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Successful Approaches to Recycling Urban Wood Waste

Abstract

This report presents eight case studies of successful urban wood waste recycling projects and businesses. These studies document the success of recovered products such as lumber and lumber products, mulch, boiler fuel, and alternative cover for landfills. Overall, wood waste accounts for about 17% of the total waste received at municipal solid waste landfills in the United States. In 1998, the amount of urban wood waste generated was more than 160 million tons, with 29.6 million tons available for recovery. Similarly, in 1998, new construction in the United States generated 8.7 million tons of wood waste, with 6.6 million tons available for recovery; demolition waste generated 26.4 million tons of wood waste, with 9 million tons available for recovery. The case studies were selected on the basis of the following criteria: an emphasis on partnerships among communities, businesses, governments, and non-governmental organizations; efficient use of funds; sustained creation of enterprise; and a high benefit/cost ratio.

Keywords: recycling, urban wood waste, energy, pallets

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SI conversion factors

English unit	Conversion factor	SI unit
acre	0.4047	hectare (ha)
British thermal unit (Btu)	$1.054 \Delta 10^3$	joule (J)
cubic yard (yd^3)	0.836	cubic meter (m^3)
foot (ft)	0.3048	meter (m)
horsepower	$7.46 \Delta 10^2$	watt (W)
inch (in.)	25.4	millimeters (mm)
pound (lb)	0.454	kilogram (kg)
yard (yd)	0.9	meter (m)

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Solid Waste Association of North America
Applied Research Program
Silver Spring, Maryland

Introduction

Urban wood waste can include sawn lumber, pruned branches, stumps, and whole trees from street and park maintenance. The primary components of urban wood waste are used lumber, shipping pallets, trees, branches, and other wood debris from construction and demolition clearing and grubbing activities (California Integrated Waste Management Board 2001).

The end uses of wood recovered from construction and demolition activities are sometimes limited. This is because the wood is commingled with other materials and contaminants or is in such poor condition that the cost of processing and cleaning limits the economic viability of processing and reusing the material.

Wood waste generated at residential and commercial wood frame construction sites offers a greater potential for reuse because of the ease of separating the wood during various stages of construction. Cut-offs and scraps generated during framing and trimming constitute a relatively clean and homogeneous waste stream that can make an excellent feedstock for engineered wood production. This type of wood waste represents a highly desirable form of recyclable material that processors are eager to obtain.

Demolition operations usually generate a far less desirable form of wood waste as a result of its non-uniform nature, compounded by commingling of the wood with other materials. The wood can still be reused, but it generally has low value and is destined for uses such as boiler fuel or mulch feedstock. Since demolition activities generate far more waste per square foot than do construction activities, disposal costs represent a much larger portion of operating expenses.

Available Resources and Markets

Overall, wood waste accounts for about 17% of the total waste received at municipal solid waste landfills in the United States (EPA 1999). In 1998, the amount of urban wood waste generated was more than 160 million tons, with 29.6 million tons available for recovery (McKeever 1999). Similarly, in 1998, new construction in the United States generated 8.7 million tons of wood waste, with 6.6 million tons available for recovery; demolition waste generated 26.4 million tons of wood waste, with 9 million tons available for recovery (California Integrated Waste Management Board 2001).

Markets for wood waste include feedstock for engineered woods, landscape mulch, soil conditioner, animal bedding, compost additive, sewage sludge bulking medium, and boiler fuel. All these end uses have similar processing requirements in that the wood waste has to be separated from other wastes, cleaned by removing contaminants and fasteners, and, in some cases, processed through grinding or chipping. The final use of the wood waste often determines how clean and consistent the feedstock must be (California Integrated Waste Management 2001).

- **Lumber**—A desirable option for wood waste management would be to reuse the structural or architectural elements, which include casings, banisters, and molding. Large timbers from older or unique structures can be salvaged and reused as structural elements in new buildings. If lumber is reused as a structural element, it must be re-certified by a lumber grading inspector.

- **Engineered wood products**—Another desirable option for wood waste is feedstock for engineered wood. Engineered wood is the term given to material derived from smaller pieces of wood that are bound together through a variety of glues, resins, and other chemicals to make a wood-like product. Examples of engineered wood include oriented strandboard, particleboard, glued-laminated timber, laminated lumber, wood I-joists, and finger-jointed studs.

- **Mulch or compost feedstock**—Chipped wood and bark are common mulches. Wood is an excellent bulking agent for composting, although a nitrogen source usually needs to be added.

- **Biomass fuel**—Ovendry wood produces about 9,000 Btu/lb when burned, and it can be converted to liquid or gaseous fuel. In addition, different forms of solid fuel such as charcoal are possible. Industrial wood residues are commonly used for boiler fuel.

- **Miscellaneous uses**—Other uses for waste wood include alternative daily landfill cover, animal bedding, wood flour filler for plastic products, and a source of biofuels and chemicals.

Table 1 shows an example of the range of values for various products that can be produced from a recovered wood pallet. Reusing wood as lumber can potentially bring revenues 20 to 32 times as high as selling the same amount of wood for fuel or mulch. Similarly, reusing wood in the manufacturing of engineered wood products can potentially bring revenues four times as high as selling the same amount of wood for fuel or mulch. Note that processing and handling costs associated with the reuse of lumber and engineered wood product feedstock options are also much greater than those associated with using waste wood for fuel or mulch.

Table 1—Relative value of wood recovery options[a]

Wood pallet usage	Value of standard 48- by 40-in. pallet
Reuse as lumber	$5.00 – $8.00
Feedstock for engineered wood products	$1.00
Biomass fuel or mulch	$0.25

[a]Araman and others 1997.

Why Recycle Wood Waste?

There are a number of important reasons to recycle urban wood waste; the following discussion summarizes the primary reasons.

Landfill Cost and Space Savings

Landfill costs can be avoided by recycling wood wastes, generating savings that, along with revenue from the sale of recovered wood waste materials, can be credited toward the processing costs associated with recovery. For example, assuming an average national tipping fee of $38/ton, the 29.6 million tons of urban wood waste disposed of annually represent more than $1,124 million in annual disposal costs. Cost savings could be even greater in certain parts of the United States. Assuming a landfill density of 1,000 lb/yd^3, the 29.6 million tons of wood waste disposed of annually consume about 59 million yd^3 of landfill space each year. If the landfill averages 50 ft in height and a 3/1 side slope is assumed, this volume translates to more than 1,350 acres of landfill space consumed by wood wastes per year. [Truncated pyramid formula: H/3(area of base + area of top + square root of (A base Δ A top))]

Environmental Benefits

The environmental benefits attributable to wood waste utilization depend on the method of recovery. The major direct environmental benefits appear to be most noteworthy and quantifiable when wood waste is used to displace coal for electricity or steam generation. As shown in Table 2, wood has an almost negligible amount of sulfur. When wood is used to displace high sulfur bituminous coal, sulfur emissions can be reduced by more than 80%. Using wood waste frees up landfill space, contributes to sequestering of carbon, reduces carbon dioxide emissions from processing virgin material, and contributes to sustainable use of natural resources.

Environmental issues accompany the environmental benefits of recycling wood waste, especially demolition wood waste. For example, in the case of waterborne wood preservatives, there is a concern about chemical leaching (if the wood is used as mulch) or concentration in the ash (if the processed wood is used as boiler fuel). These environmental issues are currently being researched.

Natural Resource Benefits

Recovering and recycling wood from the waste stream result in the conservation of natural resources. For example, more than 1.9 billion (billion = 10^9) pallets are put into circulation each year in the United States; 50% of these pallets are designed for a single-use trip (WoodWins 2000). The pallet market is an important outlet for lumber mills that serve the high quality furniture industry. By developing new markets for wood waste, forest owners have more opportunities to offset the costs of sustainable forest management and improve the overall health of the forests. Seventy-one percent of the nation's productive forestland is privately owned; 84% of that is owned by 10 million non-industrial private owners (Smith and others 2001). Most non-industrial private owners do not have timber production as an objective, but they need some income to offset the cost of responsible forest management. Healthier, more productive non-industrial private forestland means fewer and less severe wildfires, which in turn benefits not only private landowners but also the public.

Table 2—Chemical analysis of wood waste[a]

Element	Amount by weight (%)
Carbon	41.20
Hydrogen	5.03
Oxygen	34.55
Nitrogen	0.24
Chlorine	0.09
Sulfur	0.07
Moisture	16.00
Ash	2.82

[a]Tillman 1991.

Case Study Overview

The case studies presented in this report are listed in Table 3. These studies represent a variety of approaches that have been successfully used for the recovery of urban wood waste. The studies include a description of each company, participants, benefits, type and quantity of wood waste processed, recovered products, economics, and contact for additional information. These case studies are testimony to the fact that wood waste can be successfully recovered from the waste stream in ways that are economical, benefit the environment, and conserve natural resources.

Table 3—Wood waste recovery case studies

Case study	Recovered wood product
Community Woodworks, Oakland, CA	Lumber and lumber products
Willard Brothers Woodcutters, Trenton, NJ	Lumber and lumber products
WoodWins, St. Paul, MN	High-end wood products
Orange Regional Landfill, Chapel Hill, NC	Salvage (metal, pallets, wood chips, items reused by public)
Rainier Wood Recyclers, Seattle, WA	Wood chips
Texas Department of Transportation Dallas, Abilene, Tyler, and Amarillo	Compost and mulch
Mid-Michigan Recycling, LLC, Flint, MI	Boiler fuel
Recovermat, Mid-Atlantic, LLC, Baltimore, MD	Alternative daily cover for landfills

Community Woodworks, Oakland, California

Product

Lumber and lumber products

Description

Community Woodworks is a custom mill house specializing in reclaimed and salvaged urban lumber. The mill is located on the Oakland Army Base. The bulk of the inventory is Douglas-fir that was reclaimed from deconstructed warehouses on the Oakland Army Base.

Community Woodworks offers a customized line of 100% reclaimed wood products. In addition to producing large quantities of flooring and paneling for resale, the mill offers custom milling and woodworking services, including furniture, doors, windows, cabinet face frames, countertops, molding, and trim.

Participants

Wood waste source:	Beyond Waste, C & K Salvage, individual contributions
Wood waste mill & woodshop:	Community Woodworks
Product buyers:	General public

Start Date

Community Woodworks was incorporated as a California public benefit nonprofit organization. The mill house was started in September 1998. Funding to establish Community Woodworks was provided by the Department of Health and Human Services, Job Opportunities for Low Income Individuals Program; the William and Flora Hewlett Foundation; and the U.S. Environmental Protection Agency, Region 9. Current support is provided by the East Bay Community Foundation, the Richard and Rhoda Goldman Fund, the Alameda County Homeless Collaborative, and the Alameda County Source Reduction and Recycling Board.

Benefits

Community Woodworks supports deconstruction enterprises that employ or train low-income individuals in building deconstruction and wood reuse.

Benefit	Quantity
Savings in landfill space	0.006 acres[a]
Employment of disadvantaged persons	Goal of 8% by end of 2001

[a]Assuming density of landfilled wood waste at 1,000 lb/cubic yard and landfill height of 50 ft.

Wood Waste

Only clean solid wood, excluding plywood, is processed; painted or treated wood is avoided. Community Woodworks purchases only from dedicated deconstructed job sites where the wood is carefully dismantled. Emphasis is placed on dimension lumber, from 2 by 4s through 2 by 10s.

Products

Building materials—paneling and siding, flooring, ready-to-assemble decking packages and custom doors, windows

Manufactured reclaimed wood products—outdoor furniture, such as picnic tables and benches, and custom furniture components

Raw lumber—without resurfacing, deconstruction lumber for use

Economics

Community Woodworks is nonprofit and subsidized because of the need for recycling and job training. Purchase price of materials varies depending on size, age, and level of processing needed, as well as supply and market price. The company manufactures value-added wood products because the price of recovered products is frequently less than that of green wood.

Contact

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Willard Brothers Woodcutters, Trenton, New Jersey

Product

Lumber and lumber products

Description

Willard Brothers Woodcutters is a sawmill/wood processing company in central New Jersey. Raw materials for this business are 100% urban tree removals provided by Shear Penn Corporation, the tree removal portion of the company. Willard Brothers Woodcutters produces a complete range of lumber product supplies for artisans, hobbyists, architects, and homeowners. Their kiln-dried, high quality lumber and molding product lines fit into a significant and high value market.

Utilization of urban tree removals is a result of the processing and marketing capability of this company. Firewood and mulch made from branchwood, log slabs, planer shavings, and trimmings create a complete picture of utilization of a resource that at one time was a significant disposal problem and costly. Willard Brothers Woodcutters now uses this resource to provide jobs and revenues for the company and products for societal needs.

Participants

Wood waste source:	Shear Penn Corporation
Wood waste processor:	Willard Brothers Woodcutters
Product buyers:	Artisans, hobbyists, architects, and homeowners

Start Date

Mr. Willard began Willard Brothers Woodcutters in 1974. At that time, the parent company was paying about $20,000/year to dispose of tree removals.

Benefits

The most direct benefit is landfill cost savings that accrue to Shear Penn Corporation since it no longer needs to dispose of tree removals in a landfill. Another key benefit is the recovery of rare types and pieces of wood, such as walnut, for use by artisans and hobbyists.

Benefit	Quantity[a]
Savings in landfill space	0.14 acres/year

[a]Assuming landfilled wood waste density of 1,000 lb/yd^3 and landfill height of 50 ft.

Recovered Products

Recovered products include usable lumber (produced from logs), firewood (from large topwood), mulch (from branches), and sawdust, which is sold to local horse owners for use as bedding.

Recovered product	Quantity (tons/year)
Usable lumber	150
Mulch	2,500
Firewood	1,250
Sawdust	333

Economics Both Shear Penn Corporation and Willard Brothers Woodcutters are private companies; therefore, little economic data are available. However, the fact that the wood recovery company has been in business for more than 15 years suggests the economic viability of their approach.

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WoodWins,
St. Paul, Minnesota

Product High-end wood products

Description The St. Paul Neighborhood Energy Consortium (NEC) started an innovative new business called WoodWins, which employs disadvantaged people and uses wood from pallets, crates, and other scrap wood to manufacture high-end products, such as planters, window boxes, and garden benches. The goals of this business are to increase the recovery and recycling of discarded wood and to provide jobs and job training opportunities in Minnesota.

Participants WoodWins is a business venture of the St. Paul Neighborhood Energy Consortium, a non-profit community organization. WoodWins depends on wood waste sources around the Twin Cities, including municipal yard waste programs and local industries.

Wood waste source:	Various places around Twin Cities
Wood waste processor:	WoodWins
Labor provider:	WoodWins and Midway Training Services
Product buyers:	Retail customers through garden centers, distributors, and direct sales

Start Date Pilot production began in summer 1999.

Benefits This project was developed in response to a critical waste problem. About 40% of the total domestic hardwood lumber production milled is made into pallets. In Minnesota alone, 2,720,000 pallets are disposed of each year (WoodWins 2002).

The NEC developed WoodWins to "help combat overflowing landfills, global warming, and the disastrous effects of deforestation." However, WoodWins goes beyond providing environmental benefits, by bringing the social benefits of economic development and job training to the community.

The NEC has formed alliances with organizations that provide job opportunities to people with developmental disabilities, as well as to economically disadvantaged residents. The unique partnerships formed by WoodWins provide a needed social service and address critical waste management and natural resource issues.

Benefit	Quantity
Savings in landfill space	0.014 acres/year[a]
Employment of disadvantaged persons	10 to 15 workers

[a]Assuming landfilled wood waste density of 1,000 lb/yd^3 and landfill height of 50 ft.

Wood Waste

Waste wood type	Quantity (ton/year)[a] 1999	2000
Urban demolition waste	30	60
Furniture plant residues	25	50
Spent pallets and crates	95	190
Total	150	300

[a]Projected for full year production

Recovered Products

Year	Recovered product—garden products (units)
1990	6,750
2000	10,250

Economics

As indicated in the following table, WoodWins relies heavily on grants to support its activities. However, it receives no revenue from the companies that supply the pallets and therefore avoids the costs associated with disposal. If WoodWins received $100/ton in avoided disposal costs, this would increase revenue by $30,000/year. Therefore, grant funds would still be required to support the continued operation of WoodWins.

Category	Cost/revenue ($)[a]
Annual revenue	
Grants	128,000
Product sales	106,466
Landfill tip fees	0
Subtotal	234,466
Annual cost	
Labor	55,283
Administration	98,000
Utilities	3,000
Facility rental	7,300
Other (e.g., equipment, advertising)	114,424
Subtotal	278,007

[a]Projected first full year.

Future Applications

WoodWins is currently expanding its product line. They are also creating manual detailing and replication opportunities in other communities.

Contact

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Orange Regional Landfill, Chapel Hill, North Carolina

Product

Salvage—metal, pallets, wood chips, items reused by public

Description

In December 1997, the Orange Regional Landfill of Chapel Hill began a salvage program at the construction and demolition waste area of the publicly owned landfill in Orange County, North Carolina.

Participants

The program is operated by one full-time staff member, who has a pick-up truck and a skid steer loader. Pallet Express of Greensboro buys the undamaged pallets for 50 cents each. Mixed scrap metal is sold to DH Griffin of Greensboro.
Salvaged reusable goods range from lumber and bricks to furniture and stuffed animals. These goods are generally donated to local schools and nonprofit organizations, including Habitat for Humanity, Vietnam Veterans of America, and a variety of smaller organizations from theater groups to high school shop classes.

Wood waste source:	Construction and demolition waste haulers
Construction and demolition processor:	Orange Regional Landfill
Scrap metal buyer:	DH Griffin
Salvagers of reusable goods:	Habitat for Humanity, Vietnam Veterans of America, other non-profit groups

Start Date

December 1997

Benefits

In fiscal year (FY) 1998/1999, a total of 465 tons of construction and demolition waste was diverted from the landfill. About 285 tons of construction and demolition waste was diverted in FY 1999/2000. The lower tonnage in FY 1999/2000 is attributed to lack of a staff person for 3.5 months. The success of the program relies on a staff person to actively direct the placement of materials as well as sort by hand. By taking a proactive approach, George Pierce, the current on-site staff member, increased the diversion level, from January to June 2001, close to the highest 6-month figures.

Benefit	Quantity[a]
Savings in landfill space	0.02 acre

[a]Assuming landfilled wood waste density of 1,000 lb/yd^3 and landfill height of 50 ft.

Recovered Products

Salvageable material recovered through this program is about half lumber and half fixtures, furniture, and other building materials. The latter includes significant quantities of wood pallets, wood furniture, and scrap lumber.

Recovered product	Quantity/year (ton)
Scrap metal	359.2
Pallets	38.4
Wood chips	2.9
Items reused by public	50.1

Economics

Program costs are covered from landfill tipping fees. A State grant from the North Carolina Division of Pollution Prevention and Environmental Assistance was used to pay $10,000 of the total cost of the skid steer loader. Annual program costs are approximately $36,000. Program revenue from the sale of scrap metals and pallets was about $4,500 for fiscal year 1998–1999. (The price received for scrap metal has ranged from $10 to $30 per ton, and used pallet revenues have typically been sold for $0.50 each.) Net program costs are about $31,500/year, which equates to $68/ton. When discounted by the landfill tipping fee of $38/ton for construction and demolition waste, the net cost of the recovery program is $30/ton.

To encourage source separation, reduced tipping fees are charged for clean lumber and yard waste ($12/ton); no tipping fee is charged for scrap metal. However, the full tipping fee of $38/ton is charged for pallets because of the high handling costs.

Future Applications

The county believes that the salvage program has the potential to divert more materials with additional labor, better markets for scrap wood, steeper differential fees for separated materials, and penalties for mixing recyclables with other wastes (e.g., corrugated cardboard). A pilot program is being set up to grind most of the wood waste into colored mulch for landscaping. This “decorative mulch” is best suited for large commercial needs, such as along roadway median strips. The mulch will be dyed with EPA-approved water-based, non-toxic dyes.

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Rainier Wood Recyclers, Seattle, Washington

Product Wood chips

Description Rainier Wood Recyclers currently operates two wood waste recycling yards in Washington, in Covington and Fall City. The Covington facility has been operating continuously for more than 10 years, the Fall City yard for more than 3 years.

Both facilities are designed to receive and process all kinds of wood wastes, with tipping fees dependant on the type of waste. Self-haul customers include 16 municipalities and 3 counties. All major private refuse haulers in the region utilize Rainier facilities, as do most major construction companies. In addition to providing wood processing services, Rainier Wood Recyclers began a wood waste collection and trucking service 3 years ago. Finally, the company offers a "processing for hire" service, through which the wood waste processing equipment is delivered to the customer and the wood waste is processed on site.

To process the wood wastes received at both facilities, the company owns five large primary grinders, each powered by 60-horsepower engines. These grinders are portable and are used at both the company's facilities and customer sites. Ancillary equipment includes large thumbed trackhoes, pickup and service trucks, loaders, water trucks, dozers, and screening plants. A unique feature of the Rainier service is that the air permits for its processing equipment are not site specific, but are valid anywhere within King, Pierce, Snohomish, and Thurston counties.

Participants Rainier Wood Recyclers is a private company that processes wood waste from yard waste programs operated by local governments in the Seattle metro area. Its sources of wood waste include 16 municipalities and 3 counties, in addition to construction and demolition companies and large waste haulers.

Wood waste source:	16 municipalities; 3 counties; large waste haulers; construction and demolition firms
Wood waste processor:	Rainier Wood Recyclers (3 permanent facilities; mobile on-site processing equipment)
Product buyers:	Landscapers, manufacturers of wood-based products

Start Date Rainier Wood Recyclers was incorporated in 1986.

Benefits This project has resulted in the diversion of approximately 180,000 tons of wood waste from landfill disposal per year.

Benefit	Quantity[a]
Savings in landfill space	12.75 acres/year

[a]Assuming landfilled wood waste density of 1,000 lb/yd^3 and landfill height of 50 ft.

Wood Waste

About 85% of wood waste processed by Rainier Wood Recyclers consists of nonrecoverable tree parts, such as non-marketable limbs and tree stumps. Rainier Wood Recyclers also processes new construction scrap, spent pallets and crates, furniture plant residues, demolition wood waste, and wood waste from new construction activities.

Recovered Products

Ranier Wood Recyclers produces wood chips from wood waste, which can be used for manufacturing of wood-based products or as a mulch or boiler fuel.

Recovered product	Description
Manufacturing, furnish products	Sized wood chips used in manufacture of particleboard or low-grade paper pulps
Landscape products	Mulches, arena chips, and wood chips for temporary road and erosion control
Boiler fuel (hog fuel)	Low-grade wood chip residual for boiler fuel

Economics

The tipping fees charged for land-clearing debris, brush waste, and urban wood waste are set lower than those that would be charged for the same materials at local landfills. (For reference, the tipping fee charged for yard waste at the King County Cedar Hills landfill is $75/ton.) The revenue from tipping fees, along with revenue from the sale of wood chips, is enough to offset collection, processing, and transportation costs associated with producing wood chips.

Future Applications

Future applications may include providing wood for manufacturing recycled plastic and wood-based products.

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Texas Department of Transportation, Dallas, Abilene, Tyler, and Amarillo

Product Compost and mulch

Description As the result of a partnership of the Texas Department of Transportation (TxDOT), Texas Natural Resources Conservation Commission (TNRCC), and Texas State Soil and Water Conservation Board, compost was applied to roadways in Texas as a part of TxDOT's emphasis on the use of recycled products. Unlike similar demonstration projects, the demonstrations were conducted with compost from cow manure.

A key feature of these demonstration projects is the significant market for wood waste that could develop as a result. Wood chips and manure are blended at a ratio of three parts manure to one part chips. The wood chips act as a bulking agent in the composting process, providing surfaces upon which active microorganisms complete the composting process. The composting reaction gives off heat sufficient to destroy pathogenic bacteria in the manure. The resulting compost consists of long organic polymers with the consistency of humus. After the compost is completed, large chips are screened for re-use and smaller chips are left in the mix. The resulting compost mixture significantly reduces water and wind erosion.

The use of compost along roadways has been demonstrated in the Dallas, Abilene, Tyler, and Amarillo districts of TxDOT, often with remarkable results. In one case, TxDOT went through five unsuccessful attempts to establish vegetation on a steep, severely eroded overpass near Big Springs. The site is in a low rainfall area and had been barren since 1968. Compost was applied, and 1 month later grass was thriving on the site.

The use of compost along roadways is not a new concept. A 1997 document lists 17 states that had demonstrated the use of compost and had developed specifications for its use to establish vegetation or otherwise beautify roadways and right-of-ways (Mitchell 1997). However, not all states allow the use of compost made from manure. Some limit the use of compost to that made from composting yard debris and other organic material, in the belief that such compost has a low risk of containing pathogens.

Compost is applied to the soil surface as a top dressing as well as applied and tilled into the soil. Applications range from 1/2 to 2 in. deep, with most studies showing that the maximum benefit of compost occurs at a depth of 1 in.

The success of the Texas demonstration projects led to the development of statewide TxDOT Special Specification Item 1027, Furnishing and Placing Compost (Texas Department of Transportation 1999). The Texas specification, like its counterpart in other states, sets minimum requirements for the quality of material and construction methods. The specification will make it easier to develop the statewide use of compost.

Participants Participants in this demonstration project include the Texas Department of Transportation (TxDOT), the Texas Natural Resource Conservation Commission (TNRCC), and the Texas State Soil and Water Conservation Board. Manure for composting is supplied by Texas dairy farmers, and wood chips are supplied through local government yard waste programs.

Demonstration project sponsors:	Texas Department of Transportation Texas Natural Resource Conservation Commission Texas State Soil and Water Conservation Board
Compost supplier:	Texas dairy farmers
Wood chips suppliers:	Local governments
Compost/wood chip users:	State highway construction contractors

Start Date This demonstration project started in 1999.

Benefits TxDOT officials cite a three-fold benefit of using composted manure:

- Compost protects the often-fragile soils along roadways.
- The use of compost strengthens the market for wood chips produced from urban wood waste recycling programs. Wood chips serve as a bulking agent for compost and mulch for eroded soil.
- The use of compost helps manage the surplus of manure in some locations.
- TxDOT recognizes the value of composted chicken litter as well as cow manure and notes that the finished product meets strict EPA standards for Class A biosolids (Bishop 1999).

Wood Waste Various wood wastes collected through municipal wood waste recycling programs are used in the Texas demonstration projects. The primary constituents of urban wood waste are used lumber, trim, shipping pallets, trees, branches, and other wood debris from construction and demolition clearing and grubbing activities.

Wood chips and manure are blended at a ratio of three parts compost to one part wood chips. The resulting compost is coarse screened; the mixture of small chips and compost reduces water and wind erosion of compost and topsoil.

Economics Current TxDOT policy provides an economic incentive for the rapid establishment of vegetation in disturbed areas. Compost has been demonstrated to be a viable option for successfully completing the vegetation process. One demonstration reported in Texas showed the cost of a compost-based treatment as $17,000 compared with an estimated $30,000 for the traditional treatment of topsoil, seeding, and an erosion control blanket (Block 2000). Cost savings would be reduced when additional thickness of compost is used, but the thickness used to compute the $17,000 cost was not given.

From the viewpoint of a livestock producer, the composting process makes economic sense. A study at Texas A&M–Commerce for a 400-cow dairy showed composting the manure could yield an annual net income of approximately $20,000. Composting was done in an in-vessel composter at a cost of approximately $11/yd^3 at the site. Texas A&M–Commerce estimated the value of the finished compost as $20/yd^3. One of the weakest links in the manure composting effort has been the development of markets where the value of the compost can be realized, so these profits must be considered to be potential.

Future Applications The use of compost for highway vegetation establishment and beautification would create markets in areas where a market does not currently exist. Region 6 of the EPA is encouraging the use of composted cow manure through funding of a section 319 grant. Contractors using compost made from cow manure from the Bosque Watershed (Erath County, Texas) will receive a payment per cubic yard of compost used. The 319 grant is provided as an incentive to use manure from an area where manure is in excess, thus developing the market potential.

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Mid-Michigan Recycling, LLC, Flint, Michigan

Product Boiler fuel

Description Each year, about 200,000 tons of urban and other wood wastes are recovered by Mid-Michigan Recycling, LLC, for combustion at the Genesee Power Station in Flint.

Mid-Michigan Recycling was created in 1994 for the sole purpose of providing boiler-ready wood fuel to the Genesee Power Station. Since the Power Station started burning wood in 1995, Mid-Michigan Recycling has supplied the following quantities of wood waste to the Genesee Power Station:

Year	Wood waste supplied to Genesee Power Station (ton)
1995	71,700
1996	95,000
1997	125,000
1998	150,000
1999	197,000
Total	638,700

Participants Sources of wood waste include wood waste recycling yards, municipal yard waste processing sites, and industries in the metropolitan area of Detroit. Mid-Michigan Recycling uses a portable grinder to process wood wastes at these locations. The resulting fuel is then combusted at the Genesee Power Plant to generate electricity.

Wood waste source:	Wood waste recycling yards, municipal yard waste processing sites, and industries
Wood waste processor:	Mid-Michigan Recycling, LLC
Purchaser of wood chips for boiler-ready fuel for electricity:	Genesee Power Station, L.P.

Start Date Mid-Michigan Recycling, LLC, was founded in February 1994. Genesee Power Station began burning wood waste in 1995.

Benefits Project benefits include the displacement of a non-renewable energy resource (coal) with a renewable and less polluting energy resource that would otherwise be landfilled (as wood waste). Each year more than 100,000 tons of coal is displaced through the combustion of wood chips from wood wastes. At the same time, about 200,000 tons/year of wood waste is not landfilled, resulting in landfill space savings of about 1.13 acres/year.

Because wood is a low sulfur fuel, it is estimated that more than 2,000 tons of sulfur dioxide emissions are reduced through this project every year. Greenhouse gasses—about 16,000 metric tons of carbon equivalents—are also reduced.

Benefit	Quantity/year
Displacement of non-renewable fossil fuels	108,000 tons coal[a]
Reduction in waste landfilled	200,000 tons[b]
Savings in landfill space	1.13 acres[c]
Reduction in air emissions	
Sulfur dioxide (SO_2) emissions	2,100 tons[c]
Greenhouse gases (MTCE reductions)	16,000 MTCE[d]

[a]Assumes displacement of anthracite coal at 13,500 Btu/lb with wood waste at 7,300 Btu/lb.

[b]Assumes landfilled wood waste density of 1,000 lb/yd^3 and landfill height of 50 ft.

[c]Assumes sulfur content of wood waste is 0.07% by weight and that no acid gas emissions from wood waste are controlled. Assumes 40 lb SO_2 reduced per ton of bituminous coal displaced through wood waste combustion.

[d]Metric ton of carbon equivalent (MTCE) reduction of greenhouse gasses based on following assumptions: (1) 0.32 tons of CO_2 (fossil) reduction per ton of wood waste combusted (2) 0.25 MTCE per ton of CO_2 reduction.

Wood Waste

Mid-Michigan Recycling uses a variety of wood waste types to produce boiler fuel, including new construction scrap, particle board trimmings from furniture plants, used pallets and crates, and unmarketable tree parts from land-clearing operations.

Waste wood type	Description
New construction scrap	Lumber end pieces, panel trim
Furniture plant residues	Primarily particleboard trimmings
Industrial wood	Spent pallets and crates
Land-clearing debris	Unmarketable trees from land clearing (whole trees, tops and limbs, stumps)

Recovered Products

Wood waste is processed through tub grinders at waste wood recycling yards, municipal sites, and industrial sites. Approximately 200,000 tons/year of boiler fuel is recovered.

Economics

Mid-Michigan Recycling has a 35-year contract to supply all of Genesee Power's wood fuel needs. This unique contract has a complex formula that protects Genesee Power from excessive fuel cost while providing a mechanism to maximize up to 20% return on equity to Mid-Michigan Recycling. Incentives are in place to drive the cost per bone dry ton (BDT) to the smallest number possible. Mid-Michigan does not pay for the wood waste from the respective providers, yet it charges those providers for transportation costs involved in processing and removing their wood wastes.

Future Applications

Future applications may include the screening of stump grindings to produce a topsoil amendment.

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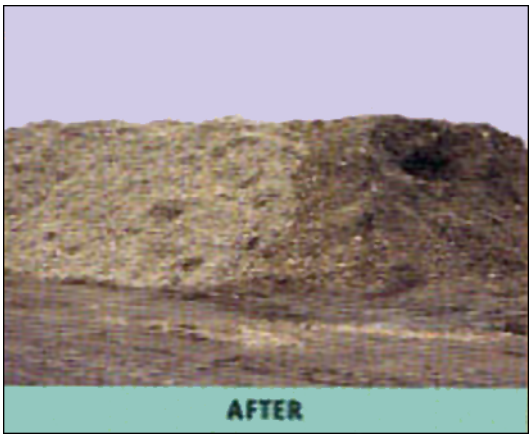
Recovermat Mid-Atlantic, LLC, Baltimore, Maryland

Product Alternative daily cover for landfills

Description In September 1996, Recovermat Mid-Atlantic LLC opened for business, processing construction and demolition waste to produce an alternative daily cover for use at municipal and industrial waste landfills.

Participants Recovermat Mid-Atlantic LLC is a private company in Baltimore and is a licensee of Recovermat Technologies, LLC. The Recovermat process is trademarked and patented. Recovermat LLC processes construction and demolition waste that is brought to its facility by private haulers. Ferrous metals recovered during the processing operation are sold for scrap. The Recovermat alternative daily cover is given away to regional municipal solid waste and industrial landfills.



Wood waste providers:	Construction and demolition haulers
Construction and demolition processor:	Recovermat Mid-Atlantic LLC
Users of Recovermat alternative daily cover:	Municipal and industrial landfill owners and operators

Start Date September 1996

Recovered Products The Recovermat is given away as an alternative daily landfill cover. Many landfills, including those that dispose of municipal and industrial waste, are required to cover waste at the end of each day with 6 in. of soil. The purpose of this daily cover is to control blowing litter, scavenging, fires, odors, nuisance animals, and disease vectors such as flies. Several states have approved the use of alternative daily cover, which can reduce the use of cover soil at a landfill. Alternative daily cover provides the dual benefit of saving landfill airspace (because less than 6 in. of cover material is typically required) and saving soil costs (especially if cover soil has to be imported from off site). The Recovermat alternative daily cover material is produced from processing construction and demolition waste. It has been used on 15 municipal and industrial landfills in 6 states.

Economics Major sources of revenue for this company are the tipping fees charged to construction and demolition haulers and revenue from the sale of recovered ferrous metals. Recovermat LLC is making a profit, even though no fees are charged for the alternative daily cover that is produced.

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Conclusions

Based on the case studies presented in this report, the following conclusions are offered with respect to wood waste recovery from the municipal solid waste stream.

- Although estimates vary, wood waste represents a major portion of the municipal solid waste stream, especially if construction and demolition wastes are included.

- A large volume of wood waste is still being landfilled. In 1998, more than 160 million tons of wood waste was generated, with about 30 million tons suitable for additional recovery.

- The majority of wood waste recovery programs are targeting low-end markets, which pay the equivalent of $0.25 for a recovered wood pallet. The higher end markets pay 20 to 32 times as much for an equivalent amount of wood. Although these higher markets increase processing costs substantially, they are worth pursuing for at least a portion of the urban wood waste stream.

- Environmental and natural resource conservation benefits need to be documented and quantified. These benefits are rarely documented and almost never quantified. Environmental benefits include sequestration of renewal carbon, reduced carbon dioxide and sulfur emissions when used in co-firing with coal, conservation of landfill space, conservation of natural resources, and production of biodegradable erosion control material.

- Although most environmental effects of wood waste recovery are generally positive, certain environmental issues require additional investigation. One issue is the environmental effect of recycling or combusting preservative-treated wood.

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