DYNAMICS OF KSU COMPOSTING RESEARCH AND ANALYSIS

The research focuses on the composting of food waste at Kansas State University, including an analysis of the current composting program. The composting of food waste is the focus of our research. Our group also discusses possible recommendations to further establish and expand the current program.

MELISSA BAER
SHELLY BLATTNER
KEVAN BOSS
THOMAS OSTMEYER
SCOTT WIENS

NATURAL RESOURCES AND ENVIRONMENTAL SCIENCES CAPSTONE COURSE
MAY 5, 2009

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Our goal for this project is to discuss the current composting program at Kansas State University, explore and expand on what possible directions the program may go, and give our recommendations on the future of the composting program at Kansas State University. In this summary, the basics of composting will be discussed, as well as the current situation campus and community wide, and the future of the composting program with some recommendations if the current program were to expand.

Composting is a very complex process in which waste is decomposed and recycled into a useable product. The use of bacteria and fungi are a vital component in the composting process to help breakdown the waste material to form stable humus that can be useful to humans. There are many methods of composting that all use the same complex process. In windrows, compost is piled in a straight line, and then tractor turners turn the compost to allow oxygen to be mixed into the compost. In-vessel composting is performed in an enclosed cage or tub in which the process is the same except that heat is added to the tub to speed up the decomposition process. Using earthworms can also help increase the decomposition process due to the soil and organic matter that it eats.

The current program at Kansas State University uses the pre-consumed food waste from Housing and Dining Services to compost. Three Dining Centers make up Housing and Dining Services; they include Derby Dining Center, Kramer Dining Center, and Van Zile Dining Center. Food compost is currently being collected from Derby and Kramer Dining Center. Currently two composting sites on campus allow food compost. These include the North Farm run by the Agronomy Department and the Student Learning Farm run by the Horticulture Department. The current program in Riley County is being run by the Riley County Transfer Station just south of Manhattan. They currently do not allow food waste only brush, grass clippings, and wood chips. Elementary Schools also have been involved in composting in the community.

The future composting program at Kansas State University will need to find ways to increase the amount of food waste collected from the dining centers. More efficient methods of collection, storage, and transportation are needed. A huge increase in collected food waste will result from the collection of post-consumer waste. As of right now, all post-consumer waste is either run through the garbage disposal or thrown in the dumpster.

Recommendations for the future composting program at Kansas State University include that food waste audits are needed for better data to predict future outcomes for community composting. That understanding the social interest in composting or other sustainable issues may encourage more community wide awareness. Finally, the possibility of refining grease and oils collected from the dining centers could be used for campus vehicles while mitigating disposal-tipping fees for hazardous waste.

CHAPTER 1 INTRODUCTION

One important aspect of this project is to provide a basic overview of how composting works and the current composting system at Kansas State University and its interaction with the Manhattan Kansas community. The second is laying a solid foundation for continued research and expansion. The documentation of the current KSU composting system will provide future project managers with variables that are qualitatively and quantitatively measureable. The potential for sustainable growth will depend on the incorporation of three philosophical questions, where did the project start, where is the project currently, and where is the project going?

Since Kansas State University's composting project is in its beginning phases of development, ensuring a structural dialectic platform that incorporates social themes such as policy, networking, marketing, advertising and economics is critically speculative that this project will present ideas that can be revisited, and recreated as campus composting takes the forefront of environmental issues at KSU and the Manhattan Kansas community.

Our approach is that food waste composting is an underutilized facet and there is potential for not only saving money, but also making money. Ecologically there are benefits for eliminating pulverized food from garbage disposals that inundate the Manhattan City municipal water treatment facilities; and benefits for reducing costs related to transporting solid waste volume.

CHAPTER 2 HOW DOES COMPOSTING WORK

BIOLOGICAL PROCESS

From a mixture of various raw materials to the formation of finished humus, composting is a natural biological process. The process of composting involves the efforts of a diverse group of microorganisms that work together to break down complex substances into simple, useable material. The most important aspects of composting are the population of organisms involved and the chemical makeup of the compost pile (Gershuny and Martin, 1992).

Population of Organisms

The composting process is the work of an intricate, complex community of organisms. These organisms are naturally present to recycle material and transform it into a useable product, whether the location is a compost pile or the forest floor. Organisms decompose material through enzymatic digestion while the chemical processes of oxidation, reduction, and hydrolysis occur simultaneously in the system. Microorganisms use these products as an energy source and as a source of the chemicals they use to make their enzymes. This succession of organisms continually breaks complex biodegradable material into simple, useable, and stable humus. The stability of the product is due to the molecular structure.

Humus is more resistant to bacterial attack, thus more biologically stable. The diversity of the organisms involved in composting make the process stable as well, keeping the process from collapsing when conditions change. Both chemical decomposers and physical decomposers work together to create humus (Gershuny and Martin, 1992).

Chemical decomposers are microscopic and can be mesophilic (medium-temperature) or thermophilic (high-temperature) species. Bacteria, actinomycetes, and fungi make up the microorganisms in a compost pile.

Bacteria, the most numerous microorganisms, are vital to the composting process. Deborah L. Martin and Grace Gershuny, editors of *The Rodale Book of Composting*, introduce bacteria as the most important microorganism, stating, "A pea-sized amount of garden soil has been found to contain up to a billion bacteria (Gershuny and Martin, 1992)." The type of bacteria found within a pile differs with each location. Materials and conditions vary between piles and continuously change, creating localized environments (Rynk, 1992). Bacterial species differ with materials, heat, air present, moisture, and geographic location of the pile. Bacteria are nutritionally diverse, using living or dead tissue as a source of carbon for over 100 different organisms. Due to their small size and simple organization, bacteria cannot easily escape unfavorable conditions (Gershuny and Martin, 1992). They flourish in the early stages of composting, before the easily degraded materials are consumed.

Actinomycetes are a higher form of bacteria that form filaments like fungi. They are present in the outer areas of the pile during the early stages of composting and become active when the temperature of the pile lowers (Gershuny and Martin, 1992). They are most numerous after easily degraded compounds are gone and when moisture levels are low (Rynk, 1992). Actinomycetes produce antibiotics that inhibit bacterial growth, causing the population of bacteria in the pile to decrease. They also liberate carbon, nitrogen and ammonia, making nutrients available to plants (Gershuny and Martin, 1992).

Fungi play a key role in the final stages of the composting process. These primitive plants are saprophytes and are good at decomposing woody substances and other decay-resistant material. They are more tolerant of low-moisture and low-pH conditions but less tolerant of low-oxygen environments than bacteria (Rynk, 1992).
After the compost pile has cooled, physical decomposers take up residence, further enriching the compost. These organisms vary from first- to third-level consumers, each level maintaining balance within the pile. Some of these mesophilic organisms include:

- Mites- second-level consumers who also directly attack plant matter
- Millipedes- feed directly on plant material
- Centipedes- third-level consumers who feed on living animals, especially insects
- Sow bugs- feed on decaying vegetation
- Snails and slugs- generally eat living plant material but will eat fresh garbage
- Spiders- third-level consumers who help control garden pests
- Springtails- feed on decomposing plants, pollen, grains, and fungi

- Beetles (rove and ground)- third-level consumers often imported to control snails and slugs
- Beetles (feather-winged and most adults)- feed on fungal spores and decaying vegetation
- Ants- bring fungi and other organisms into their nests within compost piles, add phosphorus and potassium into the pile by moving materials
- Flies- carriers of bacteria, provide air-borne transportation to pile
- Earthworms- till and enrich the soil by ingesting, decomposing, and depositing casts high in bacteria, organic matter, available nitrogen, calcium, magnesium, phosphorus, and potassium (Gershuny and Martin, 1992)

Some composters add microorganisms into the system in order to accelerate composting or improve efficiency. These added microorganisms are referred to as inocula, and may not be necessary or advantageous to the process. Availability is rarely a problem because these organisms are present naturally. Some pathogens may also be present in the mix of materials. Animal and plant pathogens can be found in manure, crop residue, and yard waste. Human pathogens are not present in many compostable materials but can be found in sewage sludge. The high temperatures obtained during the composting process reduce the number of pathogens, therefore decreasing the risk of disease.

Chemical Makeup

Elements within a compost pile are not in their pure form. They occur in different forms at different stages, and organisms use them in specific forms and at specific ratios. Composting involves many transformations.

Energy fuels the processes that drive composting. Organic material contains stored energy obtained through the conversion of solar energy to chemical energy (photosynthesis). Microorganisms break these chemical bonds to obtain energy for growth, transforming organic raw materials into simpler compounds and changing the nature of the materials. They convert raw material into simpler forms of proteins and carbohydrates, making them more accessible to a larger variety of bacterial species. Carbohydrates break down rapidly into sugars, organic acids, and carbon dioxide. Proteins break down into peptides and amino acids and then become available ammonium compounds and atmospheric nitrogen. Nitrifying bacteria change the ammonium compounds into nitrates available to plants (Gershuny and Martin, 1992).

The volume of a compost pile is reduced by one-quarter to more than one-half of its initial volume due to a loss of carbon dioxide and water to the atmosphere. Some nitrogen is also lost as ammonia. However, compost retains most nutrients and stores them within stable organic compounds. These nutrients remain within the bodies of microorganisms and as humus. This reduces their immediate availability, but it allows them to be released at a gradual rate. A gradual release rate reduces losses due to leaching (Rynk, 1992).

As compost progresses, the diverse mix of particles and compounds initially present become more uniformly mixed and less biologically active. Exchange capacity increases, pH neutralizes, and the particles become consistent and soil-like in texture. Particle size decreases along with C:N ratio. The decrease in C:N ratio is due to a loss of carbon dioxide from original materials. The loss in carbon usually exceeds the loss in nitrogen; too much carbon makes the process inefficient. An excess amount of carbon compared to the amount of nitrogen makes the process take more time. If this 'immature' compost is added to the soil, microorganisms continue to consume oxygen and steal it from plant roots (Rynk, 1992).

Thus, the curing process is vital to compost production. Curing is the stage of composting during which compost matures. Oxygen consumption, heat generation, and moisture evaporation are much lower than in the active composting stage. The time needed for curing increases under poor management or if the active composting stage was not completed. A long curing period can act as "safety net" that helps to overcome the shortcomings of the composting method, according to Robert Rynk of the Food Engineering Department of the University of Massachusetts (Rynk, 1992).

FACTORS AFFECTING THE COMPOSTING PROCESS

Compost must be properly managed in order to create a useable product. Some manageable factors include oxygen and aeration; nutrients (C:N ratio); moisture; porosity, structure, texture, and particle size; pH; temperature; and time.

Oxygen and Aeration

In the early stages of rapid decomposition, aerobic activity consumes large quantities of oxygen. Microbial activity is at its peak and heat is generated through oxidation, or biological burning. Microorganisms metabolize readily degradable components and use up large quantities of oxygen. When oxygen is limited, the decomposition process slows. Anaerobic organisms with slower and less efficient processes take over. Their processes also develop intermediate compounds such as methane, organic acids, and hydrogen sulfide. Under anaerobic conditions, the compounds continue to accumulate and strong odors and safety issues may arise. A level of 5% minimum oxygen concentration is needed within the pore spaces of the compost pile (air contains 21%). Aeration can manage the amount of oxygen present as well as remove heat, water vapor, and other trapped gases (Rynk, 1992).

Nutrients (C:N ratio)

The carbon to nitrogen ratio (C:N ratio) influences the value and efficiency of the compost. Carbon is needed for energy and growth of microorganisms, and nitrogen is needed for protein development and reproduction. Usually, a proper C:N ratio also ensures other nutrients are present in adequate amounts. Raw materials should ideally range from 25:1 to 30:1 (25:1 being the required amount for most biological organisms) but ranges of 20:1 to 40:1 have also produced quality compost. If the C:N ratio is too high, a longer composting time is required. If the ratio is too low, not all of the nitrogen is stabilized. Some may be lost to the atmosphere as ammonia or nitrous oxide and odor may become a problem. The C:N ratio also acts as a guide to creating compost blends. Carbon compounds decompose at different rates. For example, straw decomposes faster than wood, which contains organic compounds highly resistant to breakdown. If carbon is present in a form that is difficult to decompose, the process slows (Rynk, 1992).

Moisture

Moisture supports the metabolic processes of microbes. Biological activity is optimal when materials within a compost pile are saturated. The ideal moisture content range is 40-65%. If it falls below 40%, microbial activity slows. A moisture content above 65% leads to the displacement of air in pore spaces, which creates anaerobic conditions. Moisture content should begin at a level well above 40% because the percentage will decrease throughout the process. Even with the addition of moisture by rain or snow, evaporation reduces the moisture level to a point below the starting level. Moisture levels depend on the materials involved. Materials with a high porosity can contain more moisture without creating anaerobic conditions, while densely packed materials must contain a lower moisture level (Rynk, 1992).

Porosity, Structure, Texture, and Particle Size

The physical properties of the soil greatly affect the composting process. Soil porosity, structure, texture, and particle size all influence aeration and can be adjusted by the selection of materials and grinding or mixing. Bulking agents or amendments can also be added. Porosity is the measure of air space between particles. It is determined by particle size, size gradation of materials, and continuity of air space. High porosity is achieved with large, uniform particles. Structure is the rigidity of particles and their ability to resist settling and compaction. Good structure prevents loss of porosity. Texture describes the available surface area for aerobic microbial activity. Most aerobic decomposition occurs on the surface of particles. Since the amount of surface area increases with smaller particle size, the rate of aerobic decomposition increases with smaller particle size. Smaller particle size, however, also reduces porosity so a compromise must be reached. Usually $^{1}/_{8}$ - 2 inch diameter particles produce good results (Rynk, 1992).

pH

Compost is largely insensitive to pH due to the multitude of organisms and materials involved. A near neutral pH of 6.5- 8.0 is ideal. If raw materials high in nitrogen are used in the composting process, pH becomes more important. A high pH encourages the conversion of nitrogen compounds to ammonia, which can be lost into the atmosphere. In order to reduce ammonia loss, additives like lime and ash can be incorporated, but this is usually not necessary or advisable. Throughout the composting process, the pH levels of materials change continuously. In the initial stage, there is a low pH due to the release of organic acids. As the process continues, production of ammonia from nitrogen compounds raises the pH of the pile. Regardless of the pH of the initial materials, the process yields a product with a stable pH (Rynk, 1992).

Temperature

The temperature of the compost pile ranges from 50 degrees F to 150 degrees F. Mesophilic temperatures range from 50- 105 degrees F and thermophilic temperatures occur over 105 degrees F. Specific organisms are active in each temperature range, but thermophilic temperatures are recommended to destroy pathogens, weed seeds, and fly larvae. The critical temperature for destroying human pathogens is 131 degrees F, which also kills most plant pathogens. In order to destroy most weed seeds, temperatures must reach 145 degrees F. Temperatures are highest in the early stages of decomposition, when microbial activity releases a large amount of heat. This heat should give way to mesophilic temperatures in order to cater to a new host of organisms, but the self-insulating quality of compost piles may contribute to continued heat accumulation. This slows the composting process, killing many microorganisms or causing them to become dormant. If this 'thermal kill' occurs, the composting process will be suspended until populations recover. Temperatures must be monitored and controlled through turning and aeration (Rynk, 1992).

Time

The time needed to complete the composting process depends on the materials, temperature, moisture, frequency of aeration, and user requirements of the compost. Time frames can range from two weeks to over two months for the entire decomposition and stabilization of the compost. A short time period requires proper moisture and C:N ratio coupled with frequent aeration. Long time periods result from a lack of moisture, a high C:N ratio, low temperatures, insufficient aeration, large particles, and a high percentage of resistant materials (Rynk, 1992).

COMPOSTABLE MATERIALS

Compost ingredients are organic by-products or waste material. The primary raw material is usually a waste material needing treatment and/ or disposal. Other materials are then added to achieve the desired characteristics required for efficient composting (Rynk, 1992). Several materials with different characteristics are blended to obtain the proper balance of green matter, animal wastes, manure, and soil (Gershuny and Martin, 1992). Amendments must often be gathered from outside sources. When combining materials, issues like odor should be considered (Rynk, 1992).

Recipes

Compost recipes can be determined by trial and error or through calculations. These calculations predict moisture content and C:N ratio of a mix from the characteristics of the raw materials involved. Usually a recipe focuses on either moisture or C:N and then proportions are adjusted to fine-tune the second characteristic. The calculations are done on a dry weight basis. For each ingredient, the moisture content, the percentage nitrogen (dry weight) and either the percentage carbon (dry weight) or the C:N ratio must be known (Rynk, 1992).

Three types of material blended to achieve the proper compost mix or recipe. First, begin with a wet, high-nitrogen primary ingredient. This is the activator, which is usually manure, garbage, compost, humus-rich soil, dried blood, or urine. Next, a bulking agent with large stiff particles is added along with a dry, high-carbon amendment. These ingredients are chosen and mixed to the right proportion to produce characteristics within the proper moisture, C:N, and pH ranges. Some materials require extra caution and should be used in small quantities. When using manure, make sure the compost reaches the proper pathogen-killing temperatures. Use small quantities of materials that do not decompose readily, like wood, or shred the material first. Diseased plant material should be burned rather than used for compost. Grease and oil should not be used in large quantities because it inhibits biochemical processes. Some commonly composted materials include:

- Crop residuals- moderate to high moisture content; moderate C:N ratio; good structure/ degradability; good composting material
- Spoiled hay and silage- moderately dry to wet; moderate to high C:N ratio; good structure/degradability; moderate composting material (possible odor, leachate)
- Straw- dry; carbonaceous; good structure/degradability; excellent composting material
- Sawdust and shavings- dry; carbonaceous; moderate to poor degradability; low cost; good to moderate composting amendment
- Leaves- dry, high carbon; large quantities but seasonal; good to moderate composting material
- Grass clippings- low C:N ratio, decompose quickly; good composting material if mixed (can become compact and anaerobic if left alone)
- Fruit and vegetable waste- moderate to wet; moderate to low C:N ratio; good degradability; poor structure; good to fair composting material
- Cardboard- dry; high carbon; good degradability/structure; good to fair amendment (Rynk, 1992)

Using Manure

Manure is an important ingredient to compost; there are few materials that are as beneficial to the compost pile. It contains one-third of the total nitrogen, one-fifth of the total potash, and nearly all of the phosphoric acid voided by the animal. The value of the manure varies with the food eaten by the animal, the age of the animal, and the physical condition and health of the animal. For example, the manure of mature animals or animals who feed on wheat bran, gluten meal, and cottonseed meal will be richer in nutrients than the manure of young animals that are forming bones and muscles or animals that are fed straw or hay without grains. The nutrients are not, however, the manure's greatest asset. The most important aspect of manure is its bacterial population, which is as much as 30 percent of its mass (Gershuny and Martin, 1992). Therefore, the addition of manure aids in the timely breakdown of materials within the compost pile. Cattle manure is very wet and generally requires a large amount of dry high-carbon amendment. There is a relatively low odor risk if composted within a few weeks. Overall, it is a very good composting material (Rynk, 1992).

COMPOSTING METHODS

Composting can be defined by the amount of oxygen present in the system. Microorganisms are capable of both aerobic and anaerobic decomposition, but aerobic decomposition is more timely and efficient. Thus, it is wise to maintain aerobic conditions in order to achieve rapid composting. Different methods accomplish this in different time frames and through changes in various factors. The four general groups of composting methods used on farms are passive composting, windrows, aerated piles, and in-vessel composting.

Passive Composting of Manure Piles

Passive composting of manure piles involves little agitation and management. The high nitrogen manure is mixed with a bedding material in order to decrease moisture content, improve porosity, and raise the C:N ratio. This mixture is stacked into piles less than 6 feet high and 12 feet wide to decompose over long time periods. The pile may still mainly decompose anaerobically, but some aerobic activity aids in moisture removal and further breaks down the products of anaerobic decomposition. This method is similar to the windrow method without frequent turning. It is commonly used for leave piles and requires minimum labor and equipment. Problems may arise in the form of odors and the large amount of time needed to complete the composting process (Rynk, 1992).

Windrows

In the windrow method, material is formed into long, narrow piles (windrows) that are periodically turned with a bucket loader or special turning machine. The turning equipment and the material density dictate the size of the rows, which usually range from 3-12 feet tall and 10-20 feet wide. These rows are primarily aerated by natural or passive air movement. Turning mixes the composting materials and enhances passive aeration. It also further breaks up particles, rebuilds porosity, and exposes all material equally to the air at the outer surface, and releases trapped heat, water vapor and gases. Turning can be eliminated if windrows are passively aerated by embedding perforated pipes into the base of the windrow. The ends of the pipe are open, allowing air to flow into and through the pipes. The base of passively aerated windrows must be peat moss, straw, or finished compost in order to absorb moisture and insulate the windrow. Height should be 3-4 feet, and materials must be thoroughly mixed before they are added into the pile (due to a lack of mixing through turning). Studies in Canada have found that manure mixtures can be composted using this method in ten to twelve weeks while containing odors and conserving nitrogen effectively (Rynk, 1992).

Figure 1: Two distinct windrows are seen piled high. These piles are limited by the width of the turner that will be used to aerate the compost pile. Mechanized aerators are used to mix fresh oxygen into the compost pile to maintain aerobic decomposition.

Aerated Static Piles

Aerated static piles build upon the piped aeration system of passively aerated windrows by adding a blower to supply air to the pile. This blower allows for larger piles of manageable compost. No turning or agitation is necessary, and the composting period can be completed in three to five weeks. Aerated static piles are constructed on a base of wood chips, chopped straw, or other very porous material. This base material contains the perforated pipe, which is connected to the blower, which forces air through the pile. The height of these piles should range from 5-8 feet, and the pile may be topped off with some finished compost or bulking agents in order to protect the pile from the elements, reduce heat loss, and filter odors (Rynk, 1992).

In-Vessel Composting

In-vessel composting confines the composting materials within a building, container, or vessel. These methods rely on mechanical turning and forced aeration. Some in-vessel methods used for farm composting include bin composting, rectangular agitated beds, silos, rotating drums and transportable containers (Rynk, 1992).

Classifications by Temperature

Methods also vary by temperature and can be classified by their range of temperatures. Listed below are some composting methods in order from hot to cool:

- California method- rapid-return method; hot
- City people's method- fast aerobic process; hot
- Compost tumblers- good for small amounts of waste; hot
- Raised bins- open-hearth-bottom bin on a cement slab; cool end of hot spectrum
- Movable compost for raised beds- composting system for use with intensive raised beds; hot or cool
- Windrows and piles- hot or cool
- Biodynamic composting- layers of compost materials alternated with layers of soil; cool or hot
- Indore method- systematic use of traditional procedures; cool
- Ogden's step-by-step composting- partly anaerobic method involving the gradual addition of materials; cool
- Pit composting- compost-holding containers that go down into the ground at least one foot; cool
- Mulch and sheet composting- spreading a thin layer of organic material directly on the garden; beyond the cool end of the spectrum
- Trench and posthole composting- burying compost in trenches or holes; beyond the cool end of the spectrum
- Anaerobic composting- creating compost without air (i.e. by covering with plastic); beyond the cool end of the spectrum (Gershuny and Martin, 1992)

Using Earthworms

Earthworms are capable of consuming their own weight in soil daily. They work their way through the earth, consuming soil and organic material and creating an enriched product. Gershuny and Martin describe how earthworms 'work their magic,' stating, "The secretions of their intestinal tracts act chemically to liberate plant nutrients with the aid of soil microorganisms." The castings left behind by earthworms contain five to eleven times the amount of available nitrogen, phosphorus and potassium as the original soil (Gershuny and Martin, 1992).

These creatures greatly aid in compost production, but their needs must be met by the system's environment. The heat of some compost piles is too much for earthworms. In addition, different species of earthworms have different environmental requirements. Some compost systems naturally attract earthworms, like the Indore Method, which is built upon a base of brush that the earthworms attack from the bottom. A variation of this method, the No-Heat Indore Method, makes it possible to produce compost quickly with very little heating (Gershuny and Martin, 1992).

In order to maintain earthworm populations, hold over some of the worms when transferring finished compost to a new site. This can be accomplished by only removing half of the pile at a time, spreading the remainder as the new base. Bins and pits dug beneath the frost line can protect worms from harsh winters and predators like moles (Gershuny and Martin, 1992).

Furthermore, earthworms can be used to create compost indoors during the winter months. According to Gershuny and Martin, "Generally, one pound of earthworms will eat one pound of garbage and produce one pound of compost each day." Some systems are commercially available, but one can also be easily crafted from materials such a vegetable lug box from a local market (Gershuny and Martin, 1992).

CHAPTER 3 CURRENT COMPOSTING ISSUES

Many different stakeholders are currently involved in composting efforts throughout Kansas State University and the surrounding Manhattan community. These efforts are often done unilaterally or occasionally in integrated systems between different professors and departments, and community organizations and groups. This section will explore the current roles and activities of different organizations and community groups, as well as identify key strengths, resources, concerns, and needs of the involved parties.

KANSAS STATE UNIVERSITY

At Kansas State University, many different composting efforts have begun throughout the campus. Many of these actions and alliances have strategically emerged because of specially vested concerns and resources. One example of this is the coordinated work between the Derby Dining Center and Kramer Dining Center (both operated by Housing and Dining Services), the Agronomy Department, and the Student Farm operated by the Horticulture Department (Kennedy, 2009). This partnership combined the food scraps produced by the dining centers with agronomy and horticulture expertise and research. Throughout the analysis of KSU's current composting practices major points of application will be reviewed.

Housing and Dining Services

The largest provider of meals at Kansas State University, K-State's Housing and Dining Services has a huge impact on food composting issues across campus. Three campus cafeterias are operated by Housing and Dining Services: Derby Dining Center, Kramer Dining Center, and Van Zile Dining Center. Food compost is currently being collected from both Derby Dining Center and Kramer Dining Center; Derby produces approximately 220 pounds per week of food scraps while Kramer collects 50-60 pounds per week. No food compost is currently being collected from the Van Zile Dining Center. Derby Dining Center serves meals to approximately 3400 people for lunch daily (Edwards, 2009). Kramer Dining Center serves about 1400 lunches daily, while the Van Zile Dining Center serves almost 1000 lunches (Klobasa, 2009). This large volume of fresh, prepared meals creates a large amount of food composting scraps from both kitchen preparation, pre-consumer, and post-consumer waste.

"Kitchen prep" waste is defined as the food waste that is created in the production of food that will served, such as lettuce leaves, onion scraps, and potato skins (Edwards, 2009). Pre-consumer waste is that waste that is produced during the serving of students, such as sauces and dressings that are left out for an entire meal, trimmings and cooking waste, and uneaten food that is deemed too poor to be served again or reused within the dining center (Edwards, 2009). Both of these food waste groups are being collected and composted. Derby Dining Center, the largest of the three dining centers on campus, does the majority of the food preparation for all dining facilities on campus and thus produces the majority of compostable waste. All food scraps currently being used for the composting program are either kitchen prep or pre-consumer wastes.

Post-consumer possesses the greatest quantity of food scraps from the three types of food compost and includes all food that is taken by guests but is not consumed. A five-day study of post-consumer waste at Kramer Dining Center in October found that 970 pounds of food were wasted at an average rate of .17 pounds of food waste per student per meal per day, or 3.5 pounds per week (K-State Housing, 2009). Currently post-consumer waste is not being collected or composted because of issues with collecting the material including process, appearance, and current cleaning practices. Other concerns about collecting post-consumer waste is the large increase in the volume of food waste that will be handled, and possible problems with storing food wastes in a sanitary and safe manner for composting pickup (Kennedy, 2009).

Collection of post-consumer waste is one barrier to composting. Housing and Dining Services view the students they serve as guests at their fine eating establishment, similar to the attitudes reflected at a conventional restaurant. Sheryl Klobasa, unit director of Kramer Dining Center, cited specific concerns about having guests scrape their food into a bucket or specified trashcan because that would require guests to exert more effort than other restaurant establishments (2009). Appearance is another issue with guest-designated food scrap collection. Tray and plate return is a prominent part of the dining center's floor layout and issues could arise with cleanliness, appearance, and even sanitation worries if food is collected outside in the guest area. Collection of post-consumer waste in the dishwasher units would be expensive to begin. Currently food is scraped into a trough that runs to a garbage disposal and is released to the wastewater treatment plant. Food purveyors can be bought that recapture food after the garbage disposal, separate the food scraps from the water, and recycle the water back to the collection system (Klobasa, 2009). These units are quite expensive, however. Another obstacle is training workers in a different food disposal technique (Edwards, 2009).

Derby Dining Center

Mark Edwards, the unit director for Derby Dining Center, shared several particular resources and concerns that are specific to the food-composting program in Derby. Several resources that are particularly helpful for Derby Dining Center include a refrigerated trash room, a mechanized lift, and tray return process. When Derby Dining Center was made, a specialized room was created with outside access for the storage of food waste. Originally, kitchen prep and pre-consumer waste was stored in this room and distributed to area pork producers who would feed this "slop" to their hogs (Edwards, 2009). Originally, K-State was paid for this resource and later the food was picked up for free because of cost increases. Only recently, with changes in food safety and disposal laws, have these food scraps been thrown away instead of organically recycled. The refrigerated trash room allows food waste to be stored on-site for several days before compost pickup. When workers come to pick up the compost a mechanized lift is used raise the barrels into the bed of a pickup truck to be transported. This is critical, as some of these barrels can weigh 200 pounds because of overfilling the buckets by kitchen workers (Kramer, 2009).

Another resource that could be beneficial in the Derby Dining Center is in the details of building construction. The food is served and eaten on the second floor, but because the dishwasher is located on the first floor a special conveyor system is used to transport trays between floors (Edwards, 2009). To prevent possible broken plates caused by unbalanced trays a student worker is employed to rearrange the silverware and dishware before it is moved downstairs. One possibility is this person could scrape some post-consumer food into a special food waste receptacle.

One concern at the Derby Dining Center includes finding newer, smaller barrels to use for food waste collection (Edwards, 2009). Training techniques, warning labels, and fill lines have not reduced the amount of food that is being deposited in the large, fifty-five gallon barrels (Edwards, 2009). New, smaller barrels that would reduce the volume of material that could be stored will help create an easier working environment for those workers picking up the material for composting and disposing of it at the appropriate site.

Kramer Dining Center

Sheryl Klobasa, unit director of Kramer Dining Center, and Jennifer Kennedy, assistant supervisor at Kramer Dining Center and one of the initiators of current composting program, discussed how composting is currently being handled at Kramer, as well as key concerns they have about expanding the program. Kramer Dining Center is currently composting about 50 – 60 lb. of food waste per week and comes from vegetable preparation done on-site (Klobasa, 2009). Because Kramer does not have a refrigerated trash room, this kitchen prep compost is stored in a controlled climate area inside the building. The compost is stored in cardboard boxes that are removed and composted along with the food waste at the farm. The lack of a refrigeration unit for trash has Mrs. Klobasa very concerned about any implementation of a post-consumer food collection system, which would create the necessity to store 200 lb. of compost daily (Klobasa, 2009). Because compost is currently collected only twice a week, upwards of 600 – 800 lb. of compost may be required to be stored onsite during a complete composting effort. Kramer Dining Center does not possess a mechanized lift to raise the food waste into the bed of truck during collection (Klobasa, 2009). Currently that is not a problem because of the small weights of collected food, but an expansion of a composting program would need to address this issue.

Food waste at Kramer Dining Center is disposed of by a garbage disposal currently. In information obtained from Richard Brenner, the supervisor of utilities for Housing and Dining Services, Kramer used 718 CCF (thousand cubic ft.) of water from February 12, 2009 through March 17, 2009 (2009). This cost is $1,279.85 total (Brenner, 2009). A significant volume of water is used in the garbage disposal, but exact volumes are not known.

Agronomy Department

Another of the main three organizations in the current food composting partnership is the Agronomy Department, under the direction of Dr. Deann Pressley. She obtained a composting permit for a pilot program through the Kansas Department of Health and Environment to begin research and work on this project. The trial site is located at the north side of the agronomy "North Farm" location on the corner of College Ave. and Kimball Ave. As part of the agreement, she has procured an agreement with the North Farm to use a tractor and turner (a piece of machinery that aerates the compost by mixing it as it decomposes) free during the pilot program. She cited three main reasons for the success of the current composting effort; these are initial opportunities, the kindness of others, and progressive student labor. She is conducting research about food composting at the composting site.

Horticulture Department

The third department acting in coordination in the current composting effort is the Horticulture Department through the actions of Dr. Rhonda Janke. Currently student workers use a Kansas

State University pickup truck supplied and maintained through a grant obtained by Dr. Janke (Yoder, 2009). The same grant is also used to pay for the student labor; two workers are hired every semester. Some of the compost is taken to the student farm, a small field outside of town that the Horticulture Club uses to produce vegetables and honey. A small compost windrow is located at the student farm; eventually the compost created from the leftover food scraps will be used to produce a product that will be sold back to the university and around the community.

Student Farm

The student farm is located three miles northwest of Manhattan near Willow Lake. This farm is the production site for vegetables grown by horticulture students in the horticulture club. Accessibility is limited as three separate gates are padlocked barring entry into the farm. One compost windrow is located at the farm. This compost contains half of the total produced by the dining centers. Housing and Dining Services are excited to donate their food scraps to be used for compost. One aspect that most especially intrigues Housing and Dining Services is the prospect of being able to purchase locally grown "heirloom" foods. These specialty foods are costly for the dining centers to obtain but are easily producible by the student farm. They hope to trade raw compost for fresh, quality vegetables for food preparation during the late spring, summer, and fall seasons. The Student Farm provides the workers who are responsible for the daily management of the composting program (Yoder, 2009).

North Farm

The North Farm is the site of the research being conducted by Dr. Deann Presley. This site has three windrows each measuring about 15 yards onsite. The compost is laid on exposed soil; the compost is covered with straw or hay to provide large volumes of carbon to the decomposing biomass and to limit rodent issues and smell concerns associated with decomposing food (Yoder, 2009). This site is much more accessible for compost delivery than the Student Farm, because it is approximately three miles closer to campus. The compost site can be reached in minutes from campus and is located on the corner of Kimball Ave. and College Ave. No gates exist to prevent easy access to the compost. A turner and tractor are located onsite for compost mixing. A preliminary permit through the Kansas Department of Health and Environment (KDHE) has been issued for the site during the pilot program state. This permit specifies that the maximum compost area is .5 acres and the total compost must be less than 360 cubic yards. Roads and site travel may be restricted on very wet days because of the likelihood of muddy conditions.

Figure 2: The North Farm is the site of the Agronomy Department's research facility conducted by Dr. Deann Presley. This site is permitted through the Kansas Department of Health and Environment as a special pilot program. Three windrows are located onsite, with an average height of 1.5 ft. and a length of 30 ft.

Facilities

Kansas State University's Division of Facilities is a major contributor on campus landscaping and environmental issues. Responsible for maintaining the entire campus grounds, Facilities and Maintenance is responsible for all outdoor gardening, lawn care, branch and tree removal, and general campus cleanliness. All leaf, grasses, and tree waste handled on campus is removed by the Grounds Department and is taken to the leaf and tree compost site found north of campus along Serum Plant Road. A wood chipper is owned by the Grounds Department, which is used to create wood chips from all woody plants, branches, and wood pieces less than ten inches in diameter (Myers, 2009). These wood chips are used on campus as mulch for the flowerbeds and landscaping. Also, found onsite is a dedicated site for grass and leaf compost. This site, approximately thirty yards by thirty yards, is the final resting place for all leaf waste created on campus. During peak production times during the summer approximately 2,000 lbs. of leaves will be added to the site daily (Myers, 2009). This location is directly across the road from several livestock pens located near the College of Veterinary Medicine. This site is one possibility for the future location of a food-composting program. In addition, the leaf waste currently being collected from campus could be used to supply the needed "brown" waste (that material consisting of high C:N ratio) to be intermixed with the "greens" of food compost, which has a very low C:N ratio.

Current Program

Initial work on a food-composting program began over the summer when Housing and Dining Services hired a student intern to research composting efforts happening at other universities and to explore how a food-composting program could be established at Kansas State. This intern's summer project culminated in an agreement being reached between professors in three different departments and one student organization (Kennedy, 2009). The Horticulture Club, the group responsible for the Student Farm, currently supplies the workers used for compost collection and maintenance (Yoder, 2009). The current food-composting program is organized between the Housing and Dining Services and the Horticulture and Agronomy Departments.

Twice every week two student interns drive to both Derby and Kramer Dining Centers to pick up food scraps stored from the previous several days. Collection days are usually Monday and Friday. Food waste is loaded onto the Student Farm truck (managed by Dr. Janke) at Derby Dining Center by rolling each fifty-gallon barrel on a mechanized lift, which is used to lift the barrel into the truck bed (Yoder, 2009). The truck has a capacity of 8 barrels, which is the maximum number required so far during the pilot program. At Kramer Dining Center, the food waste is typically stored in a cardboard box or small bucket which can be easily carried into the truck bed and emptied at the compost site (Klobasa, 2009). Currently the compost created from the dining center waste is used onsite at the student farm, but not much volume has been produced so far.

After food waste is picked up the compost is transported to the North Farm on Mondays and the Student Farm on Fridays (Yoder, 2009). The food waste is added to composting windrows established at each site. Hay is used as mulch between layers of food waste to provide the high

C:N materials needed for microbial breakdown of food scraps and to reduce rodent and smell issues. For the entire process from initial pickup of material to depositing the food waste on the windrow it takes approximately 1.5 hours/trip (Yoder, 2009). Interns are paid through the grant obtained by Dr. Rhonda Janke and produce sales from the Student Farm and receive $8.00/hour wage. The total yearly cost of human labor at this point is approximately $1,500, and does not include vehicle maintenance or fuel costs (Yoder, 2009).

As told by Aaron Yoder (2009), a student who worked with this program over the fall 2008 semester, “Right now the Student Farm and North Farm are ideal for demonstration purposes, but if the composting program is to expand to include post consumer waste, I think that a new site would need to be developed, preferably close to campus”. Because of the increased volume expected from a post-consumer waste program (expected food waste weight composted could increase from 250 lb. per week to as much as 3,000 – 4,000 lbs.) a more centralized location closer to campus would significantly reduce the time required to move compost. This would also reduce energy input needed to transport the food compost. Yoder cited other needs in a future expansion of the composting program to include “a new transporting system, some kind of truck with a hydraulic lift” (2009).

The current composting system is currently managed by separate entities. The Horticulture Department is responsible for compost pickup, the Agronomy Department manages the North Farm, and the food collection system is managed by Housing and Dining Services. Coordination between departments is critical for passing information. No outside organizations are involved in organizing or leading this effort.

Waste Management

Currently all food wastes at the dining centers not sent through the garbage disposal are thrown away in the trash. Trash services at the dining centers currently cost $250 per month to rent and maintain trash compactors, with an emptying fee of $110 per trip to empty the compactor. It is not known the number of times monthly that each compactor is emptied.

COMMUNITY

Community Survey

In order to receive community input, compost surveys were distributed at Eastside Market, a local produce market and garden center. Surveys were voluntary; a sign posted behind the checkout counter stated: “Do You Compost? Help us get community input for expanding/ improving Kansas State’s program!” Cotton Burr Compost and Scott’s Humus and Manure is available for customer purchase, but many patrons practice composting at their homes with yard waste and food trimmings.

Barbara Norton creates her compost be combining several materials. “I finish the compost that I get for free from the dairy and swine compound with yard trimmings. Food waste mainly goes into my worm bin, says Norton (2009). Norton then uses this compost, manure, vermicompost, and 'teas' made from these in her fertilizing routine (Norton 2009). Other community members use products like slow-release Miracle Grow and Epsom salts. These products are purchased based on factors such as quality, price, and location. Some consumers look for organic products as well. Concerns with composting included odor, animals, bugs, and chemicals. Norton voiced her concern with "antibiotics and other medications that the animals have been given or chemicals applied to plants winding up in the compost (Norton 2009)." Overall, participants in the survey were still optimistic about composting despite these possible problems.

When asked if she would purchase a local compost product from K-State, Norton said, "I prefer free (I'm pretty low income) but I like to bring in compost from other sources just to be sure there's a wide range of nutrient materials. I also would want to support the KSU composting cause with my consumer dollars; how often and how much I buy would depend on the price (Norton 2009)." Kim Belanger says she would purchase it because she cannot create enough of her own (Belanger 2009). She plans to supplement the compost she produces with purchased compost.

Community involvement is important to a successful composting program and many patrons had suggestions for encouraging community involvement. Jen Kaczynski recommends making information available and "perhaps having a discounted price on composters for yards." Many market patrons expressed interest in composting but did not know much about the actual process. The most appealing aspect of the program was its local nature. Most customers are looking for local, sustainable products, and compost created in Manhattan is ideal for these consumers. Belanger added, "Have community workshops at farmers' markets (or just advertise it there!) (Belanger 2009)." Norton suggested, "Making the end product affordable for poor people like me."

Transfer Station

The Transfer Station is operated by the City of Manhattan and is used as the waste collection location for the city. At the site leaves, grasses, small branches, and pine needles are collected in one of over twelve different compost windrows. Each windrow is over fifty yards long and is approximately four and a half feet tall. These piles are left alone except for the aeration that is done by the tractor and turner. Also attached to the turner is a water application to add moisture to the compost if needed. Material is added every day and is removed occasionally by area homeowners, gardeners, and landscapers.

Figure 3: The compost project at the Riley County Transfer Station collects only leave, grass, and branches. Over ten windrows of compost are at the site; each windrow is over four feet high and 50 yards long. This site has a dedicated tractor and turner and is located on an asphalt pad.

Compost is distributed for $10 per ton. Residential people can leave grasses, leaves, and other brush material free but commercial operators must pay $3 per ton to leave material at the location (Riley County, 2009).

The location is located on a large asphalt pad, with clean driving lanes between windrows. The compost is not managed at all to ensure quality, so care must be taken to that the compost selected for removal comes from good source material. The location of the Transfer Station is at 1881 Henton Rd., approximately three miles south of Manhattan, KS near the Kansas River. Equipment found onsite looks very clean and new.

Elementary Schools

One interesting community development in respect to composting issues is a pilot program called Project PLANTS, an elementary after-school program being conducted by a professor at Kansas State University. The project is studying if a local food systems approach of gardening can have a significant effect on reducing childhood obesity by increasing physical activity through games and gardening and improving personal nutrition. It is hoped that by both classroom lessons and personal involvement with the production of high-quality vegetables elementary school children will desire to eat more healthy foods, with the extra motivation of eating those foods that they have personally harvested. One aspect of the class instruction and outdoor experience is the use of a composting program onsite at these schools.

The program meets twice weekly for approximately 1.5 hours (Domenghini, 2009). During the fall semester one lesson was devoted to composting issues, including information on both food and vegetation composting. During the lesson, each class constructed a small outdoor compost pile for leaf and grass waste and a small bin for worm composting. Some food products are recycled as school children bring leftover snacks and add these to the composting piles (Domenghini, 2009). These classes are happening at four of the nine area elementary schools, with approximately 20-25 children and 3-9 adults per site (Domenghini, 2009). This program is not currently composting very much volume but has a direct impact on citizens through the education of schoolchildren and adult volunteers.

CHAPTER 4 FUTURE COMPOSTING & RECOMMENDATIONS

Outlook

K-State's compost pilot program has been successful in fulfilling its original purpose, but remains fragile. The success can be attributed to both the good will of a cooperative food service staff that goes out of its way to sort, collect, and store pre-consumer scraps, and the generosity of department heads in allocating land and mechanical and human resources. Once the current trial period ends, there is no plan to renew a license. In order for K-State to continue composting, the program must become economically feasible or at least cost-neutral. A future composting method will have to expand upon the KSU pilot program to incorporate more compostable wastes and possibly more land, labor, and capita (Presley).

KSU COMPOSTING PHASE II

The simplest primary steps to progress the compost initiative to a more self-sustaining program would be to cut costs where available and increase compost output. Both can be attained by using aspects of the current method but also by involving more stakeholders. The second phase of KSU composting should maintain the pilot program's land and mechanical usage while increasing the collected amount of food waste and "brown" sources for bulk.

Increasing campus food waste collection

The pilot program only collects waste from Kramer and Derby dining centers. This is post-consumer waste—that is, leftover food from the service line and inedible prep-scraps. By comparing Tables 3 and 4, we can see that the amount collected from the KSU dining centers is only about 11.2 percent of the actual amount produced. This is derived by comparing the recorded amounts of food waste collected from the dining centers to the standard average pre-consumer food waste per meal per day. For example, an average of only 0.035 and 0.004 pounds per meal per day was collected from the Derby and Kramer dining centers, respectively, since the pilot program's inception. An average of these two amounts (0.019 lbs/meal/day) should give an idea of about how much waste is actually being collected for the purpose of the pilot program. This average is only 11.2 percent of the standard 0.17 pounds of waste per meal per day (Table 5).

The cause of this discrepancy is unknown, but there is a large margin of error since the actual empirical data available to create this estimate is limited to inconsistently reported figures over the course of only 18 weeks. However, it is evident that stricter collection practices of pre-consumer waste could yield more scraps available for compost.

For all practical purposes, it may be simpler to assume two possible methods for compost collection. The first method would be based off the current collection technique where about 11.2 percent of the post-consumer food waste created is collected from the two dining centers. On the other extreme, collecting 100 percent of the estimated food waste (Table 4) would be ideal, but improbable. Other factors influencing the amount of food waste collected would be the options to retrieve food waste from various other cafeterias. Again, there are many factors that could go into how much food waste each food center produces, but estimates are shown on Table 4.

If the current collection techniques demonstrated by the dining centers are used to collect food waste from other university-affiliated or local cafeterias, the annual amount of food waste collected could increase drastically. Food waste estimates are shown in Table 5 for possible benefactors of KSU compost and estimated amounts collectable. The first step should be to collect from the other major on-campus cafeteria in the Strong complex. Greek houses, although much smaller and individually owned and operated, are often philanthropic toward sustainable initiatives and could be a willing and, if regarded collectively, a large contributor of food wastes from their individual kitchens. Also included in Tables 4 and 5 is a list of Manhattan's local schools and an estimate of their food waste production. By no means is the list of cafeterias comprehensive. Citizens and local restaurants could be encouraged to donate their food scraps to K-State's program; however, specific food waste amounts for these entities are incommensurable for all practical purposes. It should be noted that some citizens and local restaurants collect conveniently-attainable food scraps for donations to the Flint Hills Breadbasket, while most corporately operated restaurant chains are mostly opposed to collect their food waste as it is often more economically feasible to simply dispose of it.

Collecting post-consumer waste would greatly increase the amount of compostable food waste, but often at the inconvenience of the service staff. The collection of post-consumer waste—that is, food or paper napkins retrieved from plates—would at least double the amount of food waste (Food Waste Analysis), and possibly triple (Shanklin). Often overlooked, beverage waste from cups in the form of ice or liquids would also drastically increase the weight while minimally increasing the volume of food waste (Shanklin).

A hybrid of better collection methods and incorporating more contributors would be the ultimate goal for a second phase in K-State's compost program. As Table 4 shows, an estimated 188.573 tons of waste could be collected from local food service centers under ideal collection conditions, nearly 11-fold to the current pilot program amounts.

Using local bulk material sources

Currently, the food waste distributed in the windrows is supplemented with hay, which costs about $100 per bale (Janke). However, K-State Facilities' grounds crew manages a leaf compost pile of its own North of Weber Hall of off Serum Plant Road. The 1.5 acre site contains two windrows about 60' x 18' x 6' each consisting of litterfall and small plant debris solely from the KSU campus. This fodder was collected over the course of one school year and transported to the site periodically by Facilities' trucks, pickups, or Gators as needed. The leaf windrows are located on campus very near to the Agronomy Farm and some could be transported to the Horticulture Farm as needed (Meyer).

Assuming about 360 cubic yards of waste (Table 1), the pile could easily supply brown bulk for the current pilot program and comfortably for a program utilizing up to 10-times the amount of food waste (Total Volume, Table 2). Annual additions of seasonal leaves and debris from campus would continue to supply KSU's composting program indefinitely. This resource would also eliminate the cost of hay bales for bulk supplement.

Cooperation with the Manhattan Transfer station could also benefit K-State's future composting program. The Transfer station holds and estimated 1,350 cubic yards of waste in the form of leaves, lawn clippings, and other assorted yard and plant waste. Transporting this free resource or accepting community yard waste to on-site KSU composting areas would be a huge source of bulk for composting that could presumably provide all the bulk material needed for the second phase of KSU composting.

KSU COMPOSTING PHASE III

Phase II is manageable under the current infrastructural conditions, but up to a certain point manpower, space, and licensing regulations must be addressed. It is possible to expand local composting further, involving more compostable sources and more stakeholders, but consequently more land, machinery, and paid labor positions. Many factors are involved in a possible campus-initiated, large-scale compost facility, some of which can be addressed here.

Land Requirements

The current pilot program's permit authorized KSU to produce up to 430 cubic yards of compost per half-acre, which is sufficient for the current composting methods employed through the pilot program (Presley). However if the K-State compost program could extend to encompass the community, local business, a restructuring of collection means to adjust for more efficient and post-consumer wastes, all the while meeting Kansas Waste Management regulations, a more structured method needs to be implemented. After the volume limit is reached, additional space must be obtained to meet the needs of a larger composting program and to conform to state regulations. The actual size of the required site depends on the many things, including:

- the anticipated volume of raw materials,
- which composting technology would be used,
- the equipment to be used (which will depend on the method and materials composted),
- and the projections for growth (Cornell Waste Management).

Other factors that should be considered in choosing a future long-term, large-scale site include accessibility (roads suitable and convenient for traffic and transportation of materials), population density (should be no houses within half a mile), and type of neighbors. Desirable site characteristics include slightly sloped land (for drainage), a firm soil type that packs well, not located in a flood plain, convenient utilities, and a rectangular or square site (Cornell Waste Management).

Regardless of the method used, an ideal plot of two to five acres dedicated to windrow composting would be suitable a large scale compost facility in Manhattan. Both of the current KSU compost windrows are on bare plots (the Transfer station is paved). A future site would have to have to be paved under to direct drainage and prevent leachates. Paved pads serve several purposes, including water quality protection, providing a good working surface, allowing access through wet weather conditions and preventing the mixing of soil into the compost when it is turned. In dry conditions, most soil types provide a good working surface, but many will be problematic after a storm event or during spring thaw. Pads need to provide a solid working surface so that machinery can function throughout the year (Cornell Waste Management).

Labor Requirements

The labor involved will ultimately depend on the composting method and the size of the operation. According a Cornell Waste Management report, a large-scale compost facility could be managed by two full-time employees. Duties for the employees would include operating dump trucks for pickup and transportation to composting site, operating compost turners, and have knowledge of the biological process of composting to be able to adjust techniques for proper compost outputs.

If a large-scale community-wide compost facility were implemented, administrative duties would also be needed to enforce policy, regulations, mediate university, and municipal relations. Again, these positions are relative to exactly what type of facility may be in use and the stakeholders involved.

ALTERNATIVE METHODS

Although strictly food and plant waste compost in windrows is the contemporary approach as initiated through the pilot program, other sustainable waste management methods such as in-vessel composting, vermicomposting and biofuel refining are feasible for K-State. However, given the current conditions, continued windrow composting or in-vessel compost options are most suitable.

In-Vessel Composting

In-vessel composting is the most viable solution for a low- to mid-volume composting program that K-State could seek in the future. In-vessel composting involves applying compostable solid, liquid, or sludge waste into an often-enclosed bin and turning the waste via an internal auger. The benefits of in-vessel composting include less labor and time needed for operation, a quicker composting process that reduces volume more rapidly, less need for bulking agents, and temperature and odor control (Green Mountain Technologies). Green Mountain Technologies, based out of Vermont, offers services and products like the Earth Tub and the Earth Bin designed for mid-scale, in-vessel composting (Table 6).

For K-State, an in-vessel method may be the simplest solution if large-scale compost facilities become unrealistic to keep the compost initiative going. These vessels are easy to maintain and could be placed at high-volume waste sites to mitigate transportation, labor, and permit costs. One downside is that focusing waste collection at specific locations would not encourage more community involvement from other cafeterias and food service centers.

Recommendations

-Food waste audits are needed for better data to predict future outcomes for community composting.

-Understanding the social interest in composting or other sustainable issues may encourage more community wide awareness.

-The possibility of refining grease and oils collected from the dining centers could be used for campus vehicles while mitigating disposal-tipping fees for hazardous waste.

TRANSPORTATION

Collection/ Labor

The transportation of food waste from Housing and Dining Services is all done by the Agronomy Department. A truck (supplied by the Horticulture Department) comes by each Monday and Thursday to pick up the food waste. The food waste is collected into fifty-five gallon trashcans on top of a support system with rollers to maneuver the immensely heavy trashcans. These trashcans when filled with food waste can weigh upwards of a few hundred pounds. With this type of weight, there is no way to pick up the trashcans without an extreme amount of labor or a mechanized lift. Derby Dining Center has a mechanized lift to allow the hoisting of trashcans into the composting truck. On the other hand, Kramer Dining Center does not have such capabilities, therefore the waste collectors have to physically pick up the trashcans and load them onto the composting truck. Each semester two students are employed by K-State to be in charge of collecting and transporting the food waste to the composting site.

Transportation to Compost Sites

After the food waste has been collected, it is taken to the compost site itself. Here at K-State we have two composting sites that allow food waste. The first one is at the "North Farm" which is run by the Dr. Deann Presley of the Agronomy Department, and the second composting site is at the "Student Farm" which is run by Dr. Rhonda Janke of the Horticulture Department. Both sites have relative easy access to drop off compost and are very close to the collection site. This close commute distance is great for cost because the trip to collect and transport the food waste does not waste very much gasoline.

Future Transportation Needs

The incorporation of adding the more collection sites such as high schools, elementary and middle schools, fraternities and sororities, and the K-State Student Union will require more trucks to pick up the food waste or create a schedule to pick up different collection sites on different days. The incorporation of more collection sites also brings up the concern of creating a uniform collecting operation. The usage of the fifty-five gallon trashcans would mean a mechanized lift would be needed at each collection site, and a holding area to keep the food waste until pickup would be needed. The possible need for a few trucks to use as collection trucks would make the process easier. Labor would need to be increased due to the number of collection sites and schedules of pickup days.

SOCIO-ECONOMIC VS. ENVIRONMENTAL SUSTAINABILITY DEBATE

Many scientists believe that the Earth is entering into a new geologic epic or era called the Anthropocene. Since the last Ice Age or Holocene, circa; 13,000 years ago, humans and their interaction with the Earth have revolutionized greatly and particularly during the last two hundred years. The industrial revolution significantly changed the interconnectedness between humans and the Earth; but not until recently, or the last fifty years have scientists been able to measure the effects that humans and their technology have had.

This subject is much more complicated than just measuring direct effects that humans have on the Earth. For example, a community may have a small transfer station located close to its town. For the last five years, residents within a five-mile radius of the plant have developed similar health symptoms. Scientists are interested in exactly what those health symptoms are. They document and study everything from the health effects, the chemicals, the mileage between the residents and the transfer station; they research the actual transfer station to determine the chemicals, or potential leaching of chemicals into the soil and water, they determine the amounts and the potency of the chemicals. Scientist can quantify their collected scientific data by testing their hypothesis in labs.

Social scientists are interested in variables that are difficult to measure or that are confounding. One particular area of social emphasis is; measuring collective societal behaviorism as it relates to humans and their interaction with the Earth. Human Exemptionalism is the term environmental sociologists use to define societal behaviors at the apex of the industrial revolution and particularly during late 1960's, 1970's and early 80's. In America during the 1970's more laws were created, and amended in local, state and federal governments then in any other period of American History, excluding the creation of the constitution.

Historically the industrial revolution began a complex social web that intertwined humans and their beliefs and values involving human domination over the earth. Social scientists have tried to understand what created this social movement into a mechanical era. Why did humans suddenly have a need or a desire to dominate the earth, or create such large quantities of technology? The answer is intermixed with politics, religion, and economy. Since the beginning of the Industrial Revolution, America, along with other countries has moved into second and third phases of the Human Exemptionalism paradigm (HEP).

"In the 1960s and 1970s, social scientists' interest in the concept environmental attitude increased. There was a great deal of concern relating to the environment during this decade: the Ohio Cuyahoga River caught fire in 1969 capturing national attention; the first Earth Day was held in 1970; the National Environmental Policy Act was signed that same year; and energy conservation became a primary goal in the mid and late 1970s as oil embargoes severely impacted the nation. As a result of these and many other incidents, funding for research directed at the environment and human interaction with the environment became more of a priority." (http://www.socialresearchmethods.net/tutorial/Pelstrng/validity.htm)

A strong and controversial debate has moved into a phase that some environmental sociologists would refer to as The Practical. It addresses questions such as, if technology has created environmental consequences, what proof is there that technology can fix them? Even though humans have learned to dominate the earth through technology, is it the same societal behavior that has driven scientists to create technology that measures the damage done to the Earth; and what makes one more justifiable than another? Measuring contemporary societal changes in attitudes or wave in attitudes as they relate to the environment is called NEP or New Environmental Paradigm.

Remember the example of the transfer station located close to a community where people experienced similar health symptoms? A social science approach would be to answer a serious of different questions such as; why did residents feel a need to have a transfer station? On the other hand, would they be willing to stop using it if it affected their health? What considerations were given before bringing the transfer station to their community? Documenting these behavioral variables into charts and tables helps develop a better understanding of how people relate with their environment. Once the behavioral variables are documented, then potential changes can be consistently measured.

The food waste composting project at Kansas State University has many potential research avenues. One of those avenues is the social-value component; however, it is also one of the most subjective. The paradox of our research project currently discloses a lack of substantial social discourse and social research. This is an important discovery for a couple of reasons. Dr. Carol W. Shanklin, Dean of Kansas State University Graduate School published an extensive food waste dissertation circa; 1989-1991. Expletively detailed, her research meticulously measured volumes of biomass, by placing screens over the garbage disposals in the Derby and Kramer resident halls. She had several graduate students who also wrote thesis, and dissertations researching numerical data as it related to KSU food waste.

Not only did Dr. Shanklin's research prove that food waste was in direct correlation to cost avoidance in labor, utilities and water, but that there was a social component for the need to do such research. From a social science perspective, why did this topic surface, why were people at KSU interested in food waste and cost avoidance in the late 1980's and early 1990's? In addition, why did the research and issue lay dormant for over 15 years? And, why is this topic re-surfacing again?

Today, it is plausible that the economic recession in America has created a stronger ecological dialog, Americans and institutions are forced to cut back, securitizing areas where money can be saved. Should economics and environmental sustainability be coincided? There is an ethical debate, should KSU implement a food waste program because it is the 'environmental' or 'right' thing to do, and what is the best environmental way to do it? Should KSU implement a food waste program because it will save the university money? Alternatively, will people need an incentive to compost food waste? Placing a social value on food waste composting is difficult because it has not been done prior and second, the results may disclose an undesirable result. A common revolving social theory in education is; do people change their values, beliefs and behaviors because they want to or because they are forced to.

SUSTAINABLE FOOD WASTE POLICY

Where It Began

The latest environmental social movement includes a dialog rotating around the term sustainability. "The Sustainable Endowments Institute is a nonprofit organization engaged in research and education to advance sustainability in campus operations and endowment practices. Founded in 2005, the Institute is a special project of Rockefeller Philanthropy Advisors." (http://www.endowmentinstitute.org). The Sustainable Endowment Institute developed a cohesive method for measuring sustainability of Universities and colleges in the United States and Canada.

"Now in its third year, the College Sustainability Report Card covers the colleges and universities with the 300 largest endowments in the United States and Canada, representing more than $380 billion in endowment assets, or more than 90 percent of all university endowments. It increases the number of schools included by 50 percent relative to the 2008 edition of the Report Card and provides insights into recent trends… just as the grading system serves as an incentive in the classroom, the Report Card's grading system seeks to encourage sustainability as a priority in college operations and endowment investment practices by offering independent yearly assessments. The focus is on policies and practices in nine main categories…" (http://www.greenreportcard.org/report-card-2009/executive-summary)

- Administration
- Climate Change & Energy
- Endowment Transparency
- Food & Recycling
- Green Building
- Investment Priorities
- Shareholder Engagement
- Student Involvement
- Transportation

Kansas State University has received a report card from the Endowment Institute since 2008. KSU had an overall grade of D+ in 2008 and moved to a C in 2009. This includes all nine areas listed above. How does Kansas State University compare to other Mid-West land grant colleges? KSU ranks average to below average in comparison to Oklahoma State, Nebraska, Missouri, Colorado, and Iowa.

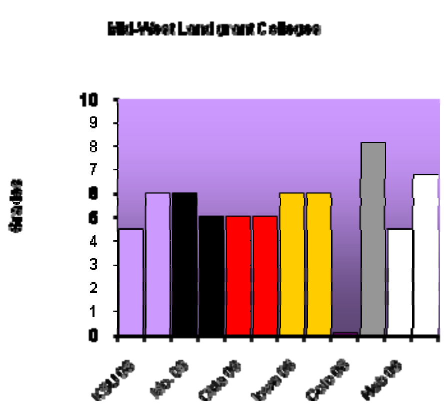


Chart 1: (6) Midwest Land grant colleges: including KSU Yrs 2008 and 2009 Overall sustainability grades.

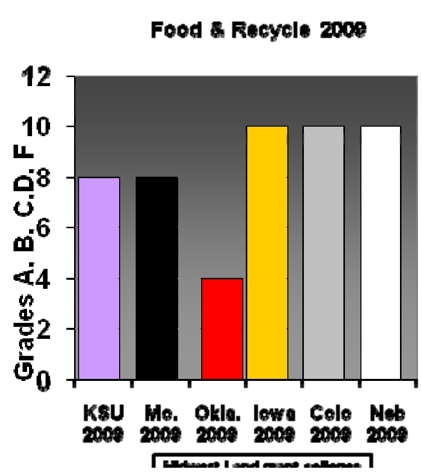


Chart 2: Food & recycling 2009 comparison 0 is F, 10 is A

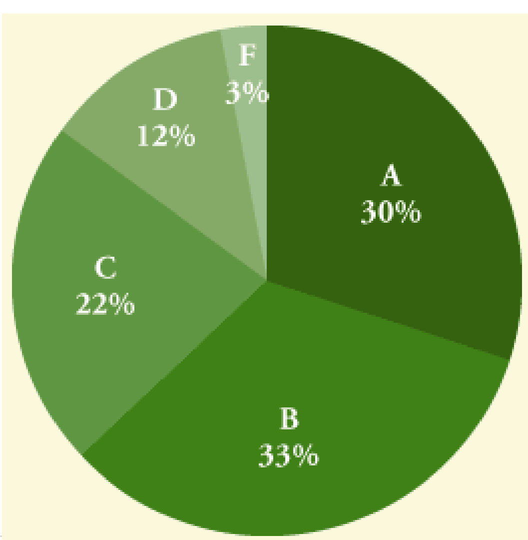
OVERVIEW: THE FOOD AND RECYCLING CATEGORY

The Food & Recycling category looks primarily at the policies and practices of dining services in relation to sustainability. Points are given based on the quantity and availability of locally grown food, as well as organic and sustainably produced food. The utilization of reusable dishware and eco-friendly to-go containers is also taken into consideration. The category also examines programs on recycling (campus-wide and dining specific) and composting (food as well as landscape waste).

Key Findings

- More than four in five schools buy food from local sources. An impressive 82 percent of schools devote at least a portion of their food budgets to buying from local farms and/or producers.
- Almost three in ten schools have a community garden or farm on campus. Campus community gardens and farms are maintained by 29 percent of schools.
- Three-quarters of schools offer fair trade coffee and other food items. Fair trade coffee and other fair trade food items are available at 74 percent of schools.
- Approximately half of schools compost food or landscape waste. Food composting programs exist at 55 percent of schools, while 46 percent of schools report composting landscape waste.
- Schools are offering food to match different dietary needs and preferences. Vegan options are offered on a daily basis at 68 percent of schools.
- Biodegradable to-go containers are available at 32 percent of schools
- The average grade for the Food & Recycling category was "B-." For a summary of grade distribution for this category, please refer to the chart below.

Grade Distribution



Pie Chart: Overall sustainability grade distribution according to the Endowment Institute 2009

More than four in five schools buy food from local sources. (2008 Sustainable Endowments Institute) According to the Endowments Institute, "Approximately half of schools compost food or landscape waste. Food composting programs exist at 55 percent of schools, while 46 percent of schools report composting landscape waste" The Food & Recycle category has many sub-divisions, one of those is composting, however the data is unclear when deciphering between food waste composting programs and landscape composting programs, and there is no mention of animal or manure composting programs.

The KSU 2009 data that was provided to the Endowments Institute included several questions for each category which eventually configured into KSU's overall grade. The same is true for the Food & Recycling Category. Our research concluded several inconsistencies, question number five read as follows:

- **5) Please describe your school's recycling and composting programs.**

  KSU responded with a description about the comprehensive recycling program … "The most current figures for waste diversion through the conventional recycling program are 716,956 pounds for fiscal year 2007 (July 2006-June 2007). This includes plastic bottles, aluminum, and cardboard, all types of paper, computer equipment, and pallets." The next question was as follows:

- **6) Has your university created sustainability initiatives in administration or policy development that are not mentioned above?**

  Part 3 under additions read as follows, "Administration has supported the creation of a major sustainability website as information hub for sustainability activities and interests at K-State. The website will be linked and featured to the K-State homepage." The KSU listed website, http://www.k-state.edu/facilities/recycling titled, Help Make A Difference K-State stands committed in building a first rate recycling program to serve the campus community and save our environment for the next generation" the website is very user friendly however completely dedicated to recycling and recycling statistics. There is not any mention of composting and especially food waste composting. Other findings included The Stewardship Subcommittee of the Campus Development Advisory Committee, which would propose strategies, principles and guidelines for environmental stewardship... and the Kansas Board of Regents in their committee to develop a statewide sustainability policy..." Our findings also concluded that there was a lack of wording devoted to the development of an environmental stewardship 'mission or vision' statement. Furthermore, the proposed student lifestyle campaign included three major areas, recycling, ped/biking, and energy efficiency.

Because KSU is, a land grant institution, consideration of its resources is crucial. Dividing the recycling and composting into separate categories would be beneficial for future funding and research. According to Ben Champion, KSU Director of sustainability, "Because we are a land-grant school with such a strong agriculture program, not just in horticulture but in other units like beef and dairy production, there are substantial amounts of manure from those operations, we've got those kinds of resources that could be mixed into this process, and we could really develop a lot of high-quality fertilizer for our use on campus and in the community."

In the 2009 survey, food waste composting was not specifically addressed in the survey, yet in a News release prepared by Erinn Barcomb-Pererson Dr. Ben Champion had this to say:

> ...with K-State dining facilities have partnered with K-State's student farm and College of Agriculture to develop a composting program for food waste. "It will help the students at the student farm with their produce, which they'll end up selling throughout the community," said Ben Champion, K-State's director of sustainability. "Part of that food will go back to the dining centers, so we've got a cycle going here."

In a research project by the University of Iowa 2006 titled "University of Iowa Compost Project" a compressive food waste composting proposal was created based on objectives from the following, "The Operations Manual for the University of Iowa states in Chapter 43 that the University will:

> "Strive to develop, design, and operate our facilities and conduct our activities taking into consideration the efficient use of energy and materials, the sustainable use of renewable resources, the minimization of adverse environmental impact and waste generation, and the safe and responsible disposal or reuse of wastes or by-products. "(University of Iowa, 2005)

Our research concluded that Kansas State University has an operations manual, but that there is a lack of environmental stewardship mission statements, policy and or sustainability provisions. The tone of Kansas State University's manual is more directed for safety procedures for students and faculty rather than sustainability. Further research is needed to confirm a correlation between Kansas State University's polices and the overall sustainability grade from the Endowment Institute. It is our speculation that there is a connection between the universities with higher-ranking grades, and their established university policies and mission statements.

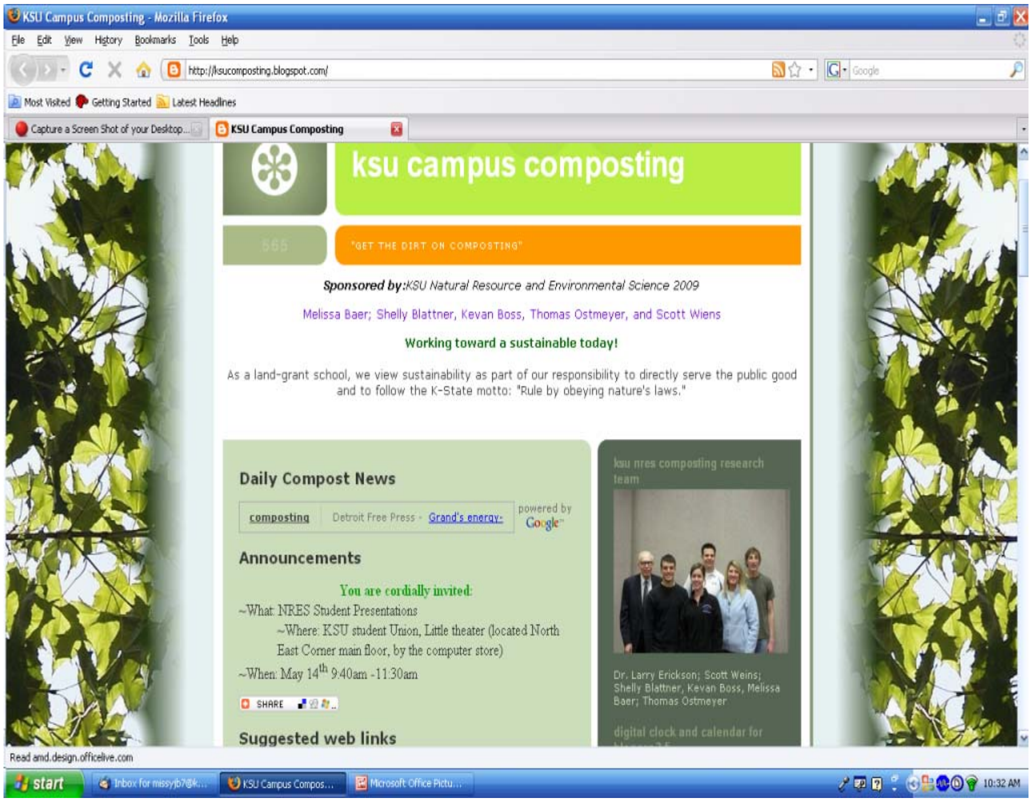
KSU MARKETING STRATEGIES

The Kansas state housing and dining facilities, the student farm, and the office of sustainability have taken interest in campus food waste composting as an avenue for cost avoidance, waste reduction, reuse of natural resources, and conservation of energy. Our primitive and limited research did not find another university that marketed compost nor proposed marketing their compost. Not only would this raise our grade, but could make KSU a leader in land grant innovations. Our proposal is that Kansas State University has the opportunity to create a niche in the composting market. Through continued research and a feasibility study, KSU could conclude marketing and selling compost, and by-products from the campus food-waste and animal manure is cost effective and potentially profitable. Call Hall has been selling ice cream and other campus agricultures products for many years.

Our general ideas included marketing techniques such as selling compost in biodegradable bags with KSU labels. (See below). The profit from selling local KSU organic compost eventually could be used for equipment needed to research composting methods such as vessel or vermin composting. Cost avoidance, and the profit margin could also be applied to such problems as installing equipment such as candy cane lifts in the dinning centers, or pulp food separators. Other ideas include developing a cohesive centralized organizational team. A web-page can be used and sustained for posting KSU campus compost news, and latest research, and 'how to buy KSU compost'. We have created a sample web page (see next page).

Certified USDA Organic Compost Bag

Grade B Compost Bag



Web page
http://ksucomposting.blogspot.com an interactive web page created by KSU composting research team

Our team created these ideas as suggestive proposals only, our goal is that our limited and restricted research is user friendly and helps keep the current KSU food waste program moving forward. By documenting KSU food waste composting in a central location such as the web site, it increases time efficiency for those dedicated to research and development and future sustainability. Policy and marketing are key for obtaining grant funding and economic self-sufficiency. It is our hope that this project continues and Kansas State University recognizes the social value related to food waste composting and the future legacy of left to our children's children.

CASE STUDIES

University campuses all over the country are implementing composting programs in order to meet waste reduction goals, educate students, and increase sustainability. Some programs have been in place for decades while others have recently emerged due to increasing demand. Penn State University has been collecting food residuals since 1997 while Ohio State began eleven years later after students voiced concern regarding waste disposal on campus. Both campuses have unique systems in place that can aid other universities in choosing which composting system to implement and achieving success.

Penn State University

"About two tons per day of food residuals are being diverted from dining halls and on-campus hotels at Penn State's main campus," states Nora Goldstein, Editor of BioCycle Magazine. In August of 2003, BioCycle featured an article covering the university's successful transition from a demonstration project to a full-scale collection site.

Penn State began collecting food residuals during an eight-week demonstration project in 1997. Students had voiced concern over the disposal of organic residuals, leading to the creation of the project to test the viability of composting campus waste. Nadine Davitt, composting coordinator for the Penn State Organic Materials Processing and Education Center (OMPEC), says, "The project has parallel goals of responding to the needs of handling organic residuals generated from within the university and enhancing teaching, research, and extension/outreach programs of a land-grant university (BioCycle 2003)." Several departments, including the College of Agricultural Sciences, Housing and Food Services, Hospitality Services, and the Office of Physical Plant, collaborated to make the program possible. Pre-consumer food and post-consumer napkins collected by Housing and Food Services employees from one dinning common were transported to an area used as a manure storage facility. The material was mixed with a manure/soybean/fodder blend and placed into windrows. Eight tons of waste was diverted by the project. "The preliminary results proved to be beneficial for all departments involved," says Davitt (BioCycle 2003).

The next step for Penn State was a follow-up one-year pilot program in 1998. Collection expanded from one to three dining commons. Participants in the program also determined several necessary modifications to operation during this period, which included larger collection containers with wheels and a truck with an automatic lift. During the demonstration, containers of waste were being manually lifted into a truck. Once the pilot ended, university officials decided to continue the composting program and purchase the recommended equipment. The demonstration and pilot program achieved success without the purchase of any specialized composting equipment. In order to expand the program, a windrow turner, a Screen USA star screen to separate fine from larger material, and a small building were also purchased (BioCycle 2003).

In 1999, Penn State went full-scale collecting pre-consumer food residuals from seven dining commons, campus day care, and the student union. Pre-consumer and post-consumer residuals were collected from the School of Hotel, Restaurant, and Recreation Management test kitchen and two hotels operated by Penn State. Post-consumer waste collection presents more obstacles than pre-consumer, such as ergonomic constraints. Dining common employees would have to separate out the compostable materials, taking the plate from the dish line and physically rotating their body to clear the plate into a collection can. Davitt states, "This process posed an ergonomic safety issue related to repetitive motion injury, and it was very messy (BioCycle 2003)." During the pilot program, Penn State tested post-consumer collection briefly. A need for pulpers, machines that crush scrapings and remove some of the water, was determined. With pulpers, plate scraps could be knocked into them before being placed in the dishwasher. A future pilot program will implement the installation of pulpers, which will double the amount of residuals collected annually (BioCycle 2003).

Soon the successful program required a capacity increase. The program was operating from a pad at the manure storage site. A highway construction company was looking for a temporary concrete plant site so the university gave them land use in exchange for installing utilities and completing site work. This partnership produced a one-acre concrete pad and five acres of gravel surface for a new composting site. In 2003, Penn State was able to begin operation at the new site with a new material handling regime. Previously, materials were emptied on a layer of yard trimmings, manure, and corn fodder and then mixed with a windrow turner. Now materials are loaded into a mixer first, which blends and reduces particle size. The recipe is one-third food residuals, one-third leaves, and one-third manure, corn fodder, and wood chip mix which is composted for about 15 weeks. The material is turned about eight times during this period and then cured. The resulting compost is stockpiled for use in the spring and fall for planting beds, potted planters, turf top-dressing, construction site soil restoration, and research projects. A tip fee is paid at the composting site for food residuals, leaves and yard trimmings. The compost is sold to departments in order to cover the composting costs incurred. "While a cost/benefit analysis hasn't been conducted, the university is avoiding the landfill tip fee of $58/ton for the organics diverted," says Davitt (BioCycle 2003).

Penn State departments are conducting research projects with the compost, examining different blends and studying the composting site itself. The program is fulfilling the university's outreach and extension functions by offering tours and presenting a model for composting for other universities. Also, the universities recycling rate has increased to 33.6%, 23.9% of which comes from organics diverted (BioCycle 2003).

Ohio University

Ohio University has taken a different approach to composting, using an in-vessel unit that composts on a large-scale. The ten-ton stainless steel vessel from Wright Environmental Management Inc. is capable of processing two tons of pre- and post-consumer food waste, biodegradable packaging, and landscaping waste per day. It accelerates the natural pace of decomposition by transforming waste to soil in 14 days followed by a 90-day curing period (Ohio University 2009).

The Grounds department operates the system and plans to use the compost on-site. The unit will run continuously, making daily deposits of compost. Pre- and post-consumer residuals are collected from the Central Foods Facility and mixed with landscaping waste, animal bedding from research labs, and sawdust from carpentry shops in order to achieve the right C:N balance. Soon, the university will collect from all campus dining areas and incorporate biodegradable service ware into the compost. Sonia Marcus, Sustainability Coordinator, states, "All of our biodegradable service ware is purchased from Gordon Food Services and Nature Friendly. The bowls are made of sugar cane fiber that is a waste product of the sugar refining process. The cutlery is made from potato and other natural plant starches. The transparent clam shell containers are made from a biologically based polymer called PLA (polylactic acid), which is derived from corn or other plants (Ohio University 2009)."

The system included a lift with compatible 64-gallon bins on wheels. The bins are collected daily by the Grounds Department, power-washed, and then returned. Patrons to the food court will sort waste, guided by educational posters displayed in the area. In the dining halls, employees will sort the waste (Ohio University 2009).

Ohio University is moving towards a zero-waste model. The cost of the in-vessel composting system was covered by two grants totaling over $300,000. The Ohio Department of Natural Resources' Division of Recycling and Litter Prevention funded the vessel while the Energy Loan Fund Grant Program funded $35,105 for solar panels to power it. A solar array provides 50% of the power needed (Ohio University 2009).

The university selected this in-vessel system over windrows due to several factors, the first of which being a lack of space necessary for windrows and static piles. Also, the composting process in accelerated by controlling temperature, moisture, and aeration which is helpful in breaking down the bio ware used in the student center. Less staff is needed for the in-vessel system and there is more odor and rodent control (Ohio University 2009).

TABLES, CHARTS, AND FIGURES

Relevant area composting sites

	Site Acreage	Windrows	Length (ft)	Width (ft)	Height (ft)	Material Volume (yd^3)*	Collection Time (months)
North Farm (Agron Dept)	-	3	45	4	3	45.000	-
Student Farm (Hort Dept)	5	1	30	3.5	2.5	7.292	6
Transfer Station	1	12	150	6	4.5	1350.000	(seasonally)
KSU Facilities' Grounds	2	2	60	18	6	360.000	12

*Estimating %75 volume of dimensions to compensate for pile shape

TABLE 1: A list of the current sites in Manhattan involved in composting. The Agronomy North Farm is situated on a 153-acre plot of land, but only about an acre of this is dedicated to compost windrows. Plant waste has been composted in windrows for about four years on the North Farm, so the amount of material in the windrows has accumulated undocumented. The volume of the material in the windrows is estimated at 75% of the cubic volume to compensate for variation in individual windrow shapes.

KSU compost pilot program amounts collected

	Number of Bins	Number of Buckets	Weeks	Number of Pickups	Total Bin Weight (lbs)	Total Bucket Weight (lbs)	Total Bin Volume (yd^3)	Total Bucket Volume (yd^3)
3 Nov 08 - 18 Dec 08	-	-	7	12	2220*		3.1968	
19 Jan 09 - 9 Mar 09	60	20	7	13	12000	400	17.28	0.576
30 Mar 09 - 23 Apr 09	37	21	4	8	7400	420	10.656	0.6048
SPRING TOTALS	97	41	11	21	19400	820	27.936	1.1808
TOTALS	-	-	18	33	20220		32.3136	

*Indicates Estimate

TABLE 2: Amounts collected from the Fall 2009 to Spring 2009 semesters for the compost pilot program. No exact collection data could be found for the Fall series, but an estimate of the total weight of the waste was given (Janke). The total weights are assumed by multiplying the number of vessels collected in the period by a standard average weight of 200 pounds per 55 gallon bin (used at the Derby dining center) and 20 pounds per 5 gallon bucket (used at the Kramer dining center). Actual weights are dependent on the type of food collected and its moisture content as well as how full the containers are filled. Volumes are derived by the following formula:

X gal * 0.00576 yd^3/gal= Y yd^3 (BioCycle)

Another useful conversion when dealing with weight to volume is:

1 lb = 0.25 gal * 0.00576 yd^3/gal = 0.00144 yd^3

This was used to estimate total bucket and bin volumes for the Fall 2009 period. Finally, separate totals are given to differentiate between more precisely documented data from the Spring series from the estimates from the Fall. The pilot program is estimated totals are the bottom row.

KSU compost pilot program food waste collected from 3 Nov 2008 to 23 Apr 2009

	Food Waste (lbs/week)	Lunches/Day	Per Meal (lbs)*
Derby	1763.636	3400	0.035
Kramer	74.545	1400	0.004
TOTAL	1838.182	4800	0.038

*assuming 2.5 lunches equals total meals/day

TABLE 3: Derived amounts from the pilot program data. Food waste is calculated by dividing the total amount of food by the number of weeks that pickups were regularly made. Per meal food waste assumes about 2.5 times the number of lunches fairly predicts the actual number of meals per day and is the quotient food waste and meals per day.

Estimated pre-consumer food waste produced by area cafeterias

	Meals/Day	Waste Per Day (lbs)	Waste Per Week (lbs)	Weekly Volume (yd^3)	Volume Per Year (yd^3)*	Waste Per Year (lbs)*	Amount per Year (tons)	Estimated Compost Output (tons)
KSU Derby Dining Center	3400	1445.00	8670.00	12.485	374.544	260,100.000	130.050	61.449
KSU Kramer Dining Center	1400	595.00	3570.00	5.141	154.224	107,100.000	53.550	25.302
KSU Strong Dining Center	1000	425.00	2550.00	3.672	110.160	76,500.000	38.250	18.073
KSU Fraternities*	1150	488.75	3421.25	4.927	147.798	102,637.500	51.319	24.248
KSU Sororities*	550	233.75	1636.25	2.356	70.686	49,087.500	24.544	11.597
Manhattan High	1893	321.81	1609.05	2.317	69.511	48,271.500	24.136	11.404
Amanda Arnold Elementary	471	80.07	400.35	0.577	17.295	12,010.500	6.005	2.837
Dwight D. Eisenhower Middle	362	61.54	307.70	0.443	13.293	9,231.000	4.616	2.181
Frank V. Bergman Elementary	526	89.42	447.10	0.644	19.315	13,413.000	6.707	3.169
Lee Elementary	309	52.53	262.65	0.378	11.346	7,879.500	3.940	1.862
Marlatt Elementary	420	71.40	357.00	0.514	15.422	10,710.000	5.355	2.530
Northview Elementary	503	85.51	427.55	0.616	18.470	12,826.500	6.413	3.030
Susan B. Anthony Middle	431	73.27	366.35	0.528	15.826	10,990.500	5.495	2.597
Theo Roosevelt Elementary	289	49.13	245.65	0.354	10.612	7,369.500	3.685	1.741
Woodrow Wilson Elementary	398	67.66	338.30	0.487	14.615	10,149.000	5.075	2.398
Bluemont Elementary	238	40.46	202.30	0.291	8.739	6,069.000	3.035	1.434
TOTALS	13340	4,180.300	24,811.500	35.729	1,071.857	744,345.000	372.173	175.852

TABLE 4: A comprehensive table of KSU's dining centers and Manhattan public schools (does not include private). Waste per day assumes 2.5 times the number of lunches fairly predicts the actual number of meals per day and is the quotient food waste and meals per day. Waste per week is product of waste per day and the number of days the food provider serves meals (six days per week for KSU dining centers, seven for Greeks, and five for public schools). Volume per year assumes 30 school weeks in one year. Estimate compost output was derived from the following formula:

Waste tons/year * (1.05) * (0.45)

Where about 5 percent of total weight will be added to food wastes in the form of bulk material and the final product would reduce in size by 55 percent during the composting process. (School enrollment data from http://www.schooldigger.com.)

Estimated pre-consumer food waste collectable from area cafeterias assuming conventional collection methods of 11.2% of total food waste produced

	Waste Per Week (lbs)	Weekly Volume (yd^3)	Volume Per Year (yd^3)	Waste Per Year (lbs)*	Amount per Year (tons)	Estimated Compost Output (tons)
KSU Strong Cafeteria	285.600	0.411	12.338	8,568.000	0.480	0.227
KSU Fraternities	383.180	0.552	16.553	11,495.400	0.644	0.304
KSU Sororities	183.260	0.264	7.917	5,497.800	0.308	0.145
Manhattan High	180.214	0.260	7.785	5,406.408	0.303	0.143
Amanda Arnold Elementary	44.839	0.065	1.937	1,345.176	0.075	0.036
Dwight D. Eisenhower Middle	34.462	0.050	1.489	1,033.872	0.058	0.027
Frank V. Bergman Elementary	50.075	0.072	2.163	1,502.256	0.084	0.040
Lee Elementary	29.417	0.042	1.271	882.504	0.049	0.023
Marlatt Elementary	39.984	0.058	1.727	1,199.520	0.067	0.032
Northview Elementary	47.886	0.069	2.069	1,436.568	0.080	0.038
Susan B. Anthony Middle	41.031	0.059	1.773	1,230.936	0.069	0.033
Theo Roosevelt Elementary	27.513	0.040	1.189	825.384	0.046	0.022
Woodrow Wilson Elementary	37.890	0.055	1.637	1,136.688	0.064	0.030
Bluemont Elementary	22.658	0.033	0.979	679.728	0.038	0.018
TOTAL	1,408.008	2.028	60.826	42,240.240	2.365	1.118

*Assuming 30 weeks in school year

TABLE 5: Using figures from Table 4 to estimate collection amounts using the current pilot program's collection average of about 11.2% of the total food waste produced. Waste per day assumes 2.5 times the number of lunches fairly predicts the actual number of meals per day and is the quotient food waste and meals per day. Waste per week is product of waste per day and the number of days the food provider serves meals (six days per week for KSU dining centers, seven for Greeks, and five for public schools). Volume per year assumes 30 school weeks in one year. (2006-07 local school enrollment data from http://www.schooldigger.com.)

Green Mountain Technologies' Earth Tub and Earth Bin figures

	Vessel Dimensions (L x W x H)	Volume	Maximum Capacity	Production Period	Cooking Period
Earth Tub	4' x 6'8" x 7'6"	3 yd^3	200 lbs/day	3-4 weeks	14 days
Earth Bin	23' x 8'3" x 7'6"	1 ton/day	5 tons	3-4 weeks	14 days

TABLE 6: Earth Tub and Earth Bin statistics from (http://www.compostingtechnology.com/)

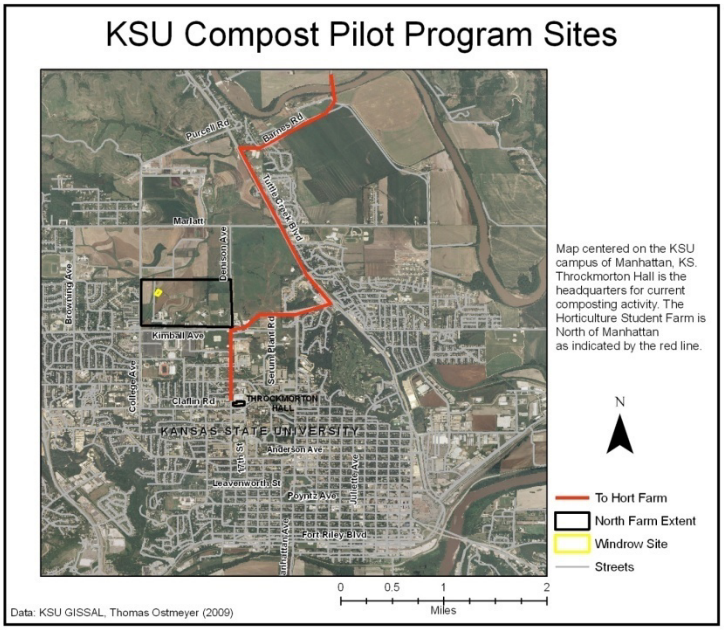


FIGURE 1: KSU Compost Pilot Program North Farm site extent and the location of the windrows.

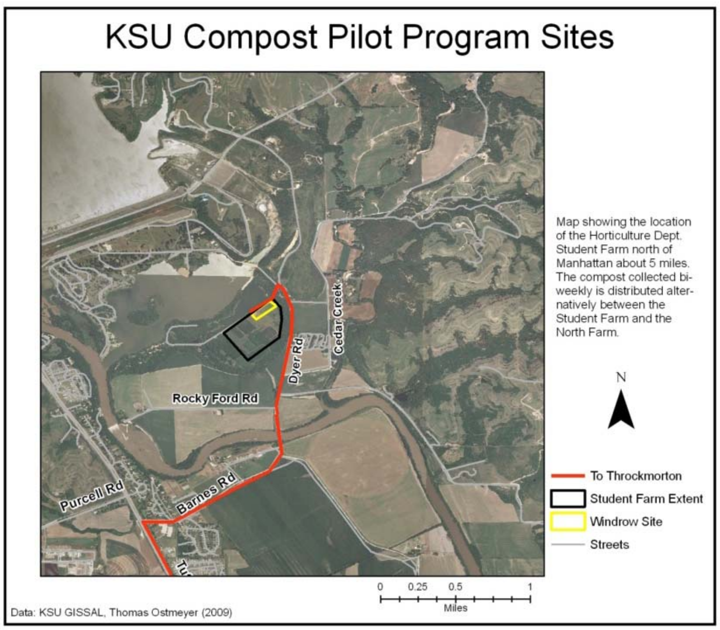
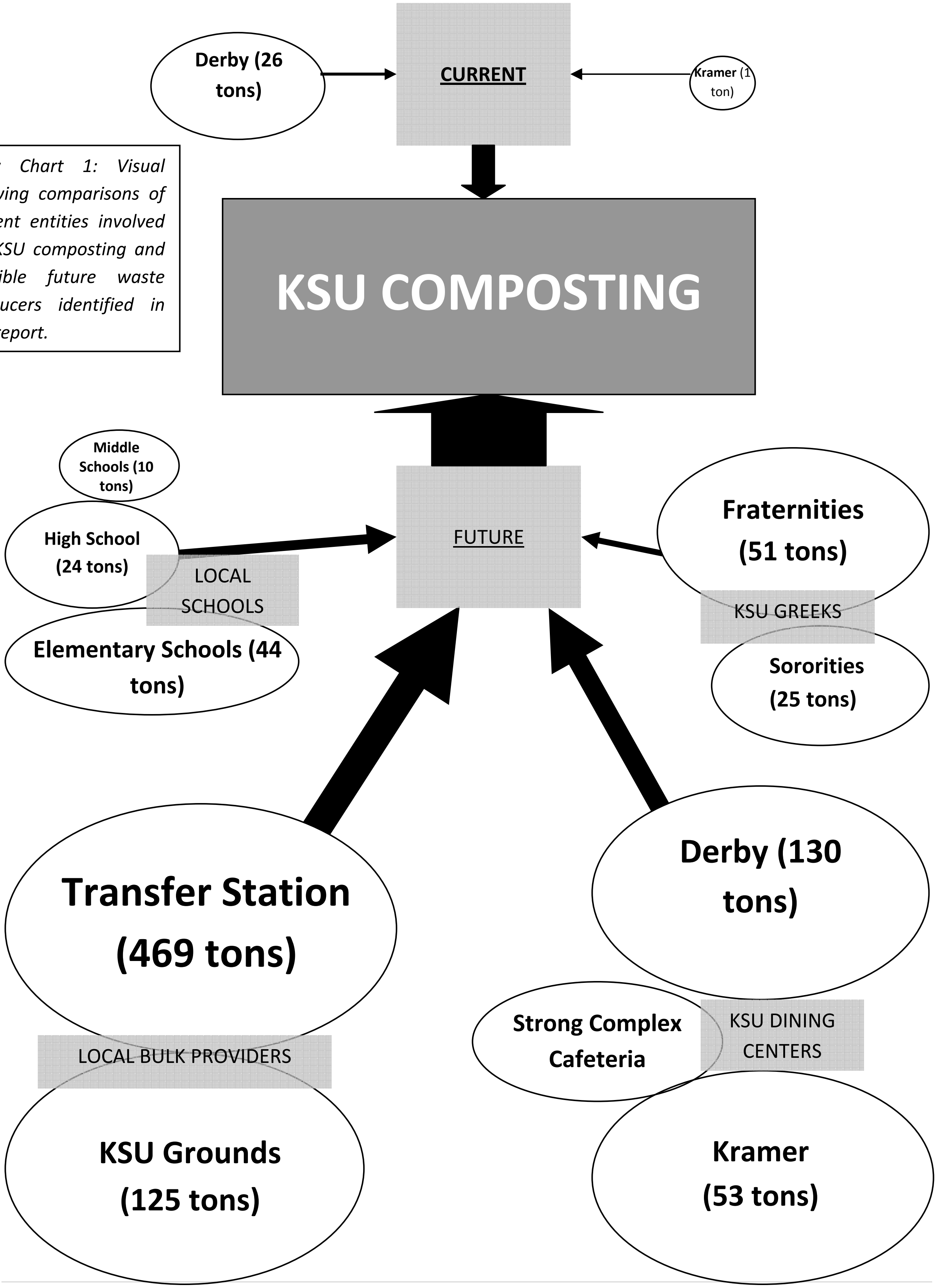


Figure 2: The Willow Lake Horticulture Student Learning Farm located north of Manhattan.



***Flow** Chart 1: Visual showing comparisons of current entities involved in KSU composting and possible future waste producers identified in our report.*

REFERENCES

Alternative Resources, Inc. Site Evaluation/Permitting of a Yard Waste Composting Facility for Yeadon Borough, Delaware, County. Report for Pennsylvania Department of Environmental Protection. March, 2003. <http://www.dep.state.pa.us/dep/deputate/airwaste/wm/recycle/Tech_Rpts/Yeadon.pdf> (Accessed 2 May 09)

Barcomb-Peterson, April 22nd 2009, "*Combining Campus Food Waste With Expertise in Agriculture, K-State Students And Faculty Undertake Composting Effort That Brings Food Full Circle"* http://www.k-state.edu/media/audio/podcats/compost.mov

Belanger, Kim. "Sustainable Composting in Manhattan." Questionnaire. Manhattan: Eastside Market, 2009.

Brenner, Richard. "Re: Composting Project." E-mail to the author. 21 Apr. 2009.

Carter-Burgess. Compost Design Narrative. Report for Hot Springs, Arkansas. November 2004. http://www.cityhs.net/pdfs/utilities/compost_design_narrative.pdf

Cornell Waste Management Institute. Composting Fact Sheets. Cornell University, College of Agriculture and Life Sciences, Department of Crop and Soil Sciences

Domenghini, Cynthia. "Re: Composting and Project PLANTS." E-mail to the author. 28 Apr. 2009.

Edwards, Mark. Personal Interview. 24 Mar. 2009.

Gershuny, Grace, and Deborah L. Martin (eds.) 1992. The Rodale Book of Composting: Easy Methods for Every Gardener. Emmaus, PA: Rodale Press.

Green Mountain Technologies. <http://www.compostingtechnology.com/ >

http://cwmi.css.cornell.edu/factsheets.htm (Accessed 3 May 09)

http://www.cgrer.uiowa.edu/sustainable_systems/Compost%20Project%20Final%20Report.pdf

http://www.dep.state.pa.us/dep/deputate/airwaste/wm/recycle/Tech_Rpts/Yeadon.pdf> (Accessed 2 May 09)

http://www.endowmentinstitute.org

http://www.greenreportcard.org/report-card-2009/executive-summary

http://ksucomposting.blogspot.com/

http://www.k-state.edu/facilities/recycling http://www.schooldigger.com/ (Accessed 1 May 09)

http://www.socialresearchmethods.net/tutorial/Pelstrng/validity.htm

Janke, Dr. Rhonda, personal interview 4/28/09

Kaczynski, Jen. "Sustainable Composting in Manhattan." Questionnaire. Manhattan: Eastside Market, 2009.

Kennedy, Jennifer. Personal Interview. 25 Mar. 2009.

Klobasa, Sheryl. Personal Interview. 25 Mar. 2009.

K-State Housing and Dining. "It's Not Easy Being Green." 25 Feb. 2009 <http://housing.k-state.edu/cms/CMSEngine/FCKeditor/

KSU Media Relations, University archives enrollment statistics, 1863-present (accessed 4/28/09).

KSU SEI Campus Sustainability Survey; Presidents Version, July 25th, 2009

Myers, Joe. Personal Interview. 27 Mar. 2009.

Norton, Barbara. "Sustainable Composting in Manhattan." Questionnaire. Manhattan: Eastside Market, 2009.

Presley, Deann, personal interview 3/15/09

Riley County, Kansas. "Rate Schedule: Riley County Solid Waste Facility, as of September 1, 2008." 28 Apr. 2009 <http://www.rileycountyks.gov/index.asp?NID=400.

Rynk, Robert. On-Farm Composting Handbook, New York: NRAES-54, June 1992: 105-17.

Shanklin, Carol; Ferris, Dennis Kansas State University "Waste Analyses of Derby and Van Zile Dining Centers At Kansas State University". Dec. 1992

Shanklin, Carol PhD, RD, Kansas State University Dean of Graduate Students, interview May 2009.

Shanklin, Carol PhD, RD, "Waste Stream Analyses at Kansas State University Dining Centers" June 23rd, 1995.

"The Biocycle Guide to Composting Municipal Wastes." Ed. BioCycle Staff. JG Press, Inc., Emmaus, Pennsylvania 1989.

"The Composting Project at Ohio University." 2009. Ohio University Office of Sustainability. 3 May 2009. http://www.ohio.edu/sustainability/compost.htm

"University Makes Strides With Food Residuals Composting." BioCycle. 44. 8 (2003): 22.

UserFiles/file/Dining/sustainable/02LearnAboutAudit.pdf>.

Volume-to-Weight Conversion Factors report. Environmental Protection Agency National Recycling Coalition Measurement Standards and Reporting Guidelines. <http://www.epa.gov/osw/conserve/tools/recmeas/> Accessed 1 May 09.

Yoder, Aaron. “Re: Composting Questions.” E-mail to the author. 23 Apr. 2009.