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# Implementing a Food Waste to Compost Program at the University of Arkansas: An Economic Feasibility Analysis

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# IMPLEMENTING A FOOD WASTE TO COMPOST PROGRAM AT THE UNIVERSITY OF ARKANSAS: AN ECONOMIC FEASIBILITY ANALYSIS

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## Abstract

*The University of Arkansas Fayetteville (UAF) is actively pursuing ways to increase sustainability on campus. Through the establishment of the Sustainability Council and campus centers, multiple projects are attempting to reduce the carbon footprint at UAF. One particular study is designed to eliminate food waste on campus through composting. The purpose of this study was to evaluate and project the economic savings of implementing a food waste composting system using Earth Tubs. Earth Tubs are an in-vessel electrical composting system capable of diverting up to 150 pounds of organic material daily with minimal odor. Results suggest that composting food waste from one dining hall only over the 15-year life of the project will likely result in an overall increase in food waste disposal costs. However composting waste from all three resident dining halls will likely reduce food waste costs for UAF over the life of the project.*

## Introduction

In February of 2007, the University of Arkansas Fayetteville (UAF) signed the American Colleges and Universities Presidents' Climate Commitment Plan (University of Arkansas, 2007). As part of this plan, the University Sustainability Council has actively searched for ways to reduce the negative environmental impact of the campus. Many efforts have been made in pursuing this goal, and managing food waste has been one suggested area of improvement.

As far back as can be verified, all food waste generated by the UAF dining facilities has been sent to landfills. This contributes to two types of negative externalities. An externality is a spillover effect that extends to a third party outside of the market, in this case UAF. Negative externalities generate costs to a third party or society (Callan and Thomas, 2007). First, the transportation of wastes to a landfill creates carbon dioxide emissions. Second, methane is generated when the food decomposes in the landfill. Methane is a by-product of microbial activity released when food waste breaks down (Lundie and Peters, 2005). One way to reduce the occurrence of these negative externalities is to implement an onsite-composting program for dining facilities' food waste. However, research related to the costs and benefits of this alternative waste disposal system is needed in order to consider a change of practice across campus. The purpose of this study was to provide an assessment of the economic costs and benefits associated with the current food waste disposal program on the UAF campus as compared to those of an on-site composting system.

## Background

### *A Student-Led Feasibility Study – Earth Tubs for Composting*

In Fall 2008, a team of UAF students conducted an initial feasibility study for composting pre-consumer food waste from the UAF dining halls. This study consisted of research into similar institutions and their food waste diversion efforts and determination of the most environmentally and economically sound method of food waste diversion for UAF. Several different options were explored, and it was determined that "Earth Tubs" provided one low-cost means of composting food waste on our campus. With student assistance at the conclusion of this study, the low cost purchase of two "Earth Tubs" to be used to implement this program was secured.

Earth Tubs are large self-contained, electrically powered composting tools (Green Mountain Technologies, 2006). Each Earth Tub has the potential of diverting 150 pounds of organic material daily with minimal odor (Green Mountain Technologies, 2006). Earth Tubs are 3 cubic yards in volume and have an electrically powered auger motor in the middle that moves throughout the tub to turn the compost and allow proper aeration. The tubs contain a bio-filter (Figure 1) to filter exhaust and liquid leachate (liquid run-off from the food waste in the tubs) from the Earth Tubs. The bio-filter contains dry organic matter and is used to control odor (Arnold, 2010).

To determine the optimal food waste diversion method for the UAF, composting initiatives at other universities were studied. Several other peer (in size) institutions such as University of California Santa Cruz (Grobe, 2001), University of Montana (DeLuca, 2004), and University of Oregon (Sims, 2004) have successfully implemented Earth Tub composting systems.

The University of North Carolina at Charlotte (UNC-C) is a campus of over 26,000 students. Earth Tubs have been in use there since 1999 using the same model of Earth Tubs as UAF. This operation was visited in the Fall of 2010 to observe operations and management logistics. At the highest volume, their Earth Tubs were able to accept 300 pounds of food waste per day (Arnold, 2010). To compost more efficiently with an uninterrupted stream of food waste, it is necessary to have two Earth Tubs, so the food waste can be rotated between the tubs. At 300 pounds per day, the Earth Tubs operate on an 18-21 day cycle with 9-10 days of filling Earth Tub A followed by 9-10 days of filling Earth Tub B while Earth Tub A "cures." It was determined that the UAF Earth Tubs would be able to operate on a similar cycle since the models were identical.

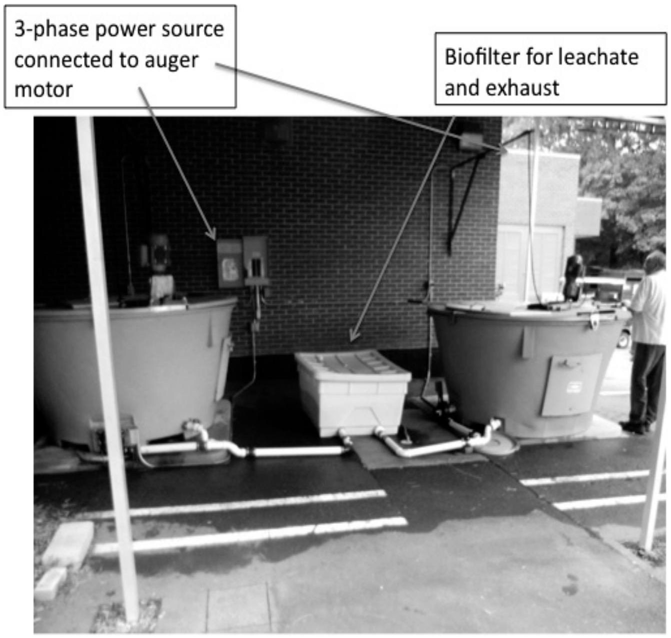


**Figure 1**: Earth Tub operation at UNC-C. October 2010.

***Current Food Waste to Compost Pilot Project***

After the Fall 2008 study, the various stakeholders – Chartwells, Facilities Management and the Division of Agriculture – met to discuss logistics, responsibilities and timelines for implementation of a pilot project using Earth Tubs for composting. Many challenges arose including 1) identification of Earth Tub installation location, 2) transportation of food waste to compost vessels, 3) labor to dedicate to the project, and 4) adequate funds to cover costs of project start up. Most challenges were overcome with the exception of funding. Without adequate financial support, the project stalled. In the Summer 2010, after active fundraising efforts, funds were collected from the Associated Student Government Executive Budget, the Associated Student Government Senate, the Residents' Interhall Congress Senate, the Office of Student Affairs, Facilities Management, the Office of the Provost, and the UA Division of Agriculture. Financial support from student-supported groups totaled over $10,000; all funds collected totaled over $16,000.

The current food waste to compost project entails the collection of food waste from the largest dining hall on campus, the Northwest Quad (NWQ). The UAF Campus has coordinated composting efforts through several organizations on campus including Chartwells Dining Services, Facilities Management, and the UA Division of Agriculture. The project began in April 2011 as a pilot study to identify the operating efficiency of working with the Earth Tubs, including transportation, the input ratio of food waste to dry carbonaceous material, and the demonstrated need of the end compost result as a soil amendment. If the pilot project is economically efficient, food waste from the two other dining facilities on campus (Brough Commons and Pomfret Dining Hall) will be included.

These three facilities produce approximately 95% of campus food waste (Chartwells, 2011). Of that quantity, approximately 90% is post-consumer food waste. Post-consumer food waste is defined as all waste that has been served to a customer, but not consumed (Arnold, 2010). The remainder of food waste is pre-consumer, mostly kitchen preparation waste such as potato peelings, lettuce clippings, etc. (Zemke, 2008). Pre-consumer food waste has not been served to customers.

The majority of institutions with an Earth Tub Composting system install Earth Tubs on food service sites. However, due to space restrictions, Earth Tubs at the UAF have been installed at the UA Division of Agriculture, about 1.5 miles north of the main campus. At the start of the pilot project, pre and post-consumer food waste is being collected from the Northwest Quad Cafeteria only by Chartwells staff and is placed in sealed 5 gallon buckets.

This food waste is taken from the Northwest Quad 3 days a week to the Farm, the UA Division of Agriculture Research Facility on Highway 112 (approximately 1 mile north of UAF Campus) (Brown, 2011). The estimated mileage spent per week in this activity is 30 miles (Brown, 2011). At the Farm, the Composting Coordinator (20 hours per week position) is responsible for mixing the food waste with the dry carbonaceous material (initially, sawdust from the School of Architecture) and collecting input-data to determine the optimal ratio of food waste to dry carbonaceous material (FW: DCM). Once the appropriate composting technique is identified, it is expected that pre and post-consumer food waste will be collected from all three dining halls: Pomfret Dining Hall, Northwest Quad Cafeteria, and Brough Commons.

While this current project focuses on waste from campus dining halls, there is other food waste production on campus at Greek houses, the Arkansas Student Union, athletic events, and other events catered by Chartwells. Earth Tubs are merely a starting point for developing a sustainable composting system for all food waste, because coordinating the logistics of food waste transport with these other entities has not yet been arranged. The ultimate goal of the UAF is to become a zero-waste institution. This would be consistent with the American Colleges and Universities Presidents' Climate Commitment Plan, which requires the diversion of 100% of food waste.

**Cost-Benefit Analysis**

Cost benefit analysis (CBA) is a tool that is used to evaluate benefits and costs to a society, in this case, UAF as a whole (Callan and Thomas, 2007). The United States federal water agencies, principally the Bureau of Land Reclamation and the U.S. Army Corps of Engineers, were among the first to make use of CBA in water-related projects. The Federal Interagency River Basin Committee produced the first guide to CBA in 1936 with the Flood Control Act, describing the costs and benefits related to flood control projects (Hanley & Spash, 1993). In 1952, a similar document was produced with the aim of replacing the Flood Control Act called Budget Circular A-47. These two publications were the first documents inspiring academic interest in developing CBA for projects suggesting environmental improvement (Eckstein, 1958). In 1981, Presidential Executive Order 12291 was devised; it explicitly required the application of CBA to all new environmental regulations in the U.S. (Hanley and Spash, 1993). CBA can capture and express in a single dimension (monetary units) many, but never all, of the effects of environmental projects (Johanesson, 1993).

A full CBA would include both explicit (monetary) and implicit (non-monetary) costs and benefits (Callan & Thomas, 2007; Field, 1997). Explicit, or market value, costs and benefits are those to which a monetary value can be assigned. An example of typical explicit costs associated with a food waste to compost system could include installation of an in-vessel composting unit. An example of a typical explicit benefit could be cost savings incurred from landfill tipping fee avoidance. Implicit costs and benefits are both difficult to fully identify and to place into monetary terms. Examples of implicit benefits and costs respectively include the reduction in carbon and methane emissions achieved by diverting food waste from the landfill and the reduced convenience for dining hall staff. In CBA, a discount rate is used to place all costs into their present value so that total costs of each program can be compared. The discount rate was determined based on projects of similar nature. The present value formula is expressed as:

$$NPV = \sum_{t=1}^{T} PVB - PVC \qquad [1]$$

$$PVB = \sum_{t=1}^{T} \frac{B_t}{(1+r)^t} \qquad [2]$$

$$PVC = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} \qquad [3]$$

where NPV is present value of net benefits, t=1 to T represents the time period, PVB is present value of benefits, B is total benefits, PVC is present value of costs, C is the total costs, and r is the discount rate.

In order to evaluate the true costs and benefits of this project, the Marginal Social Cost (MSC) and Marginal Social Benefits (MSB) must be evaluated as:

$$MSC = MPC + MEC \qquad [4]$$

$$MSB = MPB + MEB \qquad [5]$$

where MPC is marginal private costs, MEC is marginal external (or externality) costs, MPB is the marginal private benefits, and MEB is the marginal external benefit. Often, explicit benefits and costs are captured through marginal private benefits and marginal private costs, respectively. Implicit costs and benefits are usually captured through the marginal external costs and marginal external benefits, respectively. In the case of analyzing the economic feasibility of implementing Earth Tubs, a CBA of the explicit, or market value costs and benefits, is simpler to devise than the non-market values. If implicit costs and benefits cannot be measured economically, they must at least be acknowledged and some estimation of the value can be useful in determining overall whether or not total benefits (explicit and implicit) outweigh the total costs of the project. The benefits of the earth tub project will outweigh the costs if the following statements hold true:

$NPV \geq 0$ or [6]

$PVB/PBC \geq 1$ [7]

An interactive spreadsheet (Rice University, 1998) was also used in the calculation of the CBA. The workbook divides the costs and benefits of the composting program into four categories: 1) Start-up Costs - one time costs associated with the acquisition and installation of the Earth Tubs); 2) Recurring Costs - costs to operate and maintain the Earth Tubs over time; 3) One-time Benefits – one time savings associated with the Earth Tubs; and 4) Recurring Benefits – labor, waste disposal and other costs that are avoided annually due to Earth Tub activities. The workbook also shows the mechanics of the Net Present Value Calculation considering these categories, which is useful in estimating value of the project over the expected life of the Earth Tubs.

## Methods

### *Cost-Benefit Analysis*

The first step in this project was to perform a cost benefit analysis. The following assumptions were made to conduct the analysis:

1) As Earth Tubs are expected to last 15 years, the projected life of the project is from 2011to 2026 (Arnold, 2010).
2) Earth Tubs are assumed to be operational for 42 weeks of the year based on peak student presence on campus (Harrel, 2011).
3) The amount of food waste generated remains steady across the 15-year period. While student numbers are expected to increase, efficiencies in food waste management are expected to improve as well.
4) Two scenarios were considered. In the first, the total amount of estimated food waste from the three dining halls – 250,000 pounds annually – is assumed to be composted. In the second, only 100,000 pounds annually is composted, as this is the maximum amount that can be composted without a permit from the state (Brown, 2011).
5) Many of the operational costs will not vary by pounds of food waste diverted (e.g., energy is still needed to operate the earth tubs and labor is still needed to transport food waste and operate the tubs, regardless of how much is composted). Therefore, most costs (with the exception of mileage traveled due to additional pickups) are assumed constant across both food waste input rates (scenarios one and two). These constant costs represent a small percentage of overall costs of the project.

In the CBA, all costs and benefits are compiled and divided into market values and non-market values. Not only does disposal of the waste via landfills add costs to UAF, it also results in a missed opportunity for grounds management. The UAF campus spans 345 acres in Fayetteville including the University of Arkansas Agriculture Experiment Station. These grounds constitute an ongoing need for compost and fertilizer for seasonal landscaping and agricultural research plots. The compost produced by the Earth Tubs is expected to be used primarily by researchers on the Arkansas Agriculture Experiment Station.

***Costs: Market Value***

Full market value costs for implementing the Earth Tubs can be divided into four subsections: initial installation, operations/maintenance logistics, compost curing, and transportation of compost to final destination. *Initial installation costs* include the procurement of the Earth Tubs and their installation (labor, water/sewer utility access, electricity access) in their final location. *Operations/maintenance costs* include 20 hours/week labor and electricity costs. *Compost curing costs* include transportation of compost from Earth Tubs to covered curing location (6 month curing period), labor for turning of compost with shovel at 3-month period, and testing of compost before final use. Finally, *transportation of compost to final use location costs* include transportation of compost from curing location to final use location (either on UAF campus or to UA Farm research plots).

Because the plot of land used for the Earth Tubs was so small in size compared to the entire UA Farm space, the opportunity costs of this land area were not considered in this study. Identification of all costs was acquired from various departments of Facilities Management, Chartwells Food Service, and Environmental Sciences professors.

***Costs: Non-Market Value***

The only non-market value cost associated with this project is a reduced convenience for dining hall staff imposed by the new protocols for disposing of food waste. Disposing of food waste via landfill is much more convenient for dining hall and waste management teams.

***Benefits: Market Value***

The addition of full market value benefits includes cost savings from reduced landfill tipping fees and reduced compost purchases for UAF Grounds. While other studies cite some labor savings, this is not expected for the compost project. Any labor savings in waste disposal, for example, are expected to be offset in labor needed (if any) to divert food waste to the bucket containers. The quantity of compost and water saved as well as the dollar value of all benefits was acquired from the involved stakeholders, including Chartwells, UAF Facilities Management and UAF Grounds Management. Chartwells' estimates of annual food waste were used for 2011-2026 (Zemke, 2011). Average landfill tipping fees for 2005-2010 were combined with food waste projections to estimate in part future tipping fees. These and all costs were inflated annually using a five-year average inflation rate of 2.11% (Bureau of Labor Statistics, 2010). A discount rate of 5% was also assigned based on previous studies (Rice University, 1998).

***Benefits: Non-Market Value***

The general environmental benefits include reduced carbon emissions and methane emissions generated by diverting food waste to the landfill. The non-market values were not projected explicitly in this study. However, these benefits are discussed qualitatively in the CBA.

After the two CBAs were conducted, sensitivity analyses were run to determine: 1) the year in which a permit must be acquired (if any) to compost all food waste such that the NPV of the project is positive; and 2) the allowable cost of the permit process over the life of the project that would allow maximum benefits of a composting project.

**Results of Cost-Benefit Analysis**

This section presents the results of the cost benefit analyses under the two scenarios. Scenario one assumes 250,000 pounds of food waste are composted annually. Scenario two assumes only 100,000 pounds of food waste are composted while the rest is land filled, as this is the plan for the first year of the project.

***Start-Up Costs***

The start-up costs for this project included procurement, electrical installation, site preparation, and plumbing (Table 1). Labor costs were factored into these categories, but due to accounting methods practiced by Facilities Management, it was not possible to break them out individually (Conroy, 2011). Procurement costs included the purchase and transportation of the Earth Tubs to their location at the Farm as well the architectural design fee for the concrete slab and electrical connections. Total start-up costs were $4,430. Electrical installation included installing the electrical connects and locating fees for a total of $7,146. Site preparation costs of $9,076 consisted of dirt and concrete work at the site of the Earth Tubs. While the CBA spreadsheet allows for water sourcing costs, water source was already present at this site and therefore there were no additional water sourcing costs associated with this activity. Plumbing costs of $6,213 included location, materials and sanitary sewer installation. Start-up costs totaled $26,867 (Table 1). Because these start up costs are not related to food waste amounts, they are the same for both scenarios.

**Table 1:** Start-up costs for both scenarios one and two.

| Start-Up Costs | | Monetary | | Notes |
|---|---|---|---|---|
| Earth Tubs | | | | |
| | Total Cost for 2 Earth Tubs | $3000.00 | | |
| | Procurement | $953.51 | | |
| | Design | $477.09 | | |
| | Total | | $4,430.60 | |
| Electrical Installation | | | | |
| | Locator | $274.11 | | |
| | Electrical Service | $6,871.94 | | |
| | Total | | $7,146.05 | |
| Site Preparation | | | | |
| | Dirtwork | $4,163.49 | | |
| | Concrete work | $4,913.32 | | |
| | Misc. | - | | |
| | Total | | $9,076.81 | |
| Water Source | Cost of water source | $0.00 | | |
| | # of sources needed | $0.00 | | |
| | Total | | $0.00 | already present |
| Plumbing | | | | |
| | Locator | $223.28 | | |
| | Materials | $2,505.34 | | |
| | Sanitary Sewer | $3,485.09 | | |
| | Total | | $6,213.71 | |
| Total | | | $26,867.17 | |

### *Operational Costs*

The annual operational costs (Table 2) for this project include the electricity costs and maintenance labor. Electricity is needed to run the auger and the blower. Based on Facilities Management and University of North Carolina at Charlotte estimates, annual electricity usage over the 42 active weeks is approximately 374 kwh for a cost of $22. Labor costs were calculated at 20 hours a week for 42 weeks ($6720). In scenario one, transportation costs totaled $25 per year. However with the reduced food waste collection for scenario two, transportation costs fall to $12 per year. Total operational costs are $6768 for scenario one and $6755 for scenario two. Combining start up costs and operational costs, the total estimated costs of this project in year one are $33,609 for scenario two and $33,622 for scenario one.

**Table 2:** Operational costs for both scenarios one and two, respectively.

| Operational Costs | | Scenario One | Scenario Two |
|---|---|---|---|
| Electricity | | | |
| | Auger consumption (kwh) | $134.19 | $134.19 |
| | Blower consumption (kwh) | $239.90 | $239.90 |
| | Total consumption (kwh) | $374.09 | $374.09 |
| | Cost per kwh | $0.06 | $0.06 |
| | **Total** | $22.45 | $22.45 |
| Maintenance | Labor 20 hours/week | $6,720.00 | $6,720.00 |
| | Mileage for pickup | $25.20 | $12.60 |
| | **Total** | $6,767.65 | $6,755.05 |

### *One-Time Benefits*

No benefits were deemed reasonable for the UAF campus. In some cases, it is possible that the pulper/disposal in the dining halls could experience reduced usage or be discontinued (Table 3). However, in this case, the pulpers will stay in use to reduce the amount of moisture in the waste before it is moved to the Earth Tubs. This will help to ensure a more efficient composting process.

**Table 3:** One time benefits for both scenarios one and two.

| One-Time Benefits | | Monetary | Notes |
|---|---|---|---|
| **Pulper Displacement** | | | Pulper will not be displaced; will continue use, so no benefit |
| | # of pulpers | $0.00 | |
| | Cost of pulpers | $0.00 | |
| | Tubs needed per pulper | $0.00 | |
| | **Total** | $0.00 | |

### *Recurring Benefits*

The annual recurring benefits for this project include the cost-savings from avoiding the purchase of imported compost.

**Table 4**: Recurring benefits for scenarios one and two, respectively.

| Recurring Benefits | | Scenario One | Scenario Two |
|---|---|---|---|
| Compost Value | | | |
| | Pounds of food waste and bulking agent | 333,333 | 133,333 |
| | Pounds of compost generated | 200,000 | 80,000 |
| | Tons of compost generated | 100 | 40 |
| | Cubic yards produced | 133 | 53 |
| | Price per cubic yard | $1.00 | $1.00 |
| | **Total** | $133.00 | $53.00 |
| Labor Saved | | | |
| | Food transport time | - | - |
| | Yard waste transport time | - | - |
| | Hours/week | - | - |
| | **Total** | - | - |
| Kitchen efficiencies | | | |
| | Labor saved with tubs | - | - |
| | **Total** | - | - |
| Plumbing cost avoidance | | | |
| | Monthly plumbing cost | - | - |
| | Average pipe breaks/year | - | - |
| | Average cost/pipe break | - | - |
| | % reduction due to composting | - | - |
| | **Total** | - | - |
| Dispose-all displacement | | | |
| | Cost per dispose-all | - | - |
| | Lifespan (years) | - | - |
| | **Total** | - | - |
| Disposal fees | | | |
| | Tons of food waste diverted | 125 | 50 |
| | Landfill cost/ton of food waste | $81.53 | $81.53 |
| | **Total** | $10,191.00 | $4,077 |
| **Total** | | $10,324 | $4,130 |

UAF receives its compost at very low cost from the City of Fayetteville, charged by cubic yard. Assuming UAF would collect as much compost as is generated by the Earth Tubs in one year, this fee would amount to $133 per year for scenario one and $53 for scenario two. The other benefit is the avoidance of landfill tipping fees of $10,091 for scenario one and $4,077 for scenario two based on an $81 per ton charge to institutions for food waste disposal (Wilkins, 2011). Other potential recurring benefits that are not relevant to UAF may include utility savings in dining halls and labor savings in waste management crews. As the program expands, these can be reevaluated in the future. The total benefits in the first year of the project are estimated to be $10,324 for scenario one and $4,130 for scenario two (Table 4).

***Net Present Value***

The NPV calculation includes the four categories of estimated costs and benefits: start-up costs, operational costs, one-time benefits, and recurring benefits. Based on the numbers provided previously, the net present value of the project in year one is -$23,310 for scenario one (Table 5) and -$29,492 for scenario two (Table 6). This is primarily due to the large start up costs in year one.

**Table 5:** NPV for scenario one.

| Time | Costs | Benefits | Inflated Costs | Inflated Benefits | Net Benefits | Present Value of Net Benefits |
|---|---|---|---|---|---|---|
| 0 | $33,634.82 | $10,324.25 | $33,634.82 | $10,324.25 | $-23,310.57 | $-23,310.57 |
| 1 | $6,767.65 | $10,324.25 | $6,910.44 | $10,542.09 | $3.631.65 | $3,458.71 |
| 2 | $6,767.65 | $10,324.25 | $7,056.25 | $10,764.53 | $3,708.28 | $3,363.52 |
| 3 | $6,767.65 | $10,324.25 | $7,205.14 | $10,991.66 | $3,786.52 | $3,270.94 |
| 4 | $6,767.65 | $10,324.25 | $7,357.17 | $11,223.59 | $3,866.42 | $3,180.91 |
| 5 | $6,767.65 | $10,324.25 | $7,512.40 | $11,460.40 | $3,948.00 | $3,093.36 |
| 6 | $6,767.65 | $10,324.25 | $7,670.92 | $11,702.22 | $4,031.30 | $3,008.22 |
| 7 | $6,767.65 | $10,324.25 | $7,832.77 | $11,949.13 | $4,116.36 | $2,925.42 |
| 8 | $6,767.65 | $10,324.25 | $7,998.04 | $12,201.26 | $4,203.22 | $2,844.90 |
| 9 | $6,767.65 | $10,324.25 | $8,166.80 | $12,458.71 | $4,291.90 | $2,766.60 |
| 10 | $6,767.65 | $10,324.25 | $8,339.12 | $12,721.59 | $4,382.46 | $2,690.45 |
| 11 | $6,767.65 | $10,324.25 | $8,515.08 | $12,990.01 | $4,474.93 | $2,616.40 |
| 12 | $6,767.65 | $10,324.25 | $8,694.75 | $13,264.10 | $4,569.35 | $2,544.39 |
| 13 | $6,767.65 | $10,324.25 | $8,878.21 | $13,543.97 | $4,665.77 | $2,474.36 |
| 14 | $6,767.65 | $10,324.25 | $9,065.54 | $13,829.75 | $4,764.22 | $2,406.25 |
| 15 | $6,767.65 | $10,324.25 | $9,256.82 | $14,121.56 | $4,864.74 | $2,340.02 |
| | | | | **Total** | | $19,673.89 |

The net present value calculations revealed major differences depending on the amount of food waste collected. After the 15-year lifetime of the tubs, the NPV under scenario one totaled $19,673. The project breaks even in year 2019, eight years after the project begins. The majority of the savings from this project were found in the avoidance of landfill tipping fees, which averaged $10,091 annually. In scenario one, the benefits of this project outweighed the costs according to the NPV projection over the life of the project. Based on equation 6, since the NPV >0, scenario one of this project could be undertaken.

**Table 6:** NPV for scenario two.

| Time | Costs | Benefits | Inflated Costs | Inflated Benefits | Net Benefits | Present Value of Net Benefits |
|---|---|---|---|---|---|---|
| 0 | $33,622.22 | $4,129.70 | $33,622.22 | $4,129.70 | $-29,492.52 | $-29,492.52 |
| 1 | $6,755.05 | $4,129.70 | $6,897.58 | $4,216.84 | $-2,680.74 | $-2,553.09 |
| 2 | $6,755.05 | $4,129.70 | $7,043,12 | $4,305.81 | $-2,737.30 | $-2,482.82 |
| 3 | $6,755.05 | $4,129.70 | $7,191.73 | $4,396.66 | $-2,795.06 | $-2,414.48 |
| 4 | $6,755.05 | $4,129.70 | $7,343.47 | $4,489.43 | $-2,854.04 | $-2,348.02 |
| 5 | $6,755.05 | $4,129.70 | $7,498.42 | $4,584.16 | $-2,914.26 | $-2,283.40 |
| 6 | $6,755.05 | $4,129.70 | $7,656.64 | $4,680.89 | $-2,975.75 | $-2,220.55 |
| 7 | $6,755.05 | $4,129.70 | $7,818.19 | $4,779.65 | $-3,038.54 | $-2,159.43 |
| 8 | $6,755.05 | $4,129.70 | $7,983.15 | $4,880.50 | $-3,102.65 | $-2,100.00 |
| 9 | $6,755.05 | $4,129.70 | $8,151.60 | $4,983.48 | $-3,168.12 | $-2,042.20 |
| 10 | $6,755.05 | $4,129.70 | $8,323.60 | $5,088.63 | $-3,234.96 | $-1,985.99 |
| 11 | $6,755.05 | $4,129.70 | $8,499.22 | $5,196.00 | $-3,303.22 | $-1,931.32 |
| 12 | $6,755.05 | $4,129.70 | $8,678.56 | $5,305.64 | $-3,372.92 | $-1,878.17 |
| 13 | $6,755.05 | $4,129.70 | $8,861.68 | $5,417.59 | $-3,444.09 | $-1,826.47 |
| 14 | $6,755.05 | $4,129.70 | $9,048.99 | $5,531.90 | $-3,516.76 | $-1,776.20 |
| 15 | $6,755.05 | $4,129.70 | $9,239.50 | $5,648.62 | $-3,590.96 | $-1,727.31 |
| | | | | **Total** | | **$-61,221.95** |

However, in scenario two, where only a portion of food waste was composted, the NPV for the project was -$61,221. While the reduced tipping fees provided some annual benefit, they did not offset the labor costs associated with the project, thereby resulting in a net cost to the university each year for the life of the project. Without full consideration of the non-market costs and benefits, it is not possible to recommend that this project with only a partial collection of food waste be undertaken.

***Sensitivity Analysis***

It is clear from the above market costs and benefits analyses that composting only part of the university food waste will not offset the market costs of this project. Therefore sensitivity analyses were conducted to determine: 1) in what year a permit must be acquired to operate under scenario one such that the NPV of the project is positive; and 2) what is the maximum allowable market costs for a permit that would provide maximum project benefits to the university. Table 7 shows that, if the permit is acquired such that all food waste can be composted from the three dining halls beginning in 2014, the project will have a positive NPV, as long as the costs of the permit do not exceed a present value of $1,634 over the life of the project. Moreover, if this permit was actually acquired now, such that all food waste could be composted starting in 2012, the NPV of the project could increase to nearly $13,492 (Table 8) without consideration of the permit cost. The permitting process is complex and costly, and includes preparation of a geotech report, design and operation of services, and UA staff time to pursue the process with Arkansas

Department of Environmental Quality (Brown, 2011). If total costs of the permit are greater than $1,634 but less than $13,492, maximum market net benefits would be incurred if the permit was in place for 2012.

**Table 7:** NPV if permit is purchased in year 3 of the project; minimum year for purchase in order to have a positive NPV over the life of the project.

| Time | Costs | Benefits | Inflated Costs | Inflated Benefits | Net Benefits | Present Value of Net Benefits |
|---|---|---|---|---|---|---|
| 0 | $33,622.22 | $4,129.70 | $33,622.22 | $4,129.70 | -$29,492.52 | -$29,492.52 |
| 1 | $6,755.05 | $4,129.70 | $6,897.58 | $4,216.84 | -$2,680.74 | -$2,553.09 |
| 2 | $6,755.05 | $4,129.70 | $7,043.12 | $4,305.81 | -$2,737.30 | -$2,482.82 |
| 3 | $6,767.65 | $10,324.25 | $7,205.14 | $10,991.66 | $3,786.52 | $3,270.94 |
| 4 | $6,767.65 | $10,324.25 | $7,357.17 | $11,223.59 | $3,866.42 | $3,180.91 |
| 5 | $6,767.65 | $10,324.25 | $7,512.40 | $11,460.40 | $3,948.00 | $3,093.36 |
| 6 | $6,767.65 | $10,324.25 | $7,670.92 | $11,702.22 | $4,031.30 | $3,008.22 |
| 7 | $6,767.65 | $10,324.25 | $7,832.77 | $11,949.13 | $4,116.36 | $2,925.42 |
| 8 | $6,767.65 | $10,324.25 | $7,998.04 | $12,201.26 | $4,203.22 | $2,844.90 |
| 9 | $6,767.65 | $10,324.25 | $8,166.80 | $12,458.71 | $4,291.90 | $2,766.60 |
| 10 | $6,767.65 | $10,324.25 | $8,339.12 | $12,721.59 | $4,382.46 | $2,690.45 |
| 11 | $6,767.65 | $10,324.25 | $8,515.08 | $12,990.01 | $4,474.93 | $2,616.40 |
| 12 | $6,767.65 | $10,324.25 | $8,694.75 | $13,264.10 | $4,569.35 | $2,544.39 |
| 13 | $6,767.65 | $10,324.25 | $8,878.21 | $13,543.97 | $4,665.77 | $2,474.36 |
| 14 | $6,767.65 | $10,324.25 | $9,065.54 | $13,829.75 | $4,764.22 | $2,406.25 |
| 15 | $6,767.65 | $10,324.25 | $9,256.82 | $14,121.56 | $4,864.74 | $2,340.02 |
| | | | | | **Total** | **$1,633.81** |

**Table 8:** NPV if permit is purchased in year 2 of the project (2012); minimum year for purchase in order to have the maximum NPV over the life of the project.

| Time | Costs | Benefits | Inflated Costs | Inflated Benefits | Net Benefits | Present Value of Net Benefits |
|---|---|---|---|---|---|---|
| 0 | $33,622.22 | $4,129.70 | $33,622.22 | $4,129.70 | -$29,492.52 | -$29,492.52 |
| 1 | $6,767.65 | $10,324.25 | $6,910.44 | $10,542.09 | $3,631.65 | $3,458.71 |
| 2 | $6,767.65 | $10,324.25 | $7,056.25 | $10,764.53 | $3,708.28 | $3,363.52 |
| 3 | $6,767.65 | $10,324.25 | $7,205.14 | $10,991.66 | $3,786.52 | $3,270.94 |
| 4 | $6,767.65 | $10,324.25 | $7,357.17 | $11,223.59 | $3,866.42 | $3,180.91 |
| 5 | $6,767.65 | $10,324.25 | $7,512.40 | $11,460.40 | $3,948.00 | $3,093.36 |
| 6 | $6,767.65 | $10,324.25 | $7,670.92 | $11,702.22 | $4,031.30 | $3,008.22 |
| 7 | $6,767.65 | $10,324.25 | $7,832.77 | $11,949.13 | $4,116.36 | $2,925.42 |
| 8 | $6,767.65 | $10,324.25 | $7,998.04 | $12,201.26 | $4,203.22 | $2,844.90 |
| 9 | $6,767.65 | $10,324.25 | $8,166.80 | $12,458.71 | $4,291.90 | $2,766.60 |
| 10 | $6,767.65 | $10,324.25 | $8,339.12 | $12,721.59 | $4,382.46 | $2,690.45 |
| 11 | $6,767.65 | $10,324.25 | $8,515.08 | $12,990.01 | $4,474.93 | $2,616.40 |
| 12 | $6,767.65 | $10,324.25 | $8,694.75 | $13,264.10 | $4,569.35 | $2,544.39 |
| 13 | $6,767.65 | $10,324.25 | $8,878.21 | $13,543.97 | $4,665.77 | $2,474.36 |
| 14 | $6,767.65 | $10,324.25 | $9,065.54 | $13,829.75 | $4,764.22 | $2,406.25 |
| 15 | $6,767.65 | $10,324.25 | $9,256.82 | $14,121.56 | $4,864.74 | $2,340.02 |
| | | | | | **Total** | **$13,491.94** |

### *Cost-Benefit Analysis Challenges*

This cost-benefit analysis could be challenged on two grounds. First, it lacks inclusion of non-market values. Second, there is no proof that the 5% discount rate is the appropriate rate for this project. These concerns are addressed below.

The values above only include market costs and benefits. A full cost-benefit analysis would also include the value of non-market costs and benefits. As mentioned earlier, non-market costs included reduced convenience to dining hall staff to separate the food. However it is not anticipated that this will pose a significant burden on the staff, particularly once the new protocols are learned. Further, the non-market benefits of this project are potentially quite large if one considers the reduced environmental impact associated with diverting the food waste from the landfill and could thereby increase the NPV of the project. Estimation of these benefits may provide a stronger argument for usefulness of scenario two.

This project adopted the 5% discount rate used by Rice University in their study in 1998. This is admittedly a dated study and therefore the discount rate may be inappropriate for this project. Since lower (smaller) discount rates will only increase the value of net benefits over time, the concern rests in identifying the discount rate that moves the NPV from a positive value to a negative value. Sensitivity analysis around the discount rate determined that, in order for the scenario one project to move from positive to overall negative net benefits, the discount rate would have to increase to close to 15.3%. For scenario two, no reasonable change in discount rate will move this project from negative to positive net benefits, given the overwhelmingly large start up costs relative to expected annual benefits. Therefore, a reasonable choice of discount rate that is different from the one used in this study is not expected to change the general results of the analysis.

## Conclusions

This study marks the end of a two and half year effort to secure Earth Tubs and evaluate the feasibility of a food waste to compost project using these tubs at the University of Arkansas Fayetteville campus. Results of the analysis suggest that under scenario one (all three major dining halls participating), even without including the non-market net benefits of this project (which are expected to be large and positive), the Earth Tub project produces positive net benefits to the university over its expected 15-year life. However, more information is needed on the non-market costs and benefits associated with food waste to composting to determine whether the partial food waste collection will provide positive net benefits over the life of the project.

There are several opportunities for expansion and improvement of this project. First, a more accurate measurement of food waste and the ability to track actual labor associated with all activities is needed to identify costs better. Second, more accurate estimates of the compost usage at the UA Agricultural Research and Extension Center and UAF campus are needed. Third, estimates of the non-market benefits and costs associated with the project would provide a more complete analysis. Finally, the feasibility of moving earth tubs closer to dining facilities and incorporating the remaining 5% of food waste should be explored.

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**Mentor Comments:** Although Zoe's article focuses primarily on the cost-benefit analysis she conducted for her honors thesis research, Professor Popp's comments place her work in the much broader context of a long-term commitment to exploring sustainability on campus through management of food waste.

*This article is the culmination of a two and a half year research project focused on developing a food waste to compost program at University of Arkansas Fayetteville (UAF). In fall 2008, under Division of Agriculture faculty leadership, Zoe Teague and four other undergraduate students assessed the feasibility of composting food waste at UAF. During the semester long endeavor, they explored composting techniques used at peer institutions, spoke to local waste management officials, and gathered information related to UA cafeteria food waste volumes, weights, disposal costs. In the course of their investigations, the students found two idle Earth Tubs (composting vessels) at a Northwest Arkansas solid waste division and convinced the organization to sell those tubs to UAF at a fraction of their worth for use in a pilot UAF compost program. The students concluded, based on a preliminary analysis of food waste volumes and project costs, that a food waste to compost project utilizing the Earth Tubs could be a viable way to reduce campus waste and promote sustainability on campus and recommended a pilot project be initiated by the UA Sustainability Council in Fall 2009. Zoe opted to continue on with the project as the focus of her honors college thesis.*

*Financial and logistical constraints delayed the project. But Zoe, serving as student representative to the UA Sustainability Council, worked closely with others on campus (in Facilities Management, Chartwells Food Service, University Housing and the Division of Agriculture) to help identify a location for the composting vessels and facilitate coordination among the various entities that would be involved with the project. Additionally, after determining there was a $13,000 shortfall to support the installation, maintenance and operation needs of the project, she worked with student government, local businesses, faculty, as well as Division of Agriculture and campus administrators to raise the needed funds. She used her research funds to travel to an Earth Tub user for many years - the University of North Carolina Charlotte - to learn everything about the Earth Tub systems, from construction to waste collection, to compost generation, and their associated costs and benefits. This information guided much of the Earth tub installation at UAF. The pilot project, albeit smaller in scope (collecting 100,000 pounds of food waste, not the 250,000 pounds available), commenced in April with food being collected from one dining hall.*

*This manuscript focuses on a cost-benefit analysis that compares the benefits and costs of composting two different* *amounts of food waste (that from one UAF student dining hall and that from all three dining halls) to landfill of the same food waste. While cost-benefit analysis is straightforward in theory, collection of the value of the costs and benefits associated with a program that has never before existed on campus. Zoe worked for weeks with Facilities Management, Campus Housing, Chartwells, Walmart, the City of Fayetteville and others to place dollar values on market costs and benefits and to identify on a qualitative basis the non-market costs and benefits. To do this required knowledge and skills in areas of economics, environmental science and even engineering. Her work is truly multidisciplinary and highly collaborative. Furthermore, as her analysis suggests, should University of Arkansas implement a compost project that utilizes all the food waste from the three dining halls on campus, the university not only can help reduce its negative environmental impacts but also can save money as well.*