.5	23.8	24.1	24.2	24.4
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.3	2.4	2.4	2.4	2.7	2.9	3.1
TOTAL WASTES DISCARDED*	76.4	92.1	110.3	113.5	125.7	127.7	124.9	130.1	133.0	141.4	149.9	158.8
ENERGY RECOVERY**	-	0.2	0.4	0.7	2.7	2.3	3.5	5.0	6.5	13.3	22.5	32.0
NET WASTES DISCARDED	76.4	91.9	109.9	112.8	123.0	125.4	121.4	125.1	126.5	128.1	127.4	126.8

* Wastes discarded after materials recovery has taken place.
** Municipal solid waste consumed for energy recovery. Residues from these facilities are discussed in Chapter 2.

Details may not add to totals due to rounding.

Source. Franklin Associates, Ltd.

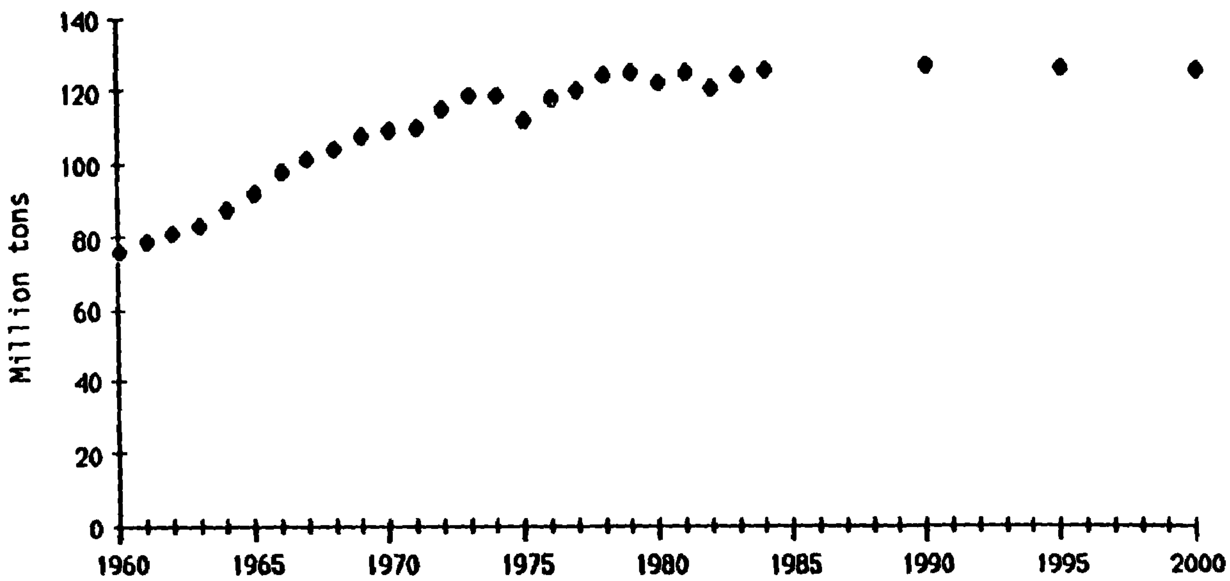


Figure 1-2. Net discards of municipal solid waste, 1960 to 2000.

Table 1-2

MATERIALS DISCARDED INTO THE MUNICIPAL WASTE STREAM, 1960 TO 2000
(In percent of total discards)

Materials	1960	1965	1970	1975	1980	1981	1982	1983	1984	1990	1995	2000
Paper and Paperboard	32.1	35.0	33.1	30.4	33.6	34.5	33.2	35.3	37.1	38.3	39.7	41.0
Glass	8.4	9.2	11.3	11.6	11.3	11.3	11.0	10.4	9.7	8.8	8.1	7.6
Metals												
Ferrous	13.0	10.9	11.2	10.6	8.9	8.7	8.8	8.5	8.3	7.8	7.4	7.1
Aluminum	0.4	0.5	0.7	0.9	1.1	1.0	1.1	1.2	1.1	1.4	1.5	1.7
Other Nonferrous	0.3	0.2	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Plastics	0.5	1.5	2.7	3.9	6.0	6.1	6.7	7.0	7.2	8.3	9.1	9.8
Rubber and Leather	2.2	2.4	2.7	3.3	3.3	3.2	3.0	2.6	2.5	2.5	2.5	2.4
Textiles	2.6	2.4	2.0	2.2	2.3	2.4	2.4	2.3	2.1	2.2	2.2	2.2
Wood	3.9	3.8	3.6	3.8	3.9	3.5	4.0	4.0	3.8	3.7	3.8	3.8
Other	-	-	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
TOTAL NONFOOD PRODUCT WASTES	63.4	65.9	67.8	67.0	70.8	71.1	70.6	71.6	72.2	73.3	74.7	75.9
Food Wastes	14.6	13.1	11.5	11.8	9.2	8.9	8.8	8.5	8.1	7.7	7.3	6.8
Yard Wastes	20.3	19.2	19.0	19.5	18.2	18.2	18.7	18.1	17.9	17.0	16.1	15.3
Miscellaneous Inorganic Wastes	1.7	1.7	1.6	1.8	1.8	1.8	1.9	1.8	1.8	1.9	1.9	2.0
TOTAL WASTES DISCARDED*	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ENERGY RECOVERY **	0.0	0.2	0.4	0.6	2.1	1.8	2.8	3.8	4.9	9.4	15.0	20.2
NET WASTES DISCARDED	100.0	99.8	99.6	99.4	97.9	98.2	97.2	96.2	95.1	90.6	85.0	79.8

* Wastes discarded after materials recovery has taken place.
** Municipal solid waste consumed for energy recovery. Residues from these facilities are discussed in Chapter 2.

Details may not add to totals due to rounding.

Source. Franklin Associates, Ltd.

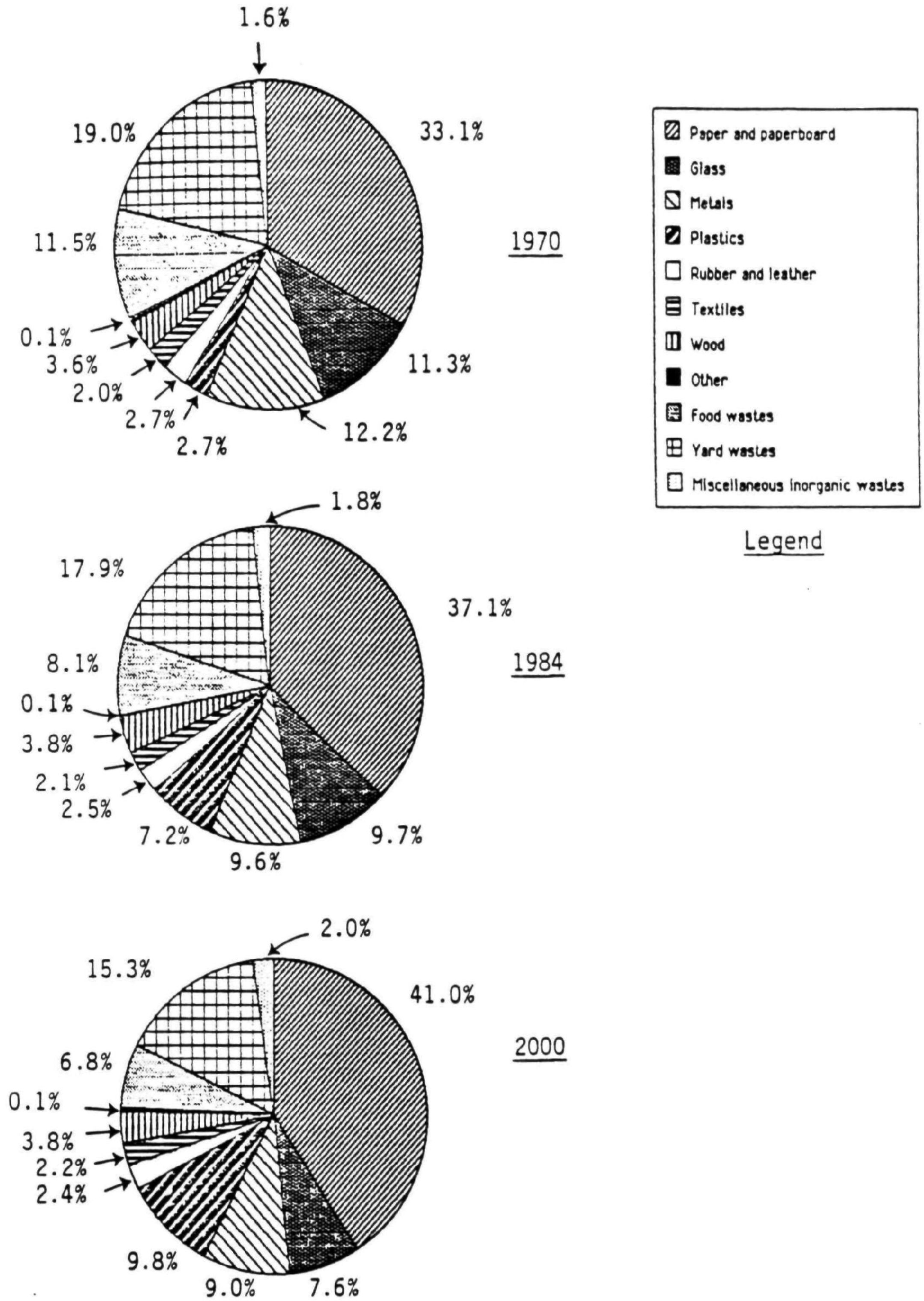


Figure 1-3. Materials discarded into the municipal waste stream, by percent of total.

Ferrous Metals

Ferrous metals total about 11 million tons in the waste strea: at present. The ferrous metals tonnage has remained fairly constant over the years; thus as a percent of the total, ferrous metals have decreased, from 13 percent in 1960 to 8 percent in 1984. This trend is projected to continue.

Aluminum

Aluminum in the municipal waste stream has increased steadily, but the tonnage of this light metal is still very small--only 1.5 million tons in 1984. In percentage, aluminum has grown from less than one-half of one percent in 1960 to just over one percent in 1984. The increasing trend is expected to continue.

Other Nonferrous Metals

These metals (e.g., copper, brass) comprise a very small share of the municipal waste stream--about one-quarter of one percent. Their tonnage has been about 300,000 tons in recent years, and this is projected to increase to 400,000 tons in 2000.

Plastics

Plastics in the waste stream have increased steadily, from about one-half million tons in 1960 to 9.6 million tons in 1984. This trend will continue, to 15.5 million tons in 2000. Plastics were less than one percent of the waste stream in 1960, were over 7 percent in 1984, and are projected to rise to almost 10 percent in 2000.

Rubber and Leather

This category, which includes rubber tires, grew in tonnage from 1.7 million tons in 1960 to 4.1 million tons in 1981. Tonnage since then has been in a decline, and any growth is expected to be very slow. Rubber and leather have ranged from 2.2 percent to 3.3 percent of the waste stream, and the percentage is projected to remain under 3 percent.

Textiles

Textiles have stayed at a fairly constant 2 to 3 percent of the municipal waste stream. Tonnage has ranged between 2 million and 3.6 million tons, and this is not projected to change.

Wood

Wood in the municipal waste stream is estimated at 3 million tons in 1960, increasing to 5 million tons in the early 1980s, and continuing to grow slowly, to 6 million tons in 2000. The percentage of wood has been about 4 percent of the total, or slightly less.

Food Wastes

Disposal of food wastes in the U.S. is poorly documented compared to other product wastes. Based on previous EPA work, the increasing use of garbage disposers in homes, and MSW sampling studies that show food wastes declining as a percent of total, food wastes are estimated to have increased from 11.2 million tons in 1960 to 13.4 million tons in 1975. Food wastes are estimated to show a slightly decreasing tonnage thereafter, to 10.8 million tons in 2000.

In terms of percentage of the waste stream, food wastes are estimated to have fallen from nearly 15 percent in 1960, to just over 8 percent in 1984, decreasing to under 7 percent in 2000.

Yard Wastes

Like food wastes, yard wastes are poorly documented, and they vary widely from region to region. Based on previous work and sampling studies, yard wastes were estimated to be 15.5 million tons in 1960, increasing to 23.8 million tons in 1984, and increasing to 24.4 million tons in 2000. Percentage of total has decreased from about 20 percent in 1960 to about 18 percent in 1984.

Miscellaneous Inorganic Wastes

This category, mostly stones and dirt, is also poorly documented. Estimates were kept similar to those that have been made before (5)(6)(7)(8). The tonnage increases slowly from 1.3 million tons in 1960 to 2.5 million tons in 1984, with a slow increase thereafter, to 3.1 million tons. This category represents less than 2 percent of the municipal waste stream.

PRODUCTS IN THE MUNICIPAL WASTE STREAM

With the exception of food, yard, and miscellaneous inorganic wastes, the materials in the waste stream are present in manufactured products. These product categories are shown in Tables 1-3 and 1-4 and Figure 1-4. The product wastes are categorized as durable goods, nondurable goods, and containers and packaging. The products are discussed below.

Durable Goods

Total durables discarded have increased from 9 million tons in 1960 to 18.6 million tons in 1984. They are projected to reach 22.9

Table 1-3

PRODUCTS DISCARDED INTO THE MUNICIPAL WASTE STREAM
(In millions of tons)

Products	1960	1965	1970	1975	1980	1981	1982	1983	1984	1990	1995	2000
Durable Goods												
Major Appliances	1.5	1.0	2.6	2.5	2.7	2.8	2.8	2.8	2.6	2.4	2.5	2.7
Furniture and Furnishings	2.1	2.7	3.4	4.1	5.1	5.2	5.9	6.3	6.0	6.4	7.2	8.0
Rubber Tires	0.8	1.0	1.6	2.3	2.3	2.3	2.0	1.5	1.3	1.6	1.7	1.7
Miscellaneous Durables	4.6	5.4	6.3	7.0	7.7	7.8	8.2	8.4	8.7	9.6	10.0	10.5
TOTAL DURABLES	9.0	10.0	13.9	16.0	17.8	18.1	18.8	18.9	18.6	20.0	21.4	22.9
Nondurable Goods												
Newspapers	5.3	6.3	7.2	6.4	8.1	8.4	7.6	8.2	9.0	9.7	10.5	11.4
Books and Magazines	1.8	2.1	2.2	2.0	3.1	3.2	3.3	3.8	4.2	4.9	5.8	6.7
Office Papers	1.3	1.8	2.0	2.0	3.1	3.1	3.2	3.6	3.9	4.6	5.3	6.1
Commercial Printing	1.1	1.6	1.8	1.8	2.7	2.7	2.8	3.2	3.5	4.3	5.0	5.8
Tissue Paper and Towels	1.1	1.5	2.1	2.1	2.4	2.5	2.4	2.6	2.8	3.1	3.2	3.4
Other Nonpackaging Paper	2.8	4.1	3.8	3.7	4.6	4.7	4.4	5.1	5.3	5.6	6.0	6.5
Clothing and Footwear	1.5	1.7	1.8	2.1	2.6	2.7	2.6	2.7	2.6	2.8	3.1	3.3
Other Miscellaneous Nondurables	0.4	0.5	0.8	1.0	2.4	2.4	2.3	2.5	2.7	3.1	3.6	4.2
TOTAL NONDURABLES	15.4	19.6	21.6	21.1	28.9	29.7	28.5	31.7	34.0	38.1	42.5	47.4
Containers and Packaging												
Glass												
Beer and Soft Drink Bottles	1.3	2.5	5.4	5.9	6.0	6.0	5.8	5.4	4.9	4.5	4.4	4.2
Wine and Liquor Bottles	0.9	1.4	1.9	2.0	2.4	2.4	2.2	2.3	2.2	2.2	2.1	2.1
Food and Other Bottles & Jars	3.7	4.2	4.4	4.4	4.8	4.9	4.8	4.7	4.7	4.6	4.5	4.5
Total Glass	5.9	8.0	11.7	12.3	13.2	13.3	12.8	12.4	11.8	11.3	11.1	10.8
Steel												
Beer and Soft Drink Cans	0.6	0.9	1.5	1.2	0.5	0.3	0.2	0.1	0.1	0.1	0.1	0.1
Food and Other Cans	3.7	3.6	3.5	3.3	2.7	2.6	2.5	2.5	2.5	2.4	2.1	1.9
Other Steel Packaging	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Total Steel	4.6	4.7	5.3	4.7	3.4	3.2	2.9	2.8	2.8	2.7	2.4	2.2
Aluminum												
Beer and Soft Drink Cans	0.1	0.1	0.3	0.4	0.6	0.5	0.5	0.5	0.6	0.7	0.8	1.0
Other Cans	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Foil and Closures	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	
Total Aluminum	0.2	0.3	0.6	0.7	0.9	0.8	0.8	0.9	0.9	1.1	1.3	
Paper and Paperboard												
Corrugated Boxes	4.7	7.7	9.7	9.5	10.1	11.2	9.9	10.9	11.9	13.0	14.5	16.2
Other Paperboard	3.5	4.1	4.3	3.9	4.3	4.3	4.3	4.6	4.9	4.8	4.9	5.0
Paper Packaging	2.7	3.1	3.4	3.0	3.7	3.8	3.8	4.0	4.0	4.1	4.2	3.8
Total Paper	11.0	14.9	17.4	16.4	18.2	19.3	18.0	19.5	20.8	22.0	23.6	25.1
Plastics												
Plastic Containers	0.1	0.3	0.9	1.3	2.1	2.1	2.0	2.2	2.4	2.9	3.4	3.9
Other Packaging	0.1	0.7	1.2	1.4	2.1	2.2	2.2	2.4	2.6	3.2	3.8	4.3
Total Plastics	0.1	1.0	2.1	2.8	4.2	4.3	4.2	4.6	5.0	6.2	7.2	8.2
Wood Packaging	2.0	2.1	2.1	2.0	2.1	2.1	2.0	2.0	2.0	2.0	2.0	2.0
Other Miscellaneous Packaging	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
TOTAL CONTAINERS AND PACKAGING	24.0	31.0	39.3	38.9	42.2	43.2	40.9	42.4	43.5	45.5	47.9	50.1
Total Nonfood Product Wastes	48.4	60.7	74.8	76.0	89.0	91.0	88.2	93.1	96.0	103.7	111.9	120.5
Other Wastes												
Food Wastes	11.2	12.1	12.7	13.4	11.6	11.3	11.0	11.1	10.8	10.9	10.9	10.8
Yard Wastes	15.5	17.7	21.0	22.1	22.9	23.1	23.3	23.5	23.8	24.1	24.2	24.4
Miscellaneous Inorganic Wastes	1.3	1.6	1.8	2.0	2.2	2.3	2.3	2.4	2.4	2.7	2.9	3.1
TOTAL OTHER WASTES	28.0	31.4	35.5	37.5	36.7	36.7	36.6	37.1	37.0	37.7	38.0	38.3
TOTAL WASTES DISCARDED*	76.4	92.1	110.3	113.5	125.7	127.7	124.9	130.1	133.0	141.4	149.9	158.8
ENERGY RECOVERY**	-	0.2	0.4	0.7	2.7	2.3	3.5	5.0	6.5	13.3	22.5	32.0
NET WASTES DISCARDED	76.4	91.9	109.9	112.8	123.0	125.4	121.4	125.1	126.5	128.1	127.4	126.8

* Wastes discarded after materials recovery has taken place

** Municipal solid waste consumed for energy recovery. Residues from these facilities are discussed in Chapter 2.

Details may not add to totals due to rounding

Source: Franklin Associates, Ltd.

Table 1-4

PRODUCTS DISCARDED INTO THE MUNICIPAL WASTE STREAM
(In percent of total discards)

Products	1960	1965	1970	1975	1980	1981	1982	1983	1984	1990	1995	2000
Durable Goods												
Major Appliances	1.9	1.1	2.4	2.2	2.1	2.2	2.2	2.1	2.0	1.7	1.7	1.7
Furniture and Furnishings	2.7	2.9	3.1	3.6	4.1	4.1	4.7	4.8	4.4	4.5	4.7	5.0
Rubber Tires	1.0	1.1	1.4	2.1	1.9	1.8	1.6	1.2	1.0	1.1	1.1	1.1
Miscellaneous Durables	6.0	5.9	5.7	6.2	6.1	6.1	6.6	6.4	6.5	6.8	6.5	6.6
TOTAL DURABLES	11.8	10.9	12.6	14.1	14.2	14.2	15.1	14.5	14.0	14.1	13.8	14.4
Nondurable Goods												
Newspapers	6.9	6.8	6.5	5.6	6.5	6.6	6.1	6.3	6.7	6.7	7.0	7.2
Books and Magazines	2.4	2.3	2.0	1.8	2.4	2.5	2.6	2.9	3.2	3.4	3.9	4.2
Office Papers	1.7	2.0	1.8	1.7	2.5	2.4	2.5	2.7	2.9	3.2	3.5	3.8
Commercial Printing	1.4	1.7	1.6	1.6	2.1	2.1	2.2	2.4	2.7	3.0	3.3	3.7
Tissue Paper and Towels	1.4	1.6	1.9	1.9	1.9	1.9	1.9	2.0	2.1	2.1	2.1	2.1
Other Nonpackaging Paper	3.7	4.5	3.5	3.3	3.6	3.7	3.3	3.9	4.0	3.9	3.9	4.1
Clothing and Footwear	2.0	1.8	1.6	1.8	2.1	2.1	2.1	2.1	2.0	2.0	2.1	2.1
Other Miscellaneous Nondurables	0.5	0.5	0.7	0.9	1.9	1.9	1.9	1.9	2.0	2.2	2.4	2.6
TOTAL NONDURABLES	20.1	21.3	19.6	18.6	23.0	23.2	22.8	24.2	25.6	26.9	28.4	29.8
Containers and Packaging												
Glass												
Beer and Soft Drink Bottles	1.7	2.7	4.9	5.2	4.8	4.7	4.6	4.3	3.7	3.2	2.9	2.6
Wine and Liquor Bottles	1.2	1.5	1.7	1.6	1.9	1.9	1.8	1.8	1.7	1.6	1.4	1.3
Food and Other Bottles and Jars	4.8	4.6	4.0	3.9	3.8	3.8	3.8	3.6	3.6	3.2	3.0	2.8
Total Glass	7.7	8.7	10.6	10.8	10.5	10.4	10.2	9.5	8.9	8.0	7.4	6.8
Steel												
Beer and Soft Drink Cans	0.8	1.0	1.4	1.1	0.4	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Food and Other Cans	4.8	3.9	3.2	2.9	2.3	2.0	2.0	1.9	1.9	1.7	1.4	1.2
Other Steel Packaging	0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Total Steel	6.0	5.1	4.8	4.2	2.7	2.5	2.3	2.1	2.1	1.9	1.6	1.4
Aluminum												
Beer and Soft Drink Cans	0.1	0.1	0.3	0.4	0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.6
Other Cans	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Foil and Closures	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
Total Aluminum	0.2	0.3	0.5	0.6	0.7	0.6	0.6	0.7	0.7	0.8	0.9	0.9
Paper and Paperboard												
Corrugated Boxes	6.2	8.4	8.8	8.4	8.0	8.8	8.0	8.3	8.9	9.0	9.7	10.2
Other Paperboard	4.6	4.5	3.9	3.4	3.5	3.3	3.4	3.5	3.7	3.4	3.3	3.1
Other Packaging	3.5	3.4	3.1	2.6	3.0	3.0	3.0	3.1	3.0	2.9	2.8	2.4
Total Paper	14.4	16.2	15.8	14.4	14.5	15.1	14.4	14.9	15.6	15.3	15.7	15.8
Plastics												
Plastic Containers	0.1	0.3	0.8	1.2	1.7	1.6	1.6	1.7	1.8	2.1	2.3	2.5
Other Packaging	0.1	0.8	1.1	1.3	1.7	1.8	1.8	1.9	1.9	2.2	2.5	2.7
Total Plastics	0.2	1.1	1.9	2.4	3.4	3.4	3.3	3.5	3.7	4.3	4.8	5.2
Wood Packaging	2.6	2.3	1.9	1.8	1.7	1.6	1.6	1.5	1.5	1.4	1.3	1.3
Other Miscellaneous Packaging	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
TOTAL CONTAINERS AND PACKAGING	31.4	33.7	35.6	36.3	33.6	33.8	32.7	32.5	32.7	32.2	32.0	31.6
TOTAL NONFOOD PRODUCT WASTES	63.4	65.9	67.9	67.0	70.8	71.2	70.6	71.6	72.2	73.3	74.6	75.9
Other Wastes												
Food Wastes	14.7	13.1	11.5	11.8	9.3	8.9	8.8	8.5	8.1	7.6	7.3	6.8
Yard Wastes	20.3	19.2	19.0	19.4	18.2	18.1	18.7	18.0	17.9	16.8	16.1	15.[illegible]
Miscellaneous Inorganic Wastes	1.7	1.7	1.6	1.8	1.8	1.8	1.9	1.8	1.8	1.9	1.9	[illegible].9
TOTAL OTHER WASTES	36.6	34.1	32.1	33.0	29.2	28.8	29.4	28.4	27.8	26.7	25.[illegible]	24.1
TOTAL WASTES DISCARDED*	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ENERGY RECOVERY**	-	0.2	0.4	0.6	2.2	1.8	2.9	3.8	4.9	9.4	15.0	20.0
NET WASTES DISCARDED	100.0	99.8	99.6	99.4	97.8	98.2	97.1	96.2	95.1	90.6	85.0	80.0

* Wastes discarded after materials recovery has taken place
** Municipal solid waste consumed for energy recovery. Residues from these facilities are discussed in Chapter 2

Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd.

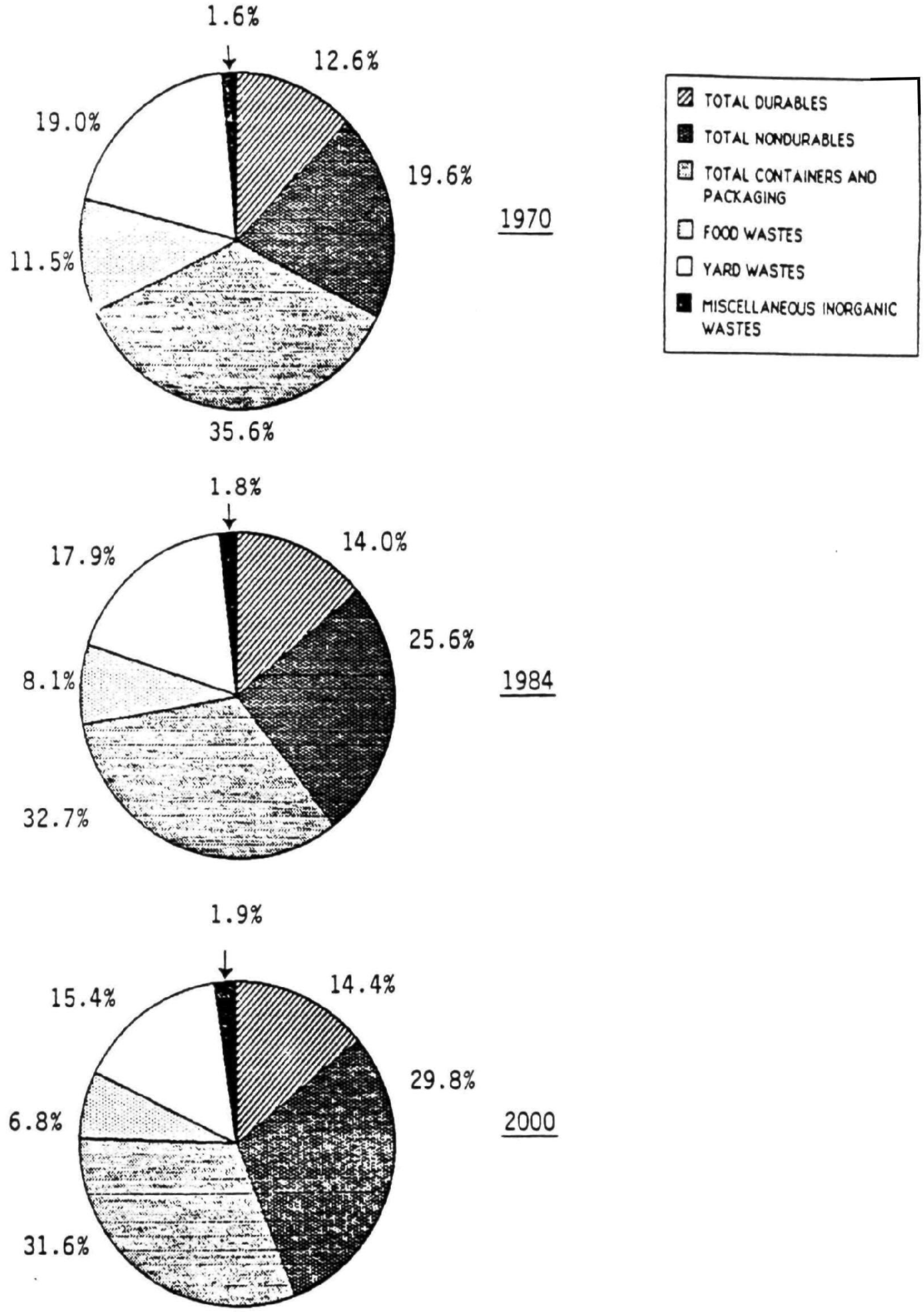


Figure 1-4. Products discarded into the municipal waste stream, by percent of total.

million tons in 2000. As a percentage of the municipal waste stream, durable goods have increased only slightly, from 12 percent in 1960 to 14 percent in 1984; this is projected to be about 14 percent in 2000 also.

Discards of major appliances increased from 1.5 million tons in 1960 to 2.6 million tons in 1970. Discards have been nearly constant since then, and are expected to remain so. Appliances have been about 2 percent of total discards for the entire period.

Discards of furniture and furnishings increased from 2.1 million tons in 1960 to 6.0 million tons in 1984. They will continue to increase to 2000. Furniture and furnishings as a percentage of total discards have increased slowly from 3 percent in 1960 to 4 percent in 1984. They are projected to comprise 5 percent of total discards in 2000.

Rubber tires are an exception to the usual increase in product tonnage discarded. Tire discards were 800,000 tons in 1960, increased to 2.3 million tons, then began to decline in 1982. There are two main reasons for the decline in discards of rubber tires--tires are smaller than they were in former years, and they last longer (13). Tires have been one to 2 percent of the waste stream historically, and this is not expected to change.

The products classified as miscellaneous durables are varied, and not well documented. Small appliances and consumer electronics are important constituents of the category. Estimated discards have increased from 4.6 million tons in 1960 to 8.7 million tons in 1984. Discards in 2000 are projected to be 10.5 million tons. These goods comprise 6 to 7 percent of the waste stream.

Nondurable Goods

The nondurable goods category has grown from 15.4 million tons in 1960 to 34.0 million tons in 1984. Nondurables are projected to contribute 47.4 million tons to the waste stream in 2000. In terms of percentage of the waste stream, nondurables were 20 percent in 1960, increased to almost 26 percent in 1984, and are projected to be almost 30 percent in 2000.

Paper products comprise the majority of nondurable goods. The total paper nondurables were 17.5 percent of the waste stream in 1960, increasing to over 20 percent in 1984. Newspapers are the largest single nondurable category; they have been nearly 7 percent of total waste discards for the entire period. The categories of books, magazines, office papers, and commercial printing have been increasing in percentage of total during the 1980s, and are expected to continue to do so. Tissue and other papers have maintained a more constant percentage in the waste stream.

Clothing and footwear consistently comprise about 2 percent of the waste stream. These goods increased from 1.5 million tons in 1960 to 2.6 million tons in 1984, with discards in 2000 projected at 3.3 million tons.

Miscellaneous nondurables in the waste stream are not well documented. They are estimated to have increased from 400,000 tons in 1960 to 2.7 million tons in 1984, with increases to 4.2 million tons in 2000. In percentage, this category has increased from one percent in 1960 to 2 percent in 1984, with a projected increase to 2.6 percent in 2000.

Containers and Packaging

Containers and packaging are a very important part of the municipal waste stream, increasing from 24 million tons in 1960 to 43.5 million tons in 1984. They are projected to contribute 50 million tons to total wastes in 2000. Containers and packaging were 31 percent of total discards in 1960, 36 percent in 1970, and 33 percent in 1984. They are projected to be under 32 percent of total discards in 2000. The decreasing percentage is apparently due to the partial replacement of relatively heavy materials--glass and ferrous metals--with lighter materials such as aluminum and plastics.*

Each material component of the containers and packaging category is discussed briefly below.

Glass. Beer and soft drink bottles, wine and liquor bottles, and food bottles and jars are the important glass container categories. Total glass containers increased from 5.9 million tons in 1960 to 13.3 million tons in 1981, then decreased to 11.8 million tons in 1984. In terms of percentage, glass containers were almost 8 percent of total discards in 1965, increased to almost 11 percent, then dropped to 9 percent in 1984.

Tonnage of glass containers in the waste stream is projected to continue to decrease to under 11 million tons in 2000. This would be less than 7 percent of total discards.

Steel. Steel containers include beer and soft drink cans, food cans, and some other miscellaneous packaging. Tonnage was 4.6 million tons in 1960, increased to 5.3 million tons in 1970, and has dropped ever since. Steel containers were 6 percent of total discards in 1960, decreasing

---

* As products decrease in weight, there may not be a corresponding decrease in volume. An aluminum soft drink can and one made of steel are the same size, to cite one example. Relationships between volume and weight of the components of MSW have not been well established, so far as is known.

to 2 percent in 1984. They are projected to be one to 2 percent of total discards in 2000.

Aluminum. Aluminum beer and soft drink cans comprise the majority of this category of containers. Aluminum containers have increased rapidly, from 200,000 tons in 1960 to 900,000 tons in 1984. Tonnage in 2000 is projected at 1.5 million tons. In spite of the rapid increase, aluminum represents only about one percent of total discards because of its light weight.

Paper and Paperboard. This category includes corrugated containers, boxboard containers (e.g., cereal boxes), and paper packaging such as grocery sacks. This is an important waste category, increasing from 11 million tons in 1960 to 20.8 million tons in 1984, with a projected 25 million tons in 2000. Paper and paperboard containers and packaging were 14 percent of total discards in 1960, increasing to almost 16 percent in 1984 and 2000.

Corrugated containers are the largest single component of this category, increasing from 4.7 million tons in 1960 to 11.9 million tons in 1984. They are projected to reach 16.2 million tons in 2000. Corrugated boxes were 9 percent of total discards in 1984.

Plastics. Plastic containers and packaging have grown dramatically, from a negligible percentage of total discards in 1960 to 4 percent in 1984. Tonnage was 100,000 tons in 1960 and 5 million tons in 1984; it is projected at 8.2 million tons in 2000.

Wood. Wood packaging includes shipping pallets and boxes. Although not well documented, this category is thought to have remained about constant at 2 million tons. As a percent of total, wood packaging has decreased from 3 percent in 1960 to 2 percent in 1984, and is projected to be one percent in 2000.

Other Miscellaneous Packaging. This category includes small amounts of textiles, leather, etc., used in specialty packaging. The category represents a negligible percentage of total discards.

TRENDS IN MUNICIPAL SOLID WASTE DISPOSAL

The tables and figures just presented show trends in tonnage and percentage of materials and products discarded. Two additional ways to look at trends are presented here.

Organics/Inorganics

The mix of organic and inorganic materials in the municipal waste stream is of interest to persons dealing with waste disposal, whether by sanitary landfill or by incineration with energy recovery.

In the former case, organics decompose into leachate and gases. In the latter instance, the organics are the fuel for combustion, while the inorganics become residue to be disposed.

Table 1-5 and Figure 1-5 illustrate the percentage breakdown of wastes discarded after materials recovery has taken place, but before energy recovery. There has been an uneven but noticeable trend toward an increased percentage of organic materials in the waste stream, from 76.2 percent in 1960 to 81.3 percent in 2000. This can be attributed to the increasing percentages of paper and plastics in the waste stream, and is occurring in spite of decreasing percentages of food and yard wastes in discards.

Table 1-5

COMPOSITION OF MUNICIPAL SOLID WASTE DISCARDS*
BY ORGANIC AND INORGANIC FRACTIONS, 1960 TO 2000
(In percent of total)

Year	Organics	Inorganics
1960	76.2	23.8
1965	77.5	22.5
1970	74.8	25.2
1975	74.9	25.1
1980	76.5	23.5
1981	76.8	23.2
1982	77.0	23.0
1983	77.8	22.2
1984	78.9	21.1
1990	79.8	20.2
1995	80.7	19.3
2000	81.3	18.7

* Discards after materials recovery has taken place, and before energy recovery.

Source: Franklin Associates, Ltd.

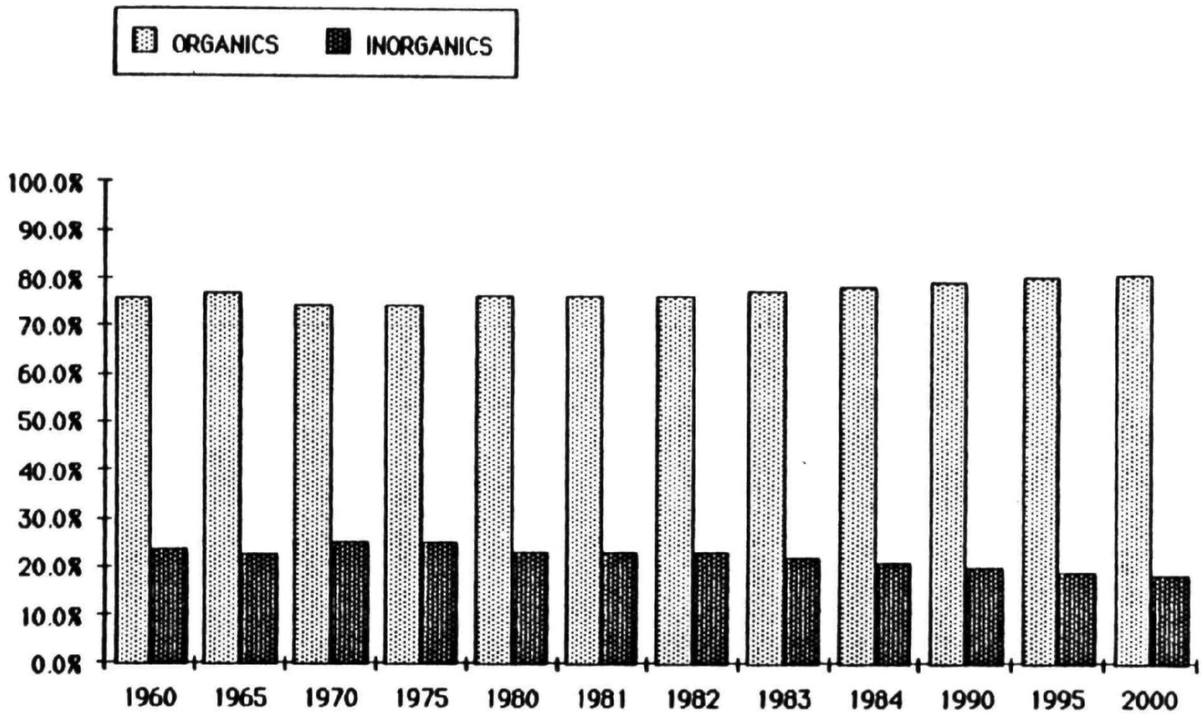


Figure 1-5. Composition of municipal solid waste discards by organic and inorganic fractions, 1960 to 2000.

Paper has the highest tonnage of any organic constituent in the waste stream. Yard wastes and food wastes also contribute large tonnages. Plastics come next in order of tonnage contributed, with rubber, leather textiles, and wood also in this category.

Discards by Individuals

Another trend of interest to planners is the increase in discards per person. This is usually expressed as pounds per capita per day (pcd). This trend is shown in Table 1-6 and Figure 1-6. (Note that these figures include residential, commercial, and institutional wastes. Per capita discards from residences alone would be lower.)

Some interesting trends are illustrated in Table 1-6. With the exception of 1975 and 1982--recession years--per capita discards of paper and paperboard products have increased steadily. Per capita discards of plastics have increased in every year tabulated. Per capita discards of glass, metals, rubber and leather, textiles, and wood have been declining or staying almost even.

For total nonfood product wastes, per capita discards have increased every year except for recession years. This is not surprising, since paper comprises about 50 percent of the nonfood product wastes.

Food wastes are shown to be declining in per capita discards, yard wastes to be declining slightly, and miscellaneous organics increasing very slightly. (These estimates are explained more fully in the Working Papers.)

Overall, total municipal solid waste discarded (after materials recovery) is estimated to have increased from 2.32 pcd in 1970 to 3.08 pcd in 1984. Discards are projected to be 3.25 pcd in 2000. After energy recovery, these discards are estimated to be 2.32 pcd in 1970, 2.93 pcd in 1984, and 2.59 pcd in 2000. The downward trend is due to increasing projected energy recovery (discussed in Chapter 3).

HOW THIS DATA SERIES DIFFERS FROM PREVIOUS ESTIMATES

The data series developed for these estimates of MSW differ from previous work published by EPA and others (8)(9)(10)(11)(12). A comparison of 1977 discards estimated by material flows methodology for EPA in 1979 (10) and those estimated for this report is shown in Table 1-7.

The estimates of total nonfood product waste discards for 1977 differ by less than one percent. There are differences in the estimates for some of the materials categories. These are caused by changes in the source data series, refinements in the methodology,* or both.

* Detailed descriptions of the methodology for each material are included in the Working Papers for this report.

Table 1-6

DISCARDS OF MUNICIPAL SOLID WASTE BY INDIVIDUALS, 1960 TO 2000
(In pounds per capita per day)

Materials	1960	1965	1970	1975	1980	1981	1982	1983	1984	1990	1995	2000
Paper and Paperboard	0.74	0.91	0.97	0.88	1.01	1.05	0.98	1.07	1.14	1.19	1.26	1.33
Glass	0.19	0.24	0.33	0.33	0.34	0.34	0.32	0.31	0.30	0.27	0.26	0.25
Metals	0.31	0.30	0.36	0.34	0.31	0.30	0.30	0.30	0.30	0.30	0.29	0.30
Plastics	0.01	0.04	0.08	0.11	0.18	0.19	0.20	0.21	0.22	0.26	0.29	0.32
Rubber and Leather	0.05	0.06	0.08	0.10	0.10	0.10	0.09	0.08	0.08	0.08	0.08	0.08
Textiles	0.06	0.06	0.06	0.06	0.07	0.08	0.07	0.07	0.06	0.07	0.07	0.07
Wood	0.09	0.10	0.11	0.11	0.12	0.11	0.12	0.12	0.12	0.12	0.12	0.12
TOTAL NONFOOD PRODUCT WASTES	1.47	1.71	2.00	1.93	2.14	2.17	2.08	2.17	2.22	2.28	2.36	2.46
Food Wastes	0.34	0.34	0.34	0.34	0.28	0.27	0.26	0.26	0.25	0.24	0.23	0.22
Yard Wastes	0.47	0.50	0.56	0.56	0.55	0.55	0.55	0.55	0.55	0.53	0.51	0.50
Miscellaneous Inorganic Wastes	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06
TOTAL WASTES DISCARDED*	2.32	2.60	2.95	2.88	3.02	3.04	2.95	3.04	3.08	3.10	3.16	3.25
ENERGY RECOVERY**	0.00	0.01	0.01	0.02	0.06	0.05	0.08	0.12	0.15	0.29	0.47	0.65
NET WASTES DISCARDED	2.32	2.59	2.94	2.86	2.96	2.99	2.86	2.92	2.93	2.81	2.69	2.59

* Wastes discarded after materials recovery has taken place.
** Municipal solid waste consumed for energy recovery. Residues from these facilities are discussed in Chapter 2.

Details may not add to totals due to rounding.

Source. Franklin Associates, Ltd.

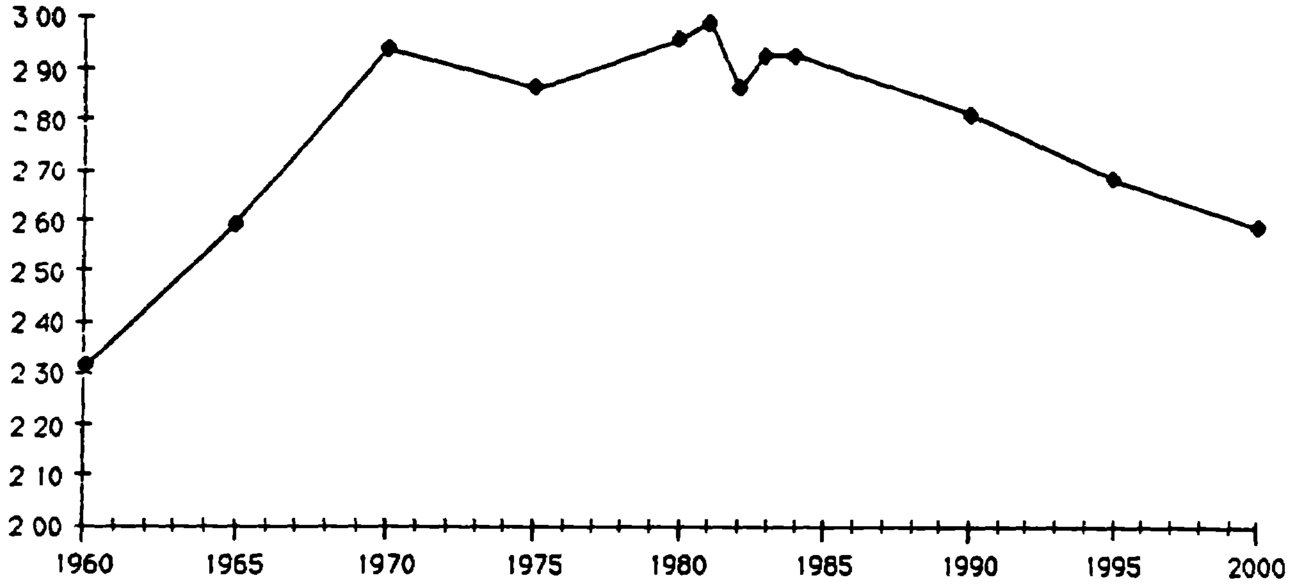


Figure 1-6. Discards of municipal solid wastes after materials and energy recovery, in pounds per capita per day.

The major revision that has been made for the current estimates is the dramatic lowering of estimates of food and yard wastes. This revision causes the 1986 estimate of 1977 discards to be 10 percent lower than the estimate made in 1979.

The EPA estimates of food and yard wastes published in 1975 (5) were based on a study of waste composition published in 1970. The data series was kept consistent after that. For this 1986 report, waste sampling reports from the 1970s and 1980s were analyzed, and a best estimate that food wastes were 10.7 percent of total MSW in the early 1970s and 7.5 percent in the 1980s, was made. The estimates for yard wastes were 17.3 percent of total MSW in the early 1970s and 16.2 percent in the 1980s. Based on this survey, new estimates of food and yard wastes were made, showing declining percentages of total MSW discards. These estimates are subject to scrutiny and revision if better data become available.

Table 1-7

COMPARISON OF 1977 DISCARDS* ESTIMATED IN 1979 AND IN 1986
(In millions of tons and percent)

Materials	1979 Estimate	1986 Estimate	% Difference
Paper and Paperboard	40.1	40.3	+0.5
Glass	14.2	13.9	-2.1
Metals			
Ferrous	11.6	11.7	+0.9
Aluminum	1.2	1.2	-
Other Nonferrous	0.4	0.3	-25.0
Plastics	5.3	6.5	+22.6
Rubber and Leather	3.4	3.4	-
Textiles	3.0	2.5	-16.7
Wood	4.7	4.7	-
TOTAL NONFOOD PRODUCT WASTE	83.9	84.6	+0.8
Food Wastes	23.2	12.9	-44.4
Yard Wastes	26.4	22.1	-16.3
Miscellaneous Inorganic Wastes	2.1	2.1	-
TOTAL WASTES DISCARDED*	135.6	121.7	-10.2

* Waste discarded after materials recovery has taken place, and before energy recovery.

Source: Franklin Associates, Ltd.

Chapter 1

REFERENCES

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

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

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

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

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

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

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

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

9. Franklin Associates, Ltd. Post-consumer Solid Waste and Resource Recovery Baseline. Prepared for the Resource Conservation Committee. April 6, 1979.

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

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

12. Franklin, W. E., M. A. Franklin, and R. G. Hunt, Waste Paper: The Future of a Resource, 1980-2000. Franklin Associates, Ltd. for the Solid Waste Council of the Paper Industry. December 1982.

13. U.S. Department of Commerce. 1986 U.S. Industrial Outlook. January 1986. Also earlier years of the same source.

14. U.S. Bureau of the Census. Current Population Reports. "Estimates of the Population of the United States, by Age, Sex, and Race: 1980 to 1984." Series P-25, No. 965. Issued March 1985. "Projections of the Population of the United States, by Age, Sex, and Race: 1983 to 2080." Series P-25, No. 952. Issued May 1984. Projections are from the middle series.

Chapter 2

OTHER MUNICIPAL LANDFILL WASTES

INTRODUCTION

The residential, commercial, and institutional municipal solid wastes quantified in Chapter 1 include well-defined product categories, plus food, yard, and miscellaneous inorganic wastes. These wastes generally are disposed of in municipal landfills or another facility such as an incinerator with energy recovery. In addition to these municipal solid wastes, other wastes are frequently disposed of in municipal landfills. Such wastes include:

- Demolition/construction wastes
- Water/wastewater treatment residues (sludge)
- Trees and brush
- Street refuse (sweepings, etc.)
- Car bodies
- Nonhazardous industrial process waste
- Incinerator residue
- Boiler residue (power plant ash, etc.)
- Household hazardous wastes
- Small quantity generator hazardous wastes
- Used oil

A discussion of these wastes and their significance in municipal landfills is presented in this chapter. The information provided represents an overview of these wastes, and estimates of quantities either generated or disposed of in municipal landfills are not developed from a database comparable to that used in Chapter 1. Comparisons with municipal solid waste disposal refer to the estimated quantity of municipal solid waste disposed of (before energy recovery) in the U.S. in 1984 (Chapter 1).

DEMOLITION AND CONSTRUCTION WASTES

Construction and demolition wastes result from demolishing existing structures and building new structures. Solid wastes from these activities include mixed lumber, roofing and sheeting scraps, broken concrete, asphalt, brick, stone, plaster, wallboard, glass, piping, and other residential building materials (1). The exact nature of construction and demolition wastes depends upon the type of structures involved, which relates to geographical location as well as the age and size of community.

The quantities of demolition and construction wastes are also highly dependent upon the specifics of a community. Values reported in various locations across the U.S. range from 0.12 to 3.52 pounds per capita per day (pcd) (1). An urban average of 0.72 pcd is a figure reported from about 1970 (2). A California study reported 0.27 pcd for communities under 10,000 people, 0.68 pcd between 10,000 and 100,000 people, and 1.37 pcd in communities of over 100,000 people (3). A study of waste generation in the Kansas City area estimated quantities of demolition and construction wastes at about 0.6 pcd (4).

At an average of 0.72 pcd, the total quantity of construction and demolition wastes generated in the U.S. is estimated at about 31.5 million tons per year. This is about 24 percent as much as the municipal solid waste disposed of in 1984.

The fraction of generated demolition and construction wastes received at municipal landfills is unknown. Since most of these wastes are generally viewed as requiring less stringent disposal than typical residential and commercial solid wastes, special landfills are often used. Some demolition and construction wastes may, however, pose health and environmental problems without certain precautions. Dust from asbestos fiber and glass, for example, may pose hazards, and uncovered demolition debris may harbor rodents and be considered an aesthetic nuisance (1). For these reasons and others, some construction and demolition wastes are disposed of in municipal landfills. Disposal practices for construction and demolition wastes vary considerably from area to area and even within the same metropolitan area.

WATER/WASTEWATER TREATMENT RESIDUES

Residues from the treatment of both water and wastewater (sewage) are generated in metropolitan areas. These residues are, typically, referred to as sludges, although some sewage sludges are burned, leaving a final residue of ash.

Water treatment sludges (filter cake wastes, etc.), consist of a variety of organic and inorganic materials, including inorganics from coagulation and softening (5). These sludges may be landfilled or subjected to chemical recovery techniques. Water treatment sludges are much lower in quantity than sewage sludges. The filter cake sludge is reportedly generated at the rate of 0.005 to 0.2 pcd.

Sewage sludge is generated from wastewater treatment. Biological wastewater treatment is the predominant method and the sludge from biological treatment may consist primarily of organic matter. If aerobic or anaerobic digestion is used in sludge conditioning to improve dewaterability, the organic fraction of the sludge solids content may be reduced by approximately 50 percent (5). Thus, total solids in sewage sludge processed for disposal, based on factors reported in the literature (4)(5)(6), are estimated to vary from about 0.2 to 0.3 pcd in the U.S. Assuming that the sludge is dewatered to about 20 percent solids content, sewage sludge quantities requiring disposal in the U.S. are estimated at 1.0 to 1.5 pcd. These figures assume inclusion of industrial wastewater and the use of garbage disposers. They equate to a range of about 44 to 66 million tons per year, which is 33 to 50 percent as much as municipal solid waste disposed.

Sewage sludge is disposed in a variety of ways, including incineration, landspreading, ocean disposal, composting, lagooning, and landfilling. Sewage sludges are often incinerated, which essentially eliminates the organic solids and removes the moisture. The residue from incineration consists primarily of an inorganic ash. This residue may be landfilled. It should be no more than a small fraction, by weight, of the original sludge quantity.

The quantity of sludge landfilled in the U.S. is unknown. While quantity estimates are not within the scope of this effort, municipal landfilling is the disposal method for a large portion of the domestic and industrial sewage sludges generated in the U.S.

TREES AND BRUSH

These wastes result from trimming trees and bushes, cutting brush and trees, and landscaping activities. The municipal solid waste quantities presented in Chapter 1 include estimates of yard wastes, including trimmings, from residences and commercial establishments. There are, however, other sources of trees and brush such as trimmings from public parks and from clearing rights-of-way along powerlines (1), and other clearing operations. Accurate estimates of generation of these wastes are not available.

Quantities of tree and brush wastes received at municipal landfills are also unknown. As with construction and demolition wastes, tree and brush wastes may frequently be disposed in special sites at less cost than municipal landfilling. Some fraction of tree and brush wastes are disposed in special sites, and some receive on-site burial or burning. Restrictions on burning, however, make this no longer a viable option in many communities. In summary, the quantities and impacts of tree and brush wastes in municipal landfills (in addition to those estimated in Chapter 1) are unknown, but believed to be small.

STREET REFUSE

Street refuse, as used here, includes material swept from urban streets, alley-cleaning wastes, and wastes resulting from periodic cleaning of storm sewer catch basins.

Street sweeping waste is the most significant of these wastes, with average U.S. generation estimated at 0.25 pcd (1). Adding wastes from alleys and catch basins results in a total street refuse estimate of between 0.35 and 0.40 pcd (1)(4). This equates to over 15 million tons per year, which is roughly 11 percent as much as municipal solid waste disposal in the U.S. in 1984.

These wastes are typically collected by municipalities and disposed of in municipal landfills.

CAR BODIES

From 1972 through 1984, almost 10 million automobiles per year were sold to U.S. consumers (8). Another 3 million trucks and buses per year were sold during that period, resulting in a total of 13 million motor vehicles sold annually in the U.S.

The number of vehicles taken out of service each year may approach the number sold. If it can be assumed that 10 million vehicles are retired in the U.S. each year, the total annual quantity is 20 million tons. This is equivalent to about 15 percent as much as municipal solid waste disposal in 1984.

While the quantity of vehicles removed from service each year is substantial, a very small fraction is estimated to be disposed of in municipal landfills. Some retired vehicles are stored in "junkyards" and used for parts, while others are shredded and baled to recover the metals. No estimate is available on quantities placed in municipal landfills.

NONHAZARDOUS INDUSTRIAL PROCESS WASTE

Manufacturing industries in the U.S. are estimated to have generated over 100 million tons of solid wastes in 1982, or approximately 2.3 pounds per capita per day (9). These wastes may include everything from packaging materials and wastes from personnel activity to process wastes and wastewater treatment sludges. Some of these wastes, such as packaging, are included in the municipal solid waste estimates in Chapter 1, while others, including process wastes, are not.

It is not possible within the scope of this report to adequately estimate industrial process and other wastes that may be received in municipal landfills. Quantities of these process wastes received at municipal landfills are highly variable, depending upon the type of industry(s) and other factors. However, there is a potential for large quantities of industrial solid wastes to have been disposed of in municipal landfills in the past, with some disposal in municipal landfills still occurring.

INCINERATOR RESIDUE

Incinerator residue may be generated from industries, institutions, and other establishments that burn their own solid wastes, or from the burning of collected municipal solid waste. The latter source of incinerator residue is judged to be the largest and reflects incineration of approximately 5 percent of generated municipal solid waste in energy recovery (waste-to-energy) facilities.

Incinerator residue, as disposed, may be essentially dry, or it may contain sizable amounts of moisture. If dry, the weight of residue from combustion of municipal solid waste may be as low as 20 percent of the waste input; if the residue is wet by virtue of being quenched in water, its weight may be as high as 45 percent of the waste input. Assuming an average residue weight of 30 percent of incinerated municipal solid waste, about 2.3 million tons of residue per year are disposed from currently operating waste-to-energy facilities in the U.S. Some additional tonnage is generated from municipal solid waste incinerators not practicing energy recovery, and from those establishments that burn their own waste. Incinerator residue from this latter category is at least partially accounted for in industrial process wastes or other industrial wastes. Conversely, residue from burning sewage sludge is not accounted for.

Some incinerator residue has been stockpiled on-site (10), and some has been disposed in special landfills used for waste-to-energy facility waste (11). The fraction of incinerator residue disposed in municipal landfills is unclear. Indeed, some tests of fly ash and bottom ash from municipal waste incineration have shown these residues to be unacceptable in municipal landfills by virtue of their heavy metals content. Future disposal of incinerator residue in municipal landfills is, therefore, somewhat uncertain.

BOILER RESIDUE

Boiler residue, as used here, refers to the waste residues remaining from combustion of fossil fuels (i.e., coal, oil, and natural gas) in boilers. (No significant residue quantity results from combustion of natural gas, so it is not discussed further.) Both coal and oil are burned in boilers at power utilities, industrial establishments, institutions, etc. The residues remaining from combustion of coal and oil include bottom ash, fly ash, and, in some cases, flue gas desulfurization wastes. Sludges from treatment of wastewater also result from boiler operations, but these are small by comparison.

The quantities of boiler residue generated in the U.S. from combustion of coal and oil are very large. Approximately 80 million tons (dry weight) of fly ash and bottom ash together are generated by electric utility boilers (12). Nearly 4 million additional tons of ash are estimated to be generated by fossil fuel boilers located at industrial, commercial, and institutional establishments. In addition to fly ash and bottom ash, large quantities of sludges and dry solids may be generated from flue gas desulfurization. Although only a small number of industrial boilers generate these wastes, they represent a significant amount of industrial boiler residues (12). The total quantity of flue gas desulfurization wastes from electric utility boilers is unknown, but may conceivably be quite significant.

Disposal of boiler residues varies considerably depending upon their source. Electric utilities seem to rely mostly upon on-site disposal, but industrial and other establishments may use either municipal or industrial landfills. Thus, whereas the total quantity of boiler residues is quite large, the impact of these wastes on municipal landfills may be relatively low.

HOUSEHOLD HAZARDOUS WASTES

A wide variety of hazardous household products eventually end up in the waste stream. They are frequently the "leftovers" from painting, cleaning, fertilizing the yard, applying pesticides, etc. These materials are often mixed in with the family trash, drained into sewers, or stored for long periods of time at the locations where they are generated. Included in household hazardous wastes are: pesticides, paints, thinners/solvents, cleaners, pharmaceuticals, chemicals, fertilizers, acids, caustics, car batteries, medications, and antifreeze (13)(14).

The issue of household hazardous wastes is being dealt with in other reports. It seems clear from the results of several local household hazardous waste collection programs that the quantities of such wastes are very small in comparison with total household wastes. This does not mean, however, that household hazardous wastes are unimportant.

SMALL QUANTITY GENERATOR HAZARDOUS WASTES

Small quantity generators of hazardous wastes, as used here, are those non-household establishments generating less than 1,000 kilograms per month of hazardous wastes. These generators have not previously been subject to managing their wastes according to the requirements of Subtitle C of RCRA, which sets forth requirements for hazardous waste management. However, amendments to RCRA signed into law November 8, 1984, require a lowering of the generator exclusion level to 100 kilograms per month. Thus, a new "small quantity generator" definition of between 100 and 1,000 kilograms per month has evolved.

The issue of small quantity generator hazardous waste is discussed in other reports. Small quantity generator hazardous wastes have gone to municipal landfills in the past, and some are still being disposed there, but the amounts are not quantified here.

USED OIL

Approximately 1.2 billion gallons of used oil were generated in the U.S. in 1983, resulting from both automotive and industrial uses of oil (15). About two-thirds of this quantity was reused; most was processed and used in burning applications, some was re-refined into lube oil, some was used in road oiling, and the remainder was used in non-fuel industrial applications.

The approximately one-third fraction of used oil generation that was disposed amounted to roughly 400 million gallons (15). Most of this was dumped on the ground, in drains, along roadsides, or in miscellaneous other places. The used oil disposed of in this manner is mostly engine oil from those who change their own automobile oil (do-it-yourselfers) and operators of large off-road equipment. About 165 million gallons (or approximately 660,000 tons) of used oil generated in 1983 were disposed in landfills or incinerators. This quantity is equivalent to less than one-half of one percent of municipal solid waste disposed.

SUMMARY

Estimated quantities of the wastes discussed in this chapter are summarized in Table 2-1. These non-municipal solid wastes were examined by virtue of their potential impacts on municipal landfills. Quantities generated, as shown in Table 2-1, are quite varied, and are not necessarily indicative of their relative importance in municipal landfills. For example, over 80 million tons of ash from electric utility and industrial boilers are generated annually, but this may not be very significant to municipal landfills. Nonetheless, the total quantity of wastes shown in Table 2-1 is large and is nearly double the quantity of estimated municipal solid waste. Much of this waste is not disposed in municipal landfills, but the potential for significant impacts on municipal landfills from these wastes is apparent.

Wastes in addition to those discussed in this chapter and the preceding chapter may also enter municipal landfills, but most of those of concern are believed to have been addressed in this study. However, more information on the wastes addressed in this chapter and their effects on land disposal is needed.

Table 2-1

OTHER WASTES POTENTIALLY LANDFILLED
(In million tons per year and pounds per capita per day)

Waste Stream	Estimated Quantity (million tons/year)	Estimated Quantity (pcd) 1/	Estimated Disposal in Municipal Solid Waste Landfills
Demolition/construction wastes	31.5	0.72	Unknown
Water/wastewater treatment sludge	45 to 70	1.0 to 1.6	Large fraction
Trees and brush 2/	7.9	0.18	Small fraction
Street refuse	15+	0.35 to 0.40	Most
Car bodies	20	0.46	Small fraction
Nonhazardous industrial process waste	100	2.3	Unknown
Incinerator residue			
(1) waste-to-energy facilities	2.3	0.05	Unknown
(2) Other	Unknown	Unknown	Unknown
Boiler residue			
(1) fly ash; bottom ash	84	1.9	Small fraction
(2) flue gas desulfurization waste	Unknown	Unknown	Unknown
Used oil	1.6	0.04	Less than 50 percent
Totals	>300	>7.0	

1/ pcd = pounds per capita per day based upon an assumed U.S. population of 240 million.
2/ Amount in addition to estimates in Chapter 1.

Source: Franklin Associates, Ltd.

Chapter 2

REFERENCES

1. Wilson, D. G., Editor. Handbook of Solid Waste Management. Van Nostrand Reinhold Co., New York, NY. 1977.

2. Guidelines for Local Governments on Solid Waste Management, U.S. Environmental Protection Agency, 1971; as quoted in Reference 1.

3. "California Solid Waste Management Study (1968) and Plan (1970)," U.S. Environmental Protection Agency/OSWMP (SW-2tsg); as quoted in Reference 1.

4. "Metropolitan Solid Waste Management Plan." Metropolitan Planning Commission, Kansas City Region. May 1971.

5. Steel, E. W., and T. J. McGhee. Water Supply and Sewerage. Fifth Edition, McGraw-Hill Book Co. 1979.

6. Steel, E. W. Water Supply and Sewerage. Fourth Edition, McGraw-Hill Book Co. 1960.

7. Metcalf & Eddy, Inc. Wastewater Engineering: Treatment, Disposal, Reuse. Second Edition. McGraw-Hill Book Co. 1979.

8. U.S. Department of Commerce. 1986 U.S. Industrial Outlook. January 1986.

9. U.S. Department of Commerce. Current Industrial Reports, Pollution Abatement Costs and Expenditures, 1982. February 1984.

10. Communication with a representative of the Massachusetts Department of Environmental Quality. February 1984.

11. Communication with a representative of Vicon Recovery Systems, Inc. November 1982.

12. Franklin Associates, Ltd., from research conducted in connection with studies on the health and environmental effects of wastes from combustion of coal and other fossil fuels, performed for the U.S. Environmental Protection Agency, 1983-1984.

13. "Household Hazardous Waste: Solving the Disposal Dilemma," Golden Empire Health Planning Center, Sacramento, California. 1984.

14. Blackmar, D. S., S. W. Horsley, L. Segall, and A. Woolf. "Results of a Regional Household Hazardous Waste Collection Program in Barnstable County, Massachusetts." Hazardous Waste. Volume 1, Number 1, 1984.

15. Franklin Associates, Ltd. "Composition and Management of Used Oil Generated in the United States." U.S. Environmental Protection Agency (EPA/530-SW-013). November 1984.

Chapter 3

FACTORS AFFECTING MUNICIPAL SOLID WASTE GENERATION AND DISPOSAL

INTRODUCTION

In this chapter the structural factors that shape the overall picture of municipal solid waste will be addressed. These are the underlying or causative factors that result in growth or reduction in the volumes of solid waste that are disposed. These factors will first be described in general terms. Then, the effect of these factors on discard and recovery for recycling of various specific materials will be assessed. This will be followed by an analysis of other factors affecting actual disposal of the discarded material, such as energy recovery and waste reduction measures.

GENERAL STRUCTURAL FACTORS

Population

Change in population is one of the most important basic factors affecting waste generation. It underlies all of the other factors. As the population of the U.S. grows, more and more people are purchasing and discarding manufactured materials. Thus, if population continues to grow at a rate of a little more than one percent per year, as it has for several decades, this produces a ratchet effect which works against any factors that would reduce or stabilize waste generation.

Social Patterns

There are basic changes occurring in U.S. society that create changes in purchase and discard habits. One of these factors is growing affluence. By any measure, the average person in the U.S. has had a significant and steady increase in real purchasing power since World War II. For example, purchases of goods have risen from $129 billion in 1945 to $1.5 trillion in 1984, an increase of nearly 1,100 percent (1). The purchase of goods is the critical category, as these are the material items that end up being discarded. In recent times, government statistics show that while purchases of services are growing faster than purchases of goods, between 1970 and 1984 purchases of nondurable goods (the category most likely to be rapidly discarded) increased from $266 billion per year in 1970 to $857 billion in 1984, an increase of 222 percent (1). Correcting for inflation, the 1972 constant dollar figures show an increase in purchases from $284 billion per year for nondurable goods in 1970 to $394 billion in 1984, an increase of 39 percent. This translates to a compound growth rate of 2.4 percent per year. Thus, the U.S. population can simply afford to purchase more goods, and therefore will dispose of more items.

Other important social factors include the changing perceptions of roles and the composition of the work force. More people are now at work than ever before, with the percentage of women holding jobs outside the home being one of the most significant changes in recent times. In 1960, 35 percent of civilian women were employed, as compared to 79 percent of the men. By 1985, this had grown to 50 percent for women, while the percent of all men employed had dropped to 70 percent. In married couple families, in 1960 only 25 percent of wives were employed, while in 1985, 49 percent of wives were employed (1).

These changes have brought about significant alterations in lifestyles in the family home. In those homes with two incomes, affluence is a factor in the purchase of more goods. Also, when both adult members of a typical married couple come home from work, there is less time to prepare meals and perform cleanup chores. This is also true of single adult households, which are increasing in numbers. Thus, to the extent possible, these households often purchase convenience foods and disposable items to lighten their chore loads. It is clear that these changing social patterns lead to more discards from homes.

While these changes have been occurring in homes, changes that increase discards have also been occurring in business and industry. As the labor costs have increased, employers have sought ways to reduce labor costs, in some cases by using prepackaged or unitized materials. This has been a strong trend in food preparation and light industrial operations. This trend also generates more packaging wastes at the level where those wastes will likely reach municipal waste streams.

Technological Changes

Future historians will almost certainly characterize the period in which we live as a unique time of rapid technological change. The industrial revolution set in motion advances in technology at an accelerating pace which is continuing in the 1980s with no end in sight. These technological advances affect work and leisure habits of disposal, as well as the nature of materials disposed.

Perhaps the most evident example of technological change is the advent of computers. In just six years--1980 to 1985--the total number of computers installed in the U.S. grew from 1.4 million to 24.2 million, an increase of over 1,600 percent, and computer installations are still growing at over 30 percent per year (2). While this was once touted as a change that would reduce discards of paper, instead it has given rise to large increases in the use of computer printers that generate paper to be discarded.

Another technological change that alters the volume and composition of discards is microwave cooking. This has greatly increased the sale and use of frozen and other packaged prepared foods in both homes and commercial establishments, increasing the packaging materials that must be discarded. In addition, making packaging compatible with microwave ovens has increased the use of plastics and paper, while decreasing use of aluminum foil.

Technology also alters discards in a more direct fashion. Packaging suppliers have active research programs, which continually examine package design and material choices in attempts to make their particular packages more competitive. Numerous examples can be cited of design changes of containers and wraps that have led to more efficient use of materials, and therefore less materials to be discarded. It is estimated that folding cartons achieved an average weight reduction of 10 to 20 percent during the period 1960 to 1975 by numerous weight-saving features such as narrower glue seams, enhanced closing flap designs and use of a lower-density boxboard (3). Other changes include lightweighting of cans and bottles, which has also been significant in recent years.

Waste is also reduced by using new and more effective materials. For example, many cheese products are now wrapped in thin plastic films which are much lighter and less bulky than older waxes, waxed papers, or cellophane. In many other cases, flexible, high-strength film bags or pouches have replaced boxes and cans with significant savings in discarded material.

Trends in Product Packaging

Running counter to this trend to reduce waste is the trend to purchase products that require extensive packaging, such as convenience foods and prepackaged hardware and other small items. While some instances may be found where these items are "overpackaged," in most cases the relatively large amount of packaging is functional in terms of providing protection for the product, theft protection, and convenience features.

These factors were all combined in a study which covered a 16-year period of 1960 to 1975 for packaging of non-fluid foods (3). Over that period, the packaging per person and the packaging per pound of product both remained essentially unchanged. Thus the trend to reduce waste by technological innovation was balanced by the trend to buy more convenience products, which are extensively packaged. No more recent studies on packaging as a component of MSW were available, but the trend in pounds generated per person appears to be downward (Table 3-1). This can be at least partially explained by the substitution of lighter materials, such as aluminum and plastics, for heavier materials, such as ferrous metals and glass.

Table 3-1

TRENDS IN PER CAPITA DISCARDS*
OF CONTAINERS AND PACKAGING
(In pounds per capita per day)

Year	pcd
1960	0.73
1970	1.05
1980	1.02
1984	1.01
1990	1.00

* Discards after materials recovery has taken place and before energy recovery.

Source: Franklin Associates, Ltd.

CHANGES IN MATERIAL AND PRODUCT CATEGORIES

Paper and Paperboard Products

Table 3-2 shows the recent status and trends of paper and paperboard products gross discards. The largest category in 1984 was corrugated packaging, accounting for 30 percent of the total, followed by newspapers at nearly 20 percent of the total. Thus, these two categories dominate the discards, accounting for 50 percent of the total. However, the most rapid growth over the period occurred in books and magazines, commercial printers, and office papers. On the other hand, there has been a decline in paper plates and cups, and a low growth in paper packaging and other paperboard.

Books and Magazines. This category increased from 6.3 percent of the discards to 7.3 percent over the five-year period, with an increase of 1.1 million tons per year in 1984 compared to 1980. To a large degree, this may be the result of a healthy economy, with a large segment of this growth attributable to advertising and to leisure time activities. However, it is also part of the changing social patterns in this country as people read more special interest publications and have more money and time to pursue hobbies and other leisure activities. This category is definitely sensitive to the state of the economy, and will be subject to fluctuations in the future.

Table 3-2

GROSS DISCARDS* OF PAPER AND PAPERBOARD PRODUCTS, 1980 AND 1984
(In thousand tons and percent)

Nondurables	1980	% of Total	1984	% of Total	Difference	Percent Difference
Newspapers	11,037	20.4	12,342	19.8	1,305	11.8
Books and Magazines	3,390	6.3	4,570	7.3	1,180	34.8
Office Papers	4,001	7.4	4,863	7.8	862	21.5
Commercial Printers	3,110	5.8	4,025	6.5	915	29.4
Tissue Products	2,373	4.4	2,755	4.4	382	16.4
Paper Plates and Cups	355	0.7	349	0.6	-6	-1.7
Other Nonpackaging	4,468	8.3	5,167	8.3	699	15.6
Containers and Packaging						
Corrugated	16,330	30.2	18,716	30.0	2,386	14.6
Other Paperboard	4,812	8.9	5,218	8.4	406	8.4
Paper Packaging	4,086	7.6	4,294	6.9	208	5.1
Total Gross Discards	53,962	100.0	62,299	100.0	8,337	15.4

* Discards before materials recovery has taken place.

Source: Franklin Associates, Ltd. (Working Papers, Part E).

Commercial Printers. This category increased from 5.8 percent of total to 6.5 percent over the period 1980 to 1984. Based on gross discards, the increase was 29.4 percent. Much of this increase is due to increased advertising, and is directly tied to the health of the economy. This category will, therefore, also be subject to fluctuations.

Office Papers. On the other hand, the dramatic growth in office papers over the five-year period, from 7.4 percent of total discards to 7.8 percent, may represent an important basic change in paper discards. This trend is in part related to increased paper consumption from use of computer printers and high-speed office copiers. This use is expected to continue to grow, and office papers will continue growing as a fraction of the total paper discarded.

Declining Categories. Penetration of paper and paperboard packaging markets by other materials is a continuing feature of the marketplace. Paper plates and cups declined 1.7 percent over the period 1980 to 1984, the only paper and paperboard category to do so. Paper packaging grew at 5.1 percent over the period, declining from 7.6 percent of the total paper and paperboard gross discards to 6.9 percent. This is largely because of the loss of markets to other materials, especially plastics. An example is the continuing conversion of consumer sacks and bags from paper to plastic.

It is also noteworthy that while total paper and paperboard grew by 15.4 percent over the period, "other paperboard" grew at the slower rate of 8.4 percent. This is primarily because of the traditional stable market for recycled paperboard, which continues to decline slowly as a total percent of packaging materials.

Recovery. Paper recovery for recycling has been a major source of raw material for the paper and paperboard industry in the U.S. for many decades. Since 1960, the tonnage of paper recycled has increased almost every year, with an occasional hiatus during recessions. Overall, the recovery of paper in 1984 was nearly 13 million tons, which was 2.4 times the 5.3 million tons in 1960. The 1960 recycling rate was 18 percent of gross discards, while the 1984 rate was 21 percent of gross discards of paper (Working Papers, Part E).

Paper recycling occurs when supplies of uncontaminated paper can be obtained at sufficiently low prices that new products can be manufactured and marketed at prices competitive with products manufactured from wood pulp. Although new contaminants that are difficult to remove continually emerge on the scene, particularly plastic materials and new inks, the industry finds new ways of dealing with these problems. Both the tonnage recycled and the percent of gross discards are expected to increase slowly over the next few years.

Glass Containers

During the 1960s and early 1970s, glass containers grew rapidly as the soft drink and beer industries boomed and glass held a prominent share of the market. From 1960 to 1973, glass beer and soft drink container gross discards grew from 1.4 million tons to 6.1 million tons, more than a four-fold increase. At the same time, discard of wine and liquor containers more than doubled, from 0.9 million tons to 2.1 million tons. Other uses for glass containers, such as for food, pharmaceuticals and cosmetics, etc., grew from 3.7 million tons to 4.4 million tons. However, in the mid-1970s, the discards of glass flattened, as product sales leveled off and plastic and metal containers began to make inroads.

Table 3-3 shows what happened in the first five years of this decade, 1980 to 1984. Because of intense competition from metals and plastic, glass containers have lost market share. Large soft drink containers have been lost to plastic, and single-service beer and soft drink consumers have expanded use of cans. Glass beer and soft drink containers have declined 14.2 percent since 1980. The wine and liquor category has also declined by 7 percent, while other uses have remained essentially unchanged.

In the future, glass is expected to continue to lose market share (Working Papers, Part I). Plastic containers are poised for possible further take-over of beer and soft drink markets, food packaging, and wine and liquor.

Recovery. Glass recycling has always been a routine part of glass plant operation, but collection of postconsumer glass declined after World War II to a very low level. By the early 1970s, recovery of postconsumer glass containers for recycling was under 2 percent of gross discards. The reason for the low recycling rate is primarily economics. When virgin raw materials can be obtained more cheaply than postconsumer glass, then the more economical alternative is pursued. In addition, contamination of glass cullet by aluminum rings, ceramics, or glass of the wrong color can result in operating difficulties in glass manufacturing plants.

During the 1970s, virgin raw materials became more costly at the same time that recycling of materials was becoming a social and political issue. As some States passed container deposit laws, glass processors and container manufacturing companies developed improved ways of processing and cleaning postconsumer glass. By 1980, use of postconsumer cullet had reached 750,000 tons per year, or 5 percent of glass discards. As gross discards fell over the following year, postconsumer recycling increased to one million tons in 1984, or nearly 8 percent of gross discards (Working Papers, Part I).

Table 3-3

GROSS DISCARDS* OF GLASS CONTAINERS, 1980 AND 1984
(In thousand tons and percent)

	1980	% of Total	1984	% of Total	Difference	Percent Difference
Beer and Soft Drink	6,766	48.4	5,806	45.4	-960	-14.2
Wine and Liquor	2,453	17.6	2,282	17.8	-171	-7.0
Other	4,755	34.0	4,711	36.8	-44	-0.9
Total	13,974	100.0	12,799	100.0	-1,175	-8.4

* Discards before materials recovery has taken place.

Source: Franklin Associates, Ltd. (Working Papers, Part I).

In the years ahead, postconsumer glass recovery and recycling is expected to continue growing slowly, although if more States pass beverage container deposit legislation, the growth should be faster.

Plastic Materials

Discarded plastic products have grown from less than 400,000 tons in 1960 to nearly 10 million tons in 1984 as industry and household consumers have increased their purchases of plastics (Working Papers, Part H). The unique features of plastics, which include high strength per pound, ease of fabrication, and the ability to tailor-make materials for a given end use, have stimulated new product development as well as displacement of other products. Historically, the largest growth has been in packaging applications, where plastic films have displaced paper, cellophane, and metal foils, while plastic containers have replaced metal cans and glass bottles. In addition, new products such as plastic "squeeze" bottles and enhanced characteristics, such as added strength for trash bags, have created new markets.

Table 3-4 shows strong growth in all areas of plastics. Additional penetration of markets is expected in the future, as well as continued development of new products, which makes plastic materials the most rapidly growing material in the solid waste stream.

Recovery. Recovery and recycling is a common occurrence within plastic product manufacturing plants. However, this is a case of having clean, uncontaminated scrap of known composition. Recovery and recycling of postconsumer plastics from the solid waste stream is another matter. Plastics of different composition may look alike, which makes source separation difficult. Many plastic products are made of several types of plastics laminated together, or affixed rigidly. There is also sometimes a problem of moisture or other contamination, which may make recycling difficult. Thus, recovery and recycling of postconsumer plastics is not common.

There are only two examples of plastic products where recycling has occurred on a wide scale--PET soft drink containers, and polyethylene milk jugs. The only significant documented postconsumer recycling is PET soft drink containers (and their polyethylene base cups) in beverage container deposit States, where 63,000 tons were recovered in 1984. This was 18 percent of the total national discard of PET bottles, and two-thirds of one percent of the gross discards of plastics.

There is additional recovery of postconsumer plastics outside of mandatory deposit States, but these are isolated cases and the total tonnage is not large.

There is currently much attention being devoted to recycling plastics. It is a highly visible and rapidly growing component of solid

Table 3-4

GROSS DISCARDS* OF PLASTIC,
1980 AND 1984
(In thousand tons and percent)

	1980	% of Total	1984	% of Total	Difference	Percent Difference
Packaging	4,273	53.3	5,088	52.6	815	19.1
Nondurables 1/	1,647	20.5	1,922	99.8	275	16.7
Durables 2/	1,724 3/	21.5	2,034	21.0	310	18.0
Other	375	4.7	636	6.6	261	69.6
Total	8,019	100.0	9,680	100.0	1,841	23.0

1/ Includes disposables, trash bags, etc.
2/ Includes housewares, toys, records, luggage, electronics, etc.
3/ 1982 was used instead of 1980 because of a discontinuity in the data series.

* Discards before materials recycling has taken place.

Source: Franklin Associates, Ltd. (Working Papers, Parts H and O).

waste. Plastics manufacturers are currently quite interested in developing new ways of recycling their products. Therefore, plastics recycling may increase in the future, but as of now there is no specific evidence that would indicate strong growth. Either products that can use mixed plastics must be developed for extensive use applications, or ways of source separating plastics to a high degree of purity must be devised. Otherwise, recycling of postconsumer plastics will not exceed a very low percent of the plastic products discarded.

Steel Packaging

The presence of steel packaging in solid waste is declining, with an overall 18 percent decline in the last five years (Table 3-5). All areas of steel packaging are declining, but the sharpest drop is in beverage containers. Steel beverage containers reached their peak in 1973, when over 30 billion cans were sold for beer and soft drinks (Working Papers, Part J). In 1984, this had declined to 4 billion cans, about 13 percent of the peak. As Table 3-5 shows, the decline in tons of steel discarded has been 76 percent since 1980. Steel cans have been

Table 3-5

GROSS DISCARDS* OF STEEL PACKAGING, 1980 AND 1984
(In thousand tons and percent)

	1980	% of Total	1984	% of Total	Difference	Percent Difference
Food Cans	2,088	57.9	1,896	64.0	-192	-9.2
Beverage Cans	516	14.3	126	4.3	-390	-75.6
Other Cans	760	21.1	748	25.3	-12	-1.6
Other Packaging 1/	244	6.8	191	6.5	-53	-21.7
Total	3,608	100.0	2,961	100.0	-647	-17.9

1/ Includes steel pails, drums, etc.

* Discards before materials recycling has taken place.

Source: Franklin Associates, Ltd. (Working Papers, Part J).

displaced in the beverage container markets, for the most part by aluminum cans. In the larger containers, such as steel drums and pails, steel has been losing out to plastic containers. Steel packaging will likely hold a small share of packaging markets in the future, but may continue to decline in some areas. The largest stable market is in food cans, where aluminum has not been successful in penetrating the market except for certain specialty areas.

Recovery. Recovery of steel packaging materials from solid waste has never been an important recycling factor in terms of the fraction of the gross discards. The historical high occurred in 1979 when 228,000 tons were recovered by a combination of source separation recycling projects, and by shredding and magnetic separation operations at energy recovery plants, transfer stations, or other waste processing operations. The 228,000 ton recovery was one percent of steel packaging discards (Working Papers, Part J).

Since 1979, recovery has declined to a low value of 113,000 tons in 1984, which is one-half of one percent of the gross discards. About 8,000 tons were from community source separation projects, and 105,000 tons were from shredders. Recovery is expected to decline even further because of the lack of good markets for the recovered material. A recent survey of shredder operations shows that only in a small number of cases can recovered steel be marketed. There are several reasons for this. One is that markets for scrap steel are generally depressed, with large surpluses of scrap available. Another reason is that postconsumer steel is considered to be contaminated and to have a low volume, thus discouraging transportation distances of more than a few miles and making any upgrading of quality an uneconomical situation. However, location of a supply of used steel cans near a detinning operation or near copper mining regions are exceptions.

Another more recent concern has arisen in the scrap industry concerning the recycling of large steel containers such as pails and drums. These are the customary containers for many products that are hazardous materials, such as pesticides and industrial chemicals. In addition, these containers are frequently reused for disposal of materials that may be hazardous wastes. Thus, scrap dealers are concerned that residual hazardous materials may be present in these containers (4).

Aluminum

Aluminum containers and packaging have shown steady growth over the 25-year history documented in this study, with nearly a ten-fold increase in beverage cans and a three-fold increase in foil (Working Papers, Part K). Table 3-6 shows that the rapid increase in the growth of aluminum beverage cans continues, with an increase of nearly 30 percent in the past five years. This rapid growth has occurred at the expense of

Table 3-6

GROSS DISCARDS* OF ALUMINUM CONTAINERS AND PACKAGING, 1980 AND 1984
(In thousand tons and percent)

	1980	% of Total	1984	% of Total	Difference	Percent Difference
Beverage Cans	926	72.8	1,203	76.9	277	29.9
Food and Other Cans	39	3.1	52	3.3	13	33.3
Foil	304	23.9	307	19.6	3	1.0
Closures	3	0.2	3	0.2	0	0.0
Total	1,272	100.0	1,565	100.0	293	23.0

* Discards before materials recycling has taken place.

Source: Franklin Associates, Ltd. (Working Papers, Part K).

steel containers, as aluminum has almost entirely replaced steel cans in the beer market. The aluminum can share of soft drinks has also increased steadily. The penetration of this market is even greater than indicated by the aluminum tonnage, because over the period the average weight of an aluminum can has decreased 7 percent.

The largest percentage increase in gross discards in the last five years is in food and other cans. While aluminum cans do not represent a large share of the food packaging market, their use is growing rapidly. The increase over the last five years was 33 percent. However, aluminum cans do not have the technical advantages over steel cans in the food market that they have in beverage cans, so penetration of this market has been much slower. In particular, most canned foods are heat processed after being sealed in the cans, requiring a high-strength can.

On the other hand, another major market for aluminum is the use of foil in packaging. The foil market grew steadily until the late 1970s, when it began to flatten out. At the present time foils are being used in numerous new applications, but are being displaced in other applications by plastic films, resulting in a relatively flat market. Some of the new markets, however, are very thin foils placed on plastic films to enhance barrier properties.

Recovery. Aluminum cans are recovered and recycled at a greater rate than any other material studied. Prior to 1970, very little recovery existed, but in the early 1970s the aluminum companies mounted enormous efforts to recover cans. The recycling rate first exceeded 50 percent in 1981, and has hovered close to that level ever since. Recovery of beverage cans has been enhanced by deposit laws now existing in nine States.

Recovery of aluminum food cans is estimated to be about 10 percent. Their recovery is more difficult than beverage cans because of sanitation problems in storing cans with residual food wastes, and because aluminum food cans are not generated in large quantities in households. This lessens the convenience of recycling. Foil and closures are also recycled from homes, but the rate is quite low.

In 1984, it is estimated that 643,000 tons of aluminum were recovered from gross discards of 1.6 million tons of aluminum containers and packaging (Working Papers, Part K). Recovery should continue to grow slowly, and if additional States adopt container deposit laws, significant increases could occur. However, the percent recovery is expected to be stable at about 50 percent of the cans in gross discards. Thus, as the number of aluminum cans increases, the recovered tons will increase, but not the percentage.

Rubber

The gross discards of tires for each year are tied to the number of automobiles sold in previous years, and to the average life of tires. In recent years, automobile sales have shown declines or low growth in a cyclical fashion since peaking in 1978 (1). At the same time, cars have become smaller, requiring smaller tires, and tires have become more durable in recent years. All of this leads to a decreasing discard tonnage for tires, which declined by 43.2 percent in the first half of this decade (Table 3-7).

Other discarded rubber products fall into two categories--hoses and belts, and fabricated rubber products. A large portion of fabricated rubber products include automobile components such as floor mats or pads and foam rubber inserts. Thus, this segment of the industry has declined along with generally declining sales and smaller cars. The category of hoses and belts includes automobile components, as well as conveyor belts and other products related to mining, agriculture, and heavy industry. All of these economic segments have shown recent declines or low growth (Working Papers, Part D). In addition, some rubber products are being displaced by plastic products. Table 3-7 shows a 47 percent decline in rubber products other than tires for 1980 to 1984.

Rubber discards are expected to grow from their low levels of 1984. Although rapid growth is not expected, car sales will probably increase as the number of people in the driving ages increases. Also, some economic recovery is expected in other industries that consume rubber and rubber products.

Recovery. Rubber is diverted from the waste stream for tire retreading or recovered from the waste stream for rubber tire splitting, reclaiming or asphalt rubber manufacture. Since 1960, demand for retread tires and other rubber reuse and recycling has dropped steadily. Recovery for reuse or recycling was 20 percent of discards in 1960, but by 1984, the recovery for reuse and recycling was 5.2 percent of discards. The actual tons of rubber diverted or recovered have dropped sharply as rubber product manufacture has declined. The tonnage of tires for retreading has dropped from a high in 1978 of 92,000 tons to 33,000 tons in 1984. Rubber recovered for other uses has declined steadily from 326,000 tons in 1960 to 103,000 tons in 1984 (Working Papers, Part D).

There is no reason for optimism in terms of tire diversion for retread or rubber recovery because the products made from recovered rubber have low demand, or are being replaced by plastics. The growing concern over problems associated with tire disposal may result in small amounts of increased recovery for use in asphalt rubber, but indications are that future recovery may rely on development of improved means of burning rubber with recovery of energy.

MATERIALS RECOVERY

Trends in recovery of various materials and products in the municipal waste stream were discussed in the preceding sections. To

Table 3-7

GROSS DISCARDS* OF RUBBER PRODUCTS, 1980 AND 1984
(In thousand tons and percent)

	1980	% of Total	1984	% of Total	Difference	Percent Difference
Tires and Tire Products	2,132	59.1	1,211	60.9	-921	-43.2
Other Rubber Products	1,473	40.9	777	39.1	-696	-47.3
Total	3,605	100.0	1,988	100.0	-1,617	-44.8

* Discards before materials recycling has taken place.

Source: Franklin Associates, Ltd. (Working Papers, Part D).

illustrate the overall effect of materials recovery on the waste stream, Table 3-8 shows gross discards of wastes before materials recovery takes place, recovery of materials, and net discards in 1984.

Overall, an estimated 15.1 million tons of postconsumer materials were recovered in 1984, or 10.2 percent of gross discards. The table and figure clearly show that paper and paperboard recovery greatly exceeds all others; recovery of these products was 86 percent of total recovery (Figure 3-1). (In addition, there is recovery of scrap from converting operations that is excluded from gross discards.) If there were no recovery of paper products, paper and paperboard would be 42 percent of discards rather than 37 percent.

Recovery of corrugated boxes contributes the most tonnage to total recovery--almost 7 million tons in 1984. Recovery of newspapers is second, at 3.4 million tons. Other grades of paper recovered include office papers, magazines, and packaging paper and paperboard (Working Papers, Part E).

Other products that are recovered for recycling include ferrous scrap from appliances, glass containers, steel containers, aluminum containers, and plastic containers. There is known to be recovery of nonferrous metals and textiles, but not in sufficient quantities to be reflected in Table 3-8. In addition, some yard wastes are composted, but the quantity is not known and is presumed to be relatively small.

ENERGY RECOVERY

Processing municipal solid waste for energy recovery may significantly affect the quantities of such waste disposed in landfills. Records of previous, current, and planned waste-to-energy facilities were used to develop historical data and to assist in developing projections of municipal solid waste processed for energy (5 through 21). The results of this effort are presented in this section.

Historical and Projected Waste-to-Energy Activity

Historical and projected estimates of municipal solid waste processed in waste-to-energy facilities are shown in Table 3-9 and Figure 3-2. A review of Table 3-9 reveals that no significant waste-to-energy facilities were found in the U.S. from 1960 through 1964. Although waste incineration was occurring prior to that time, no recovery of the resulting heat energy was evident in the 1960s until 1965. From 1965 through 1985, a relatively continuous increase in municipal solid waste quantities processed in waste-to-energy facilities occurred. This increase was far more pronounced after 1975.

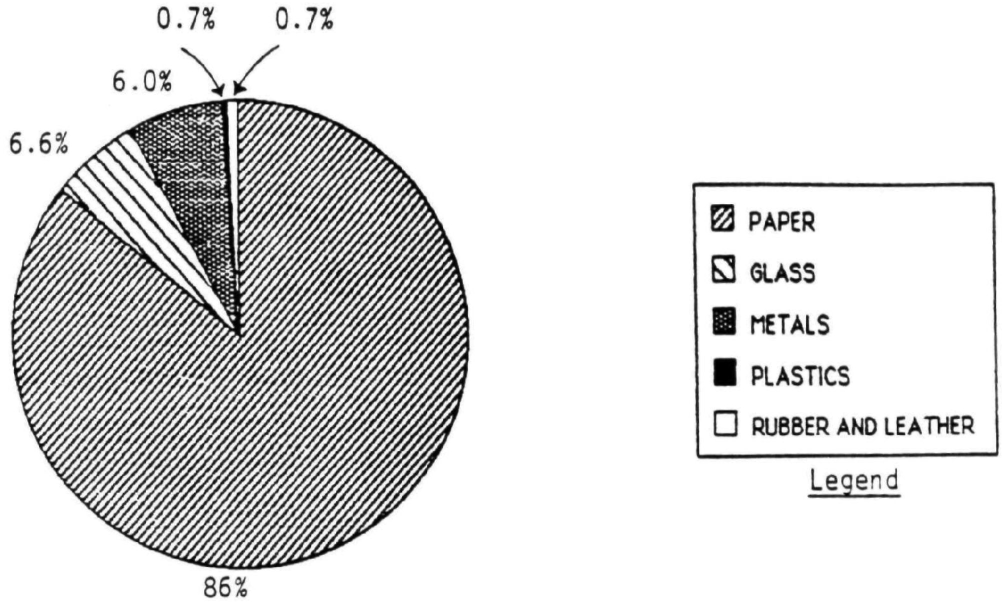


Figure 3-1. Materials recovered in 1984 from municipal solid waste, in percent of total recovery.

Table 3-8

DISCARDS AND RECOVERY OF MATERIALS IN THE MUNICIPAL WASTE STREAM, 1984
(In millions of tons and percent)

Materials	Gross Discards	% of Discards	Postconsumer Materials Recovery	Net Discards	% of Discards
Paper and Paperboard	62.3	42.1	12.9	49.4	37.1
Glass	13.9	9.4	1.0	12.9	9.7
Metals					
Ferrous	11.3	7.6	0.3	11.0	8.3
Aluminum	2.1	1.4	0.6	1.5	1.1
Other Nonferrous	0.3	0.2	0.0	0.3	0.2
Plastics	9.7	6.5	0.1	9.6	7.2
Rubber and Leather	3.4	2.3	0.1	3.3	2.5
Textiles	2.8	1.9	0.0	2.8	2.1
Wood	5.1	3.4	0.0	5.1	3.8
Other	0.1	0.1	0.0	0.1	0.1
TOTAL NONFOOD PRODUCT WASTES	111.1	75.0	15.1	96.0	72.2
Food Wastes	10.8	7.3	0.0	10.8	8.1
Yard Wastes	23.8	16.1	0.0	23.8	17.9
Miscellaneous Inorganic Wastes	2.5	1.7	0.0	2.5	1.9
TOTAL WASTES DISCARDED	148.1	100.0	15.1	133.0	100.0

Details may not add to totals due to rounding.

Source: Franklin Associates, Ltd. (Working Papers, Part O).

Table 3-9

FORECAST U.S. WASTE-TO-ENERGY FACILITY THROUGHPUT, 1990, 1995, AND 2000
(In thousands of tons per year)

Technology	1990			1995			2000		
	Low	Mid	High	Low	Mid	High	Low	Mid	High
Mass Burn	4,400	6,600	8,800	7,700	13,200	22,000	11,000	19,800	35,200
RDF (Supplemental)	800	1,190	1,590	840	1,290	1,780	880	1,390	1,970
RDF (Dedicated Boiler)	2,910	4,360	5,810	3,770	6,080	9,260	4,550	7,800	12,710
Modular Incineration	600	910	1,200	800	1,310	2,040	1,000	1,930	3,100
Other Systems*	130	200	260	350	640	1,140	570	1,080	2,020
TOTALS	8,840	13,260	17,660	13,460	22,520	36,220	18,000	32,000	55,000

* Includes codisposal of sewage sludge, pyrolysis, and anaerobic digestion generating methane.

Source: References 1 through 17.

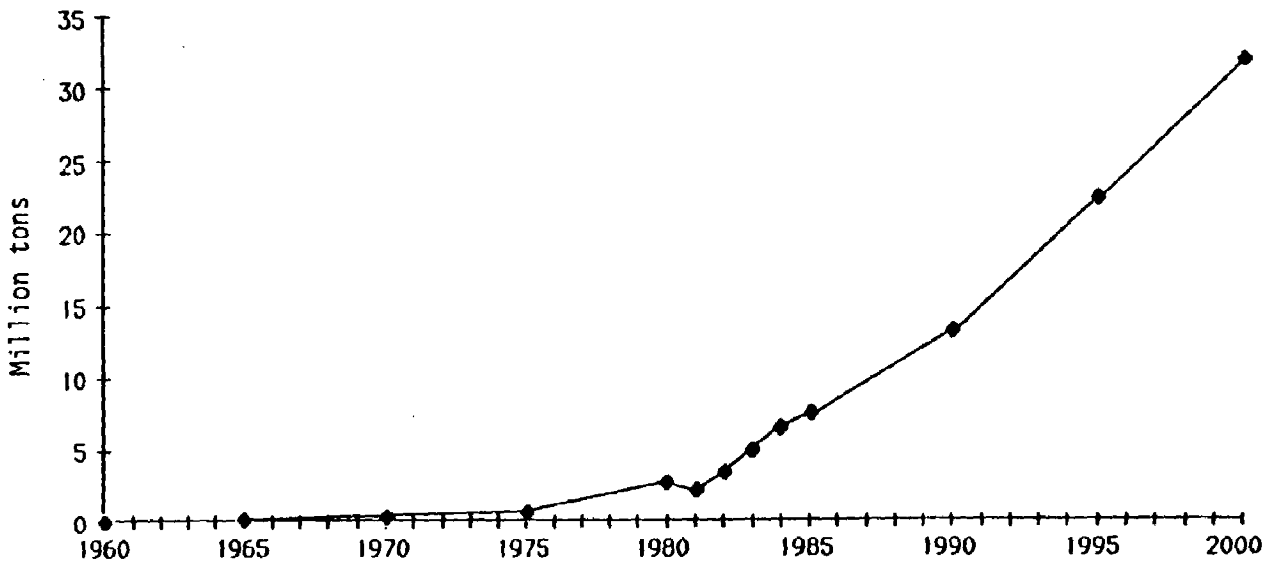


Figure 3-2. Municipal solid waste processed in energy recovery facilities, 1960 to 2000.

The quantity of MSW processed for energy recovery has risen from approximately 200,000 tons in 1965 to 6.5 million tons in 1984. In 1984 that was almost 5 percent of net waste discards (after materials recovery). Projections indicate that 32 million tons of waste will be processed in 2000, or over 20 percent of net discards. These estimates are fairly conservative; others have made much higher estimates of waste that will be processed.

Factors Having a Negative Effect on Energy Recovery

Regulatory requirements relating to air pollution emissions and solid residues from waste incineration may have significant impacts. Emissions of heavy metals, dioxins, and acids in stack gases from incinerators are of considerable concern. Both fly ash and bottom ash from waste incineration have been reported to fail the Extraction Procedure Toxicity test for heavy metals. Exceedances in levels of lead and cadmium may occur, thereby triggering a hazardous waste designation for the ash.

The potential exists for major impacts on the costs of waste-to-energy facilities. For example, California reportedly requires that fly ash from waste incineration be sent to a Class 1 landfill for hazardous waste, at a cost of up to $100 per ton. The bottom ash must go to a Class 2 landfill costing almost twice that of existing landfills. The ash from a waste-to-energy facility may be 30 percent or more (by weight) of the incoming municipal solid waste, so additional costs for handling hazardous wastes can be large.

Pending tax legislation may also have a negative impact on resource recovery. Previously-used tax incentives for building waste-to-energy facilities, including investment tax credits, rapid depreciation, and tax-exempt financing with industrial revenue bonds, could be lost under some tax reform proposals.

Adding to the negative economic impacts on energy recovery are declining oil and natural gas prices. Replacement of these fuels with energy recovered from solid waste has traditionally been the major source of revenues to support a waste-to-energy facility.

Factors Having a Positive Effect on Energy Recovery

Waste-to-energy projects should profit from tightening landfill requirements. Most proposed landfill sites face a high level of social opposition, which may eliminate them from further consideration or result in long and costly delays. In addition, as regulatory requirements become more stringent, higher landfill costs are experienced. The combined social and regulatory pressures attendant in developing new landfills are also resulting in higher waste transportation costs. One end result of tightening landfill requirements will be more emphasis on examining energy recovery as an alternative.

SOURCE REDUCTION MEASURES

The environmental movement of the 1970s (22)(23) developed something of a hierarchy of solid waste management options that begin with source reduction and proceed through a series of alternatives:

- Reduction at the source
- Reuse
- Recycle
- Burn for energy
- Sanitary landfill

Interestingly, the source reduction movement has all but disappeared. At the same time, many of the things advocated by those who support this option have seen some impact, although mostly as a result of competitive economic forces and consumer demands.

Source reduction advocates operate from the premise that waste not be created to begin with because products are designed to have an infinite life time. Obviously, the trend has been strongly in the opposite direction in both durables and nondurable goods.

Nonetheless, some interesting things have happened that can be considered source reduction even though the motivation had nothing to do with avoiding solid waste disposal. For example:

- The downsizing of automobile tires and longer tread life have reduced tire discards significantly. (Advocates used to propose the 100,000 mile tire; something approaching 40,000 or more is now the industry standard.)

- Lightweighting of products and packaging has taken place. In some cases products or packages are redesigned to reduce materials use; in some cases more durable materials are used.

Other source reduction measures have not developed. For instance, most appliances have the same useful life of many years ago and are more cost effective to replace than repair, especially small appliances. Some States have attempted (with little success) to ban certain products or materials, e.g., disposable diapers or plastic substitutes for wood and/or paperboard. Finally, source reduction sometimes included other things such as reuse of products, e.g., refillable beverage containers or design of generic packaging that could be used by any manufacturer.

In summary, some source reduction activities have occurred as a result of economic pressures, but the effectiveness of most suggested source reduction measures has not been demonstrated.

Chapter 3

REFERENCES

1. U.S. Department of Commerce. Statistical Abstract of the United States, 1986. 106th Edition.

2. International Data Corporation. Computer Industry Review & Forecast, 1980-1989.

3. Hunt, R. G., F. D. Shobe, J. C. Trewolla, and W. E. Franklin, "The Application of Technology-Directed Methods to Reduce Solid Waste and Conserve Resources in the Packaging of Non-Fluid Foods." Prepared for the National Science Foundation by Franklin Associates, Ltd. 1978.

4. "ISIS Cautions Pesticides Wastes Disposers." Phoenix Quarterly. Spring 1986.

5. "Resource Recovery Activities Report." Waste Age. November 1984 and 1985.

6. U.S. Conference of Mayors. "Resource Recovery Activities." City Currents. April 1984.

7. U.S. Conference of Mayors. "Resource Recovery Activities." City Currents. March 29, 1982.

8. "Resource Recovery Activities." National Center for Resource Recovery (NCRR) Bulletin. September 1981.

9. Alvarez, R. J. "A Look at U.S. Plants That are Burning MSW." Waste Age. January 1985.

10. "Resource Recovery." Solid Waste Management/RRJ. November 1980.

11. U.S. Environmental Protection Agency. "Resource Recovery and Waste Reduction Activities, A Nationwide Survey." (SW-432). November 1979.

12. Berenyi, E., and R. Gould. 1984 Resource Recovery Yearbook. Governmental Advisory Associates, Inc., New York, NY. 1984.

13. Payne, J. "Energy Recovery from Refuse - State of the Art." Journal of the Environmental Engineering Division. April 1976.

14. "Resource Recovery Activities." National Center for Resource Recovery (NCRR) Bulletin. March 1980.

15. "Resource Recovery: A Status Report." Solid Waste Management/RRJ. April 1978.

16. "Resource Recovery Systems - A Status Report." NCRR Solid Waste Management Briefs. March 1976.

17. National Center for Resource Recovery. "Status of Resource Recovery Systems." Solid Wastes Management/RRJ. March 1976.

18. "Operating or Planned Resource Recovery Systems." Professional Engineer. November 1975.

19. Fitzpatrick, J. V. "Energy Recovery from Municipal Solid Waste: Present Status and Future Prospects." Presented at a meeting of The Society of the Plastics Industry, Inc., Cincinnati, OH. May 22, 1973.

20. Franklin, W. E., M. A. Franklin, and R. G. Hunt. Waste Paper: The Future of a Resource, 1980-2000. Franklin Associates, Ltd. for the Solid Waste Council of the Paper Industry. December 1982.

21. McManus, F., Editor. Resource Recovery Report. Monthly editions from February through December 1985.

22. "Talking Trash." Proceedings of the Meeting of the National Coalition on Solid Waste. March 4-6, 1977. Environmental Action Foundation.

23. "REDUCE." League of Women Voters Education Fund. 1975.