

Waste Characterization Study for KSU Recycling

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Natural Resources and Environmental Sciences Capstone Course

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Introduction

The main goal of this project is to help focus the recycling committee's efforts to improve the recycling rate at Kansas State University. This report will include how recycling got started at K-State and how it has grown over the years and plans for the future. It will also compare the benefits and disadvantages of using dual stream recycling versus single stream recycling. The report will also contain information from other universities or institutions that have increased their recycling rates through single stream recycling or other methods. One important aspect of this report is the waste characterization study that helps to identify the composition of trash on campus. The waste characterization study will show what could be recycled that is currently being thrown away. Knowing the composition of trash will help the recycling committee focus their efforts on increasing the recycling rates on campus. Increases in recycling will reduce the amount of trash sent to the landfill which will lead to savings as it costs money to send trash to the landfill.

Recycling at K-State is important because as a land grant university, our motto is to rule by obeying nature's laws. Recycling is crucial in helping K-State become a more sustainable campus which is part of K-State's 2025 vision of becoming a top 50 public research university. Recycling on campus also has the potential to save money. Over the past couple of years, recycling on campus hasn't increased much despite the desk side containers and numerous recycling containers distributed throughout campus to make it easier for faculty and students to recycle. This report should contain valuable information for the recycling committee to better focus their efforts to increase recycling on campus. Hopefully it too will show administration the importance and benefits of recycling on campus and help with the realization that it is part of our mission statement.

Acknowledgements

There are several individuals who have contributed to the success of this project. We would like to thank our advisor Dr. Bonnie Lynn-Sherow for overseeing our project. We would also like to thank the recycling committee for their input and support while we were completing our project. The Research and Extension Office for Statistical Research also contributed with helping to determine a representative sample to collect trash from. We also want to thank John Woods and his staff for assisting us with the collection and sorting of the trash. Without their support, we would not have a waste characterization study to present.

Solid Waste Management

The goal of a sustainable solid waste program is to "promote waste prevention, recycling and effective management and disposal of solid wastes" (EPA 2011). The Environmental Protection Agency (EPA) provides a wealth of solid waste resources. The agency sets standards for proper disposal of waste and provides guidance and information to the general public. The Resource Conservation and Recovery Act (RCRA), subtitle D, addresses primarily nonhazardous wastes including Municipal Solid Waste (MSW), industrial waste and certain hazardous wastes such as from households, which are exempted from hazardous waste regulations. The RCRA defines the solid waste as the following:

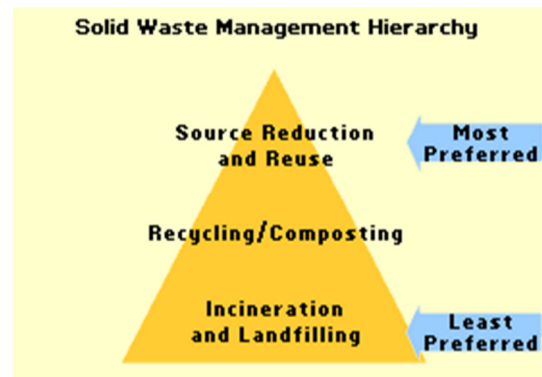
- Garbage, known as municipal solid waste (milk cartons, coffee grounds, most packaging)

- Refuse (metal scrap, wall board...)
- Sludges from waste treatment plants, water treatment plants or pollution control facilities
- Nonhazardous industrial wastes
- Crude oil and natural gas waste
- Construction and demolition debris
- Medical waste
- Agricultural waste
- Household hazardous waste
- Conditionally exempt small quantity generator waste

Solid Waste Hierarchy

The EPA ranked MSW strategies in order of the most sound and sustainable. “**Source reduction** (including reuse) is the most preferred method, followed by recycling and composting and disposal in combustion facilities and landfills” for the least sustainable option.

(<http://www.epa.gov/Region7/waste/solidwaste/>, EPA 2011). Many of these MSW management practices prevent or divert materials from the waste stream.



Source Reduction, also known as waste prevention involves making changes to the design, manufacture, or use of products and materials to reduce the amount and toxicity of landfilled waste. Example practices include mulch mowing, composting, two-sided printing and packaging material reduction. Recycling, including composting diverts items from the waste stream. Materials, such as plastic, paper and metals are sorted, collected and processed and then manufactured, sold and then bought by consumers. Composting decomposes organic wastes like food scraps and yard waste, with microorganisms to produce a nutrient rich soil amendment.

Description of K-State Recycling Program

The recycling program at Kansas State University started in 1989 and is coordinated by facilities and custodial departments. The K-State Recycling Advisory Committee oversees and advises the recycling program. The committee is composed of nine faculty, staff, and students. John Woods, director of Facilities Services, manages the recycling effort assisted by two employees and student volunteers. The committee is responsible for the main campus, the Veterinary Medicine campus and the K-State Salina campus. The link below gives information on the recycling program at K-State. There are currently thirty buildings on campus that partake in some form of recycling.

<http://www.k-state.edu/recycling/>

K-State first joined the Recycle Mania national program in Spring of 2009. The program is a benchmarking and competition recycling program between higher education institutions over a 10-week period. School recycling programs are ranked based on recycling and trash data. The program motivates schools to reduce and reuse waste in a competition for who collects the largest amount of recyclables per capita, the largest amount of total recyclables, the least amount of trash per capita, or the highest recycling rate. Students for Environmental Action and the K-State Students for Environmental Education campaign are currently the active groups participating in this effort. The accepted recycled materials include mixed paper (white and colored, letterhead, index cards, white forms, computer paper), cardboard, newspaper, plastic bottles and aluminum cans, although K-State also accepts magazines, wooden pallets, phone books, rubber bands, aluminum and other metals, electronics and other magnetic media, transparencies, film and shredded paper as well. Staff members can properly dispose of computer systems including monitors, keyboards and other accessories (a disposition of property form must be filled out, DA110). Recycling bins can be found in many K-State buildings in areas approved by the Fire Marshal.

Dual Stream versus Single Stream

Dual Stream Recycling

Since 1989, Kansas State University has participated in what is called Dual Stream Recycling. Dual Stream recycling involves sorting recyclable materials into various containers designated for that material. All around campus are individual containers for aluminum cans, plastic, glass, newspaper and cardboard. At prearranged times these containers are emptied into the Recycling trucks around campus. These trucks carry the materials to the recycling center where they remain separated until, reaching their final destination at Howie's. Dual Stream recycling has been the predominant method of recycling on campus and around the world for several reasons. First, separating materials helps to keep them from being contaminated and further devaluing the potential economic recovery of that material. For example, paper recycling and the regulations that dictate which types of paper can be collected is contingent on the separation of mixed paper from glossy paper. The prevention of the mixing allows paper to be reused more efficiently and keeps cost of processing lower leading to an economically profitable situation for secondhand manufactures. Secondly, Dual Stream prevents the obvious hardship of sorting the materials. Technology and/or labor of physically sorting materials into the designated receptacle take time which ultimately is an economic value. On the other hand, Dual stream recycling has some disadvantages. Although there has been an increase in recycling efforts over the past decade, two of the predominant reasons that cause lower participation in recycling efforts are the ignorance of how to recycle and apathy in locating the appropriate location for each recyclable. Unfortunately, on campus, as in many participating communities, high disparity between recycling containers and trash receptacles leads to the effortless choice by many community members to get rid of recyclable material in the most convenient way. Extending from the same root cause of more trash cans, less recycling containers and very similar to the previous problem, is the lack of knowledge of where to find a recycling container. Another problem with dual stream recycling, especially for those programs in the preliminary stages, is the cost of buying individual containers for each material. Additionally, lack of space for recycling bins is always an issue. Although sorted materials are much easier, and less expensive to compress and ship to the manufacture, the opportunity to collect material not commonly collected, such as plastics #5 and #4, although very common in coffee cups and yogurt containers, as evidenced by our study, is significantly diminished.

Single Stream Recycling

Single Stream recycling is a newer innovative recycling program that began in the early 90's in California. The main difference between the dual stream and single stream is the deletion of different, separate bins for each material collected. In other words, one centrally located bin collects all type of recyclables. Like the dual stream recycling, single stream recycling systems come with their own positives and shortcomings. Addressing the apathy and ignorance issue of the dual system, consumers do not have to worry about following a strict classification system for the various materials used on campus daily. Research has shown that participation in recycling efforts increased drastically when the switch was made from traditional sorting methods to the single stream method. Additionally, in theory, single stream recycling bins can be more numerous in building because the need for several different containers is not necessary and thus precious space is saved. Similarly because of the one container collection, more types of recyclables could be collected, especially different types of plastics. Another added plus to the single stream method is the decreased need for trucks used for pick-up with different bins for each material. This leads to a reduction in the cost of collection. In essence, trucks similar to trash trucks could be used for transfer to the recycling center where separation takes place either by hand or by machine. A little less obvious reason that has been supported by continued research is the comparison of collection times for collection trucks. As such, the amount of time spent collecting each individual receptacle is greater than the time it takes to dump one single stream receptacle. Unfortunately, any gains made in the reduction of labor for collection is offset by the increases in processing costs. Plainly stated, sorting occurs either by hand or by technology. As with the dual system, we meet another psychological problem with single stream. The idea of single stream recycling, and recycling in general, places too much emphasis on diverting recyclables from the waste system and doesn't place enough on the quality of recyclables entering in the recycling bins. People tend to think that throwing a dirty soda bottle into the recycling bin is a good activity, however, as the problem expands, contamination becomes a real concern. The contamination of certain recyclables can cause manufactures and processors receiving them to place them on the track for the landfill, not to mention the labor and time it takes to pick out contaminated materials.

Case Studies

Throughout the duration of our project, we referred to many case studies to help guide us in the right direction. Having information from many different sources helped to complete our study. Listed below are the most notable ones and how we used them to our benefit.

California 2008 Statewide Waste Characterization Study

This eight page report describes California's commitment to a zero waste goal to help reduce greenhouse gases, conservation resources, and to maintain their natural environment. This study identifies the amounts of materials disposed at solid waste facilities throughout the entire state. Their study methodology is much like ours in the fact that they randomly sampled from subgroups. They first divided the state into five divisions by their similarities: demographic, climate, geography, and economic characteristics. We divided the campus into three different categories; small, medium, and large buildings by their percentage of square feet.

When comparing the percentages of waste categories, their study was different than ours because they could account for leaves, grass, branches, asphalt, soil, carpet, and many other items we do not have in our trash. We did however use their main categories of paper, glass, organic, electronics, and plastics. When comparing these main categories, our numbers were remarkably similar; 30 percent not being recyclable, 26 percent paper, and 10 percent being some sort of plastic.

Characterization of Municipal Solid Waste in the United States

This report describes the national municipal solid waste for the years of 1960 through 2000. This report helped put into perspective how much solid waste could actually be recycled. In 2000, the United States, as a whole, generated around 231.9 million tons of waste. We recycled 69.9 million tons of those original 231.9 million tons. This is around 4.5 pounds of waste thrown out per person per day. The recycling rates have increased from 10 percent in 1980 to 30 percent in 2000.

This study separated the municipal solid waste into two categories. The first being “Materials”, this included paper, yard trimmings, food scraps, plastics, metals, glass, wood, rubber, leather, and others. The second being “Products”, which included appliances, non-durable and durable items, and others. They discovered that the following percentages could have been recycled from the landfills: Paper - 37.4%, Yard Trimmings - 12%, Food Scraps - 11.2%, Plastics - 10.7%, and Glass - 5.5%.

Reducing solid waste in higher education: The first step towards ‘greening’ a university campus

Recently, the Prince George campus of the University of Northern British Columbia (UNBC) conducted a waste characterization project that is very similar to the current task taken on by Kansas State University and the assisting Natural Resources and Environmental Science (NRES) group. Through the UNBC study, much insight was shed on the specific processes that needed to take place to obtain the much needed data, which is the backbone of these two studies. As the article states, “Direct waste analyses or waste characterization studies. . . offer the most effective process for examining the various wastes generated and identifying opportunities for waste reduction, reuse, recycling, and composting” (Booth, 1007).

UNBC’s study took place initially during one semester of an academic year and then expanded to a full year as to increase the accuracy of the collected data. With a university located in the heart of an environmentally conscious community, the smaller campus of roughly 5,000 students has been able to work towards the ‘greening’ of the campus with the hopes of establishing the trademark, “Canada’s Green University” (Booth, 1008). Initially, they identified busy areas on the campus as well as mapped the current recycling facilities available for the students and faculty. Using this information UNBC chose 15 activity areas on campus excluding the on-campus housing as well as the sports center. They collected trash for two separate 5 day periods and picked a sample population to hand sort and not just weigh.

The findings were astonishing. “Approximately 52,081 kg (~52 metric tons) of waste from the core campus buildings was sent to landfill during the 2007-2008 academic year.” Both hand sorted samplings also revealed amazingly large numbers. “In total, 1,359 kg of waste was sorted, of which, 640 kg was recyclable, 338 kg was compostable, and 370 kg was non-recyclable material. Electronics and hazardous by-products constituted the remaining 14 kg of waste” (Booth, 1011). That means that more than 70% of the waste collected at UNBC for those two audits could have avoided reaching the landfill. Paper

products topped the list. Of the collected waste, 29.1% was paper, paperboard, printer paper, mixed paper, newspaper, cardboard, or paper towels.

Solid waste characterization and recycling potential for a university campus

Although this study took place in Mexico, a region that is known to be different to that of the United States, it still brought relevant information to light. This waste characterization study was for the improvement of recycling and reuse on the Autonomous University of Baja California (AUBC) campus. The first important statement to take note of is one that discusses how each program needs to have background research to fit the current conditions, that a current program established elsewhere could very well not be effective at all due to differing circumstances. This is why the waste characterization study at the Manhattan campus of KSU is so important and why we cannot just implement another plan without seeing if it will be effective for the needs of this campus.

The article makes comparisons between the conditions of the study done at AUBC in Mexico with current efforts and studies within the US. It can be seen that although they are slightly behind, efforts are increasing in this less developed country to someday soon be enforcing similar policies which are thought to be beneficial to the universities there as well. Several results college studies done by universities in the US were discussed and were found to be useful for this study too. Such as, “one characterization study carried out at Brown University revealed that 45% of the wastes generated at the institution were recyclables” and they found that “other examples are those at Colorado State University and at the University of Florida which recycle 53% and 30% respectively” (Barreto et. al, 522).

AUBC’s study itself was structured very similarly to that of our other more developed countries case studies. However, it differed from our study in that they took samples from three specific areas, the academic and administrative buildings, gardens, and community centers which included the cafeteria. The gardens and community centers on KSU’s campus were purposely excluded from our study to try to make it more manageable. They also compiled their data over a longer time frame, 14 consecutive days, and found that in the buildings 43.6% of the waste was paper and cardboard which could be recycled. In the garden, it was found that 80% was organic material that could be composted. And in the community center, 23.3% was recyclable paper and cardboard, and 54.1% compostable organics. Like our study, a large percentage of waste that could be recycled was being taken to landfills.

NYU Waste Characterization Study Report

In spring 2008, the New York University Recycling Shop performed the first waste characterization study of the Washington Square Campus. NYU followed sampling procedures primarily from the Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste (ASTM D 5231-92). Samples were sorted into 12 waste categories shown below. The results collected were analyzed and differentiated the landfilled waste stream into three waste recoverable categories: compostable, recyclable and landfill material source reduction. The following waste material results were obtained from the study:

Table 1.2 Hierarchy of Solid Waste Material Classes and Categories

Material Class	Material Category
Compostable	Organics
Recyclable	Glass
	Metal
	Paper (Mixed)
	Plastic #1 and 2
	Technoscrap
	Universal Waste
Landfill	Plastic #3-7
	Plastic Film*
	Textiles
	Trash
	Unknown Plastic

* Since this study was conducted, plastic bag recycling has been implemented on campus. Since this material category contained other types of plastic film that are not recyclable, it was kept designated as landfill.

http://www.nyu.edu/fcm/waste_study_report.pdf

Percentage of Material Class for Washington Square campus

Material Class	WSQ Campus
Compostable	59.2%
Recyclable	28.4%
Landfill	12.4%

http://www.nyu.edu/fcm/waste_study_report.pdf

The NYU study results address the material class (compostable, recyclable, landfill) generated per waste generator group (academic, academic/administration, general use, residence hall, residence hall/dining facility). The analysis further describes the composition of the landfill waste stream by recyclable materials that are potentially recoverable under the existing recycling programs. The obtained results posted an impressive 29% potential waste diversion from landfills just for recyclable materials. An even more recoverable was compostable materials with over 59% that can be diverted through an organic collection program.

Waste Characterization Study

The importance of conducting a waste characterization study is to identify the composition of the waste so actions can be taken to reduce the amount trash thrown away. K-State facilities currently knows the total amount of waste that is being sent to the landfill and that is being recycled on campus but doesn't know the composition or weight output for every building. Our goal is to collect trash from a few buildings on campus that will represent the whole campuses waste stream. Knowing K-State's typical trash consumption and weight, better efforts can be made to increase recycling and to help decide if single stream recycling is beneficial for K-State.

Methods

An important part of the waste characterization study is to identify representative sample buildings that will give a good indication of the whole campus waste stream. To be 100% accurate, all buildings on campus would need to be incorporated but this was not feasible for our project. For our classification, we excluded the dormitories, dining centers, athletic buildings, facilities, and farms on campus. We contacted the Research and Extension Office for Statistical Research for assistance in determining a representative sample. They recommended randomly selecting fifteen buildings on campus divided into three categories: small, medium, and large determined by the square footage of the buildings. They also recommended collecting trash from each building for more than one week to reduce variability. At a minimum, they recommended sampling six buildings, collecting trash from each building for two weeks. Their proposed schedule is shown below in figure one. After conferring with facilities, it was decided that the proposed schedule by the Research and Extension Office was too much to collect and sort in a three week period. We as a group felt that collecting trash from six or more buildings on campus was too much to analyze based on our time constraints and the personnel required to make that happen. We felt that it would be a difficult task to do a waste characterization study that represented the entire K-State campus as there are over 60 buildings on campus and over 23,000 students for a semester project. After discussing with facilities, it was determined that we would collect trash from three buildings, one each week. These three buildings were randomly selected based on the size distributions. The large building selected was Waters Hall, medium building was Shellenberger Hall, small building was Dole Hall. Each of these buildings chosen has multiple uses to try to incorporate waste streams from offices, labs, classrooms, etc. Our final results will not be accurate to represent the whole campus waste stream but should still give a good indication of what is being thrown away that could be recycled. To represent the whole campus, the proposed schedule in figure one would need to be followed.

After the buildings were selected, we coordinated with facilities to collect the trash and recycling from the buildings. The trash and recyclables were stored at the recycling center at the end of the week. On Friday, we sorted and weighed the trash into the following categories; cardboard, newspaper, mixed paper, magazines and phonebooks, glass bottles, aluminum cans, plastics #1, other plastics, tin cans, fiberboard, batteries, organic, paper towels, and non-recyclable. Other plastics included #3-#7 and plastic sacks. After the sorting was finished, the weights were entered into an excel spreadsheet to graph the composition of the waste for each building. The results are shown and described below under the section composition of trash.

Figure 1: Proposed Collection Method by Research and Extension Office for Statistical Research.

Trash Schedule			Randomly Selected Buildings	
<u>Week 1</u>	<u>Week 2</u>	<u>Week 3</u>		
Building A	Building A		Large	Trotter Hall
Building B	Building B		Medium	Shellenberger Hall
Building C		Building C	Small	Dole Hall
Building D		Building D		
	Building E	Building E	Large	Mosier
	Building F	Building F	Medium	Fairchild
			Small	Bushnell
Color Classification				
Red	1st randomly selected buildings		Large	Waters
Orange	2nd randomly selected buildings		Medium	Edwards
Green	3rd randomly selected buildings		Small	Holtz
Blue	4th randomly selected buildings			
			Large	Weber
			Medium	Umberger Hall
			Small	Holton

Composition of Trash

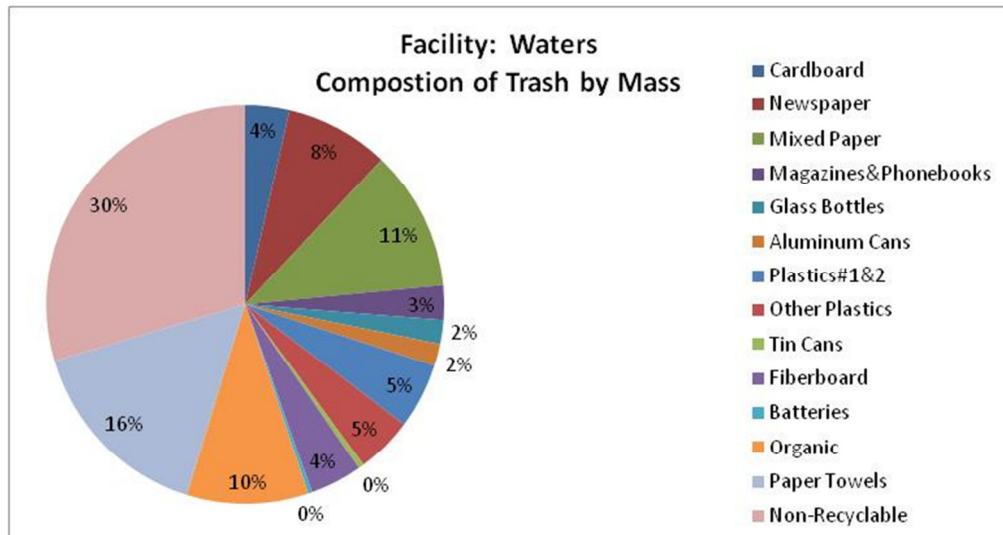
For each of the selected buildings, a table and a pie chart were created to show the results of the waste characterization study. The weights were recorded for each category and then all of the categories were summed together to get the total weight output from each building. To obtain the percentages, the weight of each category was divided into the total weight of trash from the building.

Waters Hall

Figure 2: Table showing weight and percent composition of trash for Waters Hall.

Facility: Waters Hall		
Date Sorted: 4/15/2011		
Composition of Trash Only		
	<u>Weight (lbs)</u>	<u>% Composition</u>
Cardboard	20.7	3.6%
Newspaper	48.8	8.4%
Mixed Paper	66.4	11.5%
Magazines&Phonebooks	16.2	2.8%
Glass Bottles	11.2	1.9%
Aluminum Cans	10.4	1.8%
Plastics#1&2	30.7	5.3%
Other Plastics	26.5	4.6%
Tin Cans	2.6	0.4%
Fiberboard	24.5	4.2%
Batteries	1.9	0.3%
Organic	57.2	9.9%
Paper Towels	90.7	15.7%
Non-Recyclable	171.4	29.6%
Total Weight	579.2	100.0%

Figure 3: Pie Graph showing composition of trash for Waters Hall.



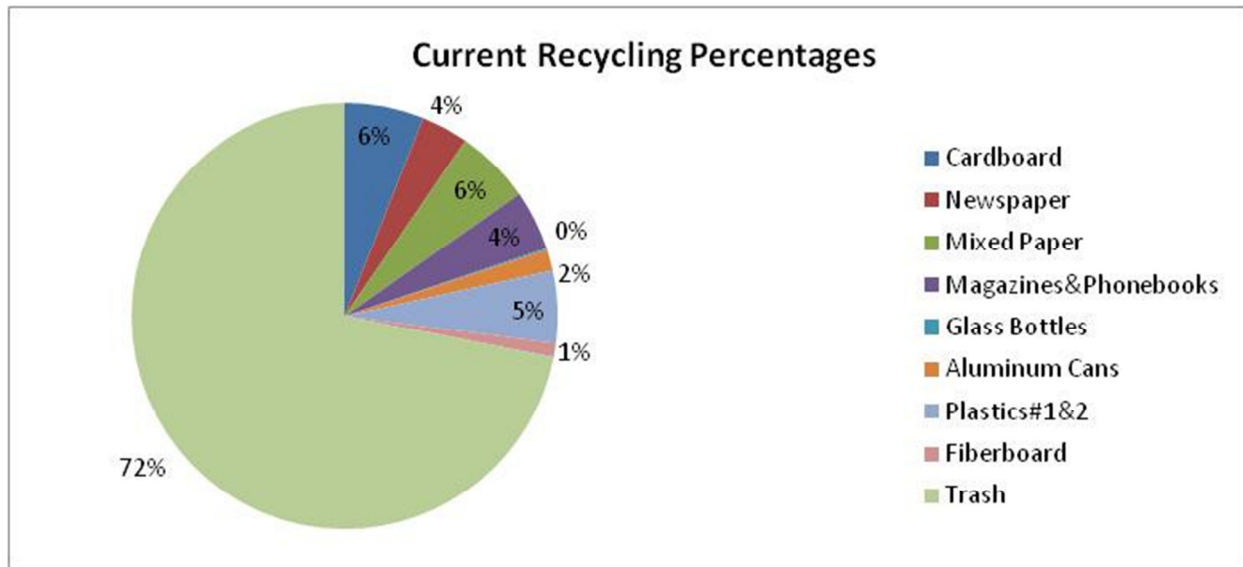
From the results, seventy percent of the trash from Waters Hall could be recycled or reduced. The greatest category of the trash was non-recyclable at 30%. The next biggest categories were paper towels followed by mixed paper, organic waste, newspaper, plastics #1, other plastics, fiberboard, cardboard, magazines and phonebooks, glass bottles, aluminum cans, tin cans, and batteries.

Figure 4: Table showing weight and percent composition of current recycling in Waters Hall.

Facility:	Waters Hall	
Date Sorted:	4/15/2011	
Composition of Current Recycling		
	<u>Weight (lbs)</u>	<u>% Composition</u>
Cardboard	48.5	6.0%
Newspaper	28.8	3.6%
Mixed Paper	45.9	5.7%
Magazines&Phonebooks	36.7	4.6%
Glass Bottles	1.1	0.1%
Aluminum Cans	12.8	1.6%
Plastics#1&2	44.2	5.5%
Fiberboard	8.5	1.1%
Trash	579.2	71.9%
Total Weight	805.7	100.0%
Total Recycled	226.5	28.1%

In the table above, the categories of cardboard, newspaper, mixed paper, magazines and phonebooks, glass bottles, aluminum cans, plastics #1&2, and fiberboard are the materials currently recycled at K-State. The category of trash is not the amount of trash found in the recycling containers but was the trash collected from the building. It was used to calculate the total weight of trash plus recyclables to achieve the composition of current recycling rates. The composition of current recycling was determined by dividing the recycled category into the total weight.

Figure 5: Pie Graph showing composition of currently recycling percentages in Waters Hall.

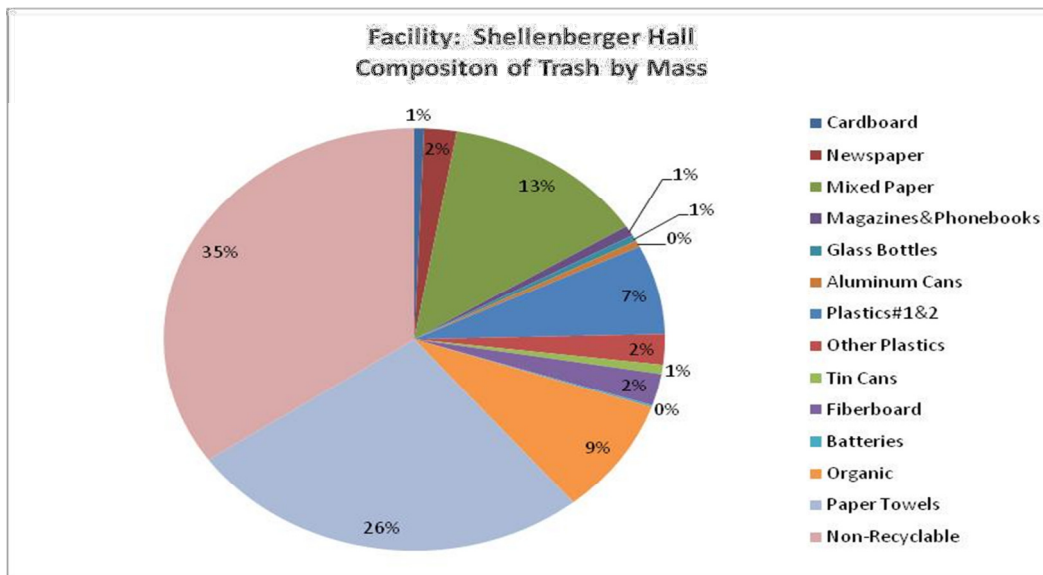


Shellenberger Hall

Figure 6: Table showing weight and percent composition of trash for Shellenberger Hall.

Facility: Shellenberger Hall		
Date Sorted: 4/22/2011		
Composition of Trash Only		
	Weight (lbs)	% Composition
Cardboard	0.9	0.6%
Newspaper	3	2.1%
Mixed Paper	19.1	13.3%
Magazines&Phonebooks	1.1	0.8%
Glass Bottles	0.7	0.5%
Aluminum Cans	0.7	0.5%
Plastics#1&2	9.8	6.8%
Other Plastics	3.3	2.3%
Tin Cans	1	0.7%
Fiberboard	3.5	2.4%
Batteries	0.2	0.1%
Organic	12.7	8.9%
Paper Towels	37.7	26.3%
Non-Recyclable	49.7	34.7%
Total Weight	143.4	100.0%

Figure 7: Pie Graph showing composition of trash for Shellenberger Hall.



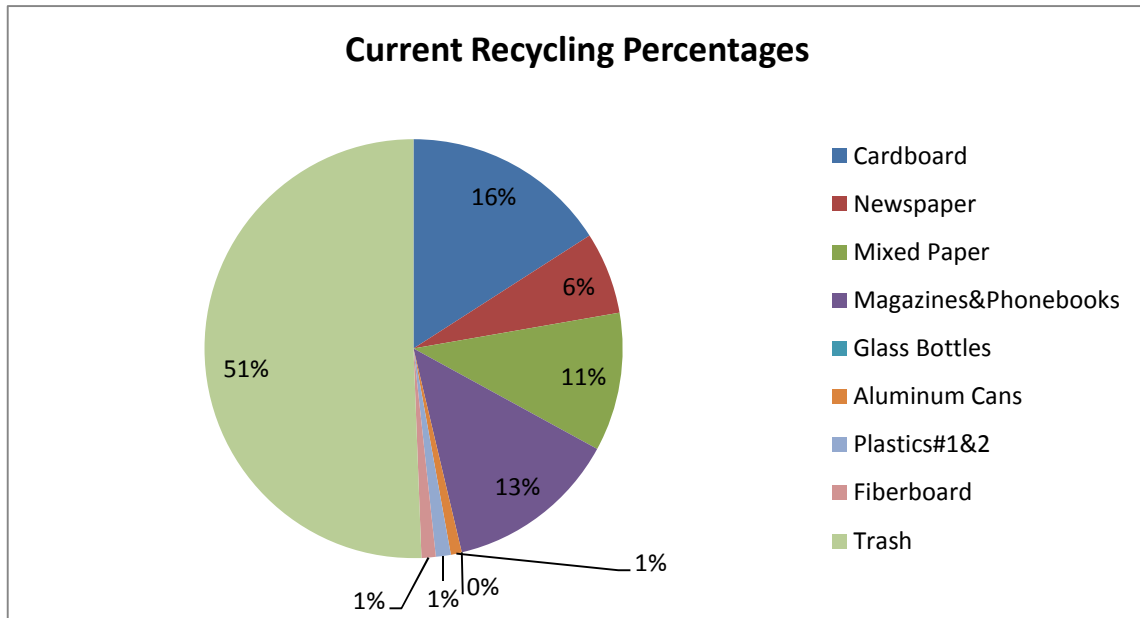
From the results, sixty five percent of the trash from Shellenberger Hall could be recycled or reduced. The largest category is non-recyclable at 35% followed by paper towels, mixed paper, organic, plastics #1, fiberboard, other plastics, newspaper, magazines and phonebooks, tin cans, cardboard, aluminum cans, glass bottles, and batteries.

Figure 8: Table showing weight and percent composition of current recycling in Shellenberger Hall.

Facility:	Shellenberger Hall	
Date Sorted:	4/22/2011	
Composition of Current Recycling		
	Weight (lbs)	% Composition
Cardboard	45.1	15.9%
Newspaper	18	6.4%
Mixed Paper	30.3	10.7%
Magazines&Phonebooks	37.8	13.3%
Glass Bottles	0	0.0%
Aluminum Cans	2.4	0.8%
Plastics#1&2	3.3	1.2%
Fiberboard	3.1	1.1%
Trash	143.40	50.6%
Total Weight	283.4	100.0%
Total Recycled	140	49.4%

In the table above, the categories of cardboard, newspaper, mixed paper, magazines and phonebooks, glass bottles, aluminum cans, plastics #1, and fiberboard are the materials currently recycled at K-State. The category of trash is not the amount of trash found in the recycling containers but was the trash collected from the building. It was used to calculate the total weight of trash plus recyclables to achieve the composition of current recycling rates. The composition of current recycling was determined by dividing the recycled category into the total weight.

Figure 9: Pie Graph showing composition of currently recycling percentages in Shellenberger Hall.

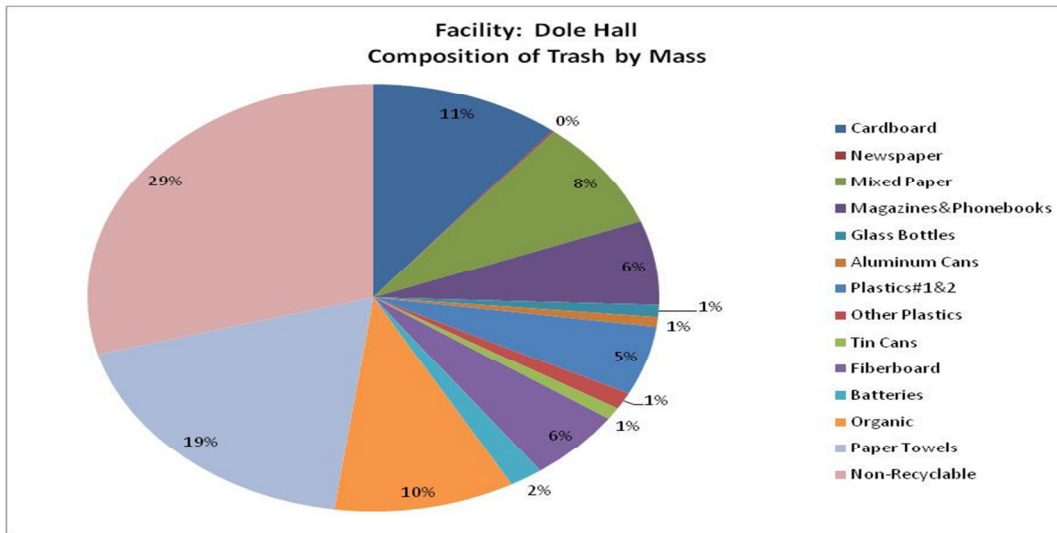


Dole Hall

Figure 10: Table showing weight and percent composition of trash for Dole Hall.

Facility:	Dole Hall	
Date Sorted:	4/29/2011	
Composition of Trash Only		
	<u>Weight (lbs)</u>	<u>% Composition</u>
Cardboard	17.7	10.8%
Newspaper	0.2	0.1%
Mixed Paper	13.7	8.3%
Magazines & Phonebooks	10.4	6.3%
Glass Bottles	1.5	0.9%
Aluminum Cans	1.2	0.7%
Plastics#1&2	8.6	5.2%
Other Plastics	2.1	1.3%
Tin Cans	1.5	0.9%
Fiberboard	9	5.5%
Batteries	3.1	1.9%
Organic	16.8	10.2%
Paper Towels	30.5	18.6%
Non-Recyclable	48.1	29.3%
Total Weight	164.4	100.0%

Figure 11: Pie Graph showing composition of trash for Dole Hall.



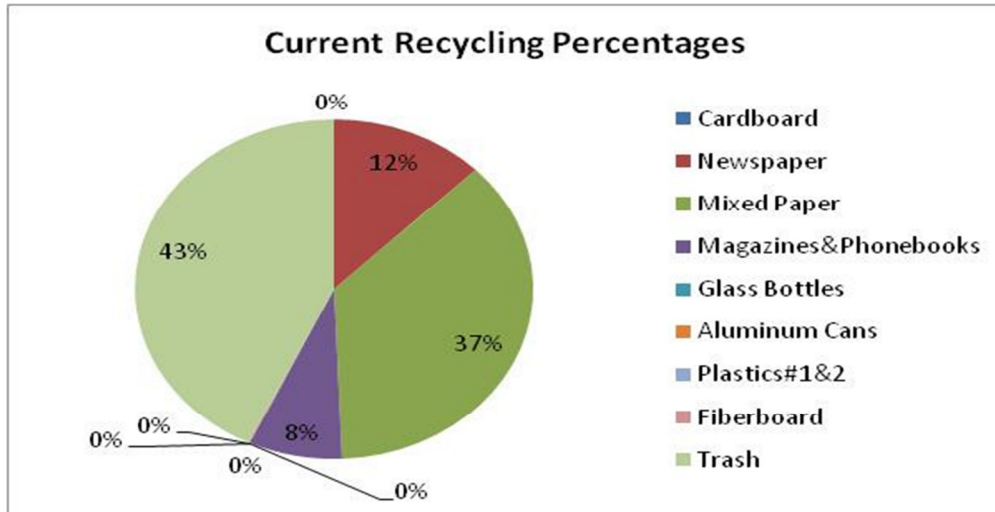
From the results, almost 71% percent of the trash from Dole Hall could be recycled or reduced. The largest category is non-recyclable at 29.3% followed by paper towels, cardboard, organic, mixed paper, magazines and phonebooks, fiberboard, plastics #1&2, batteries, other plastics, glass bottles, tin cans, aluminum cans, and newspaper.

Figure 12: Table showing weight and percent composition of current recycling in Dole Hall.

Facility:	Dole Hall	
Date Sorted:	4/11/2011	
Composition of Current Recycling		
	<u>Weight (lbs)</u>	<u>% Composition</u>
Cardboard	0	0.0%
Newspaper	48.3	12.6%
Mixed Paper	140.9	36.8%
Magazines & Phonebooks	29.2	7.6%
Glass Bottles	0	0.0%
Aluminum Cans	0	0.0%
Plastics#1&2	0	0.0%
Fiberboard	0.5	0.1%
Trash	164.40	42.9%
Total Weight	383.3	100.0%
Total Recycled	218.9	57.1%

In the table above, the categories of cardboard, newspaper, mixed paper, magazines and phonebooks, glass bottles, aluminum cans, plastics #1&2, and fiberboard are the materials currently recycled at K-State. The category of trash in not the amount of trash found in the recycling containers but was the trash collected from the building. It was used to calculate the total weight of trash plus recyclables to achieve the composition of current recycling rates. The composition of current recycling was determined by dividing the recycled category into the total weight.

Figure 13: Pie Graph showing composition of currently recycling percentages in Dole Hall.

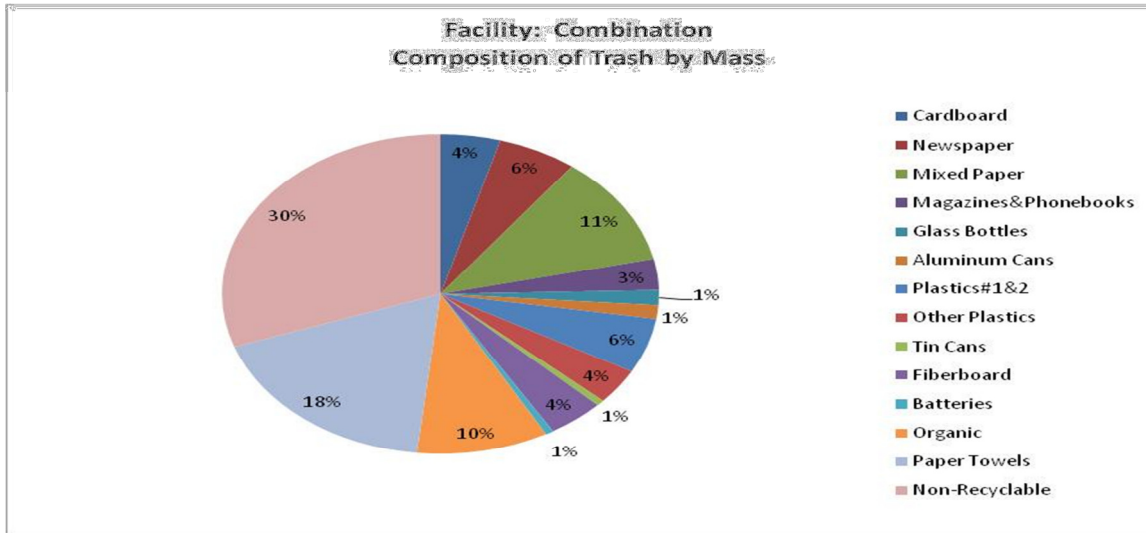


Combination of All Three Buildings

Figure 14: Table showing weight and percent composition of trash for all three buildings combined.

Facility:	All Three Combined	
Date Sorted:		
Composition of Trash Only		
	<u>Weight (lbs)</u>	<u>% Composition</u>
Cardboard	39.3	4.4%
Newspaper	52	5.9%
Mixed Paper	99.2	11.2%
Magazines & Phonebooks	27.7	3.1%
Glass Bottles	13.4	1.5%
Aluminum Cans	12.3	1.4%
Plastics#1&2	49.1	5.5%
Other Plastics	31.9	3.6%
Tin Cans	5.1	0.6%
Fiberboard	37	4.2%
Batteries	5.2	0.6%
Organic	86.7	9.8%
Paper Towels	158.9	17.9%
Non-Recyclable	269.2	30.3%
Total Weight	887	100.0%

Figure 15: Pie Graph showing composition of trash for all three buildings combined.



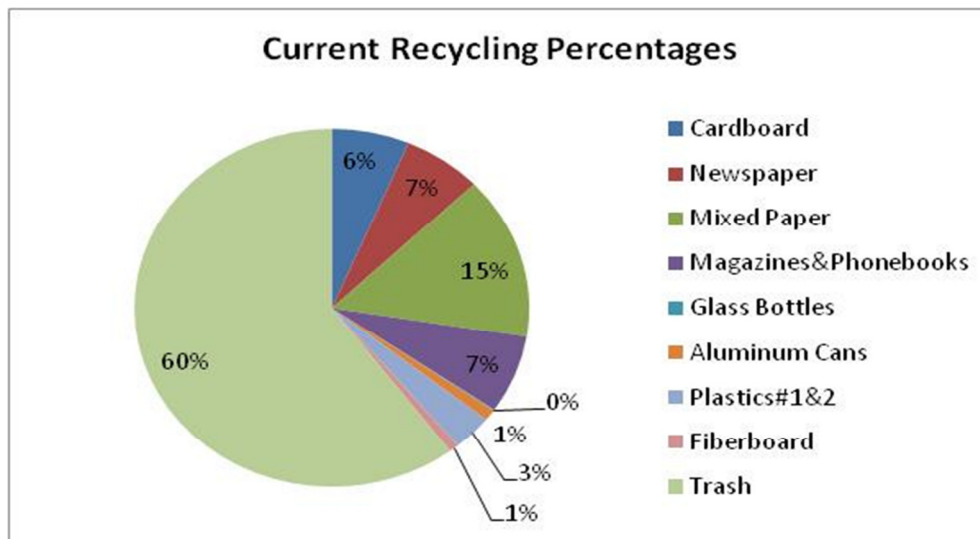
From the results, almost 70% percent of the trash from all three buildings combined could be recycled or reduced. The largest category is non-recyclable at 30.3% followed by paper towels, mixed paper, organic, newspaper, plastics #1&2, cardboard, fiberboard, other plastics, magazines and phonebooks, glass bottles, aluminum cans, tin cans, and batteries .

Figure 16: Table showing weight and percent composition of current recycling in all three buildings combined.

Facility:	All Three Combined	
Date Sorted:		
Composition of Current Recycling		
	<u>Weight (lbs)</u>	<u>% Composition</u>
Cardboard	93.6	6.4%
Newspaper	95.1	6.5%
Mixed Paper	217.1	14.7%
Magazines & Phonebooks	103.7	7.0%
Glass Bottles	1.1	0.1%
Aluminum Cans	15.2	1.0%
Plastics#1&2	47.5	3.2%
Fiberboard	12.1	0.8%
Trash	887.00	60.2%
Total Weight	1472.4	100.0%
Total Recycled	585.4	39.8%

In the table above, the categories of cardboard, newspaper, mixed paper, magazines and phonebooks, glass bottles, aluminum cans, plastics #1&2, and fiberboard are the materials currently recycled at K-State. The category of trash in not the amount of trash found in the recycling containers but was the trash collected from the building. It was used to calculate the total weight of trash plus recyclables to achieve the composition of current recycling rates. The composition of current recycling was determined by dividing the recycled category into the total weight.

Figure 17: Pie Graph showing composition of currently recycling percentages in all three buildings combined.



Pictures of Sorting the Trash



Economic Benefits

Increasing the recycling rates on campus would lead to more money being saved as it would decrease the amount of trash sent to the landfill as it currently costs \$42.00/ton to dispose of the trash at the landfill. There would also be an increase in revenue from the recycled materials as a greater amount of the waste would be recycled. The table below shows the amount of money that could be saved from disposing trash in the landfill if 100% recycling was achieved in all of the three buildings we collected from; it also compares prices between Howie's recycling and Deffenbaugh, the single stream recycling center in Kansas City. Price quotes are included in the table. We did the cost analysis over 32 weeks which is equivalent to two full semesters. As you can see, more than double the money could be earned from Howie's but this cost analysis does not include increased labor to sort the materials, transportation costs to haul recyclables to Deffenbaugh, and is assuming 100% recycling in the buildings. The weight of the recycled material in the table is the combined weight of all the three buildings. It is hard to infer from this cost analysis which option is more viable since so many factors are not included but it does compare the price quotes between dual stream and single stream.

Figure 18: Table showing price quotes between Howie's and Deffenbaugh.

Money that could be saved and earned from 100% recycling				
	Weight (lbs)	\$ saved from disposing in landfill	\$ Earned from Howies	\$ Earned from Single Stream
Cardboard	39.3	\$26.40	\$37.72	\$25.15
Newspaper	52	\$34.94	\$49.92	\$33.28
Mixed Paper	99.2	\$66.66	\$126.97	\$63.48
Magazines & Phonebooks	27.7	\$18.61	\$17.72	\$17.72
Glass Bottles	13.4	\$9.00	\$0	\$8.57
Aluminum Cans	12.3	\$8.26	\$196.80	\$7.87
Plastics#1&2	49.1	\$32.99	\$78.56	\$31.42
Fiberboard	37	\$24.864	\$35.52	\$23.68
Total	330	\$221.76	\$543.23	\$211.20
		Total Money	\$764.99	\$432.96
Price Quotes from Howie's	\$/lb	Price Quote from Deffenbaugh	\$40/ton	
Aluminum	.50/lb			
Plastics#1&2	.05/lb			
Cardboard	.03/lb			
Mixed Paper	.04/lb			
Newspaper	.03/lb			
Magazines & Phonebooks	.02/lb			
Glass Bottles	.00/lb			

Survey Results

As part of our project, we wanted to raise awareness of the importance of increasing recycling on campus. We reserved a booth during Earth Day to try to show people how much trash K-State is throwing away on campus that could be recycled or reduced. For our booth, we had a poster describing the goals and objectives of the project as well as our results from one week's worth of collecting and sorting trash. As people visited our booth, we had them fill out a short survey to get their feedback concerning their motivation with recycling on campus. The results of the survey are shown below. A total of sixty nine students filled out the survey. Prior to Earth Day, we had written an article that was published in the student newspaper to raise awareness for recycling on campus, the importance of our project, and to try to get more people to visit our booth for Earth Day. Initially, we had planned to bring containers to Earth Day that contained sorted recyclable materials from the trash to show students how much we throw away that could be recycled but due to the rainy weather, Earth Day was moved inside which prevented us from bringing the sorted trash. Hopefully the student's responses to the survey questions will spark new ideas to increase recycling on campus.

Figure 19: Results from first question of survey.

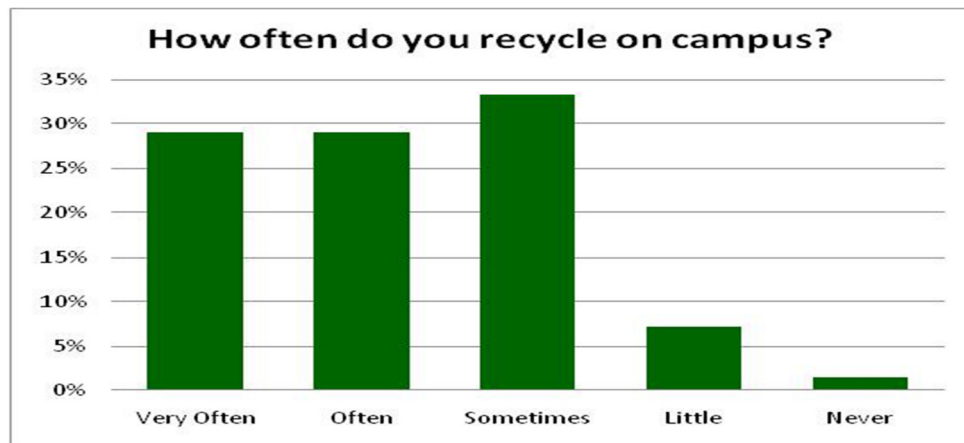


Figure 20: Results from second question of survey.

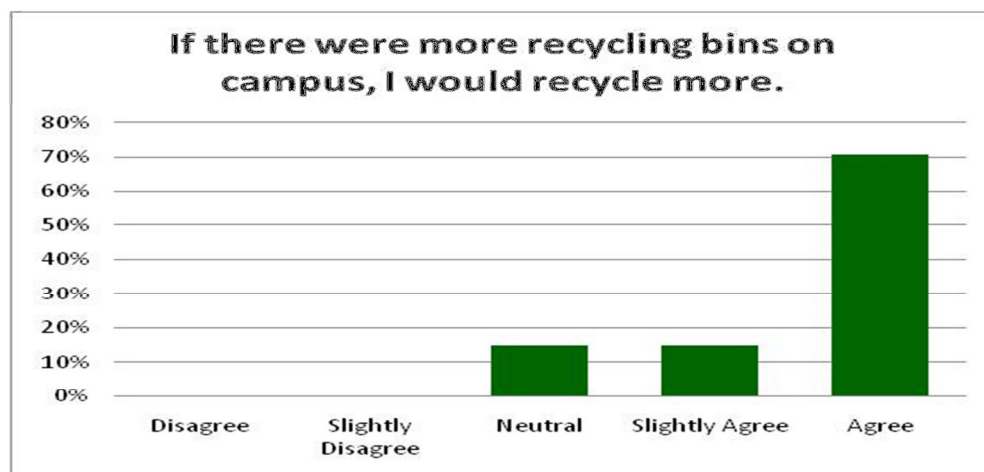
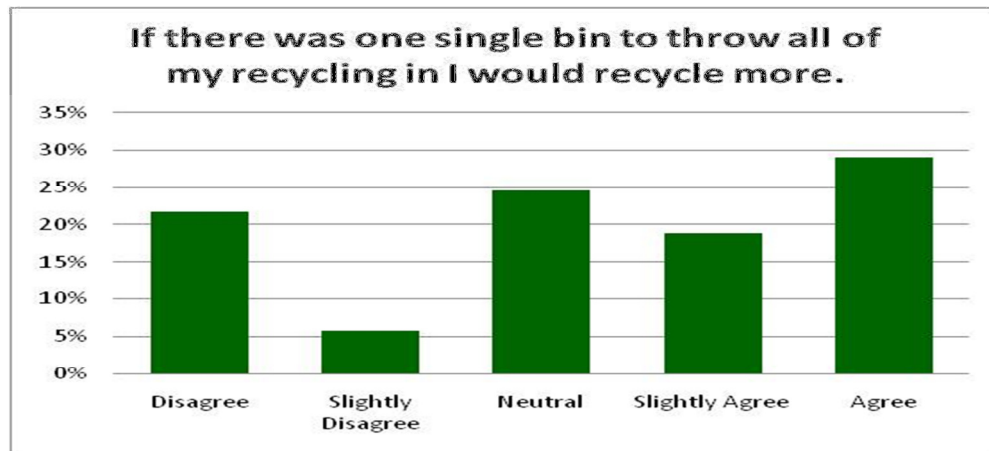


Figure 21: Results from third question of survey.



Fourth question of survey.

In your opinion, what could make recycling **better** on campus?

- More locations
- More accessible recycling bins
- More locations and accessibility
- More accessible to res. halls
- More recycling bins for things like glass, cardboard, chipboard, etc.
- More bins! And make them more convenient and easy to find. Have one recycling bin for every trash can instead of 1:50.
- More bins! Educate people
- More recycling bins around campus
- Paper, plastic, glass in all major traffic areas
- Recycling bins next to all trash cans
- Put "Land Fill" on trash cans. Reality check! :) More recycling bins in buildings.
- More attractive bins and signs that stand out more
- More participation
- More awareness and recycling bins. Especially in dorms.
- More emphasis on it. I see lots of people throw stuff away without looking for a recycling bin.
- Make sure people know about it.
- More advertising!
- I think educating people to reduce their consumption more than just relying on recycling is the best.
- More options for recycling at each building
- More recyclable containers in food court
- There needs to be a division/faculty

Figure 22: Picture of Waste Characterization Group at Earth Day.



Suggestions to Increase Recycling on Campus

After conducting the waste characterization study and analyzing our research, we have come up with some ideas and suggestions to help increase recycling on campus. There are two approaches to dealing with solid waste which are waste management and waste prevention. Waste management reduces environmental harm but can encourage consumption of resources. Waste prevention is considered a low waste approach because it reduces or eliminates the source of waste and it also discourages consumption. It is always better to incorporate waste prevention strategies whenever possible. The EPA prefers source reduction and reuse first, then recycling/composting, and then landfilling or incineration. Increasing recycling is a much better alternative than disposing of it in a landfill but preventing or reducing the waste stream is even better.

Recommendation #1

Prepare long term zero-waste goals utilizing the 5-year recycling plan as a starting point. Waste is not a required element for campus operations or any municipality, but it is a result of utilizing products lacking end-of-life design (no longer useful). Invest in facilities that take the place of landfills. Zero-waste systems hold manufacturers responsible for waste and environmental impacts of their product and packaging rather than leaving the problem to consumers. Trashing materials wastes business opportunities that can be created from those resources. California has adopted a Fantastic Three program to meet their zero-waste goal by 2020 using individual bins for recycling, composting and landfill dumping.

As our data indicates, less than 20% of the materials on campus are being recycled while over 50% of those materials could be recycled. The first step in reducing waste is to reduce usage, as mentioned above. The second step is to recycle as much as possible. The following are some ways we believe can help increase the amount being recycled on campus.

Recommendation #2

We would recommend continuing the waste characterization study to include more buildings and to collect trash from the same building for at least two weeks to reduce variability. We would recommend following the schedule that the Research and Extension Office for Statistical Research had proposed. This would be the minimum amount of buildings that would give some accurate representation for the whole campuses waste stream. We thought it would also be interesting to count the number of trash cans and recycling containers in each building to determine a ratio of trash to recycling containers. We would also recommend storing the trash in a dry place instead of outside in the open trailer where it is susceptible to the outdoor elements. Part of our trash was wet as it rained the first two weeks of collecting trash. When we sorting through the trash, we had noticed that some of the newspapers were wet, this would have skewed our composition some. Our surveys might also be a little biased since they were filled out during Earth Day. Majority of the people at Earth Day already knew the importance of recycling and recycled. There was also some confusion with the last question concerning single stream.

Recommendation #3

One of the most obvious things to notice on campus is the high ratio of trash cans to recycling bins. One would have to purposely seek out a recycling bin in order to recycle a lot of the time. The solution to this is simple – add more recycling bins around campus. It is important to make it easier for people to recycle because the average person will not go out of their way to recycle a pop bottle or aluminum can. By adding a recycling bin next to the current locations of trash cans you make it that much easier for people and provide them an opportunity to make a smart choice.

Another interesting find we discovered is the location of recycling bins in some buildings. Many offices have recycling bins alongside the trash cans, but in others there are only large recycling bins in the hallway. In the latter case, a person would have to leave their office and walk down the hallway in order to recycle an item, whereas they could simply throw it away in the trash can next to them. This seems backwards for a university trying to promote sustainability. We propose that there only be recycling bins in offices, with large trash cans out in the hallways. In this situation, a person would have to walk down the hallway to throw something away. People naturally look for the easiest route or method to do something, it is human nature. Faced with walking all the way down the hall and leaving the comfort of an office chair, we believe that many people will be more likely to think about what they are throwing away is recyclable.

Recommendation #4

An interesting find from the waste characterization study was that a significant weight of the trash was paper towels. Paper towels are used in the restrooms and in labs. Paper towels are not recyclable at Howie's or at Deffenbaugh. However, there are two approaches to reduce the amount of paper towels sent to the landfill. The first option would be to remove paper towels dispensers from the restrooms and replace them with new efficient hand dryers. This alternative would actually eliminate the waste stream altogether although there would probably be a high capital cost but may pay off in the long run by eliminating the need to buy paper towels for restrooms and to pay to dispose of them in the landfill. A cost analysis would need to be done to determine the feasibility of this. The other alternative would

be to compost the paper towels in a separate special bin to collect paper towel waste in restrooms. A group called “Partners for a Green Hill” has deployed this waste management strategy in Canadian government building restrooms to reduce paper waste in landfills and provide mulch and compost material for land use. K-State currently has a composting facility at the North Farm. It may be possible to compost the paper towels at the farm instead of disposing them at the landfill.

Recommendation #5

Participate in local electronic recycling programs that can reuse end of life electronics. The following electronic wastes can be recycled locally: computers, monitors, cell phones, various type batteries, light bulbs, office [\[http://search.earth911.com/?what=Electronics\]](http://search.earth911.com/?what=Electronics)

Recommendation #6

Replace non-recyclable products with sustainable materials. The following materials have recyclable or more sustainable replacements:

- Styrofoam lunch containers with biodegradable clamshells
- Dixie produced napkins with recycled unbleached napkins
- Plastic beverage bottles with aluminum cans

Recommendation #7

Further invest and encourage support for on-campus environmental biotechnologies such as the green roof garden on Seaton Hall and the bioretention pond at the International Student Center rain garden. Toxic wastes can be mitigated from waterways by incorporating these ‘clean’ technologies with future construction and landscaping projects. Professor Lea Skabelund (Landscape Architecture) is a recommended “steward of the campus” for consulting sustainable landscape design based on his work on the previously mentioned projects and his life’s career in environmental stewardship. Dr. Alok Bhandarhi (Civil Engineering) is a recommended contact for his research on bioremediation and *other biotechnologies*.

Recommendation #8

Education and awareness is probably the most important factor to increasing recycling rates on campus. If people don’t realize the importance of recycling, then they aren’t going to take the time to recycle. The biggest challenge is going to get people to change their habit. Once the habit of throwing trash away is broken, then recycling becomes easy and rates will increase dramatically. The million dollar question is how to get people to break the bad habit of throwing everything away. Once administration realizes the importance of recycling and breaks the habit, then they can set an example for the rest of campus by providing more resources and awareness. Students have always been a crucial part to recycling at K-State. If enough students promote the cause of recycling, we think it will have a positive effect on the rest of campus since students are the majority on campus.

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