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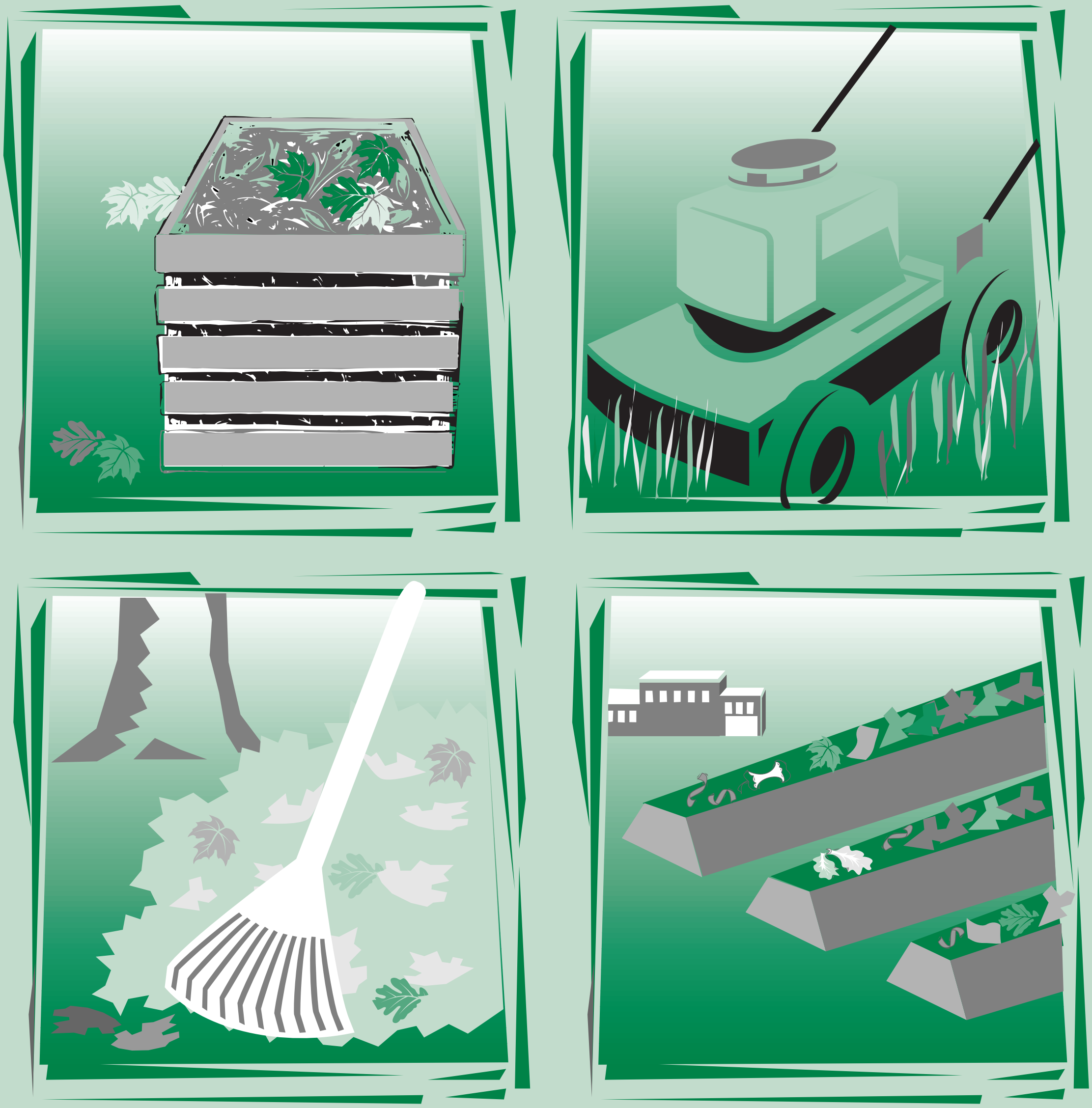
Organic Materials Management Strategies



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EXECUTIVE SUMMARY

Organic materials make up the bulk of America's discarded municipal solid waste (MSW). In 1996, organic materials accounted for 141 million tons (67 percent) of the waste stream. Some organic materials, such as newspaper, office paper, and corrugated, have a high recovery rate. Other organic materials (e.g., yard trimmings, food scraps, and certain grades of paper), however, still tend to be landfilled and represent an area with high growth potential for recovery (75 million tons). Depending on the type of waste and method of composting selected, average national savings over conventional disposal vary from $9 to $37 per ton for 62 million tons of the MSW stream.

This report describes seven composting strategies for organic materials in the U.S. MSW stream and presents an analysis of the benefits and costs of each strategy, the potential for diverting organic materials from landfills or waste-to-energy facilities, and the potential markets for diverted organic materials. This report is organized into five sections: (1) an overview of organic materials in the national waste stream, (2) estimates of avoided collection and disposal costs attributed to diversion of organic materials, (3) descriptions of the organic materials management strategies, (4) a review of compost markets and end-uses, and (5) a summary and comparison of the net costs of each composting strategy.

This report focuses on the following seven composting strategies:

- **Grasscycling:** residential, commercial, and institutional establishments leave cut grass on their lawns.
- **Backyard composting:** homeowners compost food scraps and yard trimmings on their property.
- **Yard trimmings composting:** leaves, grass, and brush are collected and composted at central facilities.
- **Onsite institutional composting:** institutions (e.g., universities, schools, hospitals, etc.) process food scraps, paper, and yard trimmings at onsite composting facilities.
- **Commercial composting:** commercial organic materials generators (e.g., supermarkets, restaurants, schools, etc.) collect and separate organic materials for collection and composting.
- **Mixed waste composting:** mixed waste composting facilities separate MSW into component streams for composting, recycling, and refuse disposal.
- **Residential source-separated composting:** homeowners separate specific organic materials and set them out for collection and processing.

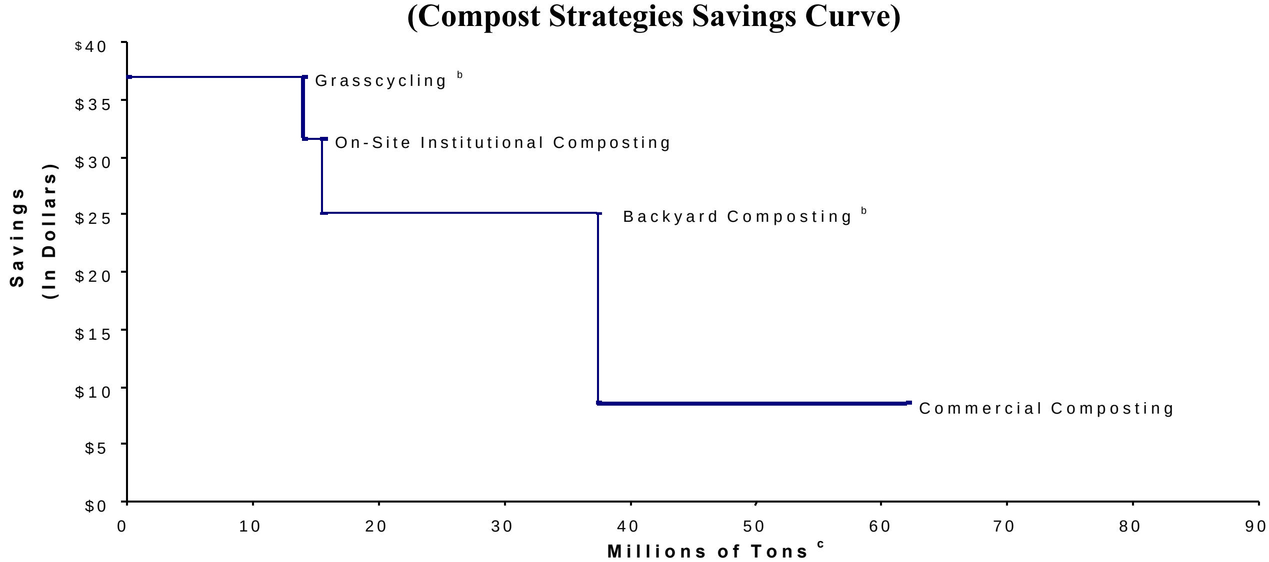
For each of these seven strategies, the following two major categories of information are presented:

- A description of the key aspects of each strategy, based on current applications, including a discussion of numerous individual programs.

- A comparative analysis of the benefits and costs of each strategy as well as an estimate of the applicable portion of the organic waste stream each strategy targets.

The comparative results in this report are summarized in the compost strategies savings curve that follows. The curve indicates that of the organic waste stream available for composting using existing strategies and technologies (approximately 75 million tons), a total of 83 percent (62 million tons) could be composted at a net benefit to society (i.e., savings over traditional disposal methods) through a combination of grasscycling, backyard composting, onsite institutional composting, yard trimmings composting, and commercial composting. The term 'available (or applicable) organic waste stream' indicates that newspaper, office paper, and corrugated have already been removed for recycling. Grasscycling, onsite institutional composting, and backyard composting programs could target 50 percent (37 million tons) of the applicable portion of the organic waste stream at the greatest net benefit to society. Alternatively, yard trimmings composting programs could capture some of the organic materials targeted by these programs. Commercial composting could capture another 33 percent (24.6 million tons) of the applicable organic waste stream at a net benefit. Composting the remaining 17 percent (13 million tons) of the applicable organic waste stream could be accomplished through more costly mixed waste composting or source-separated composting once this strategy becomes better established in the United States.

Figure ES-1
Savings [a] Per Ton of Organic Diversion
(Compost Strategies Savings Curve)



Notes:
[a] These savings are from the viewpoint of local government and assume that any additional labor required from citizens is donated at no cost to society.
[b] To be conservative, we assume no savings in collection costs. The tonnage in these composting programs is not reduced significantly enough to affect the cost of collection.
[c] Based on the applicable portion of the organic waste stream available for composting using existing strategies and technologies.

Perhaps the most striking general result revealed by the savings curve is the cost differential between onsite compost strategies (e.g., grasscycling, backyard composting, and onsite institutional composting) on the one hand and more conventional collection-based compost technologies (e.g., yard trimmings composting and commercial composting) on the other. While this result promises a real impact on local governments' budgets, it reflects an assumption that the labor required by citizens in grasscycling or backyard composting is donated at no cost to society.

More specifically, this report supports the following conclusions:

- Approximately 36 percent (75 million tons) of the U.S. MSW stream is available for composting using existing strategies and technologies. In this report we have assumed that the 75 million tons of available organic materials do not include newspaper, office paper, and corrugated, because these materials are currently being recovered for recycling at high rates.

- Depending on the type of waste and method of composting selected, average national savings over conventional disposal vary from $9 to $37 per ton.

- Organic source reduction programs, including grasscycling, onsite institutional composting, and backyard composting, are quite cost-effective when compared to other composting alternatives. This cost-effectiveness results from low program costs, which are more than offset by avoided disposal costs, under the assumption that the labor required by citizens is donated at no cost to society. In combination, these strategies could target about 37 million tons of the available organic waste stream.

- Approximately 62 million tons of the available organic waste stream could be targeted by a combination of grasscycling, backyard composting, yard trimmings composting, onsite institutional composting, and commercial composting programs at a net benefit (savings over traditional disposal methods).

- Yard trimmings composting (a form of residential source-separation) is the most well established and widespread of the composting strategies in the United States. This strategy could target about 28 million tons of leaves, grass, and brush.

- Although mixed waste composting facilities appear somewhat cost-effective, these facilities have experienced substantial setbacks in the past few years. Public opposition and technical difficulties have been troublesome for mixed waste compost facilities in the United States. As a result, the United States saw a 25 percent decline in the number of operating mixed waste compost facilities between 1992 and 1995.

- Residential source-separated compost programs, which include food scraps, soiled paper, and yard trimmings, are well established and successful in Europe. This composting strategy, however, is still in its infancy in the United States. Nevertheless, European experience suggests that residential source-separated composting programs might offer a viable alternative for capturing a significant percentage of the organic materials available for composting that are not targeted by established strategies or technologies.

- The potential market for finished compost is much larger than the potential supply. This situation is supported by the fact that virtually all municipalities and/or companies that currently produce compost products have established markets for those products. In addition, they are often unable to meet the demand for their compost products. If all applicable materials addressed in this report were captured for composting, approximately 48 million cubic yards (37.4 million tons) of finished compost would be created each year. End-uses for compost in agriculture, silviculture, residential retail, nursery sod production, and landscaping might have a market potential of more than 1 billion cubic yards of finished compost.

The conclusion of this report is that composting is feasible on almost every size scale, and it works. The more material that is composted, the lower the cost per ton to operate whatever composting strategy is used. The most important part of a successful composting operation, however, is choosing a strategy or combination of strategies that works for particular circumstances.

1. ORGANIC MATERIALS IN THE NATIONAL WASTE STREAM

Organic materials make up the bulk of America's discarded municipal solid waste (MSW). In 1995, organic materials accounted for 141 million tons (67 percent) of the waste stream, as reported in the U.S. Environmental Protection Agency (EPA) study *Characterization of Municipal Solid Waste in the United States: 1997 Update* (the *1997 Update*).[1] Some organic materials, such as newspaper, office paper, and corrugated, have a high recovery rate. Other organic materials (e.g., yard trimmings, food scraps, and certain grades of paper), however, still tend to be landfilled and represent an area with high growth potential for recovery. In recent years, numerous programs have been set up to divert organic materials from the waste stream and create beneficial uses for them. These programs include the following:

- Grasscycling, or leaving cut grass on lawns.
- Backyard composting of food scraps and yard trimmings.
- Yard trimmings composting at central facilities.
- Onsite institutional composting of organic materials.
- Commercial composting operations that target materials generated by commercial and industrial establishments.
- Mixed waste composting at centralized processing facilities that accept mixed refuse and separate this material into composting, recycling, and disposal streams.
- Residential source-separated composting systems that target specific organic materials separated by the generator, set out for collection, and processed at a central dedicated compost facility.

This report provides a detailed analysis of each of the strategies listed above, based on programs implemented by public and private organizations across the nation. Larger programs could see even greater savings since many of the programs in this study are relatively small. For each strategy, the following two major types of information are presented:

- A description of the key aspects of each strategy, based on current applications and engineering estimates, including a discussion of numerous individual programs.
- A comparative analysis of the benefits and costs of each strategy as well as an estimate of the applicable portion of the national organic waste stream each strategy could potentially divert.

1.1 Applicable Portion of the National Organic Waste Stream

Although 67 percent of the national waste stream is organic in nature, a significant portion of it (e.g., newspaper, office paper, and corrugated) is currently being recovered for recycling and is, thus, unavailable for composting. In this report, only the organic materials currently being

[1] EPA. 1998. *Characterization of Municipal Solid Waste in the United States: 1997 Update*. EPA530-R-98-007. Washington, DC.

managed by the composting strategies described, as well as the amount of compostable material these strategies potentially could handle, are evaluated. Table 1-1 shows the types and total quantities of organic materials in the national waste stream addressed by the strategies described in this report. The information presented is based on the *1997 Update*. The table suggests that 36 percent (approximately 75 million tons) of the U.S. waste stream—28 million tons of yard trimmings, 22 million tons of food scraps, and 25 million tons of soiled or unrecyclable paper—is available for composting. Please note that the *1997 Update* and this report focus only on the portion of yard trimmings that are not currently being diverted by source reduction programs (e.g., grasscycling and backyard composting programs).

Table 1-1
Applicable Portion of the National Waste Stream Targeted by the Composting Strategies Described in This Report

Organic Materials Targeted by Existing Strategies	MSW Reported in the *1997 Update* (Thousands of Tons)
Yard trimmings	28,000
Food scraps	21,900
Folding cartons	5,390
Soiled corrugated boxes [a]	7,300
Other nonpackaging paper	4,120
Tissue paper and towels	2,980
Bags and sacks	1,980
Other paper packaging	1,350
Paper plates and cups	950
Milk cartons	460
Other paperboard packaging	230
Wrapping papers	50
ORGANIC MATERIALS AVAILABLE FOR COMPOSTING	**74,710**
TOTAL MSW	**209,660**
PERCENT TOTAL MSW	**36 percent**

Notes:
[a] According to the *Composting Task Force Report* by the Grocery Committee on Solid Waste of the Food Marketing Institute (1991), 6.6 million tons per year of food scraps plus unrecyclable cardboard (soiled, wet, or waxed) from food retailers are generated at a 3:1 ratio.

1.2 Regional Variation in Yard Trimmings Composition

Yard trimmings make up approximately 13 percent (28 million tons) of the national waste stream. This number can vary widely, however, from region to region—and within regions—due to differences in rainfall, temperature, type of natural vegetation, and length of the growing season. In the southeast region, for example, Fairfax, Virginia, found yard trimmings to be 25 percent of its MSW. Orange County, North Carolina, however, had a yard trimmings average of only 5 percent. This example illustrates that locations within the same region with similar factors (e.g., rainfall and temperature) can still vary widely in their yard trimmings percentages.

2. ESTIMATING AVOIDED DISPOSAL COSTS ATTRIBUTABLE TO DIVERSION OF ORGANIC MATERIALS

The management of organic materials involves several different costs and benefits. This section focuses on one benefit in particular: the reduction in garbage collection and disposal costs, or 'avoided costs.' These avoided costs result from the diversion of organic materials from the waste stream through composting or other waste reduction programs. The costs for several leading diversion programs are addressed in Section 3, while benefits due to compost sale and use are discussed in Section 4.

This section contains the following three subsections:

- The meaning of avoided disposal costs and their relationship to landfill tipping fees
- Data on average tipping fees by state
- Avoided garbage collection costs due to organic materials diversion

2.1 Avoided Disposal Costs and Tipping Fees

Avoided disposal costs include the amount saved on tipping fees by diverting waste to another solid waste management strategy. While alternative methods for managing MSW are on the rise, most of the nation disposes of its waste at landfills or waste-to-energy facilities. For the purposes of this report, avoided disposal costs are based on reported landfill tipping fees and the costs of Resource Conservation and Recovery Act (RCRA) compliance. In simple terms, a tipping fee is the price paid by a community or solid waste company to use a waste disposal facility. Under the textbook economic assumptions of perfect competition, perfect information, and no barriers to entry (i.e., no obstacles to opening new landfills), landfill prices would be equal to avoided costs. Needless to say, such idealized conditions do not typically occur. In reality, landfilling often involves imperfect information, a lack of local competition, and substantial barriers to entry.

Landfill tipping fees are rarely based on any explicit calculation of the fixed and variable costs of building, operating, and closing a landfill.[2] How these fees are determined might not be simple or consistent from one location to another. MSW disposal facilities incur substantial fixed costs such as siting and permitting, design, land acquisition, construction, and monitoring. Landfills also will require eventual closure and long-term postclosure care. These fixed costs do not necessarily depend directly on the tonnage of waste received.

Care must be used when estimating cost avoidance based on the national averages for tipping fees because local conditions will more than likely be different. If a low cost disposal area uses these averages, then the cost avoidance estimations will be overstated. Conversely, a high disposal cost area will underestimate the savings potential.

No matter what the tipping fee is, however, there is a resulting avoided disposal cost to be gained by diverting organic materials through other management methods. In this report, a measure

[2] Although this analysis does not attempt to model costs, such as fixed costs and closure and postclosure care, these are important variables to consider. Full cost accounting is a useful tool decision-makers can use to evaluate these costs.

based in part on reported tipping fees and in part on costs of RCRA compliance is used as the best available proxy for avoided landfill costs (see next section).

2.2 State Tipping Fees and RCRA Regulations

Tipping fees vary widely across the country. One of the few comprehensive sources for this information is *BioCycle* magazine, which annually reports on state average landfill tipping fees. Figures for 1997 are shown in column three of Table 2-1 and range from $8 per ton in Illinois to $80 per ton in Alaska. The population-weighted national average is $35 per ton.

Many of the lower state tipping fees reflect the continued use of older, long-established landfills. These landfills were built before RCRA regulations went into effect on October 9, 1991, and, thus, do not incur RCRA compliance costs. Landfills built after October 9, 1991, tend to be more costly than their older counterparts because they must incorporate liner systems as required under RCRA. Engineering estimates of costs for RCRA compliance suggest that small landfills will become prohibitively expensive to build and operate. Larger landfills—those that receive more than 500 tons per day (TPD)—allow these fixed compliance costs to be spread over much larger volumes of waste. RCRA compliance costs do not rise proportionally with the tonnage of waste received; therefore, RCRA-imposed costs are lower on a per ton basis in larger landfills.

How were the estimated state tipping fees for landfills built after October 1991 determined? A $24 per ton tipping fee was assumed, based on the recent study *The Role of Recycling in Integrated Solid Waste Management to the Year 2000*, prepared by Franklin Associates for Keep America Beautiful (Franklin/KAB study). The study estimated the revenue needed to cover the total capital and operating costs of a 1,000 TPD landfill built after October 1991, again assuming that only large landfills can cover the costs of RCRA compliance. Landfills serving metropolitan areas are often located outside the urbanized area, requiring waste transportation. Landfills for nonmetropolitan areas must serve large geographical regions in order to obtain enough waste. For these reasons, $6 per ton was added to cover the costs of transfer and transportation for waste sent to new, large landfills built after October 1991. Taking both factors into account, the costs for transfer, transportation, and landfilling at facilities built after October 1991 is unlikely to fall below $30 per ton.

The $30 per ton estimate was used as a floor for disposal costs. In states reporting average tipping fees of less than $30 per ton, this report assumes that RCRA compliance will quickly push these tipping fees up to $30 per ton. In areas where tipping fees are above $30 per ton, this report assumes that the costs of RCRA compliance have already been included and no adjustment was made. The resulting costs are shown in column four of Table 2-1. The population-weighted national average tipping fee for landfills built after October 1991 is $38 per ton.

Table 2-1
Average Landfill Tipping Fees by State [a]

State	Population	Tipping Fees for Landfills Built Before October 9, 1991	Estimated Tipping Fees for Landfills Built After October 9, 1991 [e]
Alabama	4,040,587	$33	$33
Alaska	550,043	$80	$80
Arizona	3,665,228	$23	$30
Arkansas	2,350,725	$26	$30
California	29,760,021	$33	$33
Colorado	3,294,394	$17	$30
Connecticut	3,287,116	$68	$68
Delaware	666,168	$59	$59
Florida	12,937,926	$46	$46
Georgia	6,478,216	$25	$30
Hawaii	1,108,229	$50	$50
Idaho	1,006,749	$22	$30
Illinois	11,430,602	$08	$30
Indiana	5,544,159	$28	$30
Iowa	2,776,755	$32	$32
Kansas	2,477,574	$23	$30
Kentucky	3,685,296	$25	$30
Louisiana [b]	4,219,973	$20	$30
Maine [b]	1,227,928	$45	$45
Maryland [b]	4,781,468	$43	$43
Massachusetts [b]	6,016,425	$55	$55
Michigan [c]	9,295,297	$30	$30
Minnesota	4,375,099	$50	$50
Mississippi	2,573,216	$16	$30
Missouri [b]	5,117,073	$24	$30
Montana	799,065	$35	$35
Nebraska	1,578,385	$25	$30
Nevada	1,201,833	$13	$30
New Hampshire	1,109,252	$50	$50
New Jersey	7,730,188	$77	$77
New Mexico	1,515,069	$12	$30
New York	17,990,455	$55	$55
North Carolina	6,628,637	$26	$30
North Dakota	638,800	$28	$30
Ohio	10,847,115	$30	$30
Oklahoma	3,145,585	$20	$30
Oregon	2,842,321	$25	$30
Pennsylvania	11,881,643	$44	$44
Rhode Island	1,003,464	$35	$35
South Carolina	3,486,703	$28	$30
South Dakota	696,004	$32	$32
Tennessee	4,877,185	$30	$30
Texas	16,986,510	$29	$30
Utah	1,722,850	$19	$30
Vermont	562,758	$58	$58
Virginia	6,187,358	$35	$35
Washington [c]	4,866,692	$30	$30
West Virginia	1,793,477	$37	$37
Wisconsin	4,891,769	$30	$30
Wyoming	453,588	$10	$30
TOTAL [d]	**248,102,973**	**$35**	**$38**

Notes:
[a] Goldstein, N. 1997. "The State of Garbage in America." *BioCycle*. April. p. 65.
[b] Goldstein, N. 1996. "The State of Garbage in America." *BioCycle*. April. p. 60.
[c] Tipping fees for states were not reported in *BioCycle* and were estimated at $30 per ton.
[d] Total tipping fee is the population-weighted average.
[e] Assumes 'floor price' of $30 per ton. See text for an explanation of this calculation.

2.3 Avoided Mixed Waste Collection Costs

The Franklin/KAB study developed average costs for several standard collection operations, assuming different levels of recycling and yard trimmings collection. The cost of collecting mixed waste in a system with no separate collection will drop after introducing separate yard trimmings and/or recycling collections, as long as the system is rationalized with regard to routing, equipment usage, and staffing.

Table 2-2 presents the annual costs per household for mixed waste collection, both with and without separate yard trimmings collection. The annual dollar savings per household (shown on line three of the table) ranges from $6.46 in nonmetropolitan areas with no recycling programs to $12.48 in metropolitan areas with extensive recycling programs. In every case, the report estimated that separate yard trimmings collection diverted 0.416 tons per household each year. Total avoided collection costs per ton of diverted yard trimmings ranged from $15.50 to $30.00. The average avoided collection cost is approximately $23 per ton of diverted yard trimmings (line five).

Table 2-2
Avoided Mixed Waste Collection Costs Associated With Leaf and Yard Trimmings Composting Programs

Program Stipulations	Average
Costs per house per year—no yard trimmings collection	$63.06
Costs per house per year—with yard trimmings collection	$53.44
Costs per house per year saved	$9.62
Annual tons of yard trimmings diverted per house	0.416
Avoided collection cost per ton	$23.12

Source:
Franklin Associates/Keep America Beautiful. 1994. *The Role of Recycling in Integrated Solid Waste Management to the Year 2000*. Appendix H.

Less information is available on the impact of food scraps and other organic materials diversion on mixed waste collection costs. These impacts, however, are likely to be substantial in some circumstances. Institutions or commercial establishments that divert large portions of their waste stream to onsite composting options, for example, are likely to realize significant savings in mixed waste collection costs. Similarly, residential source-separated composting and mixed waste composting programs might result in decreased mixed waste collection service or frequency. These collection cost savings, however, have not been well documented.

3. ORGANIC MATERIALS MANAGEMENT STRATEGIES

This section discusses seven organic materials management strategies—grasscycling, backyard composting, yard trimmings composting, onsite institutional composting, commercial composting, mixed waste composting, and residential source-separated composting. Where possible, 6 to 10 existing operations are used as the basis for reviewing each strategy. The following generic information is provided for each strategy:

- **Strategy Description.** General features of the strategy are described, accompanied by illustrative examples from existing operations.
- **Technical Problems.** Technical difficulties and limitations of the strategy are discussed.
- **Applicable Portion of the National Waste Stream.** Information from the *1997 Update* and existing programs is extrapolated to the national level to estimate the quantity of organic materials that could be targeted annually. The applicable portion for each strategy is estimated in isolation of other strategies.
- **Costs Per Ton Diverted.** Information from existing programs is used to develop estimates of the cost per ton of organic materials diverted. Cost estimates do not include costs to homeowners. For some pilot or low-volume programs, costs per ton were high.

For each of the strategies reviewed in this section, Table 3-1 shows the applicable quantity of the national waste stream targeted, estimated cost per ton diverted, annual national diversion potential, strategy descriptions, and comments.

Table 3-1
National Summary of Strategy Impacts

Strategy	Materials Targeted	Midrange Cost Per Ton	Cost Per Ton Range	Applicable Portion of the Waste Stream (Millions of Tons Per Year)	Strategy Description	Comments
Grasscycling	Residential and commercial grass	$1.00	$0.26 to $7.04	14.0	Primarily education and promotion	A time-saving source reduction strategy for lawn care
Backyard composting	Residential yard trimmings and food scraps	$12.90	$5.00 to $15.68	30.6	Education, promotion, and possibly bin distribution	Source reduction option for those with space to compost at home
Yard trimmings composting	Residential and commercial yard trimmings	$55.00	$21.65 to $88.21	28.0	Dedicated collection and processing of leaves, grass, and brush	Well-established strategy
Onsite institutional composting	Institutional food scraps, select paper grades, and yard trimmings	$49.00	$29.00 to $98.00	2.4	Institutions, such as universities, correctional facilities, and military bases, collect and compost organic materials on site	Allows certain institutions to avoid high collection and disposal costs
Commercial composting	Food scraps and select paper grades	$72.00	$50.00 to $144.00	24.6	Dedicated collection of targeted materials; processing done off site	Viable strategy for large commercial generators
Mixed waste composting	All commercial and residential organic waste	$113.00	$102.00 to $126.00	74.7	Standard garbage collection; separation of compostable waste at a single facility; composting of organic materials	Several facilities have closed due to technical problems
Residential source-separated composting	Select residential paper grades, food scraps, and select yard trimmings	NA	NA	47.3	Dedicated collection of targeted materials; processing at a central facility	Limited experience with this strategy in the United States

3.1 Grasscycling

3.1.1 Strategy Summary

- **Strategy Description.** Residential, commercial, and institutional establishments are encouraged to leave grass clippings on the lawn after cutting rather than bagging and setting them out for collection. This strategy might include both public education and financial incentives to reduce the cost of mulching lawn mowers or the equipment required to retrofit existing nonmulching lawn mowers.
- **Technical Problems.** Heavy clippings left on the lawn can block sunlight and effectively smother the lawn. Educational information must address this point.
- **Applicable Portion of the National Waste Stream Diverted.** Fourteen million tons of grass are generated annually by the residential, commercial, and institutional sectors.
- **Costs Per Ton Diverted.** Midrange costs for grasscycling education programs are approximately $1 per ton of grass diverted.

3.1.2 Strategy Description

Grasscycling programs consist primarily of promotion and public education efforts. Press releases, brochures, newspaper advertisements, and radio and television spots are often used to promote grasscycling. Local governments often promote grasscycling by example. In New York City's 'Leave-It-On-The-Lawn' program, for example, city workers leave grass clippings on the city's parks and other lawns whenever feasible. Other organizations that often promote grasscycling include schools, community groups, garden clubs, landscape businesses and associations, garden centers, and lawn mower manufacturers and retailers. In some cases, lawn products manufacturers have become sponsors of programs through model lawn demonstrations, workshops, and cooperative advertising.

Examples of community grasscycling programs are provided below:

- **Southeastern Oakland County Resource Recovery Authority (SOCRRA), Michigan.** The authority mails and hand-delivers grasscycling flyers and developed fact sheets for residents interested in learning more about grasscycling.
- **Pinellas County, Florida.** Grasscycling establishments receive T-shirts, bumper stickers, and signs for their lawns. Brochures were distributed to nurseries and landscaping companies. In addition, two 30-minute video programs were made and shown on the University of Florida's public access channel.
- **Milwaukee, Wisconsin.** Milwaukee's 'Just Say Mow' program encourages grasscycling through television commercials, radio and newspaper ads, and yard festivals in which the city shows residents the benefits of mulching and composting grass clippings.
- **Dubuque, Iowa.** Shortly after Dubuque started charging for pickup of grass clippings in 1994, the city developed a unique program that offers a $25 rebate to residents who purchase mulching mowers.

- **Islip, New York.** The first year of Islip's grasscycling program included creating and distributing a video, sending out three direct mail pieces, and giving away several mulching mowers.
- **Huntington Woods, Michigan.** This city does not collect grass clippings, and it distributes brochures on grasscycling to educate residents.

3.1.3 Technical Problems

Leaving grass clippings on the lawn is not harmful when mowing is frequent enough to produce fine clippings or when a mulching mower is used. Still, heavy clippings left on the lawn can block sunlight and smother the lawn. Educational information must address this issue.

3.1.4 Applicable Portion of the National Waste Stream Diverted

The general category of waste addressed by grasscycling is yard trimmings. Thus, estimating national potential for grasscycling begins with the yard trimmings tonnage. According to the *1997 Update*, about 28 million tons of yard trimmings are generated annually. Data in the *1997 Update* also show that approximately 50 percent (14 million tons) of yard trimmings are grass clippings. The applicable portion of yard trimmings that could potentially be targeted by grasscycling programs, therefore, is 14 million tons (or 28 million tons times 50 percent).

3.1.5 Costs Per Ton Diverted

For the seven grasscycling programs analyzed in Table 3-2, total program costs for 5 years ranged from $10,000 in Dubuque, Iowa, to $300,000 in Islip, New York.

Staff time required to increase public education and develop outreach brochures often represents the majority of costs incurred, but most grasscycling program coordinators do not dedicate all of their time to grasscycling. For rebate programs, the majority of program costs are spent on the rebates. The cost of developing and distributing brochures and advertisements is relatively small and is commonly part of the budget for other recycling and composting efforts taking place in a municipality.

Cost per ton diverted through grasscycling programs can be calculated as program cost per ton diverted in the first year. Once residents have been educated about grasscycling (the startup program cost), however, they presumably do not need to be reeducated each year. We assume, therefore, the cost of educating a given generator to grasscycle is incurred only one time, and the program's impact (i.e., the quantity of waste diverted) lasts for 5 years before additional education or outreach is needed. This might be a reasonable estimate since most generators are likely to continue grasscycling after an initial training period and because of the low transient nature of the residents who usually participate in the programs.

The average cost per ton diverted was amortized over 5 years to arrive at an estimated average cost of $1.03. Of the seven programs analyzed, costs per ton ranged from a low of $0.26 per ton in Montgomery County, Ohio, to a high of $7.04 per ton in Dubuque, Iowa. The higher cost in Dubuque is the result of the city's innovative program of rebating $25 to each resident who purchases a mulching mower.

Table 3-2
Grasscycling Program Costs

Location	Tons of Grass Diverted Annually [a]	5-Year Program Costs [b]	Program Costs Per Ton Per Year (Over 5 Years)
Dubuque, Iowa	284	$10,000	$7.04
Huntington Woods, Michigan	450	$10,500	$4.67
Islip, New York	20,000	$300,000	$3.00
Milwaukee, Wisconsin	29,677	$200,000	$1.35
SOCRRA, Michigan	9,000	$55,000	$1.22
Pinellas County, Florida	48,889	$80,000	$0.33
Montgomery County, Ohio	25,000	$32,000	$0.26
AVERAGE			**$1.03**

Notes:
[a] Tons of grass diverted in all locations except Pinellas County and Milwaukee are estimated based on reported reductions in quantities of grass collected, processed, or disposed of after implementation of grasscycling programs. Tons of grass diverted in Pinellas County and Milwaukee are estimated based on responses to surveys conducted on residential participation in local grasscycling.
[b] Reported budgets for grasscycling programs.

3.2 Backyard Composting

3.2.1 Strategy Summary

- **Strategy Description.** Backyard composting of select organic materials is promoted through outreach, bin subsidization, education, and training.
- **Technical Problems.** Possible technical problems include odors, flies, pests, and undersized bins. Proper education and bin selection can mitigate, and possibly even eliminate, these difficulties.
- **Applicable Portion of the National Waste Stream Diverted.** The residential sector generates 7.9 million tons of food scraps and 22.7 million tons of yard trimmings annually. Some programs also target other organic materials such as select paper grades.
- **Costs Per Ton Diverted.** Midrange costs of $12.90 per ton diverted are incurred for public education and bin subsidization.

3.2.2 Strategy Description

Elements of backyard composting programs might include outreach, bin subsidization, and educational workshops.

Backyard composting program outreach efforts often include distribution of flyers and brochures, production of videos and radio advertisements, and informational displays at local events, public gardens, and gardening stores. To encourage greater participation, many programs subsidize the purchase of backyard composting bins. Some smaller municipal programs also provide education to householders on how to build bins from chicken wire, wood pallets, or other materials.

Many municipalities organize training programs such as master composter programs. In these programs, a compost specialist trains a group of volunteers, who themselves become master composters. They in turn train others in the community on proper composting techniques. Other municipalities produce show-and-tell programs. These programs include demonstration gardens and composting education in local school science curricula, which allows children to learn about composting in the classroom and then bring the knowledge home to teach to their families.

Staff needs for a successful backyard composting program depend on the size of the community and on whether bins are being distributed. Many municipalities have recycling coordinators or other staff who spend a certain percentage of their time encouraging and promoting backyard composting, while large-scale programs tend to have coordinators who work full time on the program. Volunteers often do some of the work; the monetary value of their time is estimated by the National Backyard Composting Program at less than $1 per ton diverted.[3]

Below are descriptions of specific backyard composting programs implemented by agencies throughout the nation.[4] The programs range from extensive bin subsidies, technical assistance, and outreach efforts to programs that emphasize primarily education and outreach.

- **Alameda County, California.** Alameda County initiated its program in 1990. It distributes bins at a discounted price, has a master composter program, holds composting workshops at a permanent demonstration garden, and offers a composting education component as part of a school program. The program is coordinated by 5.5 full time equivalent (FTE) staff, and 80 volunteers provide additional support.
- **Olympia, Washington.** Olympia began its program in 1993. A key component of the program is selling composting bins at wholesale prices to residents who complete a free backyard composting workshop. Olympia also has a demonstration garden sponsored by the state as an educational tool, and the city has developed a full range of free composting brochures. Staff time for this comprehensive program amounts to only 10 percent of one FTE staff per year but is supplemented by over 830 hours of volunteer labor per year.
- **Palm Beach County, Florida.** Palm Beach County initiated its program in 1993. Subsidized compost bins are sold to the public at publicized events. The county also has a master composter program, but it is provided and paid for by a separate service at no cost to the county. Staff time for the county program costs $22,000 per year.
- **Glendale, California.** Glendale began its program in 1991. The city gives away composting bins and aeration tools at no charge to residents who attend a free 1-hour workshop. The staff time for Glendale's program amounts to 6 percent of one FTE per year as well as a total of 40 hours of volunteer assistance.
- **East Chicago, Indiana.** East Chicago began its program in 1994. Free bins and composting workshops are the backbone of the program. Fifty percent of one FTE and 800 hours of volunteer labor provide the staff for this program.

[3] Composting Council. 1996. *Cost-Benefit Analysis of Home Composting Programs in the United States*. Prepared by Applied Compost Consulting. p. 7.

[4] Based on information reported in *Cost-Benefit Analysis of Home Composting Programs in the United States*.

- **Amherst, Massachusetts.** Amherst began its program in 1991. Key components of the program are bin distribution, workshops, brochures, books, and school programs. Much of the work is provided through volunteer assistance, as only $900 of the budget is allotted to pay for staff, workshops, and a hotline.
- **Austin, Texas.** Austin's backyard composting program is administered by the Austin Community Gardens. Training and education are the primary focus of the program. Each year 25 students are trained as master composters, each of whom is encouraged to contribute 24 hours of volunteer time to the program.

3.2.3 Technical Problems

The primary technical problems associated with backyard composting include odors and pests. Odors can be emitted when the compost pile is not turned often and anaerobic decomposition occurs. Pests (e.g., raccoons, rats, and mice) might enter compost bins if they are not properly enclosed and/or secured.

In order to avoid these problems and ensure that the right materials are composted, technical assistance is essential. If municipalities do not adequately educate and promote continual, correct use of a composting pile, 'individuals [might] experience minor problems and refuse to ever contemplate composting again. This, in turn, could impact other waste diversion efforts attempted by the municipality.'[5]

3.2.4 Applicable Portion of the National Waste Stream Diverted

In most cases, backyard composting applies to two major components of the waste stream—food scraps and yard trimmings. The *1997 Update* indicates that 21.9 million tons of food scraps and 28 millions tons of yard trimmings are generated by the residential and commercial sectors.

Approximately 72 percent (15.8 million tons) of food scraps are compostable.[6] This includes all food scraps except meat, fish, cheese, milk, and fats and oils. In addition, the *1997 Update* estimates that 50 percent (11 million tons) of food scraps are generated by the residential sector. The portion of food scraps, therefore, that is generated by the residential sector and that is compostable is about 7.9 million tons (or 21.9 million tons times 36 percent [50 percent times 72 percent]).

The *1997 Update* reports that about 90 percent (25.2 million tons) of yard trimmings come from the residential sector. Making an allowance of 10 percent (2.5 million tons) for large items—tree trunks and large limbs—that are not easily compostable, about 22.7 million tons of yard trimmings are available for backyard composting (or 28 million tons times 81 percent [90 percent times 90 percent]).

Based on the above, a total of 30.6 million tons of organic waste could be targeted by backyard composting programs including 7.9 million tons of food scraps and 22.7 million tons of yard trimmings. This estimate is likely to be conservative since some areas also encourage composting of select paper and other organic materials.

[5] Metro Toronto. Report 19 of the Management Committee. p. 8.

[6] Rathje, W. *The Garbage Project Composition Analyses*.

3.2.5 Costs Per Ton Diverted

The costs of backyard composting programs generally fall into four categories: staffing, public education and outreach, bin purchasing, and bin distribution. Education efforts often continue well into the project, and some communities provide home visits and instruction on composting techniques by experts for any interested residents. Frequently, bins are subsidized by grants and homeowners make up the difference. Bins are a significant element of program costs in those communities that provide or subsidize bins.

Municipally sponsored backyard composting program costs can vary significantly. Some programs include significant startup costs associated with bin subsidization and initial education and outreach programs. In these cases, the costs for initiating the programs are high compared to the amount of waste diverted after the first year. But since bins typically last for 7 years (and some are now even warranted for up to 25 years) and only minimal additional funding might be needed from the municipality to sustain the program, program costs decrease over time.

There is a wide range of compost bin prices; the simplest units can be as inexpensive as $10, while the largest and most expensive can cost as much as several hundred dollars. Prices vary depending on how many bins are purchased at once; most municipalities have been able to obtain bins at wholesale prices by purchasing bulk quantities. In general, backyard composting bin costs range from $25 to $50.

Typical backyard composting program costs are provided in Table 3-3 for the various programs described in Section 3.2.2. Tonnage impacts and costs per ton diverted assume 7 years of program impact based on the assumed life of a bin.[7]

The programs are organized in Table 3-3 based on whether or not bin subsidies are provided. Bin subsidy programs tend to cost an average of $15.68 per ton diverted over their useful life, while programs emphasizing education cost an average of $5 per ton diverted. The average cost of all backyard composting programs is about $12.90 per ton diverted.

[7] Seven years is the standard bin depreciation time.

Table 3-3
Backyard Composting Program Costs [a]

	Program Tons Diverted	7-Year Program Costs	Average Program Costs Per Ton
Bin Subsidy Programs[b]			
Alameda County, California	28,000	$537,600	$19.20
Palm Beach County, Florida	9,737	$135,500	$13.92
Amherst, Massachusetts	1,750	$13,803	$7.89
Glendale, California	7,077	$43,150	$6.10
Subtotal	46,564	$730,053	$15.68
Education Programs			
Austin, Texas	379	$20,000	$52.77
East Chicago, Indiana	1,400	$24,400	$17.42
Olympia, Washington	1,500	$11,530	$7.68
Ann Arbor, Michigan	13,000	$25,000	$1.92
Subtotal	16,279	$80,930	$4.97
TOTAL AVERAGE COST			$12.90

Notes:
[a] All data in this table are based on the Composting Council's *Cost-Benefit Analysis of Home Composting Programs in the United States*, 1996.
[b] Although no additional costs are assumed for years 2 to 7, there may be some additional costs if educational workshops, a helpline, or technical assistance are provided.

3.3 Yard Trimmings Composting

3.3.1 Strategy Summary

- **Strategy Description.** Yard trimmings (e.g., leaves, grass, and brush) are collected and composted at a central location.
- **Technical Problems.** Odors from centralized compost facilities are the primary technical problem, but stormwater management, litter control, and siting and permitting issues can be of concern as well.
- **Applicable Portion of the National Waste Stream Diverted.** Twenty eight million tons of leaves, grass, and brush are generated annually by the residential, commercial, and institutional sectors.
- **Costs Per Ton Diverted.** Midrange costs for the programs described in this section are approximately $66 per ton diverted ($44.37 per ton for collection and $21.65 per ton for composting).

3.3.2 Strategy Description

3.3.2.1 Collection Programs

Yard trimmings composting programs represent the most widespread and well established composting strategy. There are many ways to collect yard trimmings, ranging from sophisticated curbside collection programs to simple drop-off programs.

Two general methods of curbside collection are bulk collection and bag collection. Bulk collection programs often rely on vacuum machines, front-end loaders, or mobile chippers to collect loose leaves or brush that are raked to the curb or into the street. Crew size for this operation is generally three to five laborers per vehicle. Bag collection operations usually rely on existing packer fleets and crews (typically two to three laborers) to collect yard trimmings. Brush, when collected curbside, is often either chipped on the street using a mobile chipper or collected in bundles with a packer truck and taken to a composting site where it is chipped.

Drop-off systems can replace curbside collection completely or cover periods of the year when there is no curbside collection. If the composting facility is centrally located, the drop-off can simply be set up on site. In many cases this is not possible; therefore, secondary sites, such as at a municipality's department of public works, are created. A rolloff container can be used for temporary storage; when full, it can be hauled to the nearest compost facility.

3.3.2.2 Composting Facilities

Yard trimmings composting facilities range from low-technology operations, where piles of leaves are turned periodically with front-end loaders, to high-technology operations, where size reduction equipment, dedicated windrow turners, and screening equipment are used. An advantage to using high-technology processing methods, aside from producing a higher quality product, is that compost can be produced and moved off site within a year, making space for the following year's material. Low-technology operations generally require more time to complete the composting process and consequently more land area to accommodate more than one season's material. Available land, therefore, is a key criterion for determining the most appropriate composting method for a given site.

Many public works departments use front-end loaders for a variety of purposes; therefore, a portion of the equipment time can be allocated to the composting program. Capital and operating costs for this equipment can be considered proportional to the volume of the total material handled by the front-end loader or to the percentage of time the equipment is working at the composting site. In general, the cost of a windrow turner increases with increases in capacity, and operating costs increase with the complexity of the model.

If brush is accepted at the site, it must be reduced in size prior to composting. Small quantities of brush can be processed through a chipper, but a tub grinder or wood scrap processing equipment is needed to process large quantities. Brush chips can be used for landscaping or can be composted with high nitrogen material such as grass. Leaves and grass also can be size-reduced in a tub grinder to reduce the time required to complete the composting process.

Expensive equipment, such as tub grinders or compost screens, can be purchased jointly and shared among communities. Even windrow turners can be shared, although they must be transported from site to site more frequently than the other equipment.

3.3.3 Technical Problems

3.3.3.1 Collection Systems

Disadvantages of bulk collection systems include contamination of leaves by street trash and oil, leaf piles that blow into the streets, and leaf fires caused by hot catalytic converters. Bulk collection methods usually require scheduled collection and associated parking bans if needed.

Disadvantages of the bag collection system include the cost of the paper bags, which is somewhat higher than plastic bags in most locations. Additional effort is required of homeowners to purchase and fill the bags. Finally, bagged leaves take somewhat more time to compost if no grinding equipment is used because the heavy bag itself creates more material to process.

Drop-off programs are not as convenient as curbside collection strategies; therefore, participation and diversion rates for drop-off programs might be lower.

3.3.3.2 Facilities

Odor can be a problem at yard trimmings composting facilities. Factors that contribute to odor generation include types of materials collected, management issues, siting, and climatic conditions. Grass clippings in particular become anaerobic and emit offensive odors very quickly due to their high moisture and nitrogen content. It is critical to process grass clippings as soon as possible after delivery to avoid odor problems and ground-water contamination. While small amounts of grass provide necessary nitrogen to accelerate the composting process and produce finished compost with desired nutrient content, too much grass has a decidedly negative impact on composting sites. This points to the logic of promoting grasscycling programs in conjunction with leaf collection.

While grass is the primary contributor to odor, leaf composting alone also can produce odors when improperly managed. It is advantageous to site composting facilities far away from residential areas, as odorous compounds get diluted with distance; otherwise, siting and permitting battles can arise.

In addition to odor problems, stormwater management and litter problems might be of concern and must be planned for accordingly.

3.3.4 Applicable Portion of the National Waste Stream Diverted

Yard trimmings composting programs target leaves, grass, and brush generated primarily by the residential sector. According to the *1997 Update*, approximately 28 million tons of these materials are generated annually. Ninety percent (25.2 million tons) is generated by the residential sector, while the remaining 10 percent (2.8 million tons) is generated by the commercial sector.

3.3.5 Costs Per Ton Diverted

A recent study of 500 U.S. municipalities provides a median overall diversion rate through yard trimmings collection (both curbside and drop-off) of about 12 percent.[8] According to the *1997 Update*, 13.4 percent of the waste stream is comprised of yard trimmings. The 12 percent diversion

[8] Skumatz, L.A. 1996. *Nationwide Diversion Rate Study-Quantitative Effects of Program Choices on Recycling and Green Waste Diversion: Beyond Case Studies*. Skumatz Economic Research Associates, Inc. July. p. 13. The figure of 12 percent includes programs that already had some sort of backyard composting program in place, which would tend to lower the diversion rate of actual yard trimmings collection programs. Thus, this figure should be viewed as slightly conservative.

rate suggests that, on average, yard trimmings composting programs divert 90 percent (12 percent divided by 13.4 percent) of all yard trimmings generated in a given area.

A variety of factors influence the cost of yard trimmings composting programs including the collection strategy used (e.g., drop-off or curbside), the materials targeted (e.g., leaves, grass, brush, or some combination thereof), the frequency of collection, the quantity of yard trimmings generated, the technology used for turning compost windrows or grinding brush (e.g., dedicated equipment versus existing or shared resources), and numerous other factors.

One study of 60 randomly selected U.S. cities with populations of over 25,000 examined the relationship among collection frequency, diversion rates, and costs. That study yielded an average cost of $66.56 per ton collected by programs that divert between 10 and 19.9 percent of the municipalities' waste stream.[9] More mature curbside programs, which target 20 percent or more of the municipalities' waste stream, average $53.67 per ton collected.

To develop a midrange national cost estimate for yard trimmings collection, it was necessary to consider the relative quantities and costs of yard trimmings drop-off versus curbside collection programs. Curbside collection programs divert approximately two times the amount of yard trimmings as drop-off collection programs. A 2:1 curbside to drop-off diversion ratio, therefore, is used in conjunction with the cost per ton collected by curbside versus drop-off programs.[10] For drop-off programs, the cost of collection is assumed to be $0 because individuals who drop off their yard trimmings at the compost facility bear the cost of collection. For curbside collection, a cost of $66.56 per ton collected is assumed based on the study referenced above of 60 randomly selected cities that divert 10 to 19.9 percent of their waste stream through curbside yard trimmings collection programs. This estimate is conservative because the same study indicated that programs that divert larger quantities of their waste stream cost less per ton collected. Combining the curbside collection cost with the drop-off collection cost at a 2:1 ratio (to reflect the relative quantities of materials collected by curbside and drop-off programs) yields a midrange estimate of $44.37 per ton collected by yard trimmings programs.

Whether the yard trimmings are brought to a composting facility via curbside collection or dropped off by residents or commercial landscape contractors, once at the facility, further costs will be incurred as the material is turned into finished product. A recent *BioCycle* article presented the results of a survey of seven public composting facilities that process from 2,000 to 23,500 tons per year of feedstock. This survey revealed an average total cost (capital plus operating) of $21.65 per ton, as shown in Table 3-4.

Yard trimmings diversion costs for the programs analyzed range from a low of $21.65 per ton diverted for programs that rely on drop-off collection to a high of $88.21 per ton diverted for programs that use more extensive curbside collection and processing operations ($66.56 for collection and $21.65 per ton for composting). The assumed national midrange cost of yard trimmings composting is $66.02 per ton diverted ($44.37 for collection and $21.65 for composting).

[9] Stevens, B. 1995. "Yard Debris: The Relationship Among Collection Frequency, Costs, and Diversion Rates." *Resource Recycling*. January. p. 29. A followup telephone conversation on October 21, 1996, confirmed that the cities were a mix of public and private collection and that there were some vacuum programs included. Also, it confirmed that administration and overhead costs were included as part of the calculations.

[10] Skumatz, L.A. 1996. *Nationwide Diversion Rate Study-Quantitative Effects of Program Choices on Recycling and Green Waste Diversion: Beyond Case Studies*. Skumatz Economic Research Associates, Inc. July. p. 13.

Table 3-4
Select Windrow Compost Facility Throughput and Costs

Facility [a]	Throughput (Tons Per Year)	Total Costs Per Year	Operating Costs Per Ton	Capital Costs Per Ton [b]	Total Costs Per Ton
St. Petersburg, Florida [e]	16,600	$424,960	NA	NA	$25.60
Des Moines, Iowa [d]	23,500	$528,750	NA	NA	$22.50
Atlantic County, New Jersey Utilities Authority	22,000	$484,000	$11.80	$10.20	$22.00
Lehigh County, Pennsylvania	17,000	$314,500	$8.10	$10.40	$18.50
Three Rivers, Michigan [e]	2,700	$46,440	NA	NA	$17.20
Bluestem SWA, Cedar Rapids, Iowa [c]	70,000	$784,000	$7.00	$4.20	$11.20
Bozeman, Montana	2,000	$16,000	$6.50	$1.50	$8.00
WEIGHTED AVERAGE [f]		$1,814,650			$21.65

Source:
Steuteville, R. 1996. “How Much Does It Cost to Compost Yard Trimmings?” *BioCycle*, September. p. 40.
Notes:
[a] All operations utilize open air windrows with turning.
[b] Capital costs generally do not include land.
[c] Two-thirds of throughput consists of nonyard trimmings from the commercial sector.
[d] Cost estimate is based on an average of 22,000 to 25,000 tons per year throughput.
[e] Operating and capital costs are calculated together.
[f] The weighted average is based on tonnage throughput, and does not include the Bluestem SWA facility because the large majority of its feedstock is nonyard trimmings.

3.4 Onsite Institutional Composting

3.4.1 Strategy Summary

- **Strategy Description.** Institutions process food scraps, paper, and yard trimmings at an onsite composting operation.
- **Technical Problems.** Regulatory requirements are the greatest difficulty faced by institutional composting sites.
- **Applicable Portion of the National Waste Stream Diverted.** Universities, correctional facilities, schools, hospitals, and military bases generate 2.4 million tons of food scraps, paper, and yard trimmings annually.
- **Costs Per Ton Diverted.** Midrange cost is $49 per ton of material diverted.

3.4.2 Strategy Description

Institutions, such as universities, schools, hospitals, correctional facilities, and military installations, are uniquely suited to composting because they typically generate large quantities of organic materials and have land available for composting. Institutional composting can reduce disposal costs or, as is the case at many universities, provide opportunities for research and development of new compost technologies. Examples of composting operations at correctional facilities, universities, military installations, and other institutions are provided below.

3.4.2.1 Correctional Facilities

Low-technology institutional composting occurs at the Georgia Diagnostic and Classification Center (GDCC) and the New York State Department of Corrections (NYDOC), which has 30 operating composting programs at correctional institutions throughout New York.[11] Materials collected for the programs include food scraps, brush, wood scraps, and some paper. Average diversion rates reported by NYDOC are approximately 25 to 30 percent of the total waste generated.

Inmates collect materials using existing equipment that was formerly used primarily for garbage disposal. Materials collected are composted in open windrows on concrete pads. An animal feeder is used to mix the compostables, a skid steer loader is used for turning the piles, and, in some cases, the finished product is screened with a trommel screen. Finished compost is then used in prison landscape and horticultural applications as well as in community projects.[12]

A more high-technology approach is employed by the Rikers Island correctional facility in New York City.[13] This approach uses an in-vessel compost technology that is suitable for institutions with limited space. The program targets food scraps, corrugated, and a limited quantity of pallets. Approximately 200 yellow 44-gallon containers are placed near feeding lines, in food preparation areas (e.g., near vats and in vegetable preparation locations), and in cleanup areas of the kitchen. After each meal, the yellow containers are emptied by inmates into one of four 12-cubic-yard containers. These containers are collected 5 days a week by the New York Department of Sanitation and delivered to the centrally located compost facility. Corrugated is collected from kitchen loading docks by inmate work crews. The facility is currently operated under contract to the New York Department of Sanitation by Wheelabrator Water Technologies. Finished compost is used by the Rikers Island Farm Project. The operation is expected to handle about 4,000 tons of food scraps and corrugated cardboard annually when it is fully operational.[14]

3.4.2.2 Universities

Universities often generate large quantities of organic waste. A feasibility study for a composting project at Tufts University in Medford, Massachusetts, estimated that a typical undergraduate generates approximately 60 pounds of food scraps annually.[15]

The University of Vermont (UVM) implemented a pilot composting program in 1992. During 1993, approximately 17 percent of the UVM waste stream was co-composted with manure. Compostable materials diverted from the university's waste stream included 272 tons of mixed paper (68 pounds

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[11] Marion, J. 1994. "Correctional System Wins With Composting and Recycling." *BioCycle*. September. p. 30.

[12] Based on telephone conversations with Glen Sluggs of GDCC and Jim Marion of NYDOC.

[13] Rikers Island is operated by the New York City Department of Corrections, which is separate from the New York State Department of Corrections.

[14] The Rikers Island composting facility commenced operations in September 1996.

[15] This estimate was derived using food scraps per diner per meal multiplied by the number of meals over the course of the school year divided by the number of undergraduate students. In fact, some faculty, graduate students, and staff use the dining services, although the numbers were not estimated. In addition, an unknown number of undergraduate students at Tufts eat their meals outside of university dining facilities. This information is based on a waste audit performed by Caroline Ganley and Peter Allison and provided by Sarah Creighton of Tufts University.

per student) and 78 tons of food preparation scraps (19.5 pounds per student). Finished compost was used to fertilize animal feed crops.[16]

The University of Maine at Orono (UMO) began composting leaves, brush, and manure in a preliminary way in 1990. By 1992, UMO was composting dining hall food scraps, yard trimmings, chopped brush, and lumber scraps. The university began to reach out to surrounding communities by accepting leaves and found that it incurred no additional costs by doing so. When additional surrounding communities became interested in starting composting programs, UMO and four communities applied for a capital investment grant from the Maine Waste Management Agency. In this way, the program was able to generate the materials needed to support a relatively large, sustained composting program.[17]

3.4.2.3 Military Installations

Some military installations also have begun composting operations, although the targeted materials seem to be primarily limited to yard trimmings and wood waste. The Air Force has initiated many composting operations since it issued a policy statement, in May 1994, requiring each installation to operate an onsite facility or participate in composting through a regional program. When a survey of the 114 Air Force bases was conducted in 1994, 35 had yard trimmings programs or planned to have them in the near future. Nine of these had onsite composting facilities operating; the rest were either off site or in the planning stages.

Kelley Air Force Base in Texas provides one example of a planned onsite composting operation.[18] The program targets 700 tons of pallets and 100 tons of yard trimmings generated annually. A tub grinder is used to shred pallets, and a front-end loader is used for turning windrows.

3.4.2.4 Other Institutions

Other institutions, such as hospitals and primary and secondary schools, also have the potential for diverting organic materials. Two elementary schools in Concord and Conway, Massachusetts, for example, have started composting food scraps from the lunch rooms in composting bins managed by students. Although this is primarily an educational project for the students, Concord's program diverted an estimated 15 pounds per student in its first year of operation. A higher technology alternative is in operation at the London, Ontario, psychiatric hospital. This facility recently started using an onsite enclosed in-vessel composting system. The diversion of material is projected to be over 1,000 pounds per hospital bed per year.

In February 1995, the Canadian Department of Natural Resources (NRCan) in Ottawa implemented a compost operation using a small in-vessel composting system. While its cafeteria alone generated about 120 pounds of food scraps per day, NRCan decided to bring in food scraps from other institutions in the region because it had a throughput capacity of 750 pounds per day. Wood chips

[16] Personal communication with Dennis Miller, University of Vermont Solid Waste Manager.

[17] Wilderson, S. 1996. "University Composting Program Serves Four Local Communities." *BioCycle.* August. pp. 76-77.

[18] United States Air Force. 1994. *Yard Waste Composting Programs: Current and Planned Air Force Initiatives*. Civil Engineer Support Agency, Tyndall Air Force Base, Florida.

are added as a bulking agent to the food scraps. NRCan pays to have the wood delivered. The in-vessel unit produces six 95-gallon drums of compost a week.[19]

3.4.3 Technical Problems

Institutional composting facilities, including small onsite systems, are often required to undergo the same regulatory and siting process as large solid waste disposal and processing facilities. These permit requirements probably represent the single largest barrier to widespread composting by this sector.

3.4.4 Applicable Portion of the National Waste Stream Diverted

Table 3-5 shows the potential for diverting organic materials from several types of institutions using unit diversion rates estimated in this section. Assuming all institutions in each category compost, this analysis suggests that approximately 2.4 million tons of organic materials could be diverted from institutions.

Table 3-5
Potential Onsite Institutional Composting Diversion Rates

Institutions	Population [a]	Per-Capita Diversion (Annual Pounds Per Population)				Total Diversion (Tons)			
		Food	Paper	Yard [b]	Total	Food	Paper	Yard	Total
Correctional [c]	910,080	794	140	30	964	361,302	63,706	13,619	438,627
Hospitals [d]	1,158,000	500	100	30	630	289,500	57,900	17,329	364,729
Military [e]	1,397,000	0	0	30	30	0	0	20,906	20,906
Schools [f]	50,709,000	15	0	30	45	380,318	0	758,860	1,139,178
Universities [g]	7,065,703	40	68	30	138	140,431	240,234	105,738	486,403
TOTAL	**61,239,783**					**1,171,550**	**361,840**	**916,453**	**2,449,843**

Notes:
[a] Based on *Statistical Abstract of the United States: 1995*. Inmate population includes federal and state prisoners. University population includes full-time undergraduate students only. Hospital population reflects number of beds at all hospitals. Military population includes active military personnel located in the United States.
[b] Data on per-capita yard trimmings diversion was not available. Thirty pounds per capita is estimated based on information reported in the U.S. Air Force's *Yard Waste Composting Programs: Current & Planned Air Force Initiatives,* 1994.
[c] Diversion estimate for food scraps is based on the average of Rikers and NYDOC data. Estimate for paper is based on Rikers data.
[d] Diversion estimate is based on one-half of the London, Ontario, projection.
[e] No data were available on military food scraps or paper composting programs; only yard trimmings composting is assumed.
[f] Food scraps estimate is based on Concord, Massachusetts, elementary school data. No data were available for school paper generation.
[g] Diversion estimate for food scraps is based on the average of Tufts and UVM data. Estimate for paper is based on UVM data.

3.4.5 Costs Per Ton Diverted

Table 3-6 provides a summary of the cost of the five institutional programs for which capital and operating cost information is available.[20]

[19] Sinclair, R.G. 1996. "Managing Food Residuals Through On-Site Composting." *BioCycle*. January. pp. 34-36.

[20] The sources of this information are given in the footnotes to the text of the corresponding section (e.g., universities).

For correctional facilities with low-technology composting operations (NYDOC and GDCC), the combination of inmate labor and existing equipment reduces collection and operation costs significantly. Much of the cost estimated for the Rikers facility is due to site-specific constraints that would not necessarily apply to high-technology facilities in other locations.[21]

Costs for the five onsite institutional programs are organized in Table 3-6 by low-technology and high-technology options. Weighted average costs range from $29 to $98 per ton diverted for low-technology and high-technology operations respectively. Weighted average costs of low-technology and high-technology operations are $49 per ton diverted.

Table 3-6
Onsite Institutional Composting Program Costs

Facility	Tons Composted Per Year	Capital Costs	Operating Costs	Total Costs	Costs Per Ton
Low-Technology					
Kelley Air Force Base	800	$47,143	$20,000	$67,143	**$84**
GDCC	1,040	$11,429	$28,000	$39,429	**$38**
NYDOC [a]	7,800	NA	NA	NA	**$22**
Weighted Average Low-Technology					**$29**
High-Technology					
NRCan	94	$5,853	$11,274	$17,127	**$182**
Rikers	4,000	$152,070	$230,000	$382,070	**$96**
Weighted Average High-Technology					**$98**
WEIGHTED AVERAGE [b]					**$49**

Notes:
[a] Marion, J. 1994. "Correctional System Wins With Composting and Recycling." *BioCycle*. September. p. 32.
[b] The average cost per ton is weighted based on tons of material composted per year.

3.5 Commercial Composting

3.5.1 Strategy Summary

- **Strategy Description.** Commercial organic materials generators—supermarkets, restaurants, schools, and others—receive commercial collection services and separate organic materials (e.g., food scraps and unrecyclable cardboard and paper) for collection and composting.
- **Technical Problems.** Compacted food scraps can generate odorous liquids that leak from collection vehicles. Also, the containers used to store the food scraps before

[21] The Rikers Island facility is located on an island within a few hundred feet of the end of an active runway at LaGuardia Airport.

collection can become quite odorous themselves and need to be cleaned or exchanged, which itself can cause logistical problems.

- **Applicable Portion of the National Waste Stream Diverted.** The commercial sector generated 24.6 million tons of food scraps and soiled, unrecyclable paper and cardboard annually.
- **Costs Per Ton Diverted.** Midrange cost for collection and processing is estimated at $72 per ton.

3.5.2 Strategy Description

Commercial generators of organic materials that receive commercial collection services, such as supermarkets, food processing companies, restaurants, and schools, have the potential for diverting large amounts of food scraps, soiled and waxed cardboard, and paper. In a supermarket, for example, organic residues can represent 75 to 90 percent of the total waste stream.[22] In schools, restaurants, and personal care facilities, organic materials make up an average of 74 percent of the total waste stream.[23]

There are several ways that commercial organic materials are collected. For larger generators, rolloff compactors can be filled on site then hauled directly to a composting site. Smaller generators have their materials collected more frequently by packer trucks from smaller outside containers, such as toters or dumpsters, or by a service that swaps empty containers for full ones.

3.5.3 Technical Problems

Compactors without gaskets and packer trucks can leak substantially and create odors and messy conditions. This problem can be alleviated by using rolloff compactors with watertight gaskets.

Another problem is encountered by haulers that collect toters or dumpsters and clean these containers at the customers' site. The resulting wastewater must be handled appropriately. Waste Management of Fort Worth, Texas, for example, captures the wastewater in a separate container in the collection vehicle then dumps the water into its sewage system (for which it has a permit).[24]

The second wastewater handling option is to actually store the water with the organics, as is done by Food Waste Management of Vermont. This company uses an over-the-top style truck and, thus, does not have problems with leakage. The company does note, however, that this system increases collection costs.[25]

In an attempt to reduce the frequency with which the containers need to be cleaned, some haulers have tried to use degradable liners to protect the container sides. In Fort Worth, Waste Management has ordered 4,000 biodegradable bags that will be held in place in the containers with oversized

[22] Kunzler, C., and R. Roe. 1995. "Food Composting Projects on the Rise." *BioCycle*. April. p.65.

[23] Black, G. 1995. "Strategies for Commercial Organics Diversion." *BioCycle*. November. p. 63.

[24] Ibid. p. 60.

[25] Ibid. p. 60.

rubber bands. Waste Management hopes this option will reduce the number of times the containers require washing.

3.5.4 Applicable Portion of the National Waste Stream Diverted

The commercial sector has strong potential to contribute to the diversion of organic materials. One 9-month pilot examined collection of food scraps and soiled, unrecyclable paper and cardboard from 51 commercial establishments including restaurants, schools, personal care facilities, a grocery store, and others. They found that these businesses on average captured 48 percent of the materials targeted for collection.[26] Food scraps and soiled, unrecyclable paper and cardboard make up about 24.6 million tons of all material generated by the commercial sector. See Table 3-7 for a summary.

Table 3-7
Applicable Portion of the Waste Stream Available for Commercial Composting

Materials Targeted by Commercial Organics Programs[a]	% Generated by Commercial Sources[b]	Thousands of Tons Generated by Commercial Sources[c]
Tissue paper/towels	40%	1,192
Paper plates, cups	80%	760
Other nonpackaging paper	50%	2,060
Corrugated boxes[d]	90%	6,570
Milk cartons	50%	230
Folding cartons	40%	2,156
Other paperboard packaging	50%	115
Bags and sacks	10%	198
Wrapping papers	10%	5
Other paper packaging	30%	405
Food Scraps	50%	10,950
TOTAL		**24,641**

Notes:
[a] Excludes yard trimmings which are assumed to be targeted by grasscycling and municipal yard trimming programs.
[b] Derived from Table C-1 of the *1994 Update.*
[c] Material tonnage data from the *1997 Update* is applied to percentage generated by commercial sources.
[d] Unrecycled corrugated boxes. According to the Grocery Committee of the Food Marketing Institute (1991), retailers generate 6.6 million tons per year of food scraps and non-recyclable cardboard (soiled, wet, or waxed) at a 3:1 ratio. Therefore, the amount of soiled corrugated boxes is calculated by dividing the total quantity of food scraps by three.

[26] Ibid. p. 63.

3.5.5 Costs Per Ton Diverted

In the commercial sector, the costs of collection and processing are often not easily accessible, as they are considered proprietary information. The city of Seattle, the King County Solid Waste Division, and the Washington Department of Ecology, however, funded development of detailed cost models for collection and processing of commercial organics as part of the Seattle/King County Commercial Food Waste Demonstration Project.[27] The collection models were based on several factors including food scraps generation rates per employee for different types of generators, participation rates based on survey information, efficiency of organics separation by participating firms, collection frequency, and container weight limits. The model indicated that the quantity of food scraps generated at each commercial site and the distance between generators had the greatest impact on commercial organics collections costs. Collection and transport and processing cost ranges were calculated for several service areas as shown in Table 3-8. The model also estimated capital, operational, and maintenance costs and amortized total processing costs for standard processing compost facility designs.[28]

Some examples of prices charged per ton to commercial establishments for collection and/or processing of organic materials also are presented in Table 3-8. For large generators that can use compactors, such as the Shop-Rite supermarket chain in northern New Jersey, the charge for collecting organics in a 25-cubic-yard compactor depends on the distance to the composting facility but, generally, is in the realm of $250 per haul. Given that these compactors hold 15 to 20 tons, this results in an average charge of about $14 per ton for collection alone. The material is then delivered to local compost facilities that charge about $36 per ton.[29]

[27] Sasser, L. 1995. "Feasibility of Large-Scale Organics Diversion." *BioCycle*. October. p. 68. Cost models were developed by E&A Environmental and Bender Consulting, Inc.

[28] The model assumes use of an enclosed, aerated static pile for initial stabilization and that slightly differing technologies would be used after initial stabilization.

[29] Figures in this paragraph are based on personal communication with Tim Vogel, Manager of Environmental Affairs, Wakefern Corporation (owner of Shop-Rite supermarkets), October 28, 1996.

Table 3-8
Collection, Processing, and Combined Costs Per Ton

Collection Services	Costs Per Ton (Low)	Costs Per Ton (High)	Costs Per Ton (Average)
Seattle Cost Model			
Downtown service area	$34.00	$45.00	$39.50
Urban neighborhood	$46.00	$89.00	$67.50
Suburban city	$63.00	$102.00	$82.50
Seattle Cost Model average	$47.67	$78.67	$63.17
Shop-Rite	NA	NA	$14.00
Hannaford Brothers	NA	NA	$43.00
AVERAGE COST OF COLLECTION			**$40.06**
Reported Processing Costs			
Seattle Cost Model	$23.00	$42.00	$32.50
Shop-Rite	NA	NA	$36.00
Hannaford Brothers	NA	NA	$18.00
Intervale Compost Facility	NA	NA	$40.00
Earthgro Compost	NA	NA	$33.00
AVERAGE COST OF PROCESSING			**$31.90**
AVERAGE COLLECTION AND PROCESSING			**$71.96**

Source:
Seattle Cost Model was developed by E&A Environmental Consulting and Bender Consulting for the Seattle/King County Commercial Food Waste Composting Demonstration Project, 1995. See accompanying text and footnotes for details on all other cost estimates.

Many generators, however, cannot or prefer not to use compactors and, thus, use a smaller-scale approach. The food scraps from Hannaford Brothers' stores are placed in 95-gallon toters and collected one to three times per week. The company pays $40 to $45 per ton for this service.[30]

Once at a composting facility, charges will vary as well. Hannaford Brothers reports being charged $10 to $25 per ton for its material; the Intervale Compost Project in Vermont charges $40 per ton; and the Earthgro composting facility in Lebanon, Connecticut, charges $25 to $40 per ton for food scraps.[31] What has been generally noted, however, is that composting tip fees are, in most cases, less than half of the local disposal option.[32]

[30] Personal communication with Ted Brown, Environmental Affairs Manager, Hannaford Brothers, October 25, 1996.

[31] Op Cit. Farrel. p.62.

[32] Kunzler, C., and M. Farrel. 1996. "Food Service Composting Update." *BioCycle*. May. p. 49.

As summarized in Table 3-8, average costs for this strategy are assumed to be about $72 per ton diverted. Costs per ton collected and composted range from a low of about $50 ($14 plus $36) as reported by Shop-Rite to a high of around $144 ($102 plus $42) estimated for suburban areas by the Seattle Cost Model.

3.6 Mixed Waste Composting

3.6.1 Strategy Summary

- **Strategy Description.** Mixed waste composting facilities separate MSW into component streams for composting, recycling, and refuse disposal.
- **Technical Problems.** Odor problems have plagued mixed waste composting facilities, and odor mitigation initiatives have raised mixed waste composting costs. Emissions of harmful airborne fungi also have been reported. The compost produced by these facilities is often contaminated by metals present in MSW, which reduces its range of application and its value.
- **Applicable Portion of the National Waste Stream Diverted.** In theory, this strategy could divert all organic waste that is currently targeted for composting. This includes 28 million tons of yard trimmings, 22 million tons of food scraps, and 25 million tons of soiled or unrecyclable paper—resulting in an annual total of 75 million tons of material.
- **Costs Per Ton Diverted.** Midrange costs are estimated at $63 per ton for collection and $50 per ton for processing for a total cost per ton of $113.

3.6.2 Strategy Description

Mixed waste composting refers to a centralized processing system that accepts mixed MSW and separates materials into component parts for composting, recycling, and ultimate disposal. Facilities in the United States range in capacity from 15 to 220 TPD and employ a range of technologies. There are 12 mixed waste composting facilities operating in the country.[33]

Mixed waste composting once appeared to be a solid waste panacea. Mixed solid waste was promised to be transformed into high-quality products with no modification to waste collection systems while vastly decreasing our dependence on landfills. A number of mixed waste composting plants were established in the United States in the 1980s with mixed results, as discussed below.

Most mixed waste composting facilities include basic preprocessing equipment such as trommels, shear shredders, or other size reduction equipment. Composting technology ranges from relatively simple windrows to capital-intensive digester drums. This range of technologies exists to accommodate needs for more process control (in terms of odor control), finished product quality, and composting speed in order to maximize throughput for a given facility size.

Odors are controlled by a combination of facility enclosure, material handling procedures, processing technologies, competent process control, and end-of-pipe odor control technologies. The odor control technologies most often used at mixed waste composting facilities are biofilters.

[33] Steuteville, R. 1995. "MSW Composting at the Crossroads." *BioCycle*. November. pp. 44-46. A followup call was made to contributing author Nora Goldstein on October 22, 1996, who was able to separate out the source-separated organics facilities from the mixed waste composting facilities described in the article.

3.6.3 Technical Problems

Many of the early mixed waste composting facilities were built with no provisions for odor control. Odor problems have been the primary reason for closing a number of mixed waste composting facilities. In 1993, there were 16 mixed waste composting facilities in operation. At the end of 1995, there were only 12.[34]

Other concerns include the potential health problems caused by airborne fungal spores and increased truck traffic and noise in residential areas. In the past, composting facilities were easier to site than other waste handling facilities as they were considered more benign. Siting new facilities, however, has now become difficult.

Another potential concern with mixed waste composting is the quality of the finished compost. Chemical contamination, due to the heavy metals and organic chemicals found in batteries, consumer electronics, household hazardous waste, and other components of the waste stream, concerns potential end-users. Physical contaminants, such as pieces of glass and plastic, even if not regulated, can reduce the marketability of the product.

The composting industry is learning from past experience and putting much more time and effort into effective facility planning and operations, especially with regard to odor control. Technology has improved, but this has substantially increased the cost of mixed waste composting. Tipping fees have increased in the past few years. New facilities with state-of-the-art equipment will be increasingly expensive to build. In most areas of the country, tipping fees at mixed waste composting facilities are higher than landfill tipping fees.

3.6.4 Applicable Portion of the National Waste Stream Diverted

In theory, this strategy could divert all organic waste currently targeted for composting—approximately 75 million tons per year.[35] All organic materials might never be composted this way due to the cost and problems with marketing the end-product. Technically, however, this method of composting is capable of handling 100 percent of the currently discarded organic materials stream.

3.6.5 Costs Per Ton Diverted

Major cost elements for mixed waste composting facilities include siting, capital expenditures for equipment and odor control devices, and operating costs. Siting new facilities, especially in nonrural areas, is becoming increasingly time consuming and expensive as a sophisticated public actively works against these projects. These costs are very difficult to quantify, as they include a combination of public sector staff time as well as legal and engineering fees.

[34] Nora Goldstein was able to confirm that the four plant closings were all mixed waste facilities.

[35] The estimate of the quantity of materials targeted for composting is based on the *1997 Update*. It includes 28 million tons of yard trimmings, 22 millions tons of food waste, and 25 million tons of soiled or unrecyclable paper.

Mixed waste composting facilities use much higher levels of technology than other organics diversion strategies in order to sort recyclables and compostables from disposed of waste. Facilities have dramatically different capital costs depending on the level of technology employed and the reliance upon low-skilled labor for sorting. Odor control technologies also have associated design, construction, and operating costs that vary widely from project to project.

Operating costs include labor, operation and maintenance, utilities, and residuals disposal. The technology used will determine labor requirements. Residuals disposal can be a very large cost item depending on the compost quality, the corresponding degree of contaminant removal, and the cost of disposal.

One study reported estimated costs for the capital debt service (presented as Capital Cost Per Ton in Table 3-9) and operation (presented as Operating Cost Per Ton in Table 3-9) of a number of mixed waste composting facilities around the country. The estimates do not generally include the costs for land, as the facilities are all publicly owned and land was already available.[36] The resulting average cost per ton ($49.89) is within the range of tipping fees examined for this report. These tipping fees are listed in Table 3-9. In addition, it is clear from the data provided in these tables that these programs are not financially self-sufficient.

In addition to facility costs, mixed waste composting involves collection costs. Unlike other organics management strategies, however, mixed waste composting does not require a separate collection system. There is no additional collection cost, therefore, for a community that changes from hauling its waste to a landfill to hauling its waste to a mixed waste composting facility. For the sake of comparability with other strategies, a generic collection cost of $63.06 has been developed from the estimates presented in Table 2-2.[37]

Costs per ton diverted by this strategy range from a low of $102 to a high of $127. The weighted average cost of diversion for this strategy is $113 per ton.[38]

[36] It is also excluded to be consistent with the accounting of the other strategies that have sites and that do not include land costs.

[37] In Table 2-2, four estimates of collection costs for communities that have no yard trimmings collection were developed; it is reasonable to use communities with no yard trimmings collection costs as a proxy because communities that haul to mixed waste compost facilities are unlikely to also collect yard trimmings. The average of the four estimates developed is used here.

[38] The average total cost from Table 3-9 plus the estimated collection cost per ton.

Table 3-9
Mixed Waste Composting Facility Costs

Facility	Tons Per Day	Tons Per Year [a]	Capital Cost Per Ton [b]	Operating Cost Per Ton [b]	Total Cost Per Ton	Public v. Private	Tip Fee
Sumpter County, Florida	42.50	11,050	$24.25	$39.19	$63.44	Public	$49.00 [f]
Wright County, Minnesota	190.00	49,400	$26.32	$33.40	$59.72	Public	$55.00 [h]
Truman, Minnesota (Prairieland Solid Waste Board)	70.00	18,200	$41.81	$13.13	$54.95	Public	$55.00 [g]
Columbia County, Wisconsin	72.00	18,720	$14.96	$28.31	$43.27	Public	$33.00 [h]
Sevierville, Tennessee (Sevier Solid Waste)	220.00	57,200	$23.60	$15.73	$39.34	Publicly Owned, Privately Run	$35.00 [h]
Pinetop-Lakeside, Arizona	15.00	3,900	NA [c]	$32.05	NA	Public	$38.00 [e]
WEIGHTED AVERAGE[d]					**$49.89**		**$44.17**

Notes:
[a] Assumes a 5-day work week.
[b] Assumes full cost accounting.
[c] This facility has no debt service because sanitary district funds paid for the project.
[d] The total cost per ton figure is weighted based on tons per year and does not include the Pinetop-Lakeside facility.
Sources:
Solid Waste Association of North America. 1995. *Cost Information Based on Municipal Solid Waste Composting—A Status Report*. Prepared by Gershman, Brickner & Bratton, Inc. Table VI-4.
TPD information from Steuteville, R. 1995. "MSW Composting at the Crossroads." *BioCycle*. November. pp. 45-46.
[e] *BioCycle*. 1995. February. pp. 48-49.
[f] *BioCycle*. 1993. November. pp. 56-64.
[g] *Resource Recycling*. 1993. December. pp. 50-51.
[h] Solid Waste Association of North America. 1995. *Municipal Solid Waste Composting—A Status Report*. Prepared by Gershman, Brickner & Bratton, Inc. Table VI-4.

3.7 Residential Source-Separated Composting

3.7.1 Strategy Summary

- **Strategy Description.** Homeowners separate specified organic materials and set them out for collection and processing.
- **Technical Problems.** Programs are relatively new to the United States and have not been widely tested or researched.
- **Applicable Portion of the National Waste Stream Diverted.** The residential sector generates 47.3 million tons of select paper, food scraps, and yard trimmings annually.
- **Costs Per Ton Diverted.** Since this strategy is not well established in the United States and only limited operating cost data are available, no cost estimates have been derived in this report. Limited cost information is, however, provided below based on pilot results.

3.7.2 Strategy Description

Increasing sensitivity about the poor quality of mixed waste compost in Europe started a wave of residential collection programs targeting the organic fraction of solid waste. Several pilot programs in the Netherlands and Germany in the late 1980s demonstrated that the compost produced with residential source-separated feedstock contained substantially lower levels of toxic heavy metals and physical contaminants, such as glass and plastic, than mixed waste compost.

A variety of methods for collecting source-separated organics are used in northern Europe. Many municipalities that use semiautomated collection for trash issue all households standard size bins or rolling carts for organics. Other communities have tried dual compartment bins or paper bags. Collection is generally once per week.

The first U.S. pilot program was in East Hampton, New York, followed by others in Fairfield, Connecticut, and Santa Barbara, California. The main objectives of these pilot programs were to determine if residents would comply with additional separation requirements, what type of sort seemed to yield the best compost quality and diversion results, and what collection systems could be used.

Several pilot and full-scale residential organics programs are described below:

- **Mississauga, Ontario.** Four different combinations of sorting and collection were tried in four zones of the city. These methods included two-stream (i.e., wet and dry) sorts using bags and three-stream (i.e., recyclables, organics, and trash) sorts using varying combinations of containers. The report indicated a preference for a three-stream sort, even if the program cost was determined to be slightly higher, as the recyclable and compostable materials collected were of higher quality.
- **Fillmore County, Minnesota.** The source-separated composting facility in this county is one of the oldest operating plants in the United States (started in 1987).[39] Compostables (including food scraps, nonrecyclable paper, and diapers) are collected weekly. Residents source-separate organics and recyclables from refuse. The facility is permitted to accept 3,100 tons per year and is operating at close to capacity.[40]
- **Lake of the Woods County, Minnesota.** This county has mandatory source separation of organics. If materials at the curb are not separated they are not collected. Private haulers bring materials from both commercial and residential sources to the facility. Incoming loads are screened for contamination. Of the approximately 2,500 tons of material brought to the facility each year, approximately 1,200 tons are composted.[41] The system yields about 500 tons of compost and 500 tons of residuals per year.[42]

[39] Goldstein, N., R. Steuteville, and M. Farrell. 1996. “MSW Composting in the United States.” *BioCycle*. November. p.50.

[40] Personal communication with Sandra Benson, Fillmore County, Minnesota, October 23, 1996.

[41] Personal communication with Gary Lockner, Lake of the Woods County, Minnesota, October 22, 1996.

[42] Goldstein, N., and R. Steuteville. 1995. “Solid Waste Composting Plants in a Steady State.” *BioCycle*. February. p. 50.

- **Mackinac Island, Michigan.** This community converted its mixed waste composting facility to a source-separated composting facility in 1993. It maintains organics, recyclables, and refuse separation programs for both residential and commercial generators. Organics are placed in biodegradable bags that are collected biweekly for residents and daily for commercial generators.[43]
- **East Hampton, New York.** An organics composting facility in this community receives material from both residents and commercial entities. Sixty-five percent of the residents are self-haulers while the rest contract with private haulers. It is not mandatory for residents to separate organics; however, the town is finding that participation levels are good.[44]
- **Region of Peel and Town of Caledon, Ontario.** These communities began phasing in a residential source-separated organics collection program in April 1995. The program began with a pilot project that targeted 4,700 households to participate in source separation of kitchen, yard, and general household organics. During the 13-week pilot program, participation averaged approximately 50 percent each collection day. The region is now expanding its capacity and is implementing a full-scale program.[45]
- **King County, Washington.** The county conducted a pilot program with 640 households over a 13-week period in 1995. The program targeted food scraps and yard trimmings. Participation was voluntary, and residents were provided with containers. Participation ranged from 59 to 67 percent. About 12 tons of food scraps were collected from the pilot areas, and the study estimated that up to 21,000 tons of food scraps could be diverted if all single-family homes were offered the service.[46]
- **DeKalb, Illinois.** This community's 14-week pilot project ran two routes with 300 residential participants each. Dual compartment vehicles were used to co-collect wet and dry materials on one route. Recyclables also were collected in the dual compartment vehicles on the second route. Eighty-seven percent of the target area residents participated in the project.[47]

3.7.3 Technical Problems

As with any new program, it takes time to educate residents. During the initial period of source-separated organics collection programs, there will be some contamination that has to be dealt with at the composting facility.

[43] Ibid. p. 53.

[44] Personal communication with Peter Garnham, Town of East Hampton, October 23, 1996.

[45] Gies, G. 1996. "Modular Management of Residential Organics." *BioCycle*. February. pp. 80-82.

[46] King County Department of Natural Resources, Solid Waste Division. 1996. *King County Residential Food Waste Collection Pilot Project Report*.

[47] Waste Management, Inc., and E&A Environmental Consultants. 1995. *Wet/Dry Collection and Composting Project Pilot Study Results*. Prepared for the Illinois Department of Commerce and Community Affairs.

Residents sometimes complain that their organics containers become more odorous than regular mixed trash containers. This is more likely to be a problem for households that have a relatively small portion of nonfood compostables, such as paper, yard trimmings, or cardboard, in the organics container. This also is especially true for homeowners who have less than weekly collection for the organics stream. Due to concerns about odor and health, programs that include food scraps should consider collecting these materials more than once per week, especially in warmer climates.

3.7.4 Applicable Portion of the National Waste Stream Diverted

As shown in Table 3-10, approximately 47.3 million tons of the U.S. residential MSW stream (e.g., food scraps, yard trimmings, unrecyclable paper, and corrugated) can be targeted by this strategy.

Table 3-10
Applicable Portion of the Waste Stream Available for Residential Source-Separated Composting

Materials Targeted by Commercial Organics Programs	% Generated by Commercial Sources[a]	Thousands of Tons Generated by Commercial Sources[b]
Tissue paper/towels	60%	1,788
Paper plates, cups	20%	190
Other nonpackaging paper	50%	2,060
Corrugated boxes[c]	10%	730
Milk cartons	50%	230
Folding cartons	60%	3,234
Other paperboard packaging	50%	115
Bags and sacks	90%	1,782
Wrapping papers	90%	45
Other paper packaging	70%	945
Food Scraps	50%	10,950
Yard Trimmings	90%	25,200
TOTAL		**47,269**

Notes:
[a] Derived from Table C-1 of the *1994 Update*.
[b] Material tonnage data from the *1997 Update* is applied to percentage generated by commercial sources.
[c] Unrecycled corrugated boxes. According to the Grocery Committee of the Food Marketing Institute (1991), retailers generate 6.6 million tons per year of food scraps and non-recyclable cardboard (soiled, wet, or waxed) at a 3:1 ratio. Therefore, the amount of soiled corrugated boxes is calculated by dividing the total quantity of food scraps by three.

3.7.5 Costs Per Ton Diverted

Costs for residential organics programs are not readily available because such programs have not been widely implemented in the United States.

Average collection costs for the wet and dry collection technologies evaluated in the DeKalb, Illinois, pilot program ranged from $48 to $62 per ton diverted.[48] Wet and dry organics were collected weekly by a dual collection vehicle. Residents were supplied with cellulose-lined bags, 8-gallon containers to hold the wet waste bag, and 20-gallon wet waste containers to hold full wet waste bags for curbside collection. On one of the two pilot routes, recyclables were co-collected with wet and dry organics in blue bags. The cost of the recycling and wet and dry co-collection was $48 per ton diverted.

Other studies have estimated monthly food scraps collection service fees[49] as well as source separation collection costs in Europe.[50]

As with source separation collection information, there is a general lack of complete cost information specific to source separation processing technologies. Swift County, Minnesota, built a composting facility designed to receive bagged source-separated MSW as feedstock. The cost for source-separated collection and processing at this facility was compared to the cost of mixed waste composting in neighboring counties.[51] Source-separated costs ranged between $11 and $15 per month per household, whereas mixed waste composting costs ranged between $10 and $22 per household per month.[52]

The $3.5 million composting facility in East Hampton, New York, has a capacity of 40 wet tons per day. For the first 9 months of 1996, the facility received an average of 18 to 20 tons per day. Approximately 48 percent of the compostables are received from residents while the rest of the material was received from commercial sources. Operating costs were not available.[53]

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[48] Waste Management, Inc. and E&A Environmental Consultants. 1995. p. 56.

[49] See, for example, Table 2 in the *King County Residential Food Waste Collection Pilot Project Report*. 1996. p.13.

[50] See, for example, Scheinberg, A. 1996. “Going Dutch: Collecting Residential Organics in the Netherlands.” *Resource Recycling*. January. p. 37. This source provides a relatively detailed study of the costs of residential collection done in the City of Rotterdam, Holland.

[51] Op cit. Spencer.

[52] Based on the assumptions of residential solid waste generation of 4.3 pounds per person per day and 2.6 persons per household, source-separated collection and processing costs range from $65 to $88 per ton. MSW composting ranges from $59 to $129 per ton.

[53] Personal communication with Peter Garnham, East Hampton, New York, October 22, 1996.

4. COMPOST MARKETS AND PRODUCT VALUE

4.1 Review of Benefits Associated With Compost End-Uses

The demand for finished compost helps divert an increasing amount of organic materials from landfills. In addition, the use and application of finished compost result in a multitude of benefits, such as enhancing the physical, chemical, and biological properties of soils, which in turn results in various environmental and economic benefits. A summary of some of the major benefits of composting is provided below.[54]

4.1.1 Direct Benefits to Soil

- **Improves the Physical Properties of Soils**. Compost enhances water holding, soil aeration, structural stability, resistance to water and wind erosion, root penetration, and soil temperature stabilization.
- **Enhances the Chemical Properties of Soils**. Compost increases macro- and micronutrient content, increases availability of mineral substances, ensures pH stability, and provides a long-term source of nutrient input by acting as a nutrient reservoir.
- **Improves the Biological Properties of Soils**. Compost promotes the activity of beneficial micro-organisms, reduces attack by parasites, promotes faster root development, and promotes higher yields of agricultural crops.

4.1.2 Indirect Environmental and Economic Benefits

- Since compost has the ability to improve soil water holding capacity and fix nitrogen into a form that can be used by plants, its use mitigates (at least partially) nonpoint sources of pollution such as commercial fertilizers.
- By improving soil water holding capacity and reducing water loss as a result of percolation, evaporation, and runoff, compost application results in water conservation benefits.
- Compost reduces reliance on pesticides, herbicides, and fungicides by providing an environment rich in organic matter. Beneficial micro-organisms thrive in this environment and can outcompete and suppress detrimental pathogens found in soils where organic matter is low.
- Consistent application of compost reduces soil erosion resulting from wind and water by improving soil stability.

[54] Based on Pratt, W., and W. Shireman. 1994. *Agricultural Markets for Compost and Mulch: Cost, Benefits, and Policy Recommendations*. California Futures, Sacramento, California. Also based on Rhode Island Solid Waste Management Corporation. 1991. *End Use of Leaf and Yard Waste Compost*. Prepared by Tellus Institute. For more information on characteristics and benefits of compost, see *Markets for Compost*, EPA. 1993.

4.2 Overview of Compost Markets, Applications, and Constraints

Finished compost can be used in a variety of applications. A report prepared by the Composting Council identified eight existing market segments for compost, with a potential demand for over 1 billion cubic yards of compost per year.[55] This potential demand is substantially greater than the estimated 48 million cubic yards (37.4 million tons) of finished compost that would be available if the entire applicable waste stream shown in Table 1-1 were composted.[56] Each market segment identified in the report is described briefly in Table 4-1 along with the potential applications, relative market size, and potential barriers to widespread use of finished compost by the market segment.

Innovative uses for finished compost are always being explored. The Clean Washington Center in Seattle, Washington, for example, has experimented with using compost in wetland restoration applications. The project tested, monitored, and evaluated the use of yard trimmings compost to restore a wetland that had been significantly damaged by concrete production activities.[57]

Compost is increasingly being used as a medium for biofilters. These filters are designed to scrub industrial process air containing odorous and potentially toxic organic chemicals. Biofilters are large beds, usually constructed in the ground, with pipes that deliver process air placed in a layer of gravel under covers of compost and soil. The active microbial populations in compost use many organic compounds in the process air as a food source by breaking them down, reducing their odor, and rendering them harmless.

Along these lines, Solum Remediation Services, Inc., in Lake Bluff, Illinois, is investigating the potential for planted compost and contaminated soil mixes to contain or degrade toxic compounds in soil. Initial field trials indicate that certain pesticides were substantially degraded using this method.[58]

Another innovative project, in Washington County, Oregon, entails using yard trimmings compost as a treatment medium for roadway stormwater runoff. This runoff usually contains various organic and inorganic pollutants. The compost was used as a substitute for conventional treatment methods such as detention ponds and grassy swales. Preliminary results indicate that the prototype facility successfully removed contaminants from the stormwater while occupying less than 10 percent of the land required by conventional methods.[59]

[55] Composting Council. 1992. *Potential U.S. Applications for Compost*. Prepared by Batelle.

[56] Volume estimates for the applicable waste stream were calculated assuming 50 percent weight loss due to volatilization in the compost process and an average bulk density of finished compost of 0.7850 tons per cubic yard.

[57] Clean Washington Center. 1994. *Technology Brief: Compost Utilization in Wetland Restoration*. Seattle, Washington.

[58] Cole, M.A. 1994. *Remediation of Pesticide Contaminated Soil with Compost*. Symposium on the Biogeochemistry of Compost at Rocky Mountain Conference on Analytical Chemistry. Denver, Colorado. July 31 to August 5.

[59] W&H Pacific. 1993. *Compost Storm Water Treatment System*. Portland, Oregon.

Table 4-1
Compost Markets, Applications, and Potential Constraints

Market Segment	Applications	Potential Market Size	Primary Constraints
Agriculture	• Soil conditioning, fertilizer amendments, and erosion control for vegetable and field crops and forage grasses. • Development of marginal lands. • Mulching after conservation seeding.	Very large, estimated at 895 million cubic yards per year. Research indicates that the demand for compost for agricultural purposes within a 50 mile radius of the 190 largest U.S. cities would exceed the supply of compost.	• Contaminant concentrations for crop production and cumulative loading limits. • Cost of transportation to end-user. • Bulk application equipment requirements and costs.
Silviculture	• Landspreading as soil conditioner for evergreen establishment. • Mulching for woodlot soil improvement and maintenance.	Very large, estimated at 104 million cubic yards per year. This segment's potential demand could exceed the available supply of compost.	• Transportation cost and distance. • Bulk application equipment requirements and costs.
Sod production	• Blending with topsoil to reduce the amount of fertilizer needed to establish sod.	Moderate, estimated at 20 million cubic yards per year. Market potential will be dictated by the rate at which sod producers deplete existing topsoil.	• Transportation cost. • Bulk application equipment requirements and costs.
Residential retail	• Soil amendment to enrich planting areas. • Top dressing for lawns.	Moderate, estimated at 8 million cubic yards per year. Much of topsoil sold in bags is currently made with compost; thus, this market has already been penetrated.	• Postprocess requirements (e.g., screening and bagging) and associated costs. • Consistent quality assurance. • Contaminant levels must be low enough to meet requirements for unrestricted distribution.

Table 4-1
Compost Markets, Applications, and Potential Constraints (Continued)

Market Segment	Applications	Potential Market Size	Primary Constraints
Nurseries	• Potting mixes. • Topsoil amendment for areas in which field grown trees are harvested on a periodic basis.	Small, estimated at 0.9 million cubic yards per year.	• Consistent pH balance, nutrient content, particle size, shrinkage, and water-holding capacity required. • Complete and continuous testing requirements to ensure high-quality product and associated costs. • Compost suppliers will need to be sensitive and responsive to specific growing requirements.
Delivered topsoil	• Blending with marginal topsoils to produce topsoils used for establishing new lawns and planting trees and shrubs.	Small, estimated at 3.7 million cubic yards per year.	• Consistent supplies of compost required to meet seasonal demands.
Landscapers	• Soil amendment for lawn establishment. • Top dressing. • Mulch.	Small, estimated at 2 million cubic yards per year.	• Quality assurance that compost does not contain harmful amounts of contaminants. • Physical contaminants that might be visible on lawns. • Consistent supplies of compost required to meet seasonal demands.
Landfill cover and surface mine reclamation	• Topsoil amendments for lower grade and nonuniform compost products.	Small, estimated at 0.6 million cubic yards per year. There are only a limited number of landfills or mines that are undergoing reclamation at any given time.	• Transportation cost.

Source:
Buhr, McClure, Slivka, and Albrecht. 1993. "Compost Supply and Demand." *BioCycle*. January.

Portland, Oregon, sponsored a study to demonstrate compost's effectiveness in controlling erosion as compared with conventional methods such as sediment fences and wood fiber hydromulch.[60] Fewer sediments were collected from the runoff of the compost-amended plots than the others. The Federal Highway Administration formerly specified the use of straw to control erosion on road embankments. It now authorizes the use of compost and mulches as well as straw. As a followup to the Portland project, EPA will fund a demonstration project to compare the erosion controlling effectiveness of straw and compost on steep embankments.[61]

In addition to innovative uses for standard compost products, there has been increasing interest in 'value-added composts,' or composts amended with fertilizers, disease-suppressive micro-organisms, and other products to stimulate plant growth.[62] Specific organisms known to possess disease-suppressive qualities are cultivated and sprayed onto compost. Disease-suppressive compost products can be made to order based on customer requirements. O.M. Scott and EarthGro are two companies marketing lines of fertilizer-amended compost products formulated for specific applications such as lawn establishment, acid-loving shrub planting, and vegetable planting.

It is clear that many more uses for compost can be discovered with time and attention. As more organic materials are composted as part of a waste management strategy, the greater the imperative will be to develop markets with prices sufficient to cover compost production costs.

More information regarding these innovative uses for standard compost products can be found in a recently published series of EPA fact sheets:

- *Innovative Uses of Compost: Bioremediation and Pollution Prevention* (EPA530-F-97-042).
- *Innovative Uses of Compost: Erosion Control, Turf Remediation, and Landscaping* (EPA-530-F-97-043).
- *Innovative Uses of Compost: Disease Control for Plants and Animals* (EPA530-F-97-044).
- *Innovative Uses of Compost: Composting of Soils Contaminated by Explosives* (EPA530-F-97-045).
- *Innovative Uses of Compost: Reforestation, Wetlands Restoration, and Habitat Revitalization* (EPA530-F-97-046).

These fact sheets can be ordered by calling the RCRA Hotline. Callers within the Washington metropolitan area must dial 703 412-9810 or TDD 703 412-3323 (hearing impaired). Long-distance callers can call 800 424-9346 or TDD 800 553-7672. The RCRA Hotline operates weekdays 9 a.m. to 6 p.m., e.s.t.

[60] Ettlin, L., and B. Stewart. 1993. "Yard Debris Compost for Erosion Control." *BioCycle*. December.

[61] U.S. EPA. 1997. *Innovative Uses of Compost: Erosion Control, Turf Remediation, and Landscaping*. p.3.

[62] Holusha, J. 1994. Making Compost Double as Pesticide. *New York Times*. February 27.

4.3 Compost Product Quality

Compost end-product quality is highly variable depending on the type of organic feedstocks and the processing method used. Yard trimmings compost can include unscreened oak leaf compost with low contamination levels but also low nutrient value. On the other hand, screened leaf and grass compost can have relatively high nutrient content and potentially high levels of soluble salts. MSW composting, although often considered to produce lower quality products due to the unsorted feedstocks, has produced composts that meet relatively stringent quality standards.

Table 4-2 presents ranges of several beneficial use parameters for yard trimmings compost, source-separated compost, and mixed waste compost. For comparison, the table also lists typical beneficial use parameters of fertilizers, manures, and potting soil. As the table shows, compost has nitrogen, phosphorus, and potassium concentrations in the same range as manures and potting soils but vastly different characteristics from fertilizer. Conductivity in Table 4-2 refers to the soluble salts levels of compost. According to the North Carolina Extension Service, compost's conductivity must measure less than 10 millimhos per centimeter (mmho/cm) to be rated as unrestricted grade compost.[63] All composts listed in the table meet this standard except the Minnesota samples of mixed waste compost.

State environmental agencies are increasingly adopting compost product quality standards to protect public health and the environment. Several categories of compost have emerged such as unlimited distribution, nonfood chain crop use, and land reclamation. Mixed waste compost, depending on how it is prepared, might contain concentrations of chemicals that preclude it from being used on food chain crops or distributed to homeowners for gardening use. Yard trimmings compost has been found to contain only low levels of pesticide and herbicide, and the concentrations of these chemicals in no way impacts the potential end-uses for this valuable commodity. There are general trends of decreasing levels of physical and chemical contamination as a function of the degree of source separation. Yard trimmings and commercial, institutional, or even residentially collected source-separated compost is much less likely to exceed state chemical contaminant standards than is mixed waste compost.[64] The value of restricted use products will necessarily be lower than that of products that have unrestricted use.

In general, compost should be rich in organic matter, be low in soluble salts, meet all regulatory standards for its end-use, not contain any weed seeds, have no undesirable odor, have a consistent pH (usually near neutral), and have a moisture content of less than 50 percent.[65] The Composting Council has developed compost product use guidelines for several applications.[66] In all cases, producing compost of consistent quality and composition is important to ensuring that the compost is marketable.

[63] A millimho is one-thousandth of a mho, a measure of conductivity and the inverse of an ohm. Bilderback, T.E., and M.A. Powell. *Using Compost in Landscape Beds and Nursery Substrates*. North Carolina Cooperative Extension Service Water Quality & Waste Management. Publication Number AG 473-14.

[64] Richard, T.L., and P.B. Woodbury. 1992. *The Impact of Separation on Heavy Metal Contaminants in Municipal Solid Waste Composts.* Biomass and Bioenergy. 3:3-4.

[65] Alexander, R. 1994. "The Key to a Successful Composting Program." *MSW Management Elements*. p. 42.

[66] Composting Council. *Compost Parameters and Compost Use Guidelines*.

Table 4-2
Comparison of Compost Beneficial Use Parameters

Compost Type	Nitrogen Percent	Phosphorus Percent	Potassium Percent	pH	Conductivity mmho/cm
Yard Trimmings Compost [a]					
Average	0.94	0.30	0.28	7.65	2.99
Range	0.0002 to 2.1	0.009 to 0.7	0.17 to 0.37	7.1 to 8.2	1.4 to 5.6
Source-Separated Organic Compost [b]					
Average	1.15	0.62	1.01	7.6	3.9
Range	0.88 to 1.47	0.38 to 0.8	0.63 to 1.37	7.2 to 7.8	1.9 to 5.6
Mixed Waste Compost					
European samples [c]	1.11	0.37	0.49	7.66	6.23
Minnesota samples [d]	1.22	0.27	0.59	8	14.6
Range	0.51 to 1.63	0.15 to 0.69	0.14 to 0.91	6.8 to 8.4	3.2 to 22
Manure [e]					
Dairy cattle	0.50	0.06	0.31	NA	NA
Feeder cattle	0.60	0.10	0.30	NA	NA
Poultry	1.50	0.31	0.29	NA	NA
Swine	0.65	0.16	0.45	NA	NA
Sheep	0.65	0.16	0.86	NA	NA
Horse	0.75	0.10	0.55	NA	NA
Average	0.86	0.15	0.46	NA	NA
Potting Soil [f]					
Range	0.005 to 0.1	0.003 to 0.1	0.005 to 0.1	NA	NA
Fertilizers [g]					
Scotts Vegetable Garden Fertilizer	17	25	5	NA	NA
Scotts Starter Fertilizer	20	27	5	NA	NA
Lesco Professional Starter	18	24	12	NA	NA
Scotts Azalea Camellia & Rhododendron Food	15	11	11	NA	NA

Notes:
[a] Sample analyses reported from four yard trimmings composting facilities.
[b] Average of 150 samples collected in Europe. Results from Vogtmann, H. 1993. *Compost Science and Utilization*. Autumn. p. 70.
[c] Average of 14 samples from European MSW composting facilities by E&A Environmental Consultants, Inc.
[d] Average of eight compost products from Minnesota MSW composting facilities. Results from Johnson. 1993. *Resource Recycling*. December. p. 52.
[e] Brady, N.C. 1990. *The Nature and Properties of Soils*. New York: Macmillan Publishing Company. p. 500.
[f] Personal communication with Bruce Bargar, Peters Company.
[g] These values were taken from fertilizer labels at a home and garden store.

4.4 Fertilizer Substitution

Limited research has been performed to define the fertilizer displacement potential of compost. For agricultural applications, one study found a 50 percent compost and 50 percent fertilizer combination resulted in a higher wheat yield than test plots where the entire nitrogen requirement was supplied by mineral fertilizer.[67] Although this research has not been replicated in other conditions, U.S. Department of Agriculture (USDA) officials suggest a synergistic effect between the combined use of compost and fertilizer resulting in at least a 15 to 20 percent reduction in fertilizer requirements.[68] A 12-year study at the Connecticut Agricultural Experiment Station demonstrated that equivalent yields resulted on compost-amended plots when compared to those with only fertilizer after 4 to 5 years when the steady state of nutrient release is reached.[69] It is important to note that, as shown in Table 4-2, compost does not provide the immediate nutrient needs of growing crops like mineral fertilizers. Compost releases nutrients more slowly over time.

Research on horticultural compost applications also suggests a reduction in fertilizer requirements. Although fertilizer applications should be based on the specific soil type, a range of nutrient requirements for standard agricultural and horticultural plants is well known. Even the low levels of available nutrients in compost can supply plants with what they need for proper growth when applied at levels recommended for the soil conditioning properties. Assuming use of a 1 percent nitrogen product, a 20 percent mineralization rate will supply 4 pounds of available nitrogen per ton of compost. A 1-inch application, generally recommended for lawn establishment, will supply 3.5 pounds of available nitrogen per 1,000 square feet, well within the standard fertilizer recommendations of 2 to 6 pounds of nitrogen per 1,000 square feet.[70]

Once a lawn is established, grasscycling can reduce the use of fertilizers by approximately 33 to 50 percent. A 4-year Rodale Institute study found that a year's worth of grass clippings was equal to 235 pounds per acre of nitrogen (5.4 pounds of nitrogen per 1,000 square feet), 77 pounds per acre of phosphate, and 210 pounds per acre of potash.[71]

According to these findings, fertilizer use on lawns could be reduced in certain horticultural and agricultural applications. The quantities of compost needed to displace the fertilizer depends on the compost and fertilizer analysis as well as the time horizon for the displacement. Based on available nitrogen in the first year of application, 12 times as much compost is required assuming a 1 percent nitrogen compost with a 20 percent mineralization rate in the first year as compared to a 5 percent mineral fertilizer. Still, the fact that compost continues to release nutrients over time means that less compost is required in subsequent applications to achieve the same nutrient load. In fact, over a period of 4 years, less than 8 times the amount of this 1 percent nitrogen compost would be required to deliver the same nitrogen as a 5 percent mineral fertilizer.[72]

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[67] Sikora, L.J., and M.I. Azad. 1993. "Effect of Compost-Fertilizer Combinations on Wheat Yield." *Compost Science and Utilization*. Spring.

[68] Personal communication with Lawrence Sikora, USDA Beltsville, Maryland, Research Center.

[69] Maynard, A.A., and D.E. Hill. 1994. "Impact of Compost on Vegetable Yields." *BioCycle*. March.

[70] Tyler, R. 1994. "How Much is Enough?" *Lawn and Landscape Maintenance*. March.

[71] *Composting News*. May. 1994. pp. 10-11.

[72] This calculation assumes a mineralization rate of 20 percent in year one, 10 percent in year two, and 5 percent in years three and four. It also assumes a requirement of twice the necessary nitrogen load of mineral fertilizer due to leaching. These assumptions are based on personal communication with Sikora, L., USDA, and from Parnes, R. 1996. *Organic and Inorganic Fertilizers*. Woods End Agricultural Institute.

4.5 Potential Market Value of Compost

The market value of compost is influenced by a variety of factors including the demand for soil organic matter, availability of competing products, compost quality, and the effectiveness of the producer's marketing strategy. The extent of pre- and postprocessing (e.g., curing, screening, bagging, and mixing) of compost feedstocks also has a direct effect on the market value of compost.

Compost market value also is affected by the type and quality of organic materials (or feedstocks) diverted by a given compost program. Source-separated food scrap compost (typically collected in commercial, institutional, and residential source-separation compost programs) will generally have high nutrient value and low contamination. Yard trimmings compost will have somewhat lower nutrient value as well as low contamination. Mixed waste compost will usually have moderate nutrient value with higher levels of contamination.

Table 4-3 shows reported revenues received from bulk sales of compost end-products. The table organizes revenue information by type of compost program.[73] Yard trimmings composting and residential source-separated composting operations receive a similar range of revenue per ton of finished compost. While mixed waste composting products have a lower market value, these composts (as well as other types of composts produced in municipal facilities) are often used in the public sector or are given away to home gardeners and farmers. Compost produced by grasscycling and backyard composting is used by the homeowner. Similarly, onsite institutional composting facilities often use the compost they produce in their own landscaping operations. While no money is exchanged in these cases, the end-users are likely to realize economic benefits in the form of reduced fertilizer and/or soil amendment costs.

[73] Revenues are for bulk sales of compost only.

Table 4-3
Reported Revenues for Various Compost Program End-Products

Feedstocks	Revenue Per Ton
Yard Trimmings	
Metro Portland Solid Waste Department Facilities, Oregon [a]	$45
Atlantic County Utilities Authority, New Jersey [b]	$25
Rexius Forest Byproducts [c]	$30
Nature's Choice [d]	$27
AVERAGE REVENUE PER TON	**$32**
Source-Separated Organics	
Intervale Compost Project [e]	$53
Commercial Composting Company [f]	$50
Bluestem Solid Waste Agency, Cedar Rapids, Iowa [g]	$15
AVERAGE REVENUE PER TON	**$39**
Mixed MSW [h]	
Pinetop-Lakeside, Arizona	$4
Sumpter County, Florida	$6
Sevier County, Tennessee	$1
AVERAGE REVENUE PER TON	**$3**

Notes:
[a] Personal communication with John Foseid, Metro Solid Waste Department, Portland, Oregon, November 27, 1996.
[b] *BioCycle*. 1996. September. p. 42.
[c] "Nurseries, Landscapers and Soil Blenders Are Leading Compost Markets." 1994. *BioCycle*. September. p. 44.
[d] "Nurseries, Landscapers and Soil Blenders Are Leading Compost Markets." 1994. *BioCycle*. September. p. 51.
[e] Personal communication with Adam Sherman, Intervale Compost Project, December 3,1996.
[f] These costs are proprietary information of the composting company involved. The company did not wish to be identified.
[g] *BioCycle*. 1995. September. p. 44.
[h] All revenues for mixed waste compost are based on Solid Waste Association of North America. 1995. *Municipal Solid Waste Composting—A Status Report*. Prepared by Gershman, Brickner & Bratton, Inc. Table VI-4.

5. SUMMARY AND CONCLUSIONS

Building on the analyses and information in Sections 2, 3, and 4, this section addresses the potential cost impacts of compost strategies. Strategy costs (i.e., midrange compost strategy costs derived in Section 3 and shown in Table 5-1) are combined with benefits (i.e., revenues as well as collection and disposal savings) in order to derive a national 'net cost' per ton diverted and are reported in Table 5-2. A 'compost strategies savings curve' (Figure 5-1) displays the relative savings of individual compost strategies (over traditional disposal methods) and the total quantity of organic materials targeted nationally by each strategy.

Table 5-1
National Summary of Strategy Impacts

Strategy	Materials Targeted	Midrange Cost Per Ton	Cost Per Ton Range	Applicable Portion of the Waste Stream (Millions of Tons Per Year)	Strategy Description	Comments
Grasscycling [a]	Residential and commercial grass	$1.00	$0.26 to $7.04	14.0	Primarily education and promotion	A time-saving source reduction strategy for lawn care
Backyard composting [a]	Residential yard trimmings and food scraps	$12.90	$5.00 to $15.68	30.6	Education, promotion, and possibly bin distribution	Source reduction option for those with space to compost at home
Yard trimmings composting	Residential and commercial yard trimmings	$55.00	$21.65 to $88.21	28.0	Dedicated collection and processing of leaves, grass, and brush	Well established strategy
Onsite institutional composting	Institutional food scraps, select paper grades, and yard trimmings	$49.00	$29.00 to $98.00	2.4	Institutions, such as universities, correctional facilities, and military bases, collect and compost organic materials on site	Allows certain institutions to avoid high collection and disposal costs
Commercial composting	Food scraps and select paper grades	$72.00	$50.00 to $144.00	24.6	Dedicated collection of targeted materials; processing off site	Viable strategy for large commercial generators
Mixed waste composting	All commercial and residential organic waste	$113.00	$102.00 to $126.00	74.7	Standard garbage collection; separation of compostable waste at a single facility; composting of organic materials	Several facilities have closed due to technical problems
Residential source-separated composting	Select residential paper grades, food scraps, and select yard trimmings	NA	NA	47.3	Dedicated collection of targeted materials; processing at a central facility	Limited experience with this strategy in the United States

Notes:
[a] The labor required by citizens is donated at no cost to society.

To underscore the need to consider individual circumstances, cost ranges per ton diverted by individual compost strategies also are summarized in this section based on information in Section 3. This helps to show how individual compost strategy costs vary depending on the type and extent of technologies implemented.

Report conclusions are provided in the final subsection of the section.

5.1 Midrange Savings of Organic Materials Management Strategies

Table 5-2 provides an estimate of the national savings of individual compost strategies. The table is divided into five columns. The second column, Midrange Program Costs Per Ton, presents midrange strategy costs from Section 3 (see Table 3-1 for more details on these costs).

The third column, Collection and Disposal Costs Saved Per Ton, shows the avoided collection and disposal cost per ton based on information in Section 2. Avoided disposal costs for all programs assume the weighted average tipping fee of $38 per ton (which reflects all of the requirements of the October 9, 1991, landfill regulations) as reported in Table 2-1. No avoided garbage collection costs are assigned to grasscycling and backyard composting programs as it is conservatively assumed that the incremental diversion effect of these strategies is not large enough to affect garbage collection costs. An avoided garbage collection cost of $23 per ton is assigned to the commercial composting, onsite institutional composting, and yard trimmings composting strategies based on avoided collection costs experienced in well established yard trimmings programs (see Section 2.3). For mixed waste composting, avoided collection costs are equivalent to garbage collection costs ($64 per ton) since such programs are assumed to obviate the need for garbage collection.

The fourth column in Table 5-2, Revenues Per Input Ton, uses average end-product revenue per ton from Table 4-3 as a proxy for revenue received for finished compost products. Despite the avoided fertilizer cost and other benefits of grasscycling and backyard composting (see Section 4), no dollar value is assigned for end-product revenues for these strategies. Similarly, conservative bulk revenue values are assigned to all other strategies as reported in Table 4-3. The revenue values in Table 5-2 are reduced by 50 percent in order to take into account losses in the compost process.[74] In most cases, due to decomposition, the composting process reduces the weight of the incoming material by half. Revenues assumed for all strategies are conservative and, thus, do not reflect the social and/or environmental value of compost.

The final column in Table 5-2, Savings Per Ton, shows the savings per ton diverted for each strategy. Costs were calculated by subtracting the total avoided cost per ton and revenue per input ton from the total program cost per ton. Assuming midrange costs for well established compost strategies, all of the strategies with the exception of mixed waste composting would result in a net benefit when the value of avoided collection and disposal and revenues are taken into account.

The savings (over traditional disposal methods) per ton diverted for each strategy shown in Table 5-2 were combined with the applicable size of the waste stream targeted by each strategy to construct the savings curve shown in Figure 5-1 below. Mixed waste composting is not included in the curve since it did not result in a savings.

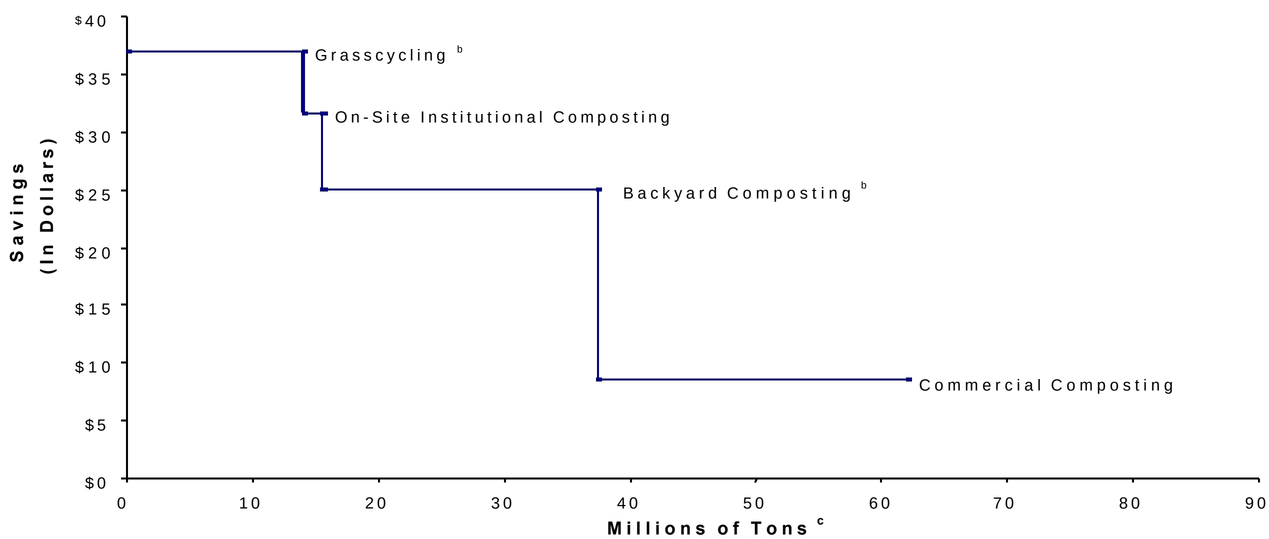
[74] As discussed, the 50 percent volatilization is assumed to ensure that revenues are properly allocated to 'diverted tons,' or the total number of tons that are input into a strategy.

Table 5-2
Midrange Savings Per Ton Diverted for Compost Strategies

Strategy	Midrange Program Costs Per Ton [a]	Collection and Disposal Costs Saved Per Ton	Revenues Per Input Ton [b]	Savings Per Ton
Grasscycling	$1	$38 [c]	$0	$37
Onsite institutional composting	$49	$61	$20	$32
Backyard composting	$13	$38 [c]	$0	$25
Yard trimmings composting	$66	$61	$16	$11
Commercial composting	$72	$61	$20	$9
Mixed waste composting	$113	$102	$2	($9)

Notes:
[a] Midrange program costs are taken from the results derived in Section 3 and rounded to the nearest dollar.
[b] In most cases, half the material (by weight) that is input into a composting strategy is 'lost' or reduced during processing to evaporation, insects, and other factors. Thus, these figures reflect the number of tons produced by a composting program, rather than the number of tons input to that program.
[c] To be conservative we assume no savings in collection costs. The tonnage in these composting programs is not reduced significantly enough to affect the cost of collection.

Figure 5-1
Savings [a] Per Ton of Organic Diversion
(Compost Strategies Savings Curve)



Notes:
[a] These savings are from the viewpoint of local government and assume that any additional labor required from citizens is donated at no cost to society .
[b] To be conservative, we assume no savings in collection costs. The tonnage in these composting programs is not reduced significantly enough to affect the cost of collection.
[c] Based on the applicable portion of the organic waste stream available for composting using existing strategies and technologies.

Eighty three percent (62 million tons) of the applicable portion of the national organic waste stream (75 million tons) could be composted at a net benefit to society through a combination of grasscycling, backyard composting, onsite institutional composting, yard trimmings composting, and commercial composting. Grasscycling, onsite institutional composting, and backyard composting programs could target about 50 percent (37 million tons) of the applicable organic waste stream at the greatest net benefit to society. Some of the organic materials targeted by grasscycling and backyard composting programs also could be captured by yard trimmings composting programs. Commercial composting could capture another 33 percent (24.6 million tons) of the organic waste stream at a net benefit. Composting the remaining 17 percent (13 million tons) of the organic waste stream could be accomplished through more costly mixed waste composting or residential source-separated composting strategies.

5.2 Cost Ranges for Organic Materials Management Strategies

The previous section estimated the savings of compost strategies based on midrange cost estimates. As indicated in Section 3, however, there is a fairly wide range of costs that might be incurred by a given strategy. Grasscycling programs, for example, that include rebates for mulching mowers and backyard composting programs that include some form of bin subsidy require more public outlay than programs that rely only on outreach and education strategies. It is important to note, however, that less costly options might not be as effective in diverting large quantities of organic materials from the waste stream. Yard trimmings programs that include curbside collection, for example, will typically incur higher costs and result in higher diversion than those that rely on drop-off collection. In some cases, composting costs are determined by the type of composting technology used. Onsite institutional composting programs that use low-technology processing options, for example, generally cost less than those that use high-technology in-vessel options.

5.3 Conclusion

This report reveals several important findings for the future development of composting:

- Approximately 36 percent (75 million tons) of the U.S. MSW stream is available for composting using existing strategies and technologies.

- Organic source reduction programs, including grasscycling, onsite institutional composting, and backyard composting, require much less public outlay (when compared to other composting alternatives) because we assume homeowners’ labor is donated. As a result, operational costs are more than offset by avoided disposal costs. In combination, these strategies could target about 50 percent (37 million tons) of the waste stream available for composting.

- About 83 percent (62 million tons) of the applicable organic waste stream could be targeted by a combination of grasscycling, backyard composting, yard trimmings composting, onsite institutional composting, and commercial composting programs at a net benefit.

- Yard trimmings composting programs are the most well established and widespread compost strategies in the United States. These strategies target about 37 percent (28 million tons of leaves, grass, and brush) of the applicable organic waste stream.

- Although mixed waste composting facilities can be cost-effective, these facilities have experienced substantial setbacks in the past few years. Public opposition and technical difficulties have been troublesome for mixed waste composting facilities in the United States. As a result, the United States saw a 25 percent decline in the number of operating mixed waste compost facilities between 1992 and 1995.

- Residential source-separated composting programs have been tried on a limited scale in several places in the United States. Trends in Europe suggest that source-separated composting programs might offer a viable alternative for capturing the remaining 17 percent (13 million tons) of organic materials that are not targeted by established strategies or technologies.

- The potential market for finished compost is much larger than the potentially available supply. If all applicable materials addressed in this report were captured for composting, approximately 48 million cubic yards (37.4 million tons) of finished compost would be created. End-uses for compost in agriculture, silviculture, residential retail, nurseries' sod production, and landscaping might have a market potential of over 1 billion cubic yards of finished compost.

- Higher technology does not necessarily yield a more efficient or cost-effective system. In many cases a low-technology method, such as static pile composting, might be more cost-effective in terms of compost sales and reduced tipping fees than a high-technology counterpart such as an in-vessel system. States and municipalities should use the level of technology that fits their needs.

While this report reflects national average statistics, the basic assumptions are easily translatable to specific programs. On a basic level, the message of this report is that composting is feasible on almost every size scale, and it works. The key is choosing the most appropriate strategy. The more MSW produced, the more organic materials are available for composting. The economies of scale dictate that the more material available for composting, the lower the cost per ton to operate whatever composting strategy is used. By their very nature, however, some composting strategies are more costly to operate than others. The most important part of a successful composting operation is choosing a strategy or combination of strategies that works for a particular situation.