COMPOST

Send Your Leaves to a MULCH Better Place

Leaf Composting
A Guide for Municipalities

The State of Connecticut Department of Environmental Protection
Local Assistance and Program Coordination Unit
Recycling Program

Leslie Carothers, Commissioner

CONNECTICUT RECYCLES!

January 1989

Prepared by
The University of Connecticut Cooperative Extension Service

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STATE OF CONNECTICUT

DEPARTMENT OF ENVIRONMENTAL PROTECTION

165 CAPITOL AVENUE HARTFORD, CONNECTICUT 06106

January, 1989

Dear Local Chief Executive Officer:

I am pleased to present you with this copy of Connecticut's leaf composting manual which has been developed in conjunction with the University of Connecticut Cooperative Extension Service to assist municipalities in the planning and implementation of community leaf composting programs.

A major goal of the State of Connecticut is to protect its environment and the health of its people by minimizing solid waste generation where possible and providing for the safe and adequate disposal of those solid wastes which are generated in the state. In order to achieve this goal, the 1987 session of the General Assembly passed Public Act 87-544 which mandates that a statewide solid waste management plan be adopted to include a strategy to recycle not less than 25 percent of the solid waste generated in the state after January 1, 1991. After that date, items designated in regulations promulgated by the Department of Environmental Protection for recycling cannot be accepted at landfills or resource recovery facilities for permanent disposal. Among these designated items is leaves.

The Department recommends leaf composting as a relatively inexpensive means of recycling which can result in up to a 10 percent reduction in a municipality's waste stream. Simply defined, composting is a naturally occurring biological process in which organic material, such as leaves, is broken down into a peat-like material by the action of microorganisms. The resulting compost can then be used as a soil conditioner.

Leaf composting has a great deal of potential for expanding the state's composting and recycling effort. It will also result in reduced volumes of waste being incinerated or landfilled, avoided disposal costs, and reduction of possible environmental impacts - all with the production of a beneficial end product. I hope that this leaf composting manual will help your community fulfill this potential.

Sincerely yours,

Leslie Carothers

Leslie Carothers
Commissioner

Acknowledgements

This document is based upon material and recommendations gathered by the authors through extensive site visits in New Jersey, New York, Massachusetts and Connecticut. State manuals from Massachusetts and New Jersey (Rutgers) provided a valuable source of information, as did the numerous consultants and researchers, with whom the authors spoke. Available scientific and industry literature was reviewed and a state-wide town level survey was conducted.

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Purpose of Manual

To a six-year old, a pile of leaves means a gleeful romp in the Autumn sun. To a public works director it can be a headache in the form one more load of soggy, solid waste to truck to an increasingly expensive disposal site. Although much of what the Department of Environmental Protection does is oriented toward ensuring the future of six-year-olds, the goal of this manual is to help the public works director and other municipal officials who are faced with disposing of tons and tons of leaves every fall.

Leaf composting is an easily managed and relatively inexpensive method of recycling. By decreasing the amount of solid waste which has to be sent to a landfill or incinerator, a well-run composting operation can reduce a municipality's disposal costs. At the same time, it can increase the visibility and viability of local recycling efforts because it results in the production of a beneficial soil conditioner which can be made available to residents and landscapers or utilized on municipal properties to enhance growth of plants by improving the general condition of the soil.

The purpose of this manual is to facilitate the establishment of municipal-scale leaf composting operations. It is intended to aid municipalities in planning, siting, designing and operating leaf composting facilities, and to identify those issues which must be addressed when applying to the Department of Environmental Protection for a composting permit.

The manual describes several approaches to leaf composting and outlines the circumstances in which each should be considered. The main focus, however, is on the "windrow and turn" method because this relatively simple technology often provides the best balance of efficiency and cost effectiveness.

Hopefully, the six-year-old's joyful attitude will last a lifetime, and with the help of this manual, the public works director can focus on the aesthetics rather than on the tonnage of the falling leaves.

Table of Contents

Figures and Tables

I. Planning a Leaf Composting Operation

II. Leaf Collection

I. Planning A Leaf Composting Operation

Planning is the first task in establishing a leaf composting facility. Several key decisions must be made regarding leaf collection, processing and end use. This section outlines the items that local officials should consider.

A. Volume

Estimate the amount of leaves to be composted. Estimates generally run between 5-10% of the total solid waste stream. More specific estimates should be made during the fall collection period by measuring truck loads collected. If leaves are collected with other solid wastes, compare weekly volume during the rest of the year to the volume of the fall collection.

B. Site Selection

Given the estimated amount of leaves to be composted, select an adequate site, the size of which should be determined by the volume of leaves collected. Approximately 3,500 to 12,000 cubic yards of leaves per year can be composted on one acre of land depending on the method used. The compost site requires relatively flat or gently sloping land and moderately drained soil which is not affected by seasonal high water. Site alterations may include grading, drainage control, security fencing, road improvements and provisions for fire protection.

C. Collection

Determine the leaf collection system. Leaf collection involves both municipal collection and independent hauling by residents, groundskeepers, and privately hired haulers. Independent hauling is common in suburban communities with leaves brought to the composting site or a supervised collection station. A major decision is whether to collect leaves in loose form or in bags.

D. End Use

Determine the end use of the compost since this decision will determine the composting method and equipment to be employed. Leaf compost is valuable as a mulch, soil amendment and topsoil substitute. Potential users can include the town parks, public works departments, residents, landscapers and nurserymen. Where high quality compost is required, additional steps will be necessary for processing and screening.

E. Processing Method

Choose a composting method appropriate to the end use. Four methods are available for composting leaves by themselves, of which the *windrow and turn* method appears thus far to be the most common and cost effective.

- *Passive Leaf Piles* involve placing the leaves in large piles and letting them remain there until a usable product is developed, a minimum of 2-3 years. Although it is a minimal management method, piling should not be considered a permanent disposal technique.
- *Windrow and Turn* requires the leaves to be placed in individual rows and turned frequently. A final product can be achieved in one year or less.
- *Aerated Static Pile* requires the leaves to be placed in a large windrow through which air is pumped or pulled. Information regarding use of this technology with leaves is limited, but it appears that in order to achieve a final product leaves composted by themselves require an estimated time of 4 to 6 months. There is extensive information regarding this method with composting sewage sludge.
- *In-vessel* composting is a fully enclosed "factory type" operation involving mechanical devices, controls and/or forced aeration. The processing period may be as short as 10 days, depending upon the mix of raw materials.

F. Program Management

Choose a management structure. A compost site can be managed in one of three ways:

- *Municipally operated and managed:* Involves the assignment of municipal employees and equipment to the site, with a designated site manager.
- *Municipally operated, privately managed:* Involves the assignment of municipal employees and equipment to the site but overall management of pile or windrow building/turning, watering, etc. is conducted by a private consultant or manager who is paid a flat fee or percentage of the tipping fee, usually calculated on a cubic yardage basis. Normally, the private firm is also responsible for marketing the final product.
- *Privately operated and privately managed:* Involves total system operation by the private sector under

contract with the community. Normally, such contracts are of a long-term (5 years or more) nature and may or may not involve the availability of municipally-owned or controlled sites for composting. As with the municipally operated/privately managed approach, the firm receives a fee for leaf delivery and markets the final product.

A further option would be for a local agricultural producer to take the leaves from the town or region and compost them on the farm, using the compost as a soil amendment for crop production.

The above management options can also be applied on a regional basis with one town supplying a site, and others providing equipment and manpower, either continuously or on a rotating schedule. In New Jersey, one such arrangement results in tipping fees covering most of the costs of the host community's composting program.

G. Budget

Define equipment and personnel requirements and project costs for collection, processing and end use.

- *Equipment:* A front-end loader is required to build, turn and break down piles. Additional equipment (turning machine, shredder, screen, vacuum trucks, etc.) will vary depending upon collection, processing and marketing needs.
- *Personnel:* Properly trained and dedicated staff must be assigned to the operation. At a minimum, a site manager and equipment operator are required. During the fall, assignment to the site will be on a daily basis, with less frequent assignments during winter, spring and summer. As with equipment, additional personnel needs will be dictated by the system selected.
- *Budget analysis:* should be an on-going process in order to evaluate alternative collection, composting and disposition methods. Worksheets are provided in Section IV for this purpose.

H. Process Management

Specify training techniques and time involved. Proper employee training and site monitoring is critical to ensure a trouble-free composting operation. Employee training should be done before operations begin and periodically thereafter. Local and/or regional training programs will be necessary.

I. Permits

Prepare a plan for permit request. A leaf composting operation is a solid waste volume reduction processing facility which will require state permits through the Solid Waste Management Unit of the Department of Environmental Protection (DEP). Specific guidelines for preparation of an application for a permit can be obtained through DEP. The plan which is submitted to DEP should include, but not be limited to: a schematic layout of the site; a listing of equipment and personnel with their qualifications (and/or what training they will receive); an explanation of the composting process; the monitoring and record keeping techniques for both the process and the end-product; provisions for control of odors and leachate from the compost piles; and a contingency plan if the compost operation temporarily ceases. Local permits may also be needed.

J. Education

Choose a program to help educate the public. An on-going public education program will help maintain long-term interest and participation. During the planning stages, public meetings should be held and/or materials distributed to explain the economic and environmental benefits of composting, as well as to alleviate concerns about its effects on the neighboring community.

Additionally, in an area where residents live in close proximity, a citizens advisory committee can be created to contribute ideas during planning and to monitor on-going operations. A staff person can be designated to respond to inquiries about the program.

Before the composting program begins, flyers or a mailing to residents should be made to generate interest in the program and to explain how to participate. Regular follow-up publicity campaigns, before and after a year's or a season's operation, are important for on-going cooperation.

K. Schedule

Prepare an estimated schedule. A leaf compost facility may take up to a year or more to select, design and build.

L. Additional Assistance Contact the following State departments for assistance on leaf composting:

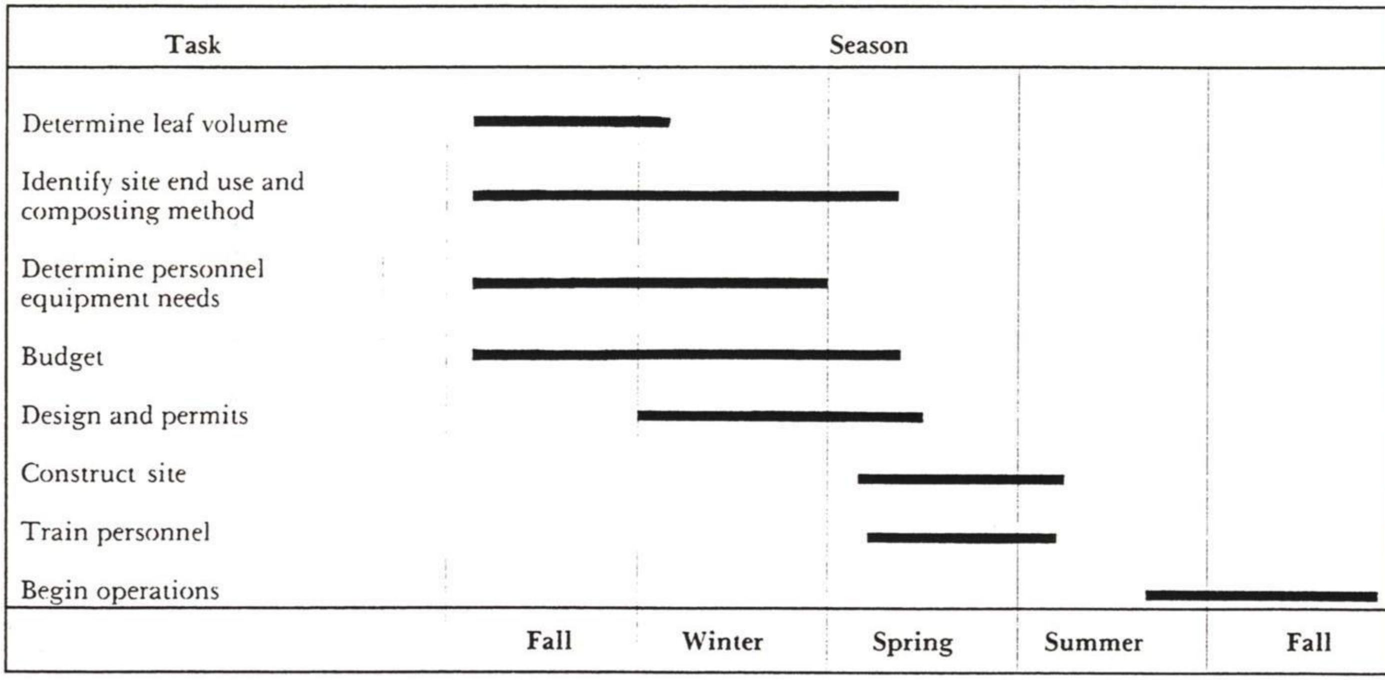
Overall Coordination and Information

DEP Local Assistance and Program
Coordination Unit
Connecticut Recycling Program
Rm 115, State Office Building
165 Capitol Avenue
Hartford, CT 06106 (203) 566-8722

Permitting and Regulatory Issues

DEP Solid Waste Management Unit
122 Washington Street
Hartford, CT 06106 (203) 566-5847

Time Schedule



Technical Assistance

DEP Local Assistance and Program Coordination Unit
Connecticut Recycling Program
Rm 115, State Office Building
165 Capitol Avenue
Hartford, CT 06106 (203) 566-8722

DEP Solid Waste Management Unit
122 Washington Street
Hartford, CT 06106 (203) 566-5847

The University of Connecticut Cooperative Extension Service
Box U-36, 1376 Storrs Road
Storrs, CT 06269-4036 (203) 486-4126

The University of Connecticut
Department of Natural Resources Management and Engineering
Box U-87, 1376 Storrs Road
Storrs, CT 06269-4087 (203) 486-2840

Connecticut Agricultural Experiment Station
123 Huntington Avenue
New Haven, CT 06504 (203) 789-7272

II. Leaf Collection

The following section describes various techniques which can be employed for leaf collection. The primary requirement of any leaf collection system is that the leaves be collected free of extraneous material, such as glass, metal, paper and household solid waste so that a high-quality compost can be produced. This means that anyone responsible for bagging or collecting leaves needs to be trained and any drop-off location, whether temporary or at the composting site itself, must be supervised. Beyond this, the choice of a specific collection technique should reflect the volume and quality needs of the end user and the cost of processing the leaves to supply that end user. If the compost is to be used as landfill cover, for instance, some extraneous material may be tolerated and screening of the end product may be unnecessary. Landscapers and nurseries, however, will not accept a product which has extraneous material and the compost may require screening to achieve uniformity.

A. Volume

As with other recyclables, the more convenient the collection service for leaves, the higher the participation rate. Consequently, the volume of leaves arriving at a municipal composting site will vary with the size of the area serviced by municipal collection and the convenience of the collection site to residents and independent haulers.

Population density, established practice, accepted levels of public service and municipal costs need to be considered when determining the size of the area to be provided with municipal leaf collection. In some cases, the appropriate approach will simply be to supervise and publicize an area near the composting site where residents, as well as landscapers, businesses and independent haulers can deliver leaves for composting. To maximize the amount of leaves composted, however, a municipality may decide to provide a collection service for the whole town in addition to providing the supervised drop-off area near the composting site.

If a municipality determines that it cannot economically provide service throughout the town but wants to ensure considerable convenience to its residents and businesses, a compromise can be achieved by providing curbside leaf collection to the more densely populated areas while providing community collection stations in the rest of the town. The latter approach involves stationing a supervised compactor truck, roll-off or other container at designated locations in accordance with a well-publicized schedule. The town takes the responsibility for transporting the full containers to the composting site.

B. Municipal Collection Methods

Municipalities which provide leaf collection must make a series of choices about collection techniques and equipment. Since these choices impact collection and processing costs and the quality of the end product, a variety of scenarios should be considered before a decision is made. The best combination of techniques and equipment for a given municipality is that which most efficiently provides the compost required by the end user. For instance, leaves can be collected bagged or unbagged. Bagged leaves typically have little extraneous material and can be collected quickly with a standard compactor truck. However, labor is required at the composting site to remove the leaves from the bags. Conversely, unbagged leaves can be collected with a vacuum truck or a front loader. This process is more time-consuming and the choice of equipment is less obvious. The vacuum works well on dry leaves; the front loader is more efficient for wet or frozen leaves. In addition, the amount of extraneous material is likely to be higher than when leaves are bagged.

A summary of the advantages and disadvantages of various collection techniques appears in Table 1. Information regarding leaf collection equipment is found in Appendix C. In utilizing this information to design an appropriate collection approach, the following issues should be considered:

(1) Effectiveness in excluding extraneous material;
(2) Availability and cost of labor;
(3) Existing equipment;
(4) Capital, operating and maintenance costs of equipment;
(5) Cost of bags (plastic, degradable plastic, paper);
(6) Convenience for residents and businesses;
(7) Susceptibility to adverse weather;
(8) Hazards associated with placing leaves at curb or in street; and
(9) Potential noise and dust from collection equipment.

C. Scheduling Municipal Leaf Collection

Leaf collection is a seasonal operation beginning in mid-October and continuing through early December. If an initial collection is made early in this period, a second collection may be necessary. In addition, some towns also make a spring collection of leaves and other yard debris. A site for receiving leaves from independent haulers should be made available even if there is not a municipal collection in the spring. The leaves from the spring collection should be composted separately from the fall collection.

D. Public Education and Notification

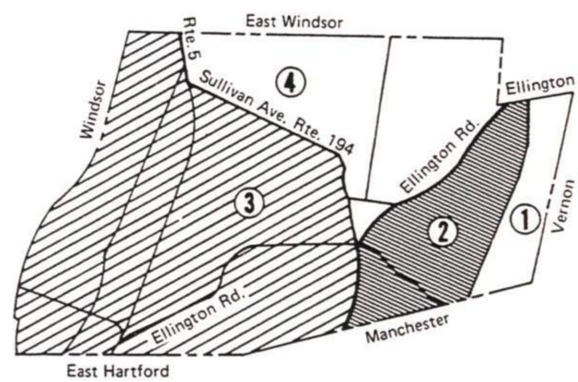
Regardless of the method of collection chosen, residents and businesses must be educated on a regular basis about the requirements for participation in the composting program and the importance of keeping extraneous material out of their leaf bags or piles. This type of education can be incorporated into the ongoing publicity for the overall recycling program. In addition, there should be a special public notification for each leaf collection. The notification should include:

(1) A statement of the intent and community benefits of the composting program;
(2) A description of the intended uses of the compost;
(3) A statement that leaves must not contain extraneous material such as branches, glass, metal, paper or household solid waste;
(4) Instructions regarding the piling, or if bags are used, the type of bag and bag closure to be used;
(5) Instructions regarding the placement of leaves at the curb or in the street;
(6) The dates when leaves will be collected in designated districts and the locations and hours of community collection stations and other drop-off locations.

Residents can be notified of the leaf collection dates by letter or announcements in the newspaper or on a local radio station. If on-street parking is banned during leaf collection, a notice should be posted on the street at least 24 hours in advance, and parking bans should be rotated within each community.

A map, such as that in Figure 1, can be provided to residents showing the designated leaf collection areas and the tentative dates for collection in each district. Since the rate of collection is dependent on weather conditions, however, any revisions to the dates need to be publicized.

Figure 1. Leaf Collection Areas Designated by Districts (Source: South Windsor)



District	Leaf Collection Start Date
1	Oct. 29
2	Nov. 4
3	Nov. 12
4	Nov. 19

Table 1. Collection Options

Procedure and/or Equipment	Advantages	Disadvantages
A. Bagged leaves	Keeps leaves out of street and prevents blowing leaves. Pickup not sensitive to weather. Pickup at low cost without specialized equipment. Instructions can be printed on bags provided by the town.	Cost of bags. Time required for debagging. Plastic in compost must be avoided.
1. Bag type:		
(a) Nonbiodegradable plastic.	Lower cost of bag. Debris can be removed when bag is emptied.	Costs and possible shortage of labor for emptying bags.
(b) Biodegradable and photodegradable plastic.	Little information is now available on the use of these bags for leaf collection or how they break down during composting.	
(c) Biodegradable paper.	Convenience in bagging and greater compaction than with plastic bags.	Higher cost of bag. Extra effort in the distribution of special bags. Shredding may be required. Possible increase in time needed for composting.
2. Equipment and procedure.		
(a) Compactor truck.	Large quantity per load due to compaction.	High equipment costs unless the compactor is used for other purposes.
(i) Empty bag into compactor.	Maximum opportunity for removal of debris. Efficient dumping into windrows. Eliminates debagging operation at site.	Inefficient use of compactor.
(ii) Empty bag at composting site.	Pickup may be quicker.	Inconvenience in emptying bags and forming piles or windrows.
(b) Dump truck.*	No specialized equipment.	Small quantity per load in absence of compaction.
B. Loose leaves		
1. Location of piles:		
(a) Curbside.	Avoid problems associated with leaves in the street.	Raking of leaves by collection crew is labor intensive, especially when collection is by front end loader. More extraneous material in leaves.
(b) In street.	Most convenient for collection in absence of parked cars.	Danger to children playing in leaves. Danger of fire from catalytic converters. Either raking or repeated collec-

*Bags can be either hand loaded directly or piled into a front end loader and then lifted into the truck.

Table 1. Collection Options — continued

Procedure and/or Equipment	Advantages	Disadvantages
		tion if cars are parked on the street. More extraneous material in leaves.
2. Vacuum leaf collector with discharge into wire or mesh-covered box on dump truck or trailer.	Leaves are shredded to some degree and are compacted, especially if somewhat damp.	Ineffective if excessively wet or frozen. Dust if dry. Noise. Moderate expense for specialized equipment.
(a) Mounting options: (i) On trailer with discharge into truck.	Load one truck while another is in transit.	Potential danger to operator and inconvenience from operation at rear of truck.
(ii) On front of truck (on hoist used for snow plow).	Driver can see operator.	Not generally available with belt drive.
(iii) On trailer with leaf box.	Can be pulled with any type of truck including one equipped for snow plowing and sanding.	Inconvenience in backing trailer to unload. Potential danger to operator and inconvenience from operation at the rear of the truck.
(b) Drive options: (i) Belt.	Belt drive reduces vibration from impeller to engine which reduces maintenance costs and increases service life.	Higher initial cost.
(ii) On engine crankshaft.	Lower initial costs.	Vibration from impeller increases maintenance costs and decreases service life.
(iii) Power take-off.	Intermediate cost relative to other options.	Intermediate cost relative to other options.
3. Catch basin cleaner.	Large units (12 inch suction hose) are fast and effective with sufficient suction for collection of wet leaves.	Small units (6-8 inch suction hose) are slow and clog in excessively wet or freezing conditions. Very high initial costs. Rather high maintenance costs. Noise.
4. Front end loader and dump truck.	Specialized equipment is optional. Effective with wet and/or slightly frozen leaves. Efficiency can be increased if front end loader works with a small snow plow and final cleanup is with a street sweeper.	Leaves must be raked into the street. (A tractor-pulled rake can be used only in suburban areas.) Inefficient with dry leaves.
5. Front end loader and compactor truck with chute for receiving leaves.	Same as in number 4 except that effective capacity is much greater with a compactor.	Same as in number 4.

III. Technical Information

III. Technical Information

This section contains detailed information about the composting process and is intended for those individuals who will design, manage and operate leaf composting facilities.

A. Basics of Composting

Composting is a biological process in which microorganisms break down organic materials, like leaves, into a soil-like product called compost. The microorganisms are naturally present among the leaves. If nutrients, oxygen and moisture are present in the proper amounts, the microorganisms will heat the leaves up to 100-140 degrees (F) and produce a near neutral (pH) product.

This section briefly describes some of the principles with which one should be familiar before developing a composting facility. The application of the principles is explained in subsequent sections.

- *Microorganisms:* Decomposition is conducted primarily by microscopic organisms naturally present in leaf waste, including bacteria, actinomycetes, and fungi. These microorganisms grow rapidly on the organic material, using it as a source of food. Heat, carbon dioxide, water vapor, and compost are produced in the process.
- *Nutrients:* The availability of carbon and nitrogen is a limiting factor in the composting process. The microorganisms need nitrogen for protein, body building and population growth, and carbon is their energy source. In addition, efficient composting requires carbon and nitrogen to be present in the proper balance.

  The optimum range of the carbon to nitrogen (C:N) ratio is from 20:1 to 30:1. The more the C:N ratio deviates from this range, the slower the decomposition process becomes. With a ratio of greater than 40 to 1, nitrogen represents a limiting factor and the reaction rate slows. With a C:N ratio lower than 15 to 1, excess nitrogen is driven off as ammonia. While this loss of nitrogen is not detrimental to the process of decomposition, it lowers the nutrient value of the compost product.

  The C:N ratio in leaves tends to range between 60:1 to 80:1. thus, leaf composting is generally slower than most composting applications. By adding nitrogen-rich materials, such as seaweed or grass clippings, the C:N ratio will be reduced and improved.
- *Oxygen:* An adequate supply of air is essential to the maintenance of efficient composting. Aerobes, the organisms primarily responsible for the rapid decomposition of organic material, require oxygen to convert organic waste to compost. Normal air is about 21% oxygen. If the oxygen content falls below the optimum level of 5%, these organisms begin to die off and the composting process is taken over by anaerobes, organisms which do not require oxygen. They operate much less efficiently and can cause severe odor problems.
- *Temperature:* Temperature is a key environmental factor affecting biological activity and should be monitored frequently. The metabolism of the microorganisms present in the leaves results in a natural temperature increase. Due to the insulating effect of the leaf compost pile, the temperature achieved in the pile affects the makeup of the microbial population. The optimum temperature range is between 100 and 140 degrees F.

  Two categories of microorganisms are active in aerobic composting. At temperatures above freezing, mesophilic organisms become active. As a result of their activity, the temperature within the compost pile increases. At temperatures in excess of 110 degrees F, thermophilic organisms become active, increasing the rate of decomposition. As the temperature approaches 140 degrees F, the rate of decomposition begins to decline rapidly as organisms begin to die off or become dormant.
- *Moisture:* In leaf composting, the optimal moisture content is 40% to 60%, by weight, or about the consistency of a wrung-out sponge. Moisture is required to dissolve the nutrients utilized by microorganisms as well as to provide a suitable environment for bacterial population growth. A moisture content below 40% limits the availability of nutrients and limits bacterial population expansion. When the moisture content exceeds 60%, the flow of oxygen is inhibited and anaerobic conditions begin to develop. Leaves usually require additional water at the start of the process.
- *pH:* During the composting process, the material will become slightly acidic and then return to near neutral conditions as stability is approached. Decomposition is most efficient with a pH of between 6.0 and 8.0. If the pH is too high, nitrogen is driven off as ammonia.

  As the pH drops below 6.0, the microorganisms begin to die off and the decomposition slows.

The pH level of the compost pile partially determines the type of organisms available to the decomposition process.

Bacteria are most successful as decomposers when the pH is between 6.0 and 7.5. Fungi have an optimum range between 5.5 and 8.0. Normally, operating leaf compost systems should not present a pH (acidic) problem. Should such an occurrence develop, the addition of lime may be necessary. To minimize this possibility, keep the pile in an aerobic state. The normal pH range for finished leaf compost is neutral to slightly alkaline (7-7.5).

- *Particle Size:* The microorganisms act on the surface of the composting materials. Smaller particles (the size of a quarter or smaller) have greater surface area and break down more quickly. However, extremely small particles limit air flow through the materials so some compromise is required.
- *Time:* The time required to transform leaves into finished compost varies considerably, depending on the process utilized, from 10 days to 3 years. Frequent aeration, fine particle size and the proper ratio of carbon to nitrogen speed the process. The process is slowed by low temperatures and materials with a high proportion of cellulose and lignin.

B. Composting Methods — An Overview

Selection of the methodology best suited for the community will depend upon a variety of factors, including marketing options, availability, site constraints, and equipment opportunities. Additionally, the availability and usefulness of other organic wastes may influence the decision-making process within each municipality. The windrow and turn method has been used most often for leaf composting. A leaf compost guidance summary can be found in Table 2.

- *Passive Leaf Piles:* Leaves are deposited in piles ranging in height from 9 to 20 feet and are left undisturbed for a minimum of two to three years. Leaf piles that are too small (less than 6 feet high) should be combined. An optional measure is to turn and aerate the leaf pile in the early spring or late fall. Although process management is minimal, the leaf piles should be maintained to avoid an unsightly appearance and should be combined after there is a noticeable volume reduction from the initial leaf pile size. Odor may be a problem when these piles are disturbed as anaerobic conditions may exist in the oxygen starved center of the pile, so wind directions should be considered before work on the piles is undertaken. Compost consistency for end use is fair, as it may retain clumps of uncomposted leaves.
- *Windrow and Turn:* Leaves are deposited on a compacted pad to form a triangular shaped windrow (Figure 2a) measuring 10 to 20 feet at the base with a height of 6 to 12 feet or higher. The windrow length can be up to several hundred feet long or as long as the site allows. In this process, the windrows are turned periodically with a front end bucket loader or a special turning machine and water is added as needed. The frequency of windrow turning is determined by the temperature and moisture content of the windrow. Windrows are combined as they shrink in size. The leaves compost through the winter and spring, cure over the summer and are available for end use by the next collection season. The finished compost can be removed from the composting site to make room for incoming leaves. The consistency of compost for end use is good as periodic turning will result in fewer clumps of undecomposed leaves.

Figure 2. Windrow and Turn Profiles

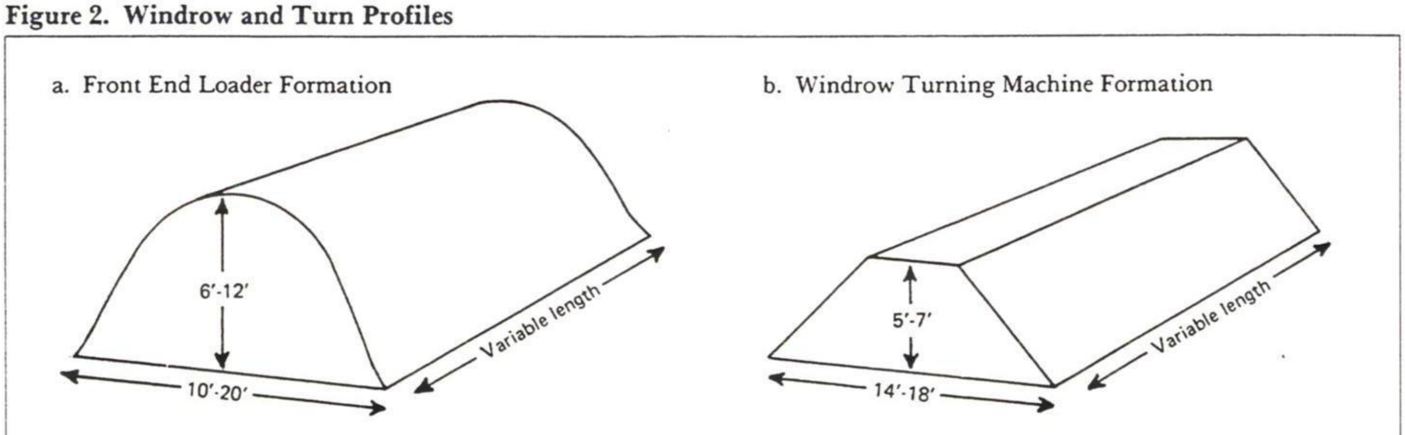


Table 2. Leaf Compost Guidance Summary.

Parameter	Method		
	Leaf Pile	Windrow and Turn	Forced Aeration
1. Site information.			
Size: cubic yards leaves/acre	8,000-12,000	3,500-8,000	5,000-10,000
Surface	Earth pad	Earth pad (paved surface acceptable)	Earth or paved
Grade	2% slope (min)	2% slope (min)	2% slope (min)
Drainage			
Subsurface	Moderate	Moderate	Moderate
Surface	Satisfy acceptable water quality criteria for discharge (or contain on site if needed). Divert surface water from piles.	Satisfy acceptable water quality criteria for discharge (or contain on site if needed). Divert surface water from windrows.	Satisfy acceptable water quality criteria for discharge (or contain on site if needed). Divert surface water from aerated windrows.
2. Suggested separation distances (in feet) from compost site.			
To residential and business complexes	200-250′	200-250′	200-250′
From adjacent property line	100′	100′	100′
From a surface water body	100′	100′	100′
From ground surface to bedrock	5′*	5′*	5′*
From ground surface to seasonal high water table (highest seasonal level)	5′*	5′*	5′*
3. Compost process time	2-3 years	Varies with frequency of turning windrows 6-12 months	4-6 months
4. Curing time (following compost process)	Not applicable	1 month (min)	1 month (min)
5. Odor generation	Can be high at time of initial pile disturbance.	Some odor potential when pile is first disturbed; proper management will reduce or eliminate this potential; decreases with pile turning frequency.	Minimal problem if the system is properly designed, installed and operated.

*Current State of Connecticut practice followed for siting solid waste land disposal facilities.

Table 2. Leaf Compost Guidance Summary continued.

Parameter	Method		
	Leaf Pile	Windrow and Turn	Forced Aeration
6. Equipment needs	Front end loader daily during leaf collection period.	Front end loader daily during leaf collection period and when windrows are turned. Three or 4 foot stem type thermometer. For large leaf composting facilities, evaluate the use of specialized mechanical equipment for turning windrows.	Front end loader, tub mill grinder, blower type fan, temperature and timer switch controls, plastic piping (both solid and perforated lengths needed), 3 or 4 foot stem type thermometer.Adequate electrical capacity. Optional leaf shredder.
7. Water supply	Required for fire control and wetting of leaves. Up to 45 gals/cu yd.	Required for fire control, wetting of leaves; can use water hose or a portable water tank source having water spray capability. Up to 45 gals/cu yd. Large operations may require on-site water.	Required for initial wetting of leaves (see windrow) and for fire control. Up to 45 gals/cu yd.
8. Operational	Nothing done to leaf piles; may combine leaf piles after initial pile shrinkage. Maintain height of at least 6 feet.	Combine windrows after pile shrinkage occurs (1 or 2 months after their formation). Turn windrows as indicated by temperature and moisture data.	Blow air through the pile. An organic material such as wood chips, sawdust or compost is used as a pile cover for insulation. The frequency and time of aeration is by timer switch or temperature controlled.
9. Comments	End product quality may limit marketablity; shredding will improve appearance.	Acceptable compost quality; screening of compost will give a more uniform product.	The field experiment data available for this application is rather limited. Method has been used successfully where leaves have been composted with sewage sludge (Greenwich, CT).

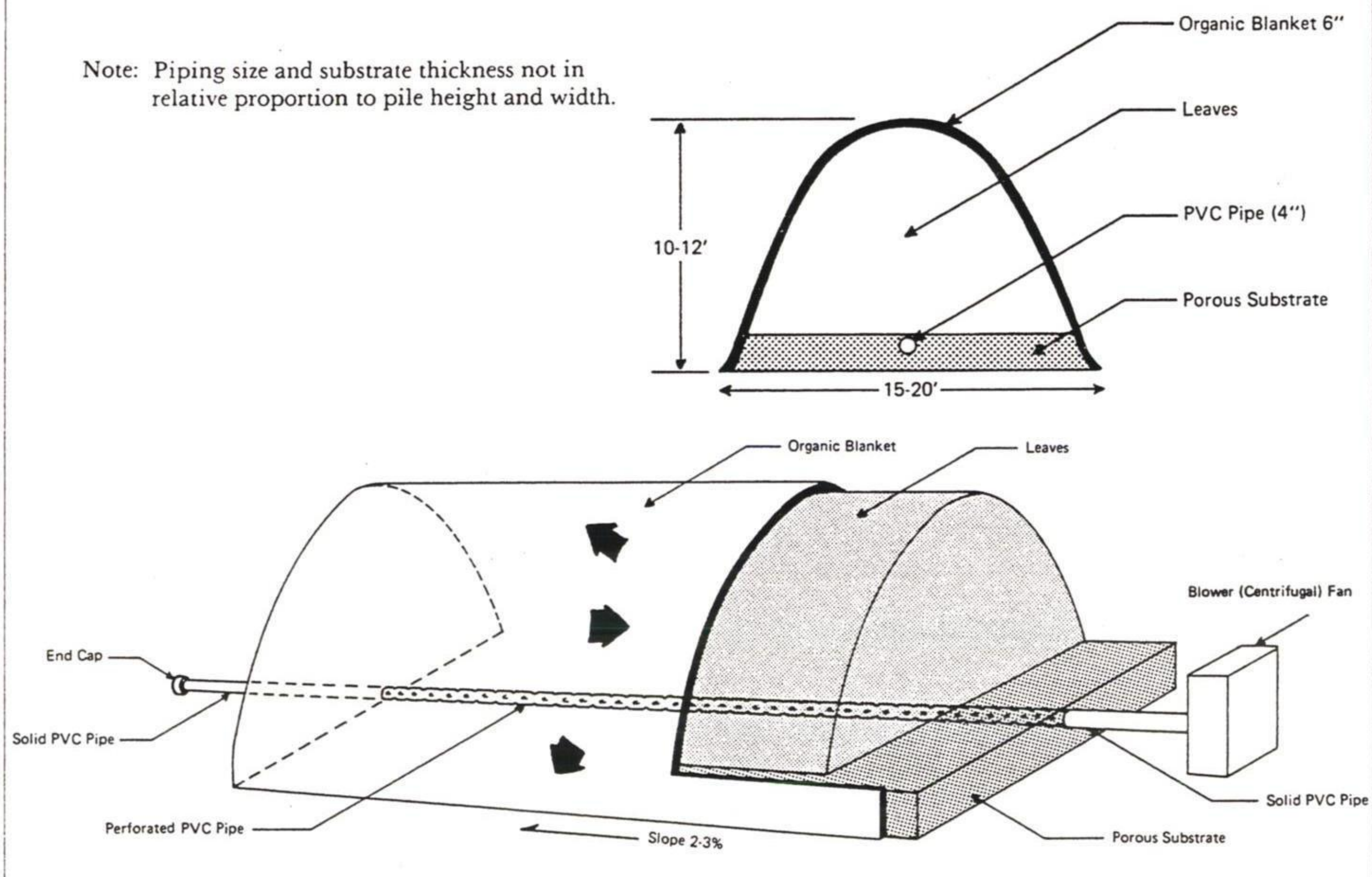
Use of specialized windrow-turning machines improves aeration, resulting in shorter time requirements for composting. The turning machine is either self-propelled or machine driven. If machine driven, it is important that the drive method selected be properly matched to the machine.

With windrow-machine turning, the machine selected limits the windrow height to 5 to 7 feet. Windrow width varies from 14 to 18 feet to give a trapezoidal shaped pile, (Figure 2b).

- *Aerated Static Pile:* The windrow configuration is similar to that described for windrow and turn except that the windrow is stationary (static pile) and has a base of wood chips or some other porous material. Since the leaves are not turned in this process, it is particularly important that non-compostable materials are removed before windrow formation. The leaves are also put through a tub grinder or shredder before forming the windrow. A perforated plastic pipe is placed over or in the base material and air is forced through the pipe into leaves using an air blower (Figure 3). After the windrow is formed, a 4"-6" layer of compost, wood chips, sawdust or an equivalent porous material is placed over the pile to help retain process heat, moisture and odor. In order to manage windrow temperature the air movement is controlled either by a timer switch or manually. Experience with this method for composting leaves is limited. It is generally used in sewage sludge composting.
- *In-vessel Composting:* In-vessel composting encompasses a variety of systems involving mechanical agitation, forced aeration and enclosure within a building. These systems are designed and supplied by consultants or commercial suppliers. They are

Figure 3. Aerated Static Pile Profile

Note: Piping size and substrate thickness not in relative proportion to pile height and width.



generally not economically feasible for composting leaves alone, but may be appropriate if sludge disposal is an issue. The advantages include fast processing, avoidance of weather problems and better process and odor control.

Composting Leaves with Sewage Sludge: Leaves can be added to sewage sludge to provide a bulking agent for the sludge. The leaves provide a carbon nutrient source and increase the number of voids (air spaces) to improve air passage for process temperature control, addition of oxygen, and removal of excess moisture. Sewage sludge composting involves environmental and health concerns far beyond those associated with leaf composting and requires additional approvals and/or permits from DEP. It should be noted, however, that using leaves in this way could serve as an alternative to the separate composting of leaves. Composting leaves with sewage sludge would normally be an option with the forced aeration and in-vessel methods. There may be other materials currently being composted for which leaves can serve as a bulking agent.

Composting Leaves With Other Plant Materials: Leaves can be composted with other forms of plant material, such as seaweed or grass clippings. One advantage of such a composting practice is an improvement in the carbon to nitrogen ratio (C:N). The fresh plant material provides the nitrogen source and results in a faster composting rate. Experimentation is advised before undertaking this method of composting on a large scale because high nitrogen levels will require much more frequent turning to prevent odor problems.

Backyard Composting: Backyard composting involves the composting of leaves and other yard wastes on a small scale within the confines of one's own property. This method is particularly appropriate for areas where the residences are located on one-half acre plots or larger. Backyard composting should be encouraged because residents benefit from readily available leaf compost and the municipality benefits by avoiding the cost of handling and processing the leaves. For further information regarding backyard composting, contact the local office of The University of Connecticut Cooperative Extension Service.

C. Facility Siting and Design Considerations

Area Requirements

Processing Sites: The facility is sized according to the yearly seasonal volume of leaves to be handled, taking into consideration the method of leaf collection and the composting method employed. A good leaf volume estimate can be made from records of the number of truck loads of leaves hauled. For this purpose, one ton of leaves is taken to be the equivalent of approximately four cubic yards of leaves. Additional information is provided in Appendix B. In the absence of such information, a leaf volume of six percent of the total annual solid waste volume can be used. Space requirements vary according to the composting method, ranging from 3,500 to 12,000 cubic yards of leaves per acre. For example, a suggested guideline for a windrow and turn facility is one acre for each 6,000 cubic yard of leaves. Additional space is required for the compost storage and site buffer areas.

Compost Storage Area: For the windrow and turn method, the storage area for finished compost should be an additional 15 percent the size of the windrow composting area. Compost will need to be kept in the storage area for a minimum of one month while it cures.

Buffer Area: Consider the impact of potential odor, on-site operational noise and visual appearance on the surrounding neighborhood when siting a compost facility. Minimum suggested separation distances of the compost processing and storage site are 200-250 feet from occupied buildings and at least 100 feet from adjacent property lines. Existing trees and landscaping may be used to improve aesthetics by screening the site from public view and to reduce equipment noise. The potential impacts of composting odor and traffic flow on adjacent areas should also be considered.

Ground and Surface Water Protection: A minimum of 5 feet should be maintained between the base of the deposited leaves and the maximum high water table or bedrock. This recommendation is based upon the current State of Connecticut practice for siting solid waste land disposal facilities but may be modified in accordance with specific site conditions such as soil permeability and hydrologic setting. High groundwater can cause severe problems for equipment movement, especially in the late winter and spring months when piles must be turned.

The compost processing and storage site should be at least 100 feet from a surface water body such as a brook, pond or stream. Facilities must be sited in accordance with the Connecticut Inland-Wetlands and Water Courses Act and the Connecticut Sedimentation and Erosion Control Act.

Site Layout and Preparation: Once an appropriate site has been chosen, a site plan needs to be prepared. Sample diagrams are found in Figures 4 and 5.

Compost Pad: This is the surface where composting occurs. It should be constructed of well-drained materials and be designed for heavy equipment use in all seasons. Windrow length should parallel the slope. To prevent ruts from forming a paved surface can be used as a pad.

Roads: Roads should be laid out to provide easy access for the public, leaf hauling vehicles and fire protection equipment. The road surface should be able to sustain the load of the vehicles indicated, and be functional in all types of weather conditions.

Drainage: Locate the site on moderately to well-drained soil. Excessively well-drained soils should be avoided, unless site modifications are made. Surface water should be diverted away from the compost process site and storage area using a diversion ditch, an interceptor berm (baled hay or other means) or an interceptor drain. Any surface or subsurface discharge away from the site must be made in an environmentally safe and acceptable manner. Design water diversions and discharge systems for a 25-year rainstorm. Slopes should be graded at 2-3 percent (2-3 foot drop in 100 feet), to assist in surface water removal from the pad. Be sure not to exceed a 5 percent grade.

Water: A source of water is needed for wetting the leaves, and provision must be made for fire protection. Where a water source such as a pond or a hydrant is not available, a water tank vehicle can be used. For very dry leaves, approximately 45 gallons of water are required for each cubic yard of leaves. For large operations, an on-site water source may be necessary.

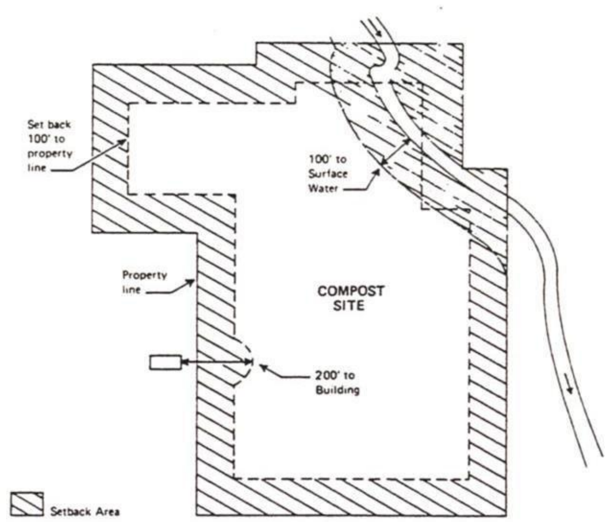
Site Clearing: Clear the site to provide enough space for roads, compost processing, storage of compost, and for fire protection. Before clearing, consider the need for a buffer zone and visual screening.

Signs: Post a sign at the entrance to the facility identifying the facility and indicating the hours of operation. Directional signs will be needed for traffic control. The leaf receiving area should be identified. Signs may also be needed to clarify the fact that the facility is for leaves only, thereby minimizing the addition of contaminants.

Security: Control access roads so that illegal dumping or vandalism does not occur.

Please see Table 2 for a summary of facility siting and design considerations.

Figure 4. Site Setback Distances



Note: Depending on site constraints such as property lines, buildings and surface water, available acreage for composting will vary. Area loss could be significant.

D. Composting Operation

The following section focuses on the windrow-and-turn method of composting leaves. In most settings, this method will strike a good balance between process efficiency and operational simplicity. Details about the operation of the other methods mentioned here can be found in the references or from consultants engaged to design a composting system. In addition, a trouble-shooting guide for operating a windrow and turn facility is included as Appendix A.

Annual Site Preparation: Prior to the start of the leaf collection season, regrade the site as needed to maintain a 2-3 percent slope and to maximize run-off and minimize ponding of surface water. Bring in fill as needed. Maintain the drainage system components such as subsurface drains or diversion ditches.

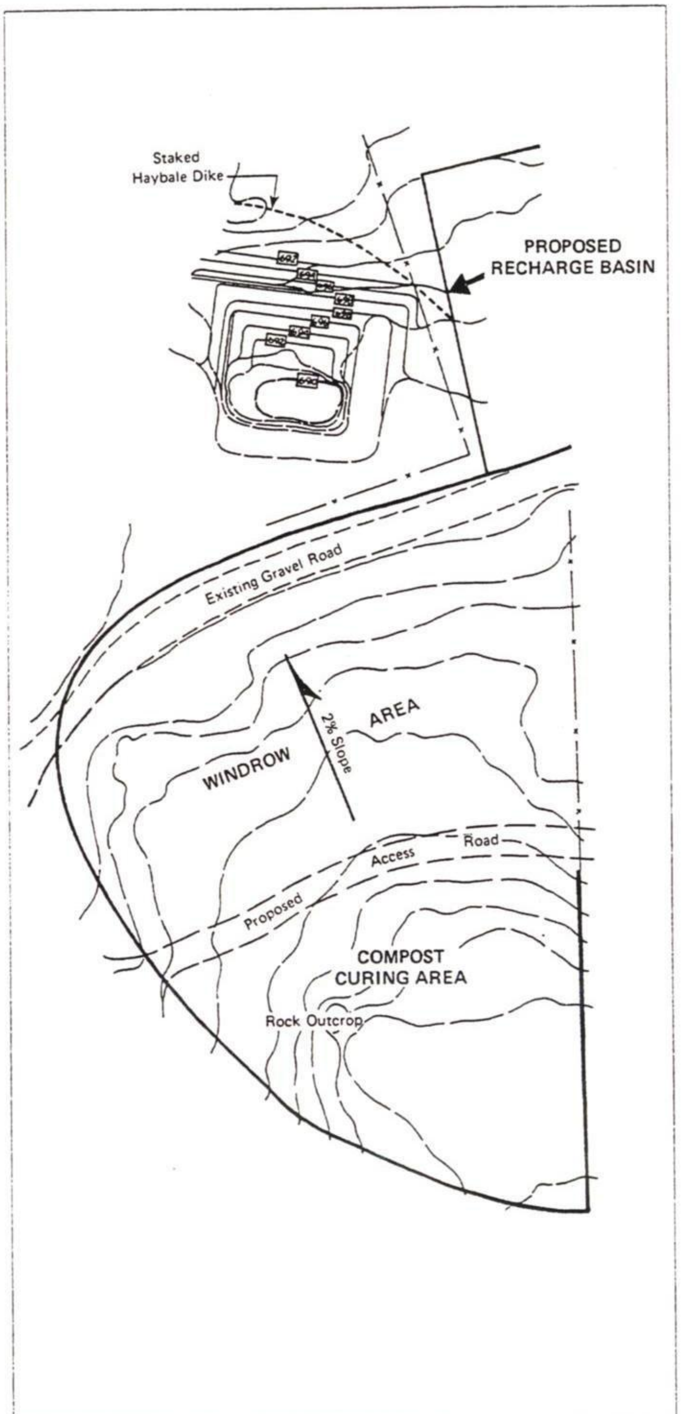
Review and prepare the site to ensure good vehicle operation conditions.

Check the availability and method for handling water to wet leaves. If there is no water at the site, a water hauling tank vehicle and a mechanism for spraying the water on the leaves will be needed.

Processing Equipment: Equipment needs and preferences will vary with each community. Use of existing equipment is encouraged but this may not always result in the most efficient operation. In some instances, it may be possible to share specialized equipment (i.e., a sieve or shredder) with nearby towns.

The basic piece of equipment needed for any type of leaf composting operation is the front end bucket loader. It is used daily at the site during the leaf collection season. With windrow-and-turn operations the loader or other turning equipment must be available for the remainder

Figure 5a. Preliminary Site Layout Showing Windrow and Curing Areas, Proposed Stormwater Management System and Access Road.
Source: Massachusetts Department of Environmental Quality Engineering, Division of Solid Waste.



of the year for windrow turning and reconstruction when needed. For large operations, specialized turning and mixing equipment may be feasible. Information regarding compost processing equipment is found in Appendix D.

For compost process temperature monitoring, a 3-4 foot pointed stem-type thermometer capable of reading between 0 to 200 degrees F is needed. A spare thermometer is recommended to confirm temperature calibrations.

Screens, shredders or tub grinders are optional but can be used to reduce volume, obtain compost uniformity and remove unwanted materials. Shredding of leaves to reduce leaf size normally is not needed at the initial stage as the leaves are adequately reduced in size through the physical process of moving and turning during collection and composting. Such shredding, however, may assist the compost process if moisture levels are low by reducing the free air space. At the end of the composting/curing process, it may be appropriate to screen the compost to remove large clumps and woody material. This creates a more marketable product with a consistent level of appearance.

Handling Incoming Leaves: Incoming leaves can be brought directly to the leaf processing area or to a receiving (staging) area for later transfer to the leaf compost pad. Compacted leaves brought directly to the compost pad must be loosened and fluffed for proper aeration. If citizens are allowed to bring leaves to the site, a separate drop-off point should be provided for debagging, traffic control and safety considerations. Site supervision is required during this period for quality control and the recording of leaf volume delivered to the site.

Although a leaf receiving area adds another step to the site operation it allows flexibility in scheduling the start of the leaf composting process and in scheduling the debagging of leaves. The leaves should be transferred to the windrows within a couple of days to prevent the compost process from starting in the receiving area.

Unless biodegradable bags are used, leaves should be debagged before they are placed in the windrow. Debaggers should work on the face of the pile — not from the ends — so that more people can work on one pile at the same time. Simple hand tearing of bags seems to be as efficient as other methods. Empty bags should be removed immediately and placed in receptacles so they do not end up in the windrows. If a staging area is used, leaves should be removed from the debagging area immediately after opening to make space for the debaggers to work.

Leaf Wetting: Incoming leaves should be checked for moisture. A "hand squeeze" test is adequate. If no water oozes from a handful of squeezed leaves, the leaves should

Figure 5b. Compost Site Cut and Fill Recommendation for Site Grading.

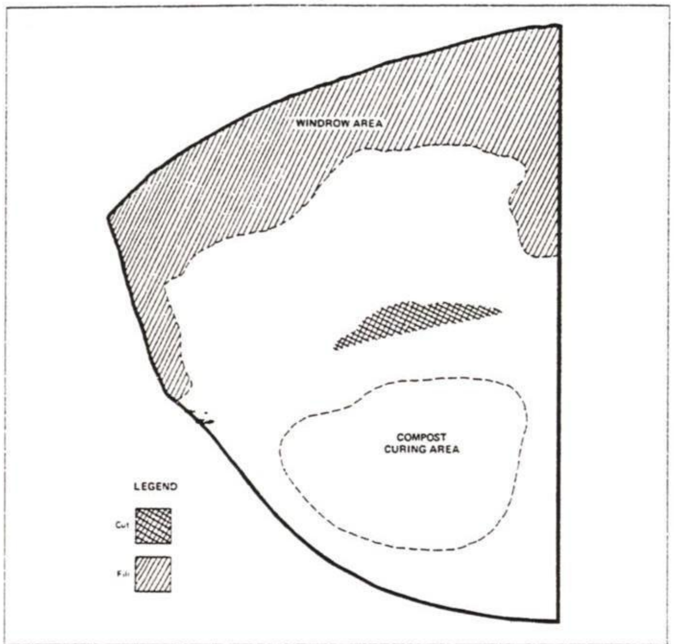
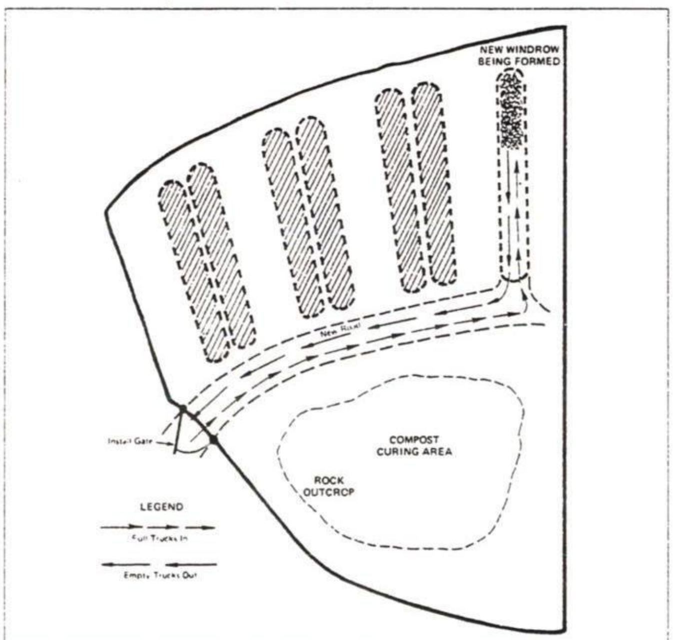


Figure 5c. Compost Windrow and Curing Areas Showing Vehicle Traffic Pattern.
Source: Massachusetts Department of Environmental Quality of Engineering, Division of Solid Waste.



be wetted before or while they are being placed in the windrow. Leaves can be wetted using a hose connected to the water source or by using a pump-spray mechanism attached to a portable water tank.

During the early stages of composting, leaves must be mixed during wetting, otherwise the water will run off the pile surface instead of penetrating the windrow. Over-watering is normally not a problem as excess water will drain off. Once the leaves start to break down, watering can be done after turning without problems.

With specialized windrow-machine turning, the leaves are wetted after the first or second turning using a fire or stick hose. The initial leaf turning breaks up the leaves to improve their water retention capability. Leaves should not be over-watered in this process. If pile moisture measurements can be made, aim for a pile moisture content of about 45-50 percent.

Windrow Formation: The windrow should be at least six feet high with a bottom width of about 10 to 14 feet. (See Figure 2). If a greater height is used, the windrows will require more frequent turning.

Start the first windrow 20 feet from the edge of the composting pad. Leave two feet between the first two windrows and a 20-foot space between pairs of windrows. Windrows should run in the direction of the slope to reduce any tendency for ponding. (Figure 6).

After the windrows have been reduced to almost one-half of the initial size (about 1 to 2 months after windrow formation), each pair of windrows is combined into a single windrow.

During specialized machine turning of the windrow, leaves will fall into the vacant aisle. It will be necessary periodically to gather these leaves and place them in the windrow. Depending on how the windrows are spaced, windrows are combined 15 to 25 days after the start of the composting process.

Windrow layout should address fire protection concerns as needed. Although a leaf windrow fire is an unlikely occurrence, the layout of the windrows and the site conditions should provide access for fire fighting equipment (fire lanes or fire hose and water hydrant).

Compost Process Monitoring: Windrow temperature measurements should be made and recorded at least twice a week to monitor the compost process and to determine when it is complete (see Table 3). Other data to record at that time are the ambient air temperature, weather conditions, odor (if detected), pile moisture conditions and site observations. There should be at least three temperature measurements per 100 feet of windrow taken at the lower third of the leaf compost pile using a 3 foot stem-type thermometer (figure 7).

Time, odor and temperature are indicators of when the compost process is complete. After a period of about 6 months begin checking for compost stabilization as follows. Place a sample of the compost in a plastic bag, seal it, store at room temperature 24 to 48 hours, and then open it. If there is no significant odor, the process is complete and the compost is ready for movement to the storage area for curing. Temperature recovery after windrow turning is another sign of stabilization. If there is no odor nor increase in temperature in the windrow occurring within seven days, the compost is stable and ready for the curing stage.

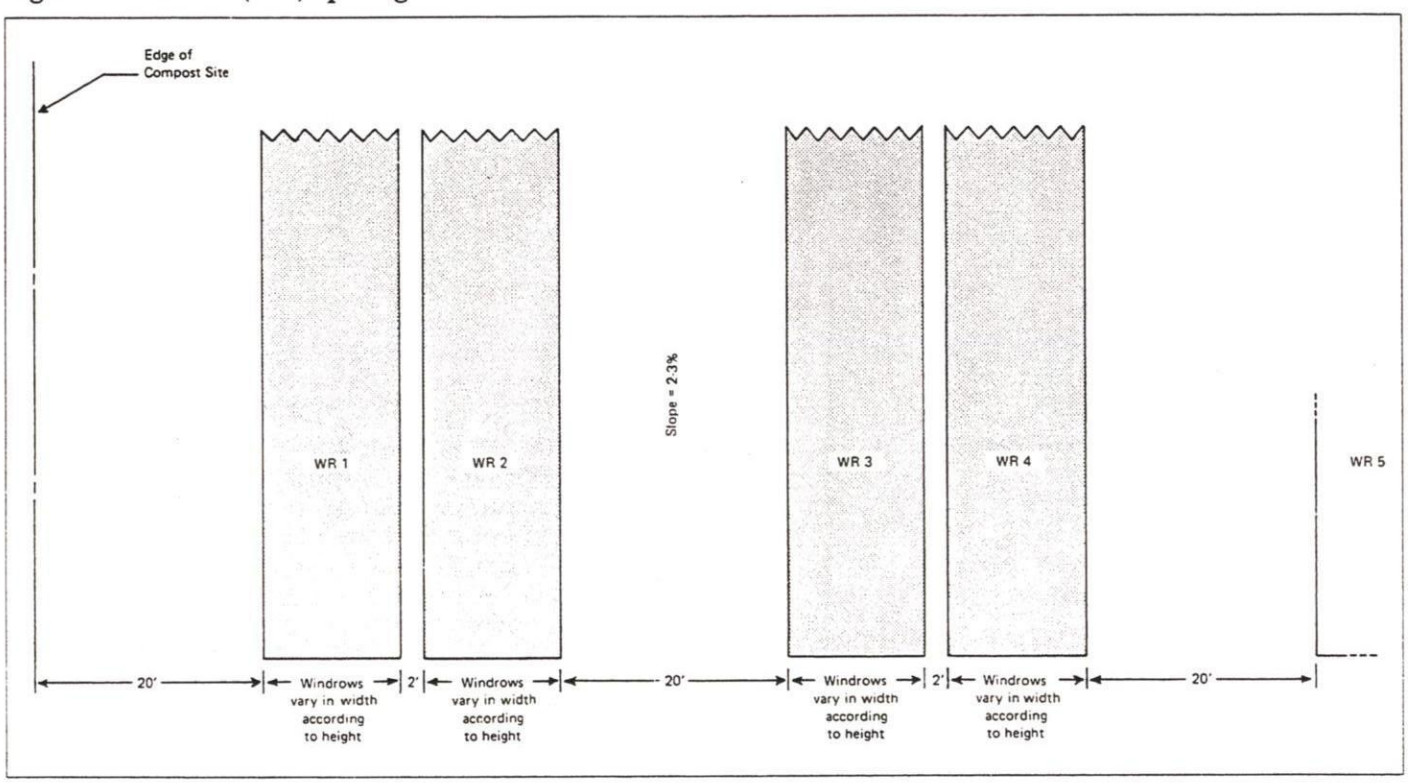
Windrow Turning: Windrows should be turned when the compost pile temperature drops to 100 degrees F or if the temperature exceeds 140 degrees F. The windrows may require turning if other process problems develop, such as odor or excess moisture at the base of the windrow. When turning, the leaves should be lifted high with a bucket and allowed to cascade to a new location (figure 8). The next turning should be done in the opposite direction. In all cases, operators should attempt to get those leaves on the bottom of the windrows to the top of the new windrows. At the time of turning, check and remove contaminants. Common ones include plastic, bottles or containers, rocks or stones, automotive hubcaps, tennis balls, and miscellaneous bulky materials.

If moisture has to be added to the windrow, try to schedule the turning operation to coincide with rain or snow to avoid having to pump or deliver water.

At compost sites near residential areas, schedule windrow turning to avoid noise and/or odor complaints. Try to select a time when the wind is blowing away from neighboring buildings. A wind sock erected at the site can be used as a wind direction indicator. Choose a time of day when most people are likely to be away or inside their buildings.

Leaf Curing: After the leaves have been composted, a brief curing period is needed to complete biological stabilization. This can be done at the compost pad or a separate bulk storage area. The compost is left as is for at least one month for curing before use. At this point, compost can be made into large piles as opposed to windrows thereby taking up less space.

Figure 6. Windrow (WR) Spacing



Finished Product: The finished compost can be screened to break up clumps to provide product uniformity and improved appearance. An analysis of compost for selected chemical constituents, such as nitrogen, phosphorus and potassium, lead, cadmium and pH, should be made. Municipalities may obtain appropriate analysis of the compost through the Connecticut Agricultural Experiment Station in New Haven.

Record Keeping: The importance of good record keeping cannot be over-emphasized. Records should be maintained on the quantity of leaves received, process temperature and moisture, operating costs, the chemical composition of the compost produced and the quantity of compost shipped. Such information is useful in assessing the efficiency of the operation and developing a cost/benefit analysis. Regular observations concerning odor, noise, and dust are important in evaluating comments received by local and/or state officials. The site observation recorded for the day that the complaint was reported might serve to substantiate whether or not the problem could be associated with the leaf composting process. Appendices E and F may be copied out of this manual for use by the site manager.

Contingency Plan: There should be an alternative arrangement available in the event that leaves cannot be composted due to unforeseen circumstances; e.g., equipment failure or natural disaster.

Figure 7. Temperature Measurement Technique

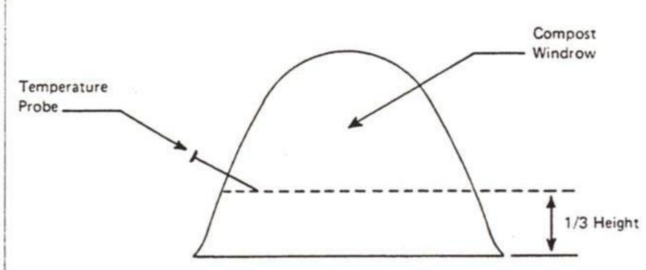
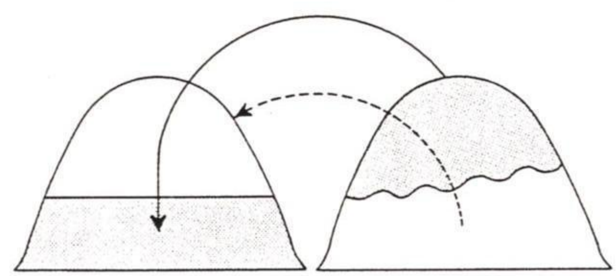


Figure 8. Windrow Turning for Aeration and Mixing of Leaves

Lift leaves high with bucket loader and let leaves fall to new location to create a cascading (mixing) effect.



Note: The principle of the mixing technique is to move the top of the windrow to the bottom of the windrow being formed, mixing the leaves well during this process.

E. Other Management Considerations

Grass Clippings: Grass clippings have a relatively higher content of nitrogen than leaves. In some instances, however, grass may have concentrations of herbicides (weed killers) used in normal lawn maintenance programs. Once applied to turf the herbicide may take a few weeks or months to degrade to a relatively harmless state. Ongoing research at Rutgers University is expected to provide additional information on this topic.

Road Salt: Road salt used in ice and snow removal has not been found to be a problem with regard to high concentrations in leaves used for composting. Generally, any concentration of salt that may be deposited on leaves (during an early fall snowstorm or over the winter for those leaves picked up in spring) becomes diluted with a larger amount of leaves that have not been in contact with road salt.

Pesticides: Pesticides used on trees are normally confined to a few insecticides and possibly some fungicides. In a normal year, only a few trees will be selectively sprayed and in most instances will be treated early in the growing season (June-July). During those years of high insect infestation (e.g., gypsy moth caterpillars), a more intensive spraying program may be necessary. However, even in this case treatment will be completed early in the season (May-June), and by the time leaf fall occurs, the pesticides will be significantly degraded.

Aspergillus fumigatus: A fungus spore *Aspergillus fumigatus,* may be produced by the composting process especially when wood chips are used as a bulking agent in sewage sludge composting. This fungus may be a cause of lung infections in susceptible humans. Little evidence exists to demonstrate that this is a concern with leaf com-

Table 3. Sample Windrow Temperature Data Sheet

Data collected by: K. C. COMPOST Year: 1989 Month: FEB.

Weather Information (Sunny, rain, etc.) RAIN

Wind direction (from Northeast, South, etc.) N.E.

Air Temperature: °F 36°F **Time of day:** 10 a.m.

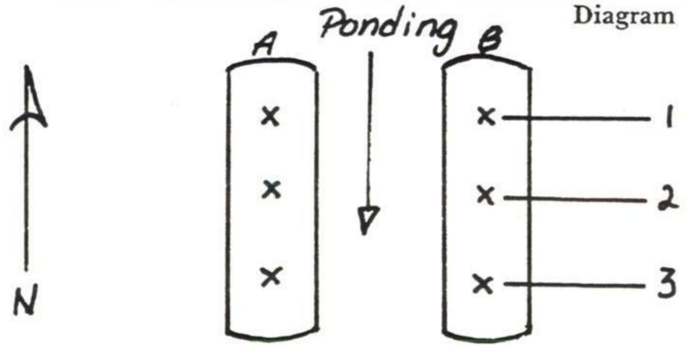
Site Observation Comments (Water ponding, dust, etc.) wet, cold, windy. Ponding between windrows A and B.

Windrow Moisture ("Hand squeeze" test observation) *circle item:* Needs moisture Satisfactory Excess

Odor *(circle item):* None Minimal Strong

Windrow temperature measurement location:	**Temperature Observation, °F**								
	Windrow Observation (See Sketch Below)								
	A	B							
1	115	106							
2	120	102							
3	118	110							

Diagram



Actions Taken (turned windrow, graded, etc.): Instructed operator to regrade between A and B.

posting operations. However, municipal compost sites should not be established in close proximity to hospitals or nursing homes. People with diseases causing immune suppression (including arthritis) should not work near compost. In addition, people taking drugs that suppress the immune system, like cyclosporin, should not work with compost.

Lead: Lead is sometimes found in finished compost products, particularly in sludge composting. Very limited data exist concerning concentrations that may be expected to be found in compost produced only from leaves, and there appears to be no published data comparing lead levels in leaves by source (e.g. street trees in an urban setting vs. yard trees in low density suburban settings). Research in New Jersey indicates that relatively low levels should be expected.

F. End Use and Disposition of Leaf Compost

General Characteristics: Leaf compost is a soil-like material valued primarily as a soil amendment. The nutrient content of leaf compost is usually too low to consider it as a fertilizer. Generally, leaf compost piles include clumps of uncomposted leaves, branches and other foreign materials which, if not screened out, significantly decrease the value of the compost. Screening or shredding increases the value of the compost.

Market Opportunities: In determining market opportunities the following procedure should be followed:

- Inventory possible markets.
- Identify their specifications.
- Identify their capacity to absorb the compost. This should include the amount used each year, the seasonality of use, and projections for long-term usage.
- Identify their shipping and delivery requirements.
- Identify revenue potentials of target markets.

There are a number of market opportunities for leaf compost. They include:

Municipalities: Continual and extensive need for compost type products as soil amendments and mulch. Screening the compost will make the product usable on a larger variety of jobs.

Landscaping Industry: Continual and extensive need for compost-type products as soil amendments and mulch. The compost should be screened to remove unwanted material and be of consistent appearance.

Greenhouse/Nursery: Large demand for compost if it is of consistently good quality based upon physical and chemical characteristics. The compost must be screened to remove unwanted materials and present a consistent appearance. Leaf compost can comprise up to 20% of the potting soil mix for either bedding plants or nursery plants. Chemical analysis of N, P, K and pH is needed to accommodate the nutrient needs of the plant.

Home Grounds/Gardening: Useful as an amendment to garden soil and as mulch around landscape plantings. Does not require screening.

Agriculture: Agricultural producers annually add organic matter to improve soil conditions and crop production. Compost is useful if conveniently and readily available in large enough quantities. Does not require screening.

Distribution Channels: Product movement off-site will be determined by the availability of users and distribution options. Distribution channels include:

Municipal: Equipment can be used to move compost off-site to road jobs, school landscaping, etc.

Giveaway: Commonly used; residents pick-up at site.

Wholesale to Distributors: Several large compost marketing companies operate in the northeast and can handle bulk or retail distribution of high quality compost. While this option will not provide much income to the compost producer, it will save time and management required for distribution.

Bulk Sales: Sold to large-scale users (landscapers, greenhouse, etc.). Charge assessed on yardage or tonnage basis. Product can be delivered or picked up at the site.

Retail: Sold directly to public, usually on a volume or vehicle basis. Usually unbagged. Requires management of funds at site for each sale. If considering sale of bagged compost, a marketing study is recommended.

IV. Budgeting

IV. Budgeting

Budgeting is a systematic procedure for estimating costs, revenues and other benefits. This section provides a broad overview of budgeting and sample worksheets to determine the cost/benefit analysis of leaf composting.

A. An Overview

Tables 4 through 7 are worksheets to be used in estimating the costs of equipment, labor and supplies needed for leaf collection and composting. Tables 5 and 7 also include procedures for estimating benefits such as the avoided cost of incinerating or landfilling leaves and the value of compost available for use by the municipality and by residents. Several copies of the worksheets may be needed in exploring and evaluating alternatives and in organizing information about the particular alternative selected for implementation. The worksheets provide a general outline for estimating municipal and non-municipal costs and benefits and should be modified to meet the needs of a particular town or group of towns if a regional project is under consideration.

A town with an established procedure for keeping leaves separate from other solid wastes and with no interest in considering alternative leaf collection policies and procedures may not need Tables 4 and 5. Any change in collection costs associated with a shift from disposal to composting would probably be directly related to the difference in hauling distances and could be directly estimated and entered in Part B1 of Table 7.

Towns now collecting leaves in combination with other solid wastes should carefully explore and evaluate alternative leaf collection policies and techniques prior to investing in specialized equipment. Table 4 provides an outline for estimating municipal costs of separate leaf collection with alternative combinations of equipment and operating procedures. General data on leaf weights, volumes and bag counts are given in Appendix B. Information on leaf collection techniques and equipment is shown in Table 1 and Appendix C. Each town will need additional information directly relevant to local conditions. Planners should visit nearby towns with similar conditions which have had experience with leaf collection.

Table 5 outlines a procedure for estimating the municipal and non-municipal change in leaf collection costs associated with a shift from disposal to composting. It is broad in scope and accounts for independent hauling and municipal contractors as well as leaf collection by municipal employees.

Because Table 5 includes items that vary from town to town, estimating procedures consistent with local policies and practices are required. Bag costs, for example, have generally been a non-municipal expense; however, a municipality that requires the use of biodegradable bags might provide the bags or sell them below cost. The Table does not include an estimate of the value of non-municipal labor in bagging leaves. This is probably a recreational activity for many residents, and the time required for bagging may be little more than that for forming and reforming loose piles. Likewise, there is no clear basis for estimating the value of time spent by residents in hauling leaves. A reasonable estimate of direct costs of hauling by residents can be based on estimates of trip numbers and average distances in combination with a standardized cost per mile, such as the municipal reimbursement rate for town employees.

Information on rates charged by privately hired haulers and municipal contractors can be determined by an informal survey within the town and in nearby communities. Groundskeepers charge for a package of services. If a shift from leaf disposal to leaf composting appears to imply little impact on leaf hauling by groundskeepers this item can be ignored in Parts A and B of Table 5.

The key to successful use of Table 5 is concentration on major cost items that are likely to be impacted by a shift from collection for disposal to collection for composting. The bottom line in the Table will indicate the change in municipal and non-municipal collection costs associated with a shift from disposal to composting.

Table 6 is a worksheet for estimating municipal costs of leaf composting. A rather specific format is provided for estimating labor and equipment costs for each major phase of the composting process. General data on leaf weights, volumes and bag counts are given in Appendix B. Basic information on compost processing equipment and approximate prices in 1988 are shown in Appendix D. However, considerable judgment and local research will be required to estimate costs for a particular site with specific types of equipment and operating procedures.

Table 7 is a worksheet for summarizing annual economic benefits and costs associated with leaf composting. The estimate of avoided cost of incinerating or landfilling leaves should include both capital and operating costs. The value of existing landfill capacity owned by the town should be based on its replacement cost rather than on the original cost of acquiring the site. The value of compost used by the town and by residents and businesses can generally be based on the cost of the soil conditioner most likely to be used in the absence of the compost. A lower value should be used in the case of compost uses beyond the quanitities that would be used in the absence of the municipal leaf composting program. Other benefit and cost categories are defined in Table 7 and preceding tables.

Table 4. Worksheet for Estimating Municipal Costs of Collection

Annual Operating Costs		$/Year
I.		
A. Cash Expenses for Equipment (operating and maintenance costs and/or rental costs)		
1. Compactor trucks: (________units) x (________hr/wk) x (________wks/yr) x ($________/hr)	=	__________
2. Vacuum leaf collectors: (________units) x (________hr/wk) x (________wks/yr) x ($________/hr)	=	__________
3. Catch basin cleaners: (________units) x (________hr/wk) x (________wks/yr) x ($________/hr)	=	__________
4. Front end loaders: (________units) x (________hr/wk) x (________wks/yr) x ($________/hr)	=	__________
5. Dump trucks: (________units) x (________hr/wk) x (________wks/yr) x ($________/hr)	=	__________
6. Other equipment: (________units) x (________hr/wk) x (________wks/yr) x ($________/hr)	=	__________
Total cash expenses for equipment....................................	=	__________
B. Labor		
1. Truck drivers: (________ workers) x (________ hrs/wk) x (________ wk/yr) x ($________ /hr)	=	__________
2. Equipment operators: (________ workers) x (________ hrs/wk) x (________ wk/yr) x ($________ /hr)	=	__________
3. Other workers: (________ workers) x (________ hrs/wk) x (________ wk/yr) x ($________ /hr)	=	__________
Total of hourly wages..	=	__________
Costs of fringe benefits ($________ Total of hourly wages) x (________%)________	=	__________
Total labor costs (total of hourly wages plus cost of fringe benefits)..................	=	__________
Total Annual Operating Costs (sum of parts A and B)............................	=	__________

Table 4. Worksheet for Estimating Municipal Costs of Collection. (continued)

Annual Operating Costs		$/Year
II. Annual Capital Costs (In each case start with the initial capital cost of the particular item and convert to an annual basis with a capital recovery factor (CRF) that includes an allowance for annual depreciation over the service life and annual interest on investment — see Appendix G. Let C/T stand for the ratio of usage in leaf collection to total usage).		
A. Compactor trucks: (______units) x ($______) x (______C/T) x (______CRF)	=	________
B. Vacuum leaf collectors: (______units) x ($______) x (______C/T) x (______CRF)	=	________
C. Catch basin cleaners: (______units) x ($______) x (______C/T) x (______CRF)	=	________
D. Front end loaders: (______units) x ($______) x (______C/T) x (______CRF)	=	________
E. Dump trucks: (______units) x ($______) x (______C/T) x (______CRF)	=	________
F. Other equipment: (______units) x ($______) x (______C/T) x (______CRF)	=	________
Total Annual Capital Costs.	=	________
Annual Costs of Leaf Collection (sum of parts I and II).	=	________

Table 5. Worksheet for Estimating the Increase in Collection Costs Associated with a Shift from Disposal to Composting.

Collection Costs		$/Year	
		Municipal	Non-municipal
A. Costs of Leaf Collection if Leaves Are to be Composted			
1. Bags	=	______	______
2. Independent hauling by:			
(a) Residents	=		______
(b) Groundskeepers	=		______
(c) Privately hired haulers	=		______
3. Municipal contractors	=	______	
4. Municipal crews (from Table 4)	=	______	
5. Other	=	______	______
Subtotal for A	=	______	______
B. Costs of Leaf Collection if Leaves Are Not to be Composted			
1. Bags	=		______
2. Independent hauling by:			
(a) Residents	=		______
(b) Groundskeepers	=		______
(c) Privately hired haulers	=		______
3. Municipal contractors	=	______	
4. Municipal crews	=	______	
5. Other	=	______	______
Subtotal for B	=	______	______
C. Change in Collection Costs (Subtotal A minus Subtotal B)	=	______	______

Table 6. Worksheet for Estimating Municipal Costs of Leaf Composting.

I. Annual Operating Costs $/Year

A. Labor

1. Site monitoring and directing of trucks while leaves are being received:[1]
(________ hrs./wk) x (________ wks/yr) x ($ ________ /hr) = ________
2. Emptying of bags:
(________ hr/cu yd) x (________ cu yd/yr) x ($ ________ /hr) = ________
3. Equipment operator during windrow formation:
(________ hrs./wk) x (________ wks/yr) x ($ ________ /hr) = ________
4. Truck driver if needed during windrow formation:
(________ hrs./wk) x (________ wks/yr) x ($ ________ /hr) = ________
5. Compost process monitoring:
(________ hr/visit) x (________ visits/wk) x
(________ wks monitored/yr) x ($ ________ /hr) = ________
6. Equipment operator for turning of windrows:
(________ hr/turn) x (________ turns/yr) x ($ ________ /hr) = ________
7. Wetting of leaves:
(_____ hr/wetting) x (_____ wettings/yr) x ($________ /hr) = ________
8. Other (shredding, loading, bagging, etc. as applicable): ($________) = ________
9. Site monitoring while compost is being sold or given away:[1]
(________ hrs./wk) x (________ wks/yr) x ($ ________ /hr) = ________

Total of hourly wages.. = ________
Costs of fringe benefits ($ ________) x (________ %)..................... = ________
Total labor costs (total hourly wages plus costs of fringe benefits)............. = ________

B. Cash Expenses for Equipment (operating and maintenance costs and/or rental costs)

1. Front end loader during windrow formation:
(________ hrs./wk) x (________ wks/yr) x ($ ________ /hr) = ________
2. Dump truck for moving leaves at the site:
(________ hrs./wk) x (________ wks/yr) x ($ ________ /hr) = ________
3. Front end loader or other equipment for turning windrows:
(_______ hr/turn) x (_______ turns/yr) x ($_______ /hr) = ________
4. Water truck (if needed):
(_______ hr/wetting) x (_______ wettings/yr) x ($_______ /hr) = ________
5. Maintenance of roads, fences, drainage and water systems, and buildings = ________
6. Other equipment for shredding, loading, bagging, etc. as applicable: = ________

Total cash expenses for equipment.................................... = ________

[1]If one person monitors more than one activity include only the time associated with or allocated to leaf composting.

Table 6. Worksheet for Estimating Municipal Costs of Leaf Composting. (continued)

		$/Year
C. Supplies and Other Expenses		
1. Training of personnel	=	________
2. Replacement thermometers	=	________
3. Laboratory analyses of compost	=	________
4. Electricity	=	________
5. Water	=	________
6. Other	=	________
Total for supplies and other expenses....................................	=	________
Total Annual Operating Costs (sum of parts A, B and C)......................	=	________
II. Annual Capital Costs (In each case start with the initial capital cost of the particular item and convert to an annual basis with a capital recovery factor (CRF) that includes an allowance for annual depreciation over the service life and annual interest on investment, see Appendix G. Since land does not depreciate, the CRF for land is the annual rate of interest).		
A. Land ($________) x (________ CRF)	=	________
B. Site Improvements		
1. Site grading, drainage and roads: ($________) x (________ CRF)	=	________
2. Fencing, gate, signs, and buffers: ($________) x (________ CRF)	=	________
3. Water system: ($________) x (________ CRF)	=	________
4. Gate house and storage shed: ($________) x (________ CRF)	=	________
5. Other	=	________
Annual capital costs for site improvements................................	=	________
C. Equipment (Let C/T stand for the ratio of composting usage to total usage)		
1. Front end loader: ($________) x (________ C/T) x (________ CRF)	=	________
2. Dump truck: ($________) x (________ C/T) x (________ CRF)	=	________
3. Water truck: ($________) x (________ C/T) x (________ CRF)	=	________
4. Other equipment for turning windrows, shredding, bagging, etc.:		
($________) x (________ C/T) x (________ CRF)	=	________
($________) x (________ C/T) x (________ CRF)	=	________
Annual capital costs for equipment..	=	________
Total Annual Capital Costs (sum of parts A, B and C).........................	=	________
Annual Costs of Composting (sum of parts I and II)...........................	=	________

Table 7. **Worksheet for Summarizing Annual Economic Benefits and Costs from Leaf Composting**

Item or Function		$/Year Municipal	$/Year Non-municipal
A. Benefits			
1. Avoided cost of incinerating or landfilling leaves	=	______	______
2. Value of compost used by the municipality	=	______	
3. Revenue from the sale of compost	=	______	
4. Value of compost used by residents and businesses in excess of payments to the municipality	=		______
5. Other revenues or benefits	=	______	______
Total Economic Benefit..........................	=	______	______
B. Costs			
1. Change in collection costs (from Table 5)	=	______	______
2. Municipal costs of composting (from Table 6)	=	______	
3. Other costs	=	______	______
Total Economic Cost............................	=	______	______
Net Economic Benefit (Total Economic Benefit minus Total Economic Cost)..................	=	______	______

V. References and Appendicies

V. References and Appendices

References

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Appendices

Appendix A: Trouble Shooting Guide For Operating Windrows

Problem	Cause	Solution
Odor	Excess moisture	Turn windrow
	Temperature greater than 140° F	Turn or reduce windrow size
	Leaf compaction	Turn or reduce windrow size
	Surface ponding	Eliminate ponding/regrade
Low windrow temperature	Windrow too small	Combine windrows
	Insufficient moisture	Add water while turning windrow
	Poor aeration	Turn windrow
High windrow temperature	Leaf compaction	Turn or reduce windrow size
	Insufficient oxygen	Turn windrow
Surface ponding	Depressions or ruts	Fill depression and/or regrade
	Inadequate slope	Grade site to recommended slope design
Rats	Presence of garbage	Remove garbage
Mosquitoes	Presence of stagnant water	Eliminate ponding

Appendix B: Weight, Volume and Bag Count Data

Description	Data*
A. Bagged or loose leaves in a compactor truck:	
(1) Actual count based on one full load of 31 cu yd, weighing 14,525 lb and containing 1,550 bags (Springfield, MA; 1987, reported by Macy)	9.37 lb/bag 50.0 bags/cu yd; 468.5 lb/cu yd;
(2) Average by truckload based on truck capacity without adjustment for partially filled loads:	
a. Averaged over 1,745,380 lb (Springfield, MA, 1987, reported by Macy)	414 lb/cu yd
b. Averaged over 1,413,010 lb (Waterbury, Ct, 1987, from town records)	555 lb/cu yd
(3) A general estimate (reported by Derr)	450 lb/cu yd
B. Loose leaves collected with vacuum equipment and blown into a leaf box:	
(1) Average by truckload based on truck capacity without adjustment for partially filled loads:	
a. Averaged over approximately 150 loads, Scarsdale, NY (reported by Rice)	190 lb/cu yd
(2) A general estimate (reported by Derr)	350 lb/cu yd
C. Loose leaves loaded into an open truck with a front end loader:	
(1) Average by truckload based on truck capacity without adjustment for partially filled loads:	
a. Averaged over 13 loads (Springfield, MA, 1987, reported by Macy)	371 lb/cu yd
(2) A general estimate (reported by Derr)	250 lb/cu yd
D. Bagged leaves in an open truck:	
(1) Based on 9.37 lb/bag and an assumed average bag volume of 25 gallons (3.34 cu ft/bag)	75.7 lb/cu yd

*These estimates reflect a variety of measurement techniques, moisture conditions, and degrees of compaction and are presented here as a general guide.

Appendix C: Leaf Collection Equipment and Approximate Prices in 1988

Description	Cost
A. Compactor trucks:	
(1) 20 cu yd; 240 hp diesel; automatic transmission; single axle	$ 80,000
(2) 25 cu yd; 270 hp diesel; automatic transmission double axle	$ 95,000
B. Vacuum leaf collectors:	
(1) Trailer mounted; belt driven; 12-inch intake; 12,000 cfm;	
a) With gasoline engine	$ 20,000
b) With diesel engine	$ 21,500
(2) Trailer mounted; power-take-off and clutch connection; 18-inch intake; 24,000 cfm; diesel engine	$ 14,000
(3) Trailer mounted; impeller on engine crankshaft; 18-inch intake; 22,000 cfm; gasoline engine;	$ 7,500
a) With 14 cu yd dump box	$ 14,500
b) With 20 cu yd dump box	$ 16,000
C. Catch basin cleaners:	
(1) Complete unit including truck; 12-inch intake; 12,000 dfm; diesel engine on vacuum unit;	
a) 10 cu yd capacity	$100,000
b) 16 cu yd capacity	$120,000

Appendix D: Compost Processing Equipment and Approximate Prices in 1988

Description	Cost
A. Front end loaders:	
(1) 90 hp with 1.75 cu yd bucket	$ 55,000
(2) 115 hp with 3 cu yd bucket	$ 70,000
(3) 155 hp tractor (without bucket)	$ 80,000
a) 3 cu yd bucket	$ 4,800
b) 7 cu yd woodchip and snow bucket	$ 7,400
c) Quick attachment system	$ 3,900
(4) 82 hp tractor (without bucket)	$ 60,000
a) Lease with 1.6 cu yd bucket	$ 2,600/month
(5) 123 hp tractor (without bucket)	$ 87,000
a) Lease with 2.4 cu yd bucket	$ 3,600/month
(6) 158 hp tractor (without bucket)	$111,000
a) Lease with 3.0 cu yd bucket	$ 4,600/month
(Note: Based on experience in Springfield, MA, a 3 cu yd loader can turn approximately 180 cu yd per hour with each load lifted high and allowed to cascade into a new windrow.)	
B. Specialized aerating and turning equipment:	
(1) Flail type; self propelled; turns windrows up to 7 ft. high and 18 ft. wide at a rate of up to 3,000 tons per hour; 360 hp; not easily transported between sites (10' 6" wide and 14' 6" high on low bed trailer)	$160,000
(2) Auger type; mounted on a tractor that can be used with numerous optional attachments; turns windrows up 6 ft. high and 10 ft wide at a rate of up to 3,000 tons per hour; engine options of 177 to 225 hp; not convenient for long distance transport; can be driven on road at a maximum speed of 20 mi/hr	$180,000
(3) Flail type; powered by 177 hp engine while attached to a front loader (loader not included); turns windrows up to 5 or 6 ft. high and 14 ft. wide at a rate of up to 800 tons per hour; can be loaded on a flat bed truck with a front end loader equipped with a quick catch system	$ 65,000
(4) Flail type; attaches to a large farm type tractor with a three point hitch and power-take-off (The tractor should have 100 to 225 hp and a hydrostatic transmission or a creeper transmission with 2 or 3 speeds under 1/3 mi/hr with power-take-off at 1,000 rpm); turns windrows 5 to 6 ft. high and 14 ft. wide at a rate of up to 600 tons per hour; special wheels for over the road transport	$ 30,000
C. Separating and shredding equipment:	
(1) 25 cu yd/hr; 18 hp gasoline engine	$ 17,000
(2) 75 cu yd/hr; 55 hp diesel engine	$ 40,000
(3) 200 cu yd/hr; 110 hp diesel engine	$ 91,000

Appendix E: Sample Windrow Temperature Data Sheet

Data collected by:____________________ Year:________ Month:________

Weather Information (Sunny, rain, etc.)____________________

Wind direction (from Northeast, South, etc.)____________________

Air Temperature: ^{0}F________ **Time of day:**________

Site Observation Comments (Water ponding, dust, etc.)____________________

Windrow Moisture ("Hand squeeze" test observation) *circle item:* Needs moisture Satisfactory Excess

Odor *(circle item):* None Minimal Strong

Windrow temperature measurement location:	**Temperature Observation, ^{0}F**								
	Windrow Observation (See Sketch Below)								

Diagram

Actions Taken (turned windrow, graded, etc.): ____________________

Appendix F: Sample Leaf Volume Data Sheet

Month____________					Year____________				
	Vehicle No.________ Type________ Cap. Cu.Yd.		Vehicle No.________ Type________ Cap. Cu.Yd.		Vehicle No.________ Type________ Cap. Cu.Yd.		Vehicle No.________ Type________ Cap. Cu.Yd.		
DATE	Loads	CY/Tons	Loads	CY/Tons	Loads	CY/Tons	Loads	CY/Tons	TOTAL
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
total									

Source: New Jersey Office of Recycling (Form OR-3A)

Appendix G: Capital Recovery Factor Values[1]

	Interest Rates			
Years	7%	8%	9%	10%
1	1.0700	1.0800	1.0900	1.1000
2	.5531	.5608	.5685	.5762
3	.3811	.3880	.3951	.4021
4	.2952	.3019	.3087	.3155
5	.2439	.2505	.2571	.2638
6	.2098	.2163	.2229	.2296
7	.1855	.1921	.1987	.2054
8	.1675	.1740	.1807	.1874
9	.1535	.1601	.1668	.1736
10	.1424	.1490	.1558	.1627

[1] The formula for computing capital recovery factors not presented here is as follows:

$$CRF = \frac{i(1+i)n}{(1+i)n - 1}$$

where: i = interest or discount rate
n = number of years

Source: Derr, Donn A. *The Economics of Leaf Composting* Department of Agricultural Economics and Marketing, Cook College, Rutgers University, Research Report Series No. P-02550-2-85

Note: This is only one of numerous methods of calculating annual depreciation and interest on investment. If an allowance is to be made for salvage, value straight line depreciation and average annual interest on investment can be calculated as follows:

annual depreciation	=	(c - s)/n
annual interest	=	i(c + s)/2
where: c	=	initial cost
s	=	salvage value
n	=	service life in years
i	=	annual interest rate

Appendix H: Glossary of Composting Terms

Aerated Static Pile Composting: A method of composting organic wastes in which oxygen and temperature levels are mechanically controlled by blowing air through a static pile.

Aerobic Composting: Decomposition of organic wastes by microorganisms in the presence of oxygen. See Composting.

Anaerobic Digestion: Decomposition of organic wastes by microorganisms in the absence of oxygen.

Buffer Zone: Area of land between the composting facility and homes or other sensitive land uses, which shields these abutting uses from impacts of the operation. The buffer zone could include vegetation.

Compost: Decomposed, humus-like organic matter produced through composting and suitable for application to the soil. Depending on the waste source, compost may have some nutrient value.

Composting: Process of accelerated organic matter decomposition based on microbial self-heating.

Composting Pad: An area within the composting site where the leaves are processed. If not a hard surface, pad should be constructed of material that drains well and will support heavy equipment in all weather conditions.

Cubic Yard: A standard measure of volume. There are 27 cubic feet in a cubic yard. For compacted leaves, one cubic yard is roughly equivalent to 500 lbs. or 1/4 ton, assuming an average rate of compaction and moisture content.

Curing: Late stage of composting, after most of the readily metabolized material has been decomposed, which provides additional biological stabilization.

Decomposition: The breaking down, or destruction, of organic materials such as fallen leaves by microorganisms.

Flail: A metal flange attached to a rotating shaft for moving and mixing leaves; need for aeration.

Front-end Loader: A tractor vehicle with a bucket type loader at the front end of the vehicle.

Heavy Metals: Metallic elements with high molecular weights. Some elements present human health risks at certain concentrations; some may be phytotoxic to plants; others may adversely affect livestock.

Inorganic: Substance in which there are no carbon-to-carbon bonds; mineral matter (example: nitrogen, phosphorous, potassium).

In-Vessel Composting: A method of composting organic wastes encompassing a variety of systems involving mechanical agitation, forced aeration normally enclosed within a building.

Leachate: That liquid which results from ground or surface water which has been in contact with solid waste and has extracted material, either dissolved or suspended, from the solid waste.

Lignin: An amorphous polymeric substance related to cellulose, that together with cellulose forms the woody cell walls of plants and the cementing material between them.

Microorganism: Living organism of a size such that it can be seen only with microscope.

Non-Compostable: Material that will not decompose naturally.

Organic: Substance which includes carbon-to-carbon bonds.

Organic Waste: Waste composed of materials which contain carbon-to-carbon bonds and are biodegradable. Includes paper, wood, food wastes, yard wastes and leaves.

Passive Leaf Piles: The composting of leaves through the placement of leaves in large piles and letting them remain there until a usable product is developed, a minimum of 2-3 years.

Pathogens: Organisms that are capable of producing disease or infection; often found in waste material.

Percolation: Downward movement of water through the pores or spaces of rock or soil.

pH: A measure of how acidic (pH less than 7) or basic (pH above 7) a material is.

Runoff: Any liquid originating from any part of a composting facility that drains over the land.

Screening: The process of passing compost through a screen or sieve to remove large organic or inorganic materials and improve the consistency and quality of the end-product.

Self-heating: Spontaneous increase in temperature of organic masses resulting from microbial action.

Shredder: A mechanical device used to break up waste materials into smaller pieces, usually in the form of irregularly shaped strips. Shredding devices include tub grinders, hammermills, shears, drum pulverizers, wet pulpers and rasp mills.

Soil Amendment/Soil Conditioner: A soil additive which stabilizes the soil, improves its resistance to erosion, increases its permeability to air and water, improves its texture and the resistance of its surface to crusting, makes it easier to cultivate or otherwise improves its quality.

Solid Waste: Any unwanted or discarded solid materials, including solid, liquid, semisolid or contained gaseous materials. Solid wastes are classified as refuse.

Stabilization: Used synonymously with decomposition.

Staging Area: A temporary holding area where newly received leaves are received, mixed or debagged before transfer to a compost pad.

Vector: Any organism capable of transmitting a pathogen to another organism, such as mosquitoes, rats, etc.

Volume Reduction: The processing of waste materials to decrease the amount of space they occupy. Compaction, shredding, composting and burning are all methods of volume reduction.

Windrow and Turn Composting: A method of composting leaves in an elongated pile called a windrow. The windrow is turned periodically to aerate and mix the leaves to speed up the decomposition process and reduce odors.

Yard Waste: Garden wastes, leaves, grass clippings, weeds, brush.