Spring 2012

Evaluating Bucknell's Waste Stream

Hallie S. Kennan
Bucknell University, hsk006@bucknell.edu

EVALUATING BUCKNELL'S WASTE STREAM

by

Hallie S. Kennan

A proposal submitted to the Honors Council for Honors in
Environmental Studies/Bachelor of Arts

April 16, 2012

Approved by:

_____
Thesis Adviser: Peter Wilshusen

_____
Department Chair: Molly McGuire

ACKNOWLEDGEMENTS

There are several people I would like to acknowledge for their contribution to my thesis research. First, Peter Wilshusen, my thesis advisor, helped guide and direct my research throughout this process. Next, Dina El-Mogazi advised me during my summer internship at Bucknell and greatly contributed to my design and implementation of the campus wide waste audit. Ben Marsh is my third reader for the thesis council and provided advice and statistical expertise with the analysis of my survey results. Lastly, I would like to thank Merritt Pedrick and John Testa from Bucknell's Facilities Department. They provided invaluable information about Bucknell's waste stream. The design and organization of the waste audit would not have been possible without their help and knowledge.

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

This thesis examines three questions regarding the content of Bucknell University's waste stream and the contributors to campus recycling and solid waste disposal. The first asks, "What does Bucknell's waste stream consist of?" To answer this question, I designed a campus-wide waste audit procedure that sampled one dumpster from each of the eleven 'activity' types on campus in order to better understand Bucknell's waste composition. The audit was implemented during the Fall semester of the 2011-2012 school year. The waste from each dumpster was sorted into several recyclable and non-recyclable categories and then weighed individually. Results showed the Bison and Carpenter Shop dumpsters to contain the highest percentage of divertible materials (through recycling and/or composting). When extrapolated, results also showed the Dining Services buildings and Facilities buildings to be the most waste dense in terms of pounds of waste generated per square foot. The Bison also generated the most overall waste by weight. The average composition of all dumpsters revealed that organic waste composed 24% of all waste, 23% was non-recyclable paper, and 20% was non-recyclable plastic. It will be important to move forward using these results to help create effective waste programs that target the appropriate areas of concern.

My second question asks, "What influences waste behavior to contribute to this 'picture' of the waste stream?" To answer this question, I created a survey that was sent out to randomly selected sub-group of the university's three constituencies: students, faculty, and staff. The survey sought responses regarding each constituency's solid waste disposal and recycling behavior, attitudes toward recycling, and motivating factors for solid waste disposal behaviors across different sectors of the university. Using regression analysis, I found three statistically significant motivating factors that influence solid waste disposal behavior: knowledge and

awareness, moral value, and social norms. I further examined how a person's characteristics associate to these motivating factors and found that one's position on campus proved a significant association. Consistently, faculty and staff were strongly influenced by the aforementioned motivating factors, while students' behavior was less influenced by them. This suggests that new waste programs should target students to help increase the influence of these motivators to improve the recycling rate and lower overall solid waste disposal on campus.

After making overall conclusions regarding the waste audit and survey, I ask my third question, which inquires, "What actions can Bucknell take to increase recycling rates and decrease solid waste generation?" Bucknell currently features several recycling and waste minimization programs on campus. However, using results from the waste audit and campus survey, we can better understand *what* are the issues of the waste stream, *how* do we go about addressing these issues, and *who* needs to be addressed. I propose several suggestions for projects that future students may take on for summer or thesis research. Suggestions include targeting the appropriate categories of waste that occur most frequently in the waste stream, as well as the building types that have the highest waste density and potential recovery rates. Additionally, certain groups on campus should be targeted more directly than others, namely the student body, which demonstrates the lowest influence by motivators of recycling and waste behavior. Several variables were identified as significant motivators of waste and recycling behavior, and could be used as program tactics to encourage more effective behavior.

INTRODUCTION

The world is now entering an era of increased environmental awareness. While this "green" culture may be viewed as a positive step for environmental improvement, it only came about after realizing humanity's desperate need to reverse its destructive impact on Earth. Environmental issues, namely air and water pollution, are more pressing than ever before. Many of these environmental issues can be avoided via advanced solid waste management practices that seek to reduce, reuse, and recycle a range of materials such as paper, glass, and plastic. If products last longer or can be recycled, factories will use fewer virgin materials, protecting our natural resources. Additionally, with reuse, fewer products will be discarded, thus reducing waste going to landfill. Often, landfills lead to air pollution by burning off waste or contribute to water pollution if chemicals from waste leach into the ground and enter the water table. Minimizing waste generation and diverting waste from landfills through reduction, reuse, or recycling methods are crucial steps toward achieving more sustainable and less impacting lifestyles.

Social consciousness regarding solid waste minimization and diversion began in the 1970's, when the Resource Conservation and Recovery Act (RCRA) initiated more strict guidelines for landfill use. Landfills and dumps that did not comply with the new rules were forced to close. With the decrease in operating landfills, more states are supporting the idea of recycling as an waste alternative to disposal and are even implementing local policies to provide recycling services to households (Kinnaman 2006: 219-220). The EPA's 2010 Municipal Solid Waste Report found that total Municipal Solid Waste (MSW) generation more than doubled from 1970 to 2010, from 121 million tons, to 249 million tons. Per capita generation grew 36% from 3.25 lbs/day to 4.43 lbs/day during this same time. 2010 data actually demonstrates the first decline in waste generation that has been reported. The highest year was 2005, when 52 million

tons of waste were generated. The highest per capita waste generation occurred in 2000, at 4.72 lbs/day (US EPA, 2010).

One of the best methods for solid waste diversion is recycling. Recycling converts used materials into new products to reduce waste and pollution emissions. Commonly recycled materials include paper, plastic, glass, aluminum, electronics, etc. Rates of recycling as a percentage of total municipal solid waste production (known as the recycling rate) increased significantly during the 1960's (Kinnaman 2006). As energy and landfill costs rose, recycling became an economically viable alternative to more typical waste disposal. As of today, some 9,000 municipalities (representing approximately half of the US population) had curbside recycling programs (Kinnaman 2006: 219).

The national recycling rate is now 34%, a major increase since 1980 when the rate was under 10%. Almost 65 million tons were recycled in 2010, and another 20 million tons were composted. This diversion of 85 million tons from landfill saves 186 million metric tons of carbon dioxide from being emitted, the equivalent of CO_2 emissions coming from 36 million vehicles. Because of increased recycling practices, the total amount of MSW going to landfills has decreased by almost 10 million tons/year in only two decades (US EPA, 2010).

Studies suggest that university recycling programs can help improve environmental awareness, attitudes, and behavior within its community. Students who learn about, or are exposed to, environmentally responsible waste practices at their university can have a significant impact on their community after their college years. Little research has been done on specific contents of university solid waste streams and the attitudes and behaviors that drive waste disposal practices. For this reason, I chose to do my research on the Bucknell University community and its waste stream. Bucknell is similar to other liberal arts universities in its effort

to become a more eco-friendly environment for its students and employees.

This thesis unfolds in four main sections. The first section provides a detailed look at the size, source, and composition of Bucknell's waste stream. During the summer and fall of 2011, I designed and implemented a campus-wide waste audit in collaboration with Dina El-Mogazi from Bucknell University's Environmental Center. We collected and sorted solid waste from 11 campus dumpsters and subsequently compiled the data to construct an initial cross-section of the university's waste stream in terms of different activity types (academic, residential, etc.)

The second section examines how attitudes and behaviors of the university's campus members shape recycling rates and the content of the solid waste stream. To pursue this line of inquiry, I created an online survey for the campus community that sought responses about (1) waste and recycling attitudes and behavior and (2) potential motivators or causal factors for their behavior.

The third section concludes my findings from both the waste audit and campus survey. I examine consistencies and discrepancies between the observed and self-reported waste behavior determined from my research In general, respondents overestimated their waste behavior while underestimating Bucknell's overall waste behavior. I also conclude that addressing the quantity of Bucknell's waste must be the priority in proper waste management practices, rather than the waste stream's quality.

The fourth section explores specific actions that Bucknell might take to install best waste management practices that reduce solid waste disposal amounts, increase its recycling rate, and encourage creative reuse of materials. Based on analysis derived from the waste audits and survey, I propose several suggestions for programs or projects achieve these goals for best management practices. Suggestions include targeting the appropriate locations, waste stream

components, and groups of people on campus where waste behavior is currently most inefficient.

PART I: WHAT DOES THE WASTE STREAM CONSIST OF?

Campus-Wide Waste Audit

A. Purpose

During the Summer of 2011, I designed a campus-wide waste audit, which was then conducted over the following Fall semester. The purpose of this waste audit was to determine the composition of Bucknell's waste stream and whether trends exist among the campus' waste habits. In order to design the waste audit, it was first necessary to review currently existing data on Bucknell's waste stream. The majority of this information was held in records by the Facilities department or Environmental Center. By understanding the data on Bucknell's waste stream that already exist, I was able to develop a waste audit that would uncover information that was not yet known. Through the audit, I was able to determine the amount (weight) and composition of each of the 11 sampled dumpsters. These results provided an objective picture of waste trends and behavior on Bucknell's campus.

> In the same way that municipal waste characterization studies provide local decision makers with a detailed understanding of a waste stream and enable waste management programs to be tailored to local needs, waste characterization studies at colleges and universities identify campus specific and regionally relevant opportunities for waste reduction and recycling, representing an essential step towards greening the campus (Smyth et al., 1007).

B. Background

Waste Audits at Other Universities

The first step I took in developing a waste audit for Bucknell's campus was to research the implementation and results of waste audits at other universities. This research helped guide me in designing Bucknell's waste audit procedure, as well as provide me with findings with

which I could later compare to Bucknell's waste audit results. The two best documented examples of university waste audits were the University of Northern British Columbia in Canada, and the University of North Florida.

- University of Northern British Columbia

In 2008, Smyth and others designed and conducted a waste audit at Prince George University within the University of Northern British Columbia. To begin their waste study, researchers reviewed waste management records, interviewed waste management staff, and extrapolated data from other institutions (Smyth et al., 1007). The questions they address in their study are: 1) What is the amount and composition of waste generated within key campus operational areas of the Prince George campus of UNBC? 2) Which campus operational areas and material types should be targeted for waste reduction and enhanced diversion efforts? And 3) What technically, financially, and administratively feasible waste management improvements and strategies should be adopted to advance the sustainability of the current system (Smyth et al., 1008)?

The University took an 'activities approach' to their waste audit, "which tracks waste from distinct areas within the institution and audits each separately (Smyth et al., 1009). The campus was divided into 15 different activity types and a sample was taken from each location. During the waste audit, a sample of waste from each of the designated campus locations was weighted and sorted into 12 primary material categories and 24 secondary material categories. Approximately 50% of the waste from these locations was sorted (Smyth et al., 1010).

Results from the audit show that about 37% of the waste stream was composed of recyclable material and about 20% was comprised of compostable material. Non-recyclable

material made up about 35% of the waste stream. Paper types, both recyclable and non-recyclable, comprised the largest portion of the waste stream (Smyth et al., 1011). There was a larger portion of recyclable materials in the waste stream than non-recyclable materials. On average, about 700 kg of waste each week are improperly disposed of at UNBC (Smyth et al., 1012).

From these results, the researchers concluded that programs must be created to address the largest components of the waste stream. Targeting recyclable materials found within the waste stream would offer the best method of minimizing waste for landfills (Smyth et al., 1012-1013). Because organic material was heaviest, it was also the most expensive to dispose of. Creating programs that reduce organic waste or divert it from landfill would provide great financial benefit to the University (Smyth et al., 1014). Other programs tackling specific materials included requiring double-sided printing or encouraging reusable drink mugs (Smyth et al., 1013). Overall, in order to make the waste stream most efficient, researchers concluded that "UNBC must adopt multiple strategies that target a range of materials and follow the principle waste management hierarchy; first reducing waste at the source, re-using materials when possible and recycling what remains (Smyth et al., 1013)."

- University of North Florida

Stacy E. Wheeler, a fellow at the UNF Environmental Center, created a report of the campus' waste audit that took place in March of 2007. Similar to the intention for Bucknell's waste audit, UNF aimed to "identify and quantify the types and sources of materials in [their] solid waste stream (Wheeler 2007: 2)". While Bucknell and UNF both examined records before the waste audit events took place, UNF additionally conducted a facility walk-through in order to

"observe campus waste-generating activities", which included note-taking on the size, location, and composition of trash and recycling bins at different areas on campus (Wheeler 2007: 3). Before conducting its waste audit, UNF considered when would be the most appropriate time to take a sample of its waste stream, in order to consider it most "representative" of the school's behavior. This meant choosing a time of the year (in this case, March) and day of the week (Wednesday) that would best represent UNF's waste stream.

For its waste categorization, UNF classified its waste into five main components; paper, plastic, glass, metal, and compost. Non-recyclables and non-compostables were classified as 'remaining trash'. These categories were similar to Bucknell's categories, yet Bucknell further divided categories not only by material, but by recyclability as well. While it is important to measure the amount of compostable and recyclable materials that compose the waste stream, categorizing and dividing the non-recyclable materials may still reveal trends and inefficiencies within the waste stream.

UNF audited four locations around its campus. Both recycling and solid waste were sorted to get an idea of what is and is not diverted from the waste stream. For UNF, teams of three or four people were organized for waste sorting. Two team members sorted the waste, one member weighed the separated materials, and the fourth member recorded its measurements (Wheeler 2007: 6). Bags were collected in a bucket and weighed, recording the total weight minus the weight of the bucket. Measurements also included volume, which was calculated by sorting the material into 60-gallon bags. The recorder would then estimate the volume based on how full the bag was. Overall, UNF had 135 volunteers to help with the auditing process. Bucknell had fewer volunteers (about 15-20 total), which was partly due to the University being much smaller.

The results from the UNF waste audit revealed that 57% of their total solid waste stream was comprised of recyclable materials (by weight). Another 12% was compostable materials. The largest component of the waste stream was paper (40% by weight, 30% by volume), most of which was mixed paper. Food packaging items made up another large portion (17% by weight, 28% by volume). Comparing the waste and recycling stream, plastics had the best overall recovery as a percent of generation; 41% of the plastics measured were recovered by diversion to recycling (Wheeler 2007: 12). UNF's total solid waste stream had a 21% diversion rate, meaning 21% of its total generated waste was recovered through recycling or composting. However, only about one-third of these recyclable materials were recovered from the waste stream.

Based on the audit results, Wheeler offers several suggestions to minimize waste and increase waste recovery. First, the University ought to establish a formal solid waste reduction program (Wheeler 2007: 16). Next, it ought to create a committee that oversees the design, implementation, and evaluation of the proposed waste reduction program (Wheeler 2007: 17). This committee would be comprised of several campus individuals with different skills and experiences so as to get a multi-dimensional perspective to create an effective program. The committee would set short- and long-term goals, gather and analyze information, monitor and evaluate, and report findings to the campus community. Third, the University ought to dedicate resources to "brand" or advertise their proposed waste reduction program. Informing campus members about the program through marketing tactics will be important in gaining involvement and cooperation. And lastly, the proposed waste reduction committee ought to primarily target the largest components of the waste stream; paper, food packaging, and plastic containers. Minimizing and diverting these materials first will make the largest impact on campus, allowing the University to see major differences in a short period of time.

Recyclemania

Determining general recycling and waste data about Bucknell was the next step in my research process. Recyclemania proved to be an excellent source in providing these data as a comparison to other universities in the United States. In 2006, Bucknell joined Recyclemania, a 10-week recycling competition among 400 other colleges and universities across the nation. For Recyclemania, Bucknell has pledged to reduce its campus waste in the following ways: by purchasing office equipment with waste prevention in mind, by creating an active program to sell or donate campus surplus property, and by promoting inter-office reusable envelopes for campus mail. Recyclemania presents its recycling results in the form of four categories; Grand Champion, Per Capita Classic, Waste Minimization, and Gorilla Prize (Recyclemania). Figure 5 shows Bucknell's Recyclemania results among these four categories.

Week	**Grand Champion**		**Per Capita Classic**		**Waste Minimization**		**Gorilla Prize**	
	weekly recycling rate		lbs/ person		lbs/ person		lbs	
	2011	2010	2011	2010	2011	2010	2011	2010
Results	19.3%	18.1%	18.8	18.7	97.2	103.47	98,703	92,079

Figure 1: Bucknell Recyclemania Results from 2010 and 2011

- Grand Champion – This category combines trash and recyclable materials to determine Bucknell's recycling rate as a percentage of overall waste generation. In 2011, Bucknell's recycling rate during the competition was 19.3%, only slightly better than the university's recycling rate in 2010, which was 18.1%. Compared to other schools in the division, Bucknell has one of the lowest recycling rates, placing 225th out of the 288 schools competing in this category.

- Per Capita Classic – This category measures the combined amount of recyclable paper, cardboard, bottles, and cans that are recycled per person at Bucknell during the competition. Between 2010 and 2011, Bucknell's per capita recycling rate increased just slightly from 18.7 lbs/person to 18.8 lbs/person. Bucknell does a much better job in this category compared to other universities, placing 73rd out of 362 schools. These results demonstrate that the Bucknell community has made an avid effort to recycle, though there is still room for improvement.

- Waste Minimization – This category measures the amount of municipal solid waste (both recyclable and non-recyclable) generated per person each week of the competition. The purpose of this category is to emphasize reduction and reuse practices before resorting to recycling. Bucknell improved its waste minimization between 2010 and 2011, reducing its per capita waste from 103.4 lbs/person to 97.3 lbs/person. Bucknell is ranked almost last in this category, placing 170th out of 182 schools. This implies that, while the University may demonstrate decent recycling behavior, we must make a better effort at waste minimization overall.

- Gorilla Prize – This last category is geared more toward larger schools, as it measures overall tonnage of recycled paper, cardboard, bottles, and cans during the competition, regardless of the campus' population. Overall, Bucknell increased its total recycling between 2010 and 2011. During the competition weeks, the university recycled 92,079 lbs in 2010 and 98,703 lbs in 2011. In this category, Bucknell placed 167th out of 362, which seems appropriate given that the Gorilla Prize measures overall recycling and Bucknell is considered a smaller university.

Breaking up Bucknell's recycling by material type, the university increased its per capita recycling rate for bottles and cans in 2011, ranking 8th in the division. On the other hand,

Bucknell also decreased its recycling rate for paper and corrugated cardboard the same year. Given Bucknell's results and its rankings compared to other universities within the Competition Division, we can conclude that Bucknell's largest issue is waste minimization. While we have improved in increasing recycling, it is still a priority to minimize waste generation overall.

Facilities Records

Records from Bucknell's Facilities Department provided more specific data about the University's recycling and solid waste stream. The majority of existing data on the subject came from Merritt Pedrick, Associate Director of Operations in the Facilities department. Overall trends show that, throughout the past decade, Bucknell has decreased its generation of waste and slightly increased its recycling (see Figure 2).

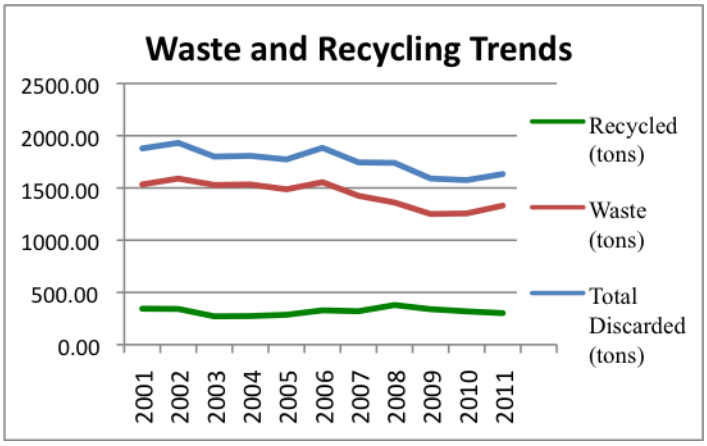

Figure 2: Yearly Totals of Waste and Recycling

These trends reverse in 2011, in which recycling totals decreased to 301 tons, while waste sent to landfill increased slightly to 1330 tons. This led to an increase in overall waste discarded and a decrease in the recycle rate to 18.5% (see Figure 3).

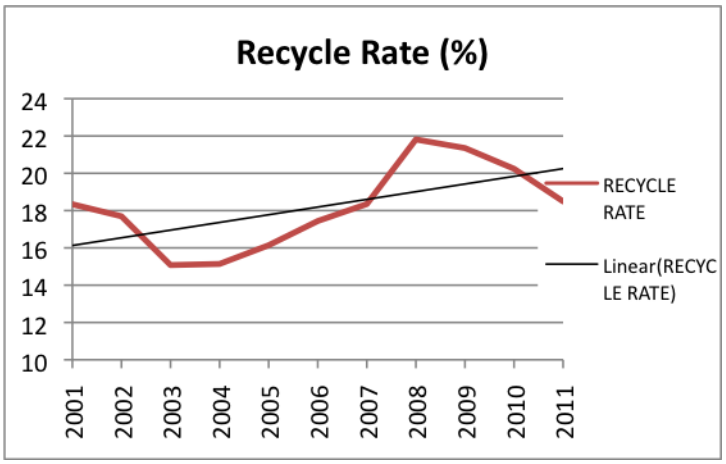

Figure 3: Yearly Recycling Rates (%)

2008 has been the most efficient year, with a recycling rate of 21.8%. During that year, 379 tons of discarded material were recycled and 1,360 tons of waste were sent to landfill. In addition to documenting recycling by amount and weight, facilities records also dissect it compositionally by material types. Looking at Bucknell's average waste stream composition over the last decade, cardboard made up the largest portion, composing 34% of the total (Pedrick, 2009).

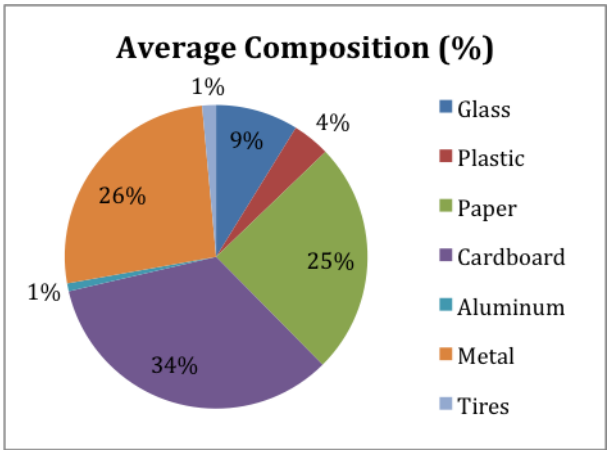

Figure 4: Average Composition of Bucknell's Recycling Stream (2000-2010)

Paper, which holds the lowest redeemable recycling value of an average $1.44/ton, makes up 25% of the waste stream. On the other hand, aluminum, with the highest redeemable recycling value, contributes only 1% of the waste stream's total waste in terms of weight. On average, aluminum has sold for over $900/ton when recycled (Pedrick, 2009). Figure 5 in the Appendix shows the fluctuation in values among different recyclable materials.

Bucknell Preliminary Waste Audit Data

Investigating the process and results from preliminary waste audits piloted at Bucknell was useful in shaping the design and procedure for the larger scale waste audit. In previous years, Bucknell conducted waste audits on two separate occasions; one that sampled Theta Chi fraternity, and another that sampled both Lambda Chi fraternity and Bertrand Library. These audits were led by the Environmental Center's Campus Greening Initiative and Bucknell's Facilities department, but were also made possible due to the help of several student and faculty volunteers. The process for both audits involved separating their waste into several categories, and then measuring the weight and volume of waste within each category to determine where the largest waste problems lie. Results for the Lambda Chi and the Library waste audit are presented here.

The Lambda Chi dumpster contained 4 days-worth of waste, of which about 60% was sorted during the audit. A breakdown of this waste by category is shown in Figure 6. The "everything else" category made up the largest portion of Lambda Chi's waste, with 38.7% of its total weight. This category contained all products whose original material could not be identified or did not have its own category (for example, non-recyclable paper products). Non-recyclable plastic made up the next largest category, capturing 18.3% of the total waste weight. (El-Mogazi,

2011). The results also showed that, by combining all of the recyclable categories (metal, plastic, paper, glass, cardboard) from the audit, 31% of Lambda's waste had the potential to be diverted from landfill if properly recycled. This implies that Bucknell's recycling programs are not as effective as they could be.

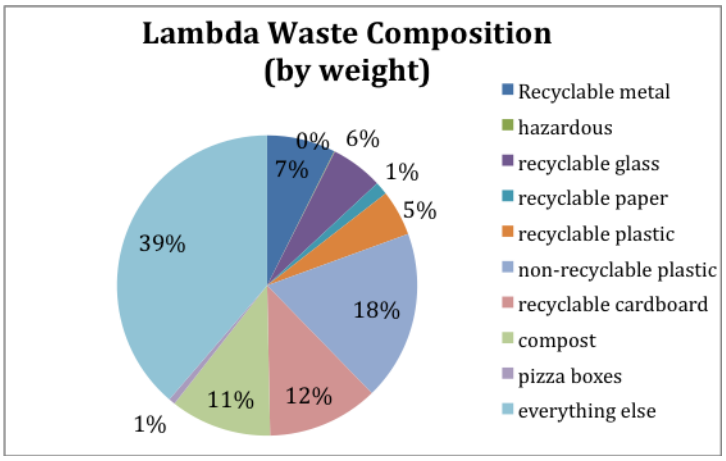

Figure 6: Lambda Chi Dumpster Composition

The library dumpster contained 1 day of waste, of which about 40% was sorted during the audit (see Figure 7). Similar to Lambda Chi's dumpster, the largest portion of library waste fell in the "everything else" category, making up one third of the total waste weight. The second largest portion was also non-recyclable plastic, which made up 28.45% of the total weight. Overall, 27% of the library's waste had the potential to be recovered or diverted from landfill (El-Mogazi, 2011). Again, these results demonstrate that a significant portion of the dumpster's waste could be eliminated with proper recycling practices.

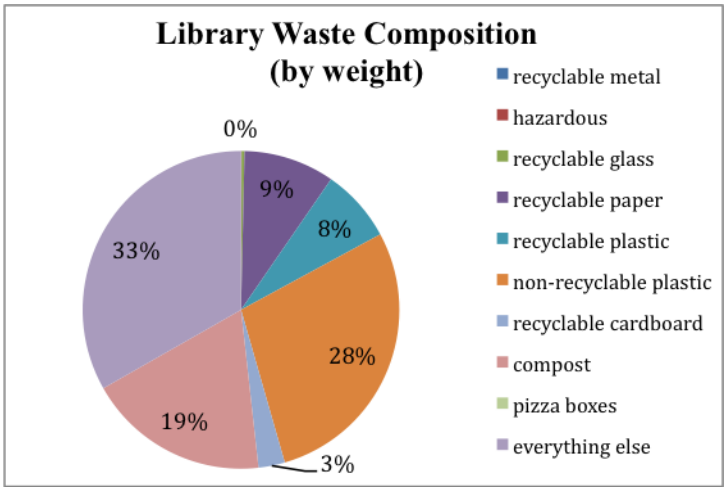

Figure 7: Library Dumpster Composition

Conducting these preliminary waste audits was important in that it allowed us to test and manipulate our audit methodology in order to create the most appropriate procedure for the campus-wide audit. The majority of the auditing procedure remained the same, yet after viewing the audit process and examining results, I decided to make several minor changes. The first change was with regard to the sorting categories. I expanded some of the categories to make them more specific by material type. I added "appliances" as its own category, rather than grouping it with "hazardous waste" because the materials are recycled in different ways. I also included a "non-recyclable paper" category because I found that a significant portion of the "everything else" category was comprised of non-recyclable paper material, namely paper towels, napkins, waxed paper cups, etc. With regard to measuring the waste, I decided to switch from using gallon bins to gallon plastic bags. Bags made waste measurements more accurate because they did not contribute any extra weight, which allowed more accurate scale readings. Plastic bags also made it easier to visually estimate a volume using proportions of the bag. Lastly, I included a "notes" section on our recording sheets to stress the importance of note-

taking during the waste audit process. Volunteers were encouraged to track trends or other observations in this section while sorting the dumpster waste.

C. Design/Procedure

Selecting Dumpsters and Categories

After examining the research that has already been collected and reviewing the results of the previous waste audits, I was able to begin the design process of the campus wide waste audit. I decided to take an "activities approach" which involves tracking the waste stream through several separate waste audits within the institution's primary operations. I chose eleven dumpsters to represent each type of activity on campus. The dumpster and its corresponding activity type are as follows:

- Cooley Hall – admin
- Davis Gym – athletics
- Bison LC – Dining
- Carpenter Shop – Facilities
- Computer Center – Lab_Science
- Library – Other
- Gateways – Residential_Apartment
- Phi Kappa Psi – Residential_Fraternity
- McDonnell Hall – Residential_Non-fraternity
- Specialty Houses – Residential_SpecialInterest
- Coleman Hall – Class/Office

I aimed to choose dumpsters that were most representative of the activity of the building for which it serves. Because of this, I made categories to divide how each dumpster serves its building. Single and Pure dumpsters were most representative of the building in which the

dumpster serves, so those categories took priority when choosing dumpsters of each activity type. The categories are defined as follows:

Single: One dumpster serves one building with one activity type
Pure: One dumpster serves more than one building, but of the same activity type
Portion: Multiple dumpsters for one building
Pure Portion: Multiple dumpsters for a building with one activity type

Using GIS features, I created a table that held the attributes of each selected dumpster. These include activity type, dumpster size, number of weekly pickups, etc. Figure 8 shows several of the columns included in the attributes table for the audited dumpsters.

FID	Shape	Comment	Point_ID	Type	size_yards	loads_week	pure_type	Tot_weight	Tot_volume	rec_rate
0	Point	Bertrand Librar	1	other	6	5	single	0	0	0%
1	Point	Carpenter Sho	4	facilities	3	4	pure porti	0	0	0%
2	Point	Cooley Hall	17	admin	3	4	pure	0	0	0%
3	Point	Gateway 1	19	res_apt	3	7	pure	0	0	0%
4	Point	Davis Gym	21	athletics	3	3	pure porti	0	0	0%
5	Point	Phi Kappa Psi	102	res_frat	3	7	single	0	0	0%
6	Point	Specialty Hous	110	res_SI	3	6	pure	0	0	0%
7	Point	Bison LC	113	dining	6	12	portion	0	0	0%
8	Point	McDonnell Hall	117	res_nonfr	6	5	single	0	0	0%
9	Point	Computer Cen	124	lab_scienc	3	6	pure	0	0	0%

Figure 8: Attribute table for selected dumpsters

Another table holds information regarding all campus buildings. Using this information, I created a GIS map that displays the campus buildings and their activity type. The map also includes all the dumpsters on campus and highlights the ten selected for the waste audit (see Figure 9).

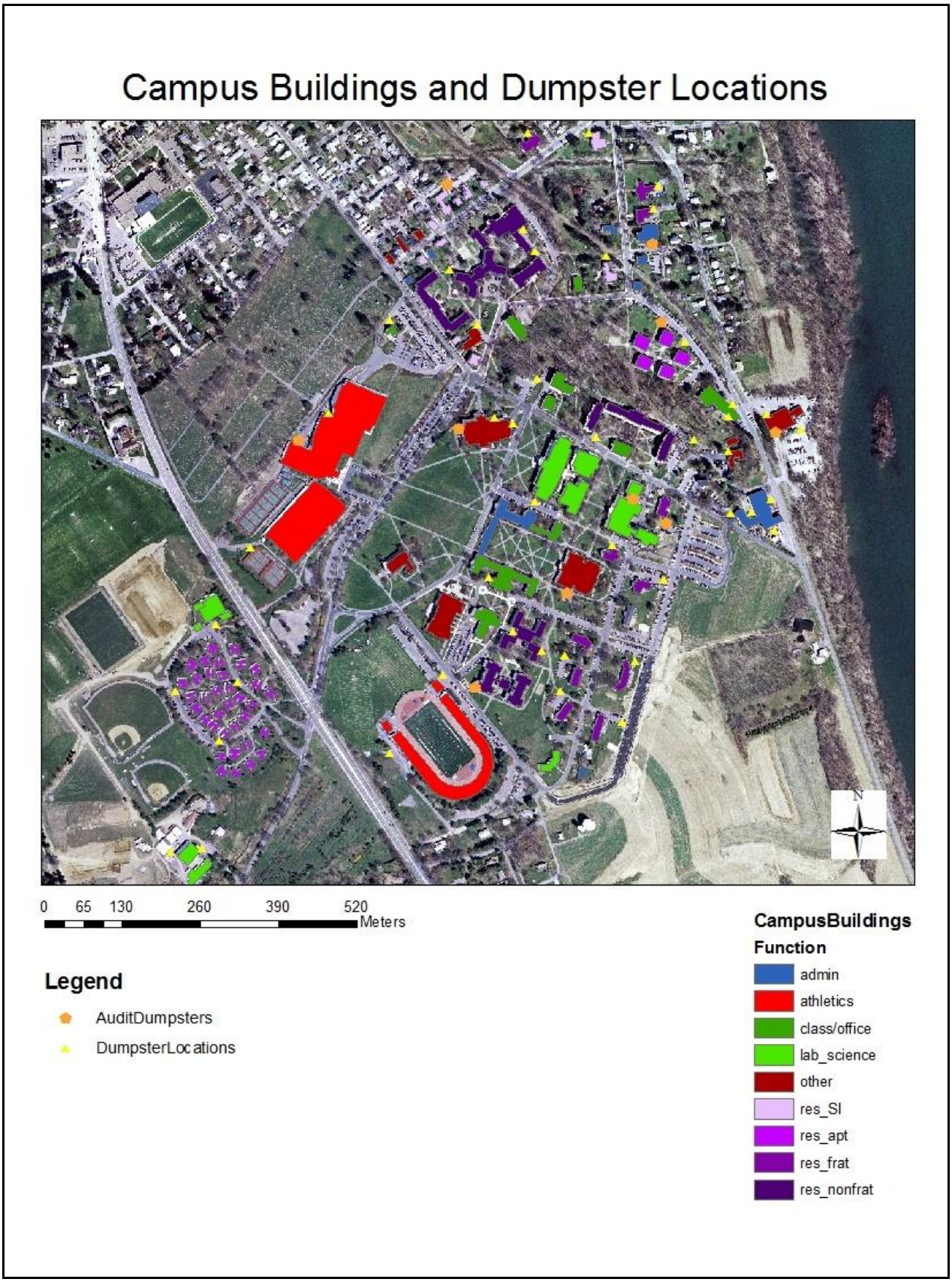

Figure 9: Map of Campus Buildings and Dumpster Locations at Bucknell

As mentioned earlier, while the materials categories from previous waste audits were fairly effective in sorting out dumpster waste, I made several alterations to allow the categories to provide us with as much information as possible. The materials categories used to sort the dumpster waste were:

- Hazardous waste – batteries, paint, cleaners, aerosol cans, etc
- Appliances – electronics
- Recyclable metal – aluminum cans, steel food cans
- Recyclable glass – clear, brown, blue, green glass
- Recyclable paper – magazines, newspaper, computer paper, envelopes, catalogs
- Nonrecyclable paper – carbon paper, tissues, paper towels, napkins, wax paper
- Recyclable plastic - #1 and #2 containers
- Nonrecyclable plastic - #3-#7 containers, Styrofoam, food wrappers
- Recyclable cardboard – corrugated boxes
- Organic waste – wood chips, yard trimmings, food scraps
- Everything else – discarded material that does not fit in any other category

Waste Audit Procedure

To conduct the waste audit, I selected several dates and locations for the event to take place. Because I chose to audit eleven dumpsters, more than has ever done in the past, I held three separate waste audit events over a span of several weeks. The first audit took place Saturday, September 17th on the lawn outside Sojka Pavilion. This location covered three of the downhill dumpsters selected for the audit; Specialty Housing, Bison LC, and Davis Gym. The second audit was held Thursday, October 6th on the Engineering Quad and covered four of the uphill dumpsters; the Computer Center, McDonnell, Bertrand Library, and Coleman Hall. The

last audit on Friday, October 28th was also held on the Engineering Quad and covered the Carpenter Shop, Gateways, Cooley Hall, and Phi Kappa Psi.

The audits were carried out through the help of Dina El-Mogazi, Facilities staff, and community volunteers. For each dumpster we first measured the total weight using an industrial scale. All the dumpsters we audited contained one day's worth of waste. We also estimated the total volume based on the size of the dumpster and how full it was. We then selected a representative sample of garbage bags from the dumpster to sort through. Several volunteers worked on each dumpster to help with the auditing process. Two volunteers sorted the waste into the above-mentioned categories. Each material was sorted into 5 or 32 gallon plastic bags, depending on the material's weight. Another volunteer weighed the filled bags of sorted materials to calculate the weight of each material category. Because the bags were essentially weightless, the weight reported on the scale was the weight we recorded. The volume was the combined total of each filled bag. We estimated the volume of partially filled bags based on how full they were (about half full would be 2.5 or 16 gallons, etc). The fourth volunteer recorded each bag to calculate the total weights and volumes of each category (see Template 1). After recording the categories, I found a ratio between measured values (weight and volume), and total dumpster values (measured at the beginning of the process) to extrapolate the measured values for each material category to represent the entire dumpster.

Based on the data collected from the audit, I further expanded our findings to cover each entire activity type. By using square footage of buildings (provided by Raymond Kacyon, Facilities Designer and Systems Coordinator for Bucknell University), I took the size of the building whose dumpster was sampled (Phi Kappa Psi, for example), and compared it to the total square footage for all buildings of the same activity type (all fraternities). I then used this ratio to

extrapolate the dumpster weight data found to represent a larger portion of campus. This information was recorded using Template 2 (see Figure 10 in Appendix). The column with "dumpster total" contained the values we calculated by extrapolating the measured weights and volumes. The "activity total" column contained the values calculated by extrapolating using square footage ratios for buildings within that activity type. The third column, "% of total", contained the value of each material category as a percentage of the total weight or volume. Though I cannot make any accurate conclusions about entire activity types by measuring one dumpster within the activity, I thought it was note-worthy to calculate the potential waste measurements for the entire campus if they translated appropriately from our observed data.

D. Results

Of the 11 sampled dumpsters, the Bison LC dumpster had the highest overall weight of 887 pounds. This seems accurate, given that a large portion of the dumpster was organic waste, which is denser than other waste materials. The Gateways and the Library dumpsters weighed the least, under 200 pounds. It is not obvious what factors contributed to such low weights for these locations, since these locations account for large populations of Bucknell campus members.

Averaging all the dumpster compositions together, I found that organic waste made up the largest portion (24%) of Bucknell's waste stream (see Figure 11). Based on audit observations it appears that much more food is wasted than is necessary, which contributes to this waste category. While organic waste was found in each of the dumpsters, the main source for most of this material type comes from food provided by Bucknell's Dining Services.

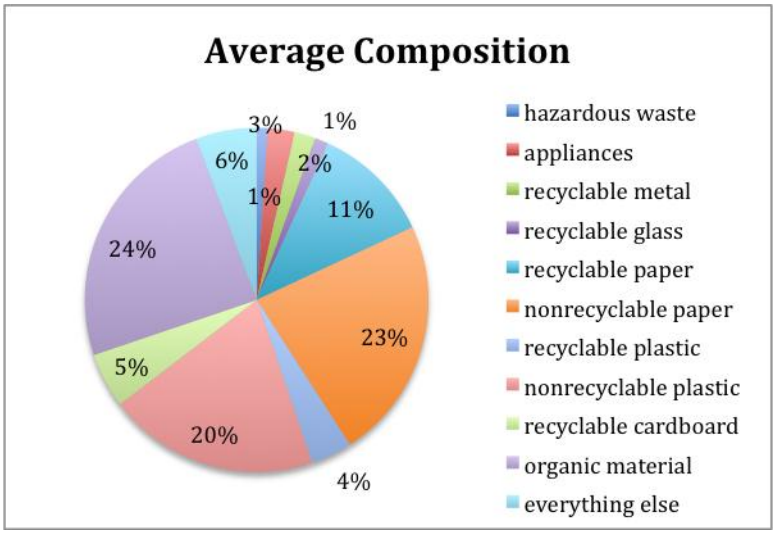

Figure 11: Average Waste Composition of Audited Dumpsters

After organic waste, non-recyclable paper and non-recyclable plastic made up the next largest compositions, 23% and 20% respectively. The dumpsters for the Library and Coleman Hall were both comprised of 38% non-recyclable paper. McDonnell followed closely with a 37% composition. Most of the non-recyclable paper came in the form of paper towels, tissues, and waxed paper cups. The Gateways' dumpster was comprised of the most non-recyclable plastic, making up 34% of its total waste. The majority of non-recyclable plastics observed in the audit were 'to-go' food containers and food wrappers.

While it is somewhat encouraging that the largest components of the waste stream were non-recyclables, meaning campus members are mostly throwing away what is not divertible; there was still a substantial amount of recyclable materials found in the dumpsters. On average, about 26% of the materials found in the dumpsters had the potential to be recycled, and 45% of materials had the potential to be either recycled or composted (see Figure 12).

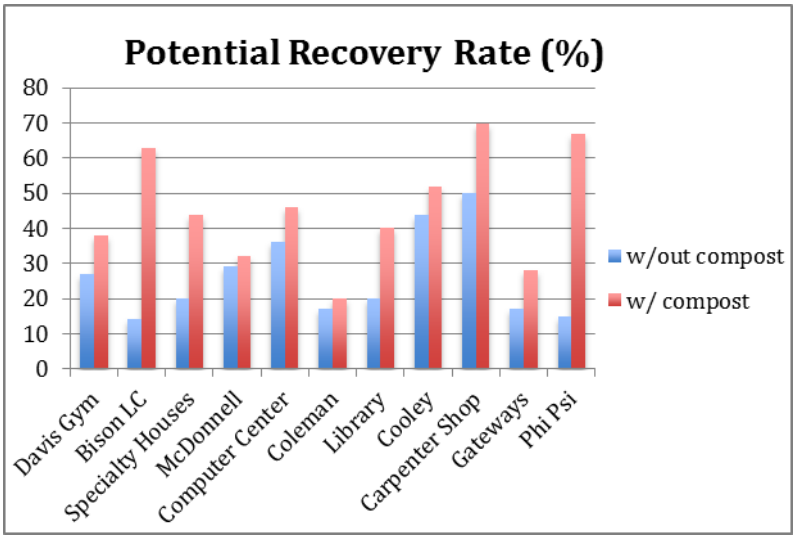

Figure 12: Portion of Waste Stream with the Potential to be Recovered (recycled or composted)

The Bison and Phi Psi dumpsters had the lowest composition of recyclables, comprised of only 14% and 15% of recyclable materials, respectively. However, once we add compostable materials into the percentage for potential recovery rate, these two dumpsters become among the least efficient, with rates of 63% and 67%, respectively. This means that the majority of waste in these dumpsters has the potential to end up outside of landfills, either through recycling or composting. The dumpsters that have the worst recovery rates for recycling without compost are the Carpenter Shop and Computer Center, with rates of 50% and 36%, respectively. The largest portion of recyclables found in these dumpsters was recyclable paper. Overall, recyclable paper made up an average 11% of the composition of all the measured dumpsters.

Waste Density Map

Based on results from the audit, I generated a waste density map, which aimed to visually represent the how much space in a building would generate a standard unit of waste. To find this, I extrapolated the total sampled weight from each dumpster to determine how much waste the

entire building would have generated. I then divided the total square footage of the building by this extrapolated waste weight to determine the waste density of each building that corresponded to an audited dumpster.

The buildings with the highest waste density were the Bison and the Carpenter Shop, creating 0.153 lbs/ft^2 and .074 lbs/ft^2, respectively. The buildings with the lowest waste density were the library and the Gateways, generating 0.0011 lb/ft^2 and 0.0033 lbs/ft^2 (see Figure 13).

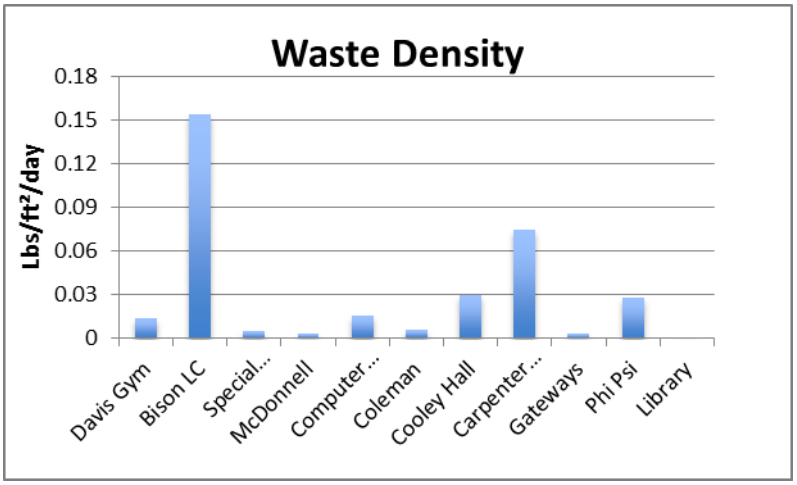

Figure 13: Waste Density Graph; Measures Pounds of Waste Generated per Square Foot

Using this information, I created the waste density map with GIS to visually demonstrate the waste densities for each campus building that corresponds to an audited dumpster (see Figure 14). Green buildings have a lower waste density, while red buildings have a higher waste density.

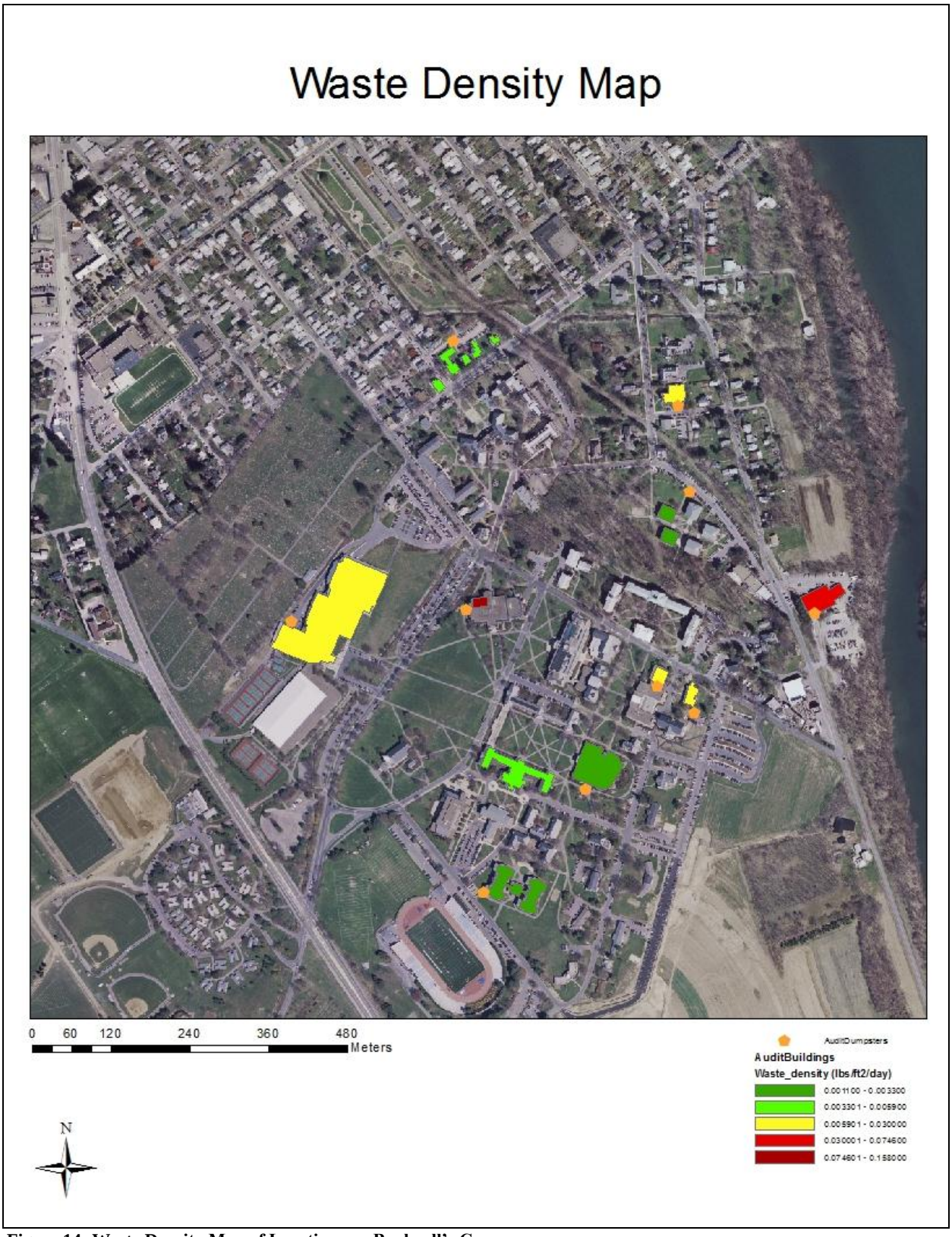

Figure 14: Waste Density Map of Locations on Bucknell's Campus

E. Waste Audit Conclusions

Based on results from the campus-wide waste audit, the largest component of Bucknell's waste stream was organic waste. To reduce this portion of waste, it is necessary to target both the production side of food waste from Dining Services as well as the consumer side of food waste from the students, faculty, and staff. Similarly to results from waste audits at the University of Northern British Columbia and the University of North Florida, paper made up one of the largest components of campus solid waste at Bucknell as well. This implies that there is a common necessity to minimize generation of paper waste on university campuses. With regard to non-recyclable plastic, it is likely this portion is so high because there is a limited amount of plastic types that are recyclable at Bucknell. Currently, only plastic types #1 and #2 can be recycled. None of the 'to-go' containers or cups qualifies as recyclable plastic, which means much of the plastic that is brought into campus must inevitably end up in landfill. To improve upon this inefficiency, Bucknell could make future efforts to purchase 'to-go' containers that can be recyclable, or install programs that minimize the use of the containers altogether. Because these last two types of waste are non-recyclable, efforts should focus on *minimization* of consumption and disposal, rather than *diversion* from landfills by recycling practices.

Even though the Bison LC dumpster held the most weight, the composition of this waste was not the more inefficient when compared to other dumpsters. In fact, the Carpenter Shop dumpster was the most inefficient by having the highest potential recovery rate, as well as having one of the highest waste densities. Cooley Hall has the second highest potential recovery rate without compost included. Because Bucknell staff contribute most of the waste to these dumpsters, given the activity types of their associated buildings, these results imply that staff members are mostly responsible for the high proportion of recyclables found in the waste stream.

However, it is important to note that the Carpenter Shop dumpster includes waste coming from maintenance projects around campus, and therefore, composition of this dumpster does not provide an accurate representation of purely facilities staff behaviors. Alternatively, the dumpsters that account mostly for student waste, such as the residence dumpsters or the library, have relatively low potential recovery rates and low waste densities for their corresponding buildings. I conclude that this low potential recovery rate is attributed to low waste generation in the corresponding buildings overall, as well as high accessibility to recycling bins which facilitate diversion to recycling in these locations.

PART II: WHAT CAUSES THE WASTE STREAM TO LOOK THIS WAY?

Waste Behavior Survey

A. Purpose

In order to get a better understanding of what causes the waste stream to look the way it does, I created an online survey that asks campus members about their behavior and attitudes and what might contribute to them. While the waste audit provides a tangible representation of Bucknell's waste stream, on its own it does not explain the behaviors that contribute to its composition. By uncovering what motivates behavior, we can create effective programs that facilitate certain behaviors to make the waste stream most efficient. It is important to note that responses to the survey are self-reported and based on perceived information and behavior, rather than the audit results which display actual behavior.

B. Methods

I used Vovici EFM Continuum software to create the survey and analyze the results. The survey was comprised of five different pages of questions, each dealing with a different topic regarding the determinants of waste and recycling behavior. The first page dealt with questions about recycling knowledge at Bucknell. These questions asked about the amount and composition of Bucknell's waste and which types of campus buildings are most wasteful. The goal of asking these questions was to determine the respondents' level of knowledge about waste and recycling specifically on Bucknell's campus. The next page asked questions about other potential determinants of waste and recycling behavior, such as convenience, awareness, and social norms. The last question on this page asks the overall question, "Why do you choose to

recycle, if you do?" which then lists several responses that can be categorized as different determinants for the respondents' behavior. The third page asks questions about the individuals' behavior to get a better understanding of how campus members currently act with regard to waste and recycling. Comparing these responses with the responses of questions from the previous pages will help determine what factors contribute to the behaviors recorded in the survey. Page four looks at attitudes regarding waste and behavior. I listed several statements and respondents were asked to rank their level of agreement using a Leikart scale. I modeled many of the statements in this section from those present in the questionnaire developed by Massey University (Kelly et al. 2006: 50). The last page asks attribute questions, such as gender, role on campus, class year, etc. I ask these questions to help understand what characteristics influence motives for waste and recycling behavior.

C. Testing Variables

Through the administration of this survey, I sought to answer two questions. The first was, "what motivates one's waste and recycling behavior?" By researching prior studies regarding similar topics, I consistently found five factors that may contribute to a person's recycling and waste behavior; knowledge, convenience, social norms, moral value, and environmental value.

Kaplowitz explains that campus members are more interested in understanding how/what/when to recycle, rather than the benefits or consequences of recycling. In other words, procedural knowledge is more important than impact knowledge, which is the information about the benefits or consequences of behavior. Moral value, both personal and communal, has also been shown to motivate proper waste behavior as well. Shalom Schwartz's "Theory of Altruistic

Behavior" explains that one behaves altruistically due to their moral values which are inherent to people (Bratt 1999: 633)". Further, Vicente and Reis comment on the importance of human values in determining a person's level of recycling participation. "When there is a strong conviction both about the benefits of recycling and the responsibility of cooperation, incentives are of minor importance (145)."

Bratt's study emphasizes the influence of social norms in shaping a person's recycling behavior. People are strongly influenced by the behavior of their peers and often perceive this behavior to be a social norm, which they then internalize to make a personal norm. "One therefore should focus on influencing people's beliefs about the contributions made by other in order to promote environmentally friendly behavior (Bratt 1999: 631)." Vicente and Reis also argue that, "attitudes about social and personal norms have the strongest positive effect on recycling participation (Vicente and Reis 2008: 144)".

Studies also showed that communities report valuing nature and behaving in ways that benefit their environment. De Young's study on recycling programs in Michigan demonstrates that a strong majority of communities surveyed "indicated they thought recycling was extremely important to the preservation of the environment (De Young 1989: 257)". The last motivator of waste behavior I included in my study was convenience. Inconvenience or difficulty in recycling has also been considered a barrier to proper recycling behavior. "Inconvenience and proximity of recycling receptacles have been widely discussed as major constraints to college students' recycling behavior (Kaplowitz 2009: 613)." Vicente and Reis also argue that simplifying the process of separating and depositing sources of waste would motivate proper waste behavior.

As mentioned in the previous section, I included questions in the survey that addressed each of these potential contributors. I then compared the respondents' answers in this section

with their answers from the behavioral questions to conclude whether any correlation existed among variables. By understanding what motivates waste behavior, we can create programs that capitalize on these motivators to encourage proper behavior.

The next question I ask is, "what characteristics of the respondents influence these motives of waste behavior?" My last page of the survey asked attribute questions, which were helpful in answering this question. Potential contributors such as role on campus, gender, class year, and residential location were all characteristics I included when investigating what might differentiate people on the basis of their waste behavior. Several of the characteristics I used in this section of my study were inspired by characteristics from T.C. Kelly's study about University responses to recycling programs. Kelly included gender, age, income, occupation, and college affiliation as characteristics. Kelly's results found that occupation (or what I called 'role on campus'), age, college affiliation, and income level to all be significant factors of waste and recycling behavior (Kelly 2006: 53). Gender did not prove to be a factor in Kelly's study, though other studies do report gender to be significant. I chose characteristics for my survey based on those from this study, as well as through observation of Bucknell's campus and what factors I believed might contribute to one's waste behavior. Once it is understood what motives are involved, it is important to identify which groups of people should be targeted in order to make new waste programs as effective and efficient as possible.

D. Surveys at Other Universities

To inform my process, I investigated studies of waste surveys from other universities that provided a foundation for my survey. These studies helped influence my

choice of questions and topics to include, as well as structural formatting and administration. The two universities I reference are Michigan State and Massey University.

Michigan State University

Though Michigan State differs from Bucknell (public vs. private, size, and geography), it possesses the same goals in creating a more environmentally friendly atmosphere at higher education institutions. In 2009, Kaplowitz et al. conducted a survey on Michigan State's campus, which I referenced when designing my survey for Bucknell. His study aimed to understand the campus community's 1) perceived barriers to recycling; 2) recycling knowledge; 3) program preferences; and 4) environmental attitudes (Kaplowitz et al., 612). Through a survey presented to a selected group of campus members, his study intends to answer three questions; What should be the focus of recycling communication for the various segments of a university population? What is the most effective medium for communicating recycling and recycling program attributes to the various constituencies of a university community? What communication strategies should be adopted to effectively convey recycling information to the various segments of the university community (Kaplowitz et al. 2009)? I followed a similar format in structuring my survey around exploratory investigation.

The survey was sent out to 30% of the campus population and divided proportionally between students, faculty, and staff. Results show that there was an overall lack of awareness of recycling locations on campus (Kaplowitz et al., 617). The campus community, however, demonstrated high willingness to learn more about the procedural knowledge of recycling. The respondents also reported high awareness levels of the environmental benefits of recycling. However, they reported low willingness to learn about further benefits of recycling (Kaplowitz et

al., 617). This study included a section regarding opinions of publicity options to communicate new recycling programs. Most students reported that promotions, such as campus competitions, would be the most effective, while faculty and staff reported personal contact to be the most effective communication strategy (Kaplowitz et al., 618).

Overall, the campus community reported positive attitudes regarding recycling and understand its benefits, yet felt that they still lacked the knowledge to recycle properly. Responses demonstrate the importance of communicating procedural knowledge of recycling (where, what, and how), rather than the benefits or reasons to recycle. Communicating this knowledge may also be done through different channels, depending on the campus group, such as through promotional competitions versus personal contact strategies.

Massey University

One university that has gained much attention for its waste minimization efforts is Massey University in New Zealand. The University implemented a Zero Waste program in 1999 as a result of students voicing their concern over a lack of proper recycling programs (Mason et al., 262). Its implementation process was modeled after Humboldt State University's five-step plan: i) Receiving visible administrative support; ii) involving the campus community; iii) hiring a waste reduction coordinator; iv) knowing the waste; and v) researching markets (Mason et al. 265-266). The program included establishing a recycling bin system, an education campaign, added signage, and a study of amount and quantity of materials collected (Kelly et al., 45). Once these initiatives were in place, the University developed a follow-up questionnaire for students and staff in order to determine the success of the program and any improvements that may be needed. The questionnaire was broken into four sections: Knowledge of and participation in the

recycling program, opinions about the program and suggestions for improvement, general attitudes toward recycling and the environment, and demographic information (Kelly et al., 46).

The responses to the first sections of the questionnaire reported that about half of the school considered themselves frequent recyclers. Regarding changes to be made in order to improve the recycling program, a slight majority responded that they did not want more information, either with regard to the campus recycling program or recycling in general. They did not believe they would recycle more if they had more information (Kelly et al., 49). Most respondents also reported that social pressures would not cause them to recycle more (Kelly et al., 51). However, a majority did report that they would recycle more if there were additional bins around campus, thus making recycling more convenient (Kelly et al., 52). With regard to attitudes about recycling and the recycling program, a majority of respondents reported that they believe in the environmental benefits from recycling (Kelly et al., 52). More staff than students chose to recycle at home and felt it was their responsibility to recycle (Kelly et al., 53).

The overall results from the questionnaire showed pro-environmental and recycling attitudes on campus. The study concluded that, "demographic factors like age and income have a positive effect on recycling attitudes and behavior (Kelly et al., 53)". Most campus members were aware of the recycling programs implemented and reported high participation rates, demonstrating their support of the program. The two main factors that inhibited recycling behavior was lack of program-specific behavior and inconvenience.

E. Survey Results

Sample group

My survey was sent out to 1200 randomly selected campus members; 900 were students and the other 300 were faculty and staff. A link to the survey was emailed to each selected campus member with a message instructing him or her in how to complete it. I received 304 responses to the survey, a 25.3% response rate. This response rate was similar to others I found for waste and recycling surveys from other universities.

Of those who responded, 62.2% were female, and 37.1% were male. Two respondents listed themselves as 'other'. Regarding the respondents' role on campus, 62.8% were students. The remaining 38.8% of campus roles were divided among staff or administrators (21.5%), faculty or professors (12.1%), and facilities staff (3.7%). The students who responded were divided relatively evenly throughout class year, likely caused by my stratification of the sample group, which was by both campus role and by class year for students. Within the group of student responders, the majority reported to live in a residential dorm (63.5%). 14.8% lived in apartment-style housing, such as the Gateways or Mods. 12.7% lived downtown or off-campus, and the last 9% of students lived in either fraternity houses or specialty houses.

1. What are the motivators that influence waste behavior?

As mentioned earlier, I used behavior as my dependent variable. The independent variables I established in the study were knowledge and awareness, convenience, moral values, environmental values, and social norms. In order to perform a proper linear regression analysis, I first had to combine responses into "scores" for each variable. The object of this was to obtain one single value that represented the 'strength' of the subject's responses regarding the variables. For example, respondents who answered more of the knowledge questions correctly or were

aware of more waste and recycling programs on campus received a higher 'knowledge and awareness score'. This same idea was applied to the other independent variables, as well as behavior (those who recycled more or wasted less received higher 'behavior scores').

Dependent variable

- Behavior -

For this study, waste and recycling behavior was the single dependent variable. The survey included a behavioral section, which asked questions about one's consumption and post-consumption activity. Out of a possible behavior score of 15, the maximum score received was 14 and the minimum was two. When asked whether respondents actively choose to purchase or use recyclable items over non-recyclable ones, 25% said yes. 41% indicated they sometimes did, while 34% responded that they did not actively seek to purchase recyclable items (see Figure 15 in Appendix).

In addition to consumer behavior, questions about post-consumer behavior indicated that 32% of respondents *always* recycled a product/material after use when it was recyclable. The majority of respondents (57%) indicated they recycled these materials *most of the time*. No respondents indicated that they *never* recycled (see Figure 16 in Appendix).

Plastic and paper were reported to be the most widely recycled materials on campus. 91% of respondents indicated they recycled plastics and 90% recycled paper. 68% of respondents indicated they recycled glass, 64% recycled cardboard, and 59% recycled aluminum/metal (see Figure 17). While only 12% of respondents found aluminum/metal to have confusing recycling requirements, this material was reported to be recycled the least frequently. Additionally, over

half of respondents found plastics to have confusing recycling requirements, though it was reported as the most widely recycled material (see Figure 18).

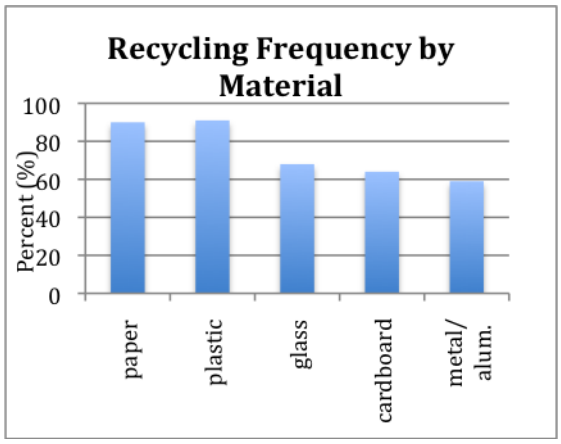

Figure 17: Graph of Recycling by Material

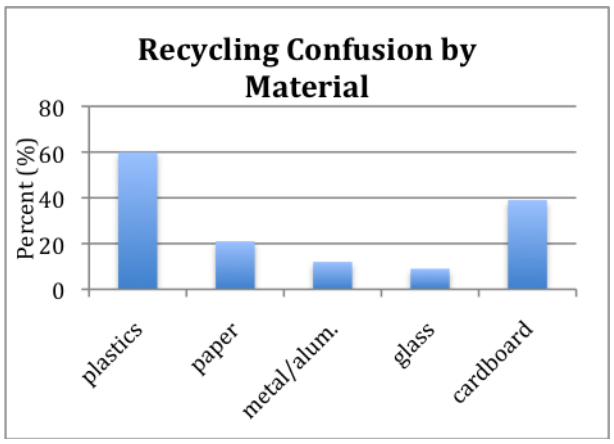

Figure 18: Graph of Recycling Confusion by Material

With regard to post-consumption behavior of food waste, 84% of respondents indicated they consumed 80-100%, or almost all, of the food they purchase on campus. 12% indicated they consumed 60-80% of their food, while only 2% stated they consumed 0-20%, or almost none, of the food they purchased (see Figure 19 in Appendix).

Independent variables

- Knowledge –

The first five questions of the survey asked about Bucknell-specific data regarding the University's waste stream. The average person only answered 28.4% of questions correctly, implying that most respondents are somewhat uninformed about Bucknell's waste stream. This section was followed by questions about the subjects' level of awareness regarding proper recycling of materials on campus and of waste minimization and recycling programs on campus. Additional statements were included about knowledge in the attitudinal section of the survey. By

adding the scores from these questions and statements, the average score for the total knowledge variable was 13 out of a total possible score of 17. The maximum score received by respondents was 16 and the minimum was four.

The first knowledge question asked how many pounds of waste are generated per person each day at Bucknell. The 2007 Environmental Assessment reported this answer to be about 2.6 lbs/day (El-Mogazi 2007). Updating this answer according to changes in the student population and in waste generation, the average still came out to roughly 2.5 lbs/day. 29.7% of respondents answered this question correctly, selecting the '2-4 lbs/day' option. The majority of respondents (32.3%), however, selected '4-6 lbs/day'(see Figure 20 in Appendix).

The second knowledge question asked the potential recovery rate for Bucknell's waste stream. Based on results from the campus-wide waste audit, I determined that Bucknell's potential recovery rate was 26.3%. 23.3% of the respondents were correct, by answering that the potential recovery rate was 20-40%. The first and second most common answers, however, were 40-60% and 60-80%, respectively, which are higher than the actual rate (see Figure 21 in Appendix).

The third question asked about Bucknell's recycling rate. Facilities data reports that 2011's recycling rate was 18.5%. 30.5% of respondents were correct in answering that the recycling rate is 10-20%. The most common answer, however, was 20-30%, meaning that campus members believe Bucknell diverts more of its waste to recycling than in actuality (see Figure 22 in Appendix).

The fourth question asked about the largest material component of Bucknell's waste stream. Based on results from the waste audit, I determined that organic material made up the largest portion of the waste stream, accounting for 24%. The most reported response to this

question was correct, in that organic material makes up the largest portion of the waste stream (see Figure 23 in Appendix). The second most widely reported answer was recyclable paper, composing 23.7% of total answers. According to the waste audit, however, non-recyclable paper actually made up the second largest composition of the waste stream. This was followed closely by non-recyclable plastic, which 10% of respondents believed to be the largest portion of the waste stream.

The fifth question asked which building type on campus generates the most waste per square footage. Based on results from the waste audit, I determined that Dining Services generates the most, at about .153 lbs/ft^2. The majority of respondents (56.7%) answered this question correctly. The second most common answer was residence halls, though this is not the second most wasteful building type. In reality, the next most wasteful building types were Facilities (Carpenter Shop) and Administration (Cooley Hall) (see Figure 24 in Appendix).

From the question, which asked, "why do you choose to recycle, if you do?" 55% of respondents indicated that they recycle because they know how to do so (see Figure 25).

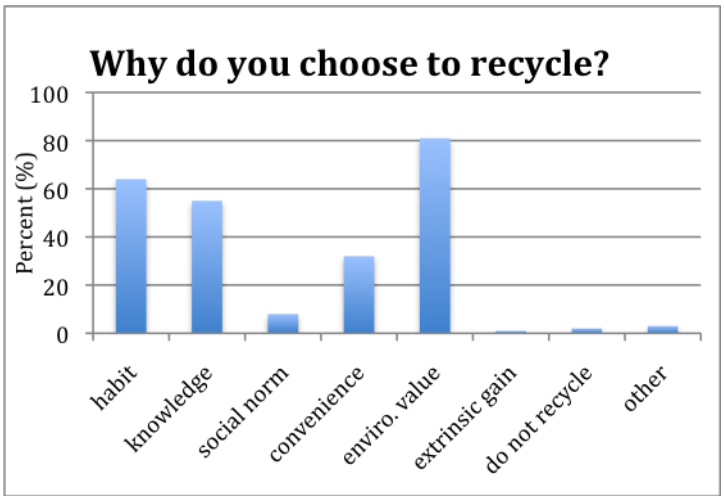

Figure 25: Percentages of Responses to Why One Chooses to Recycle

Further, 48% of respondents either agreed or strongly agreed to the statement, "If I knew how to recycle properly, I would recycle more", implying that increased recycling knowledge would contribute to one's positive waste behavior. Only 13% disagreed or strongly disagreed, and 39% responded as being neutral to the statement (see Figure 26 in Appendix).

The average respondent reported that he or she was confused by the recycling requirements for 28% of the recyclable materials (plastic, paper, metal, glass, cardboard) listed in the sixth question of the survey. Respondents reported to be most confused by plastic recycling requirements (60%) and least confused by glass recycling requirements (9%) (see Figure 18). With regard to awareness of campus waste minimization and recycling programs, the average respondent knew four of the seven listed programs. Only one subject was unaware of any programs. The program reported to be most widely known was recycling bins placed around campus (98%), while the least widely known program was the campus-wide waste audit (23%), conducted in the Fall and described in the first section of my thesis.

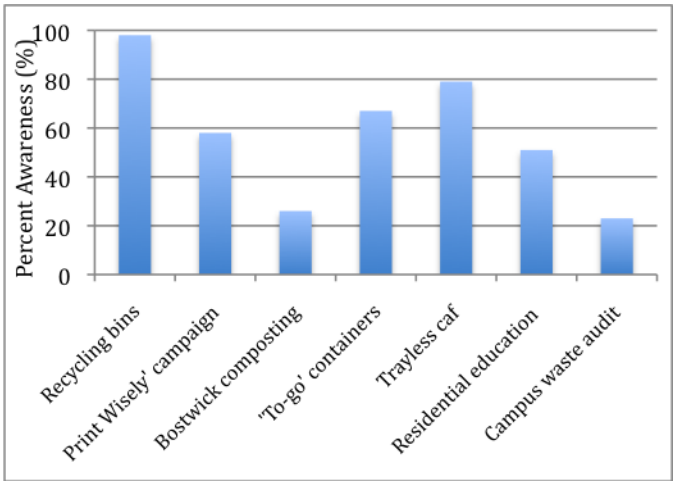

Figure 27: Percent of Respondents' Awareness of Waste Minimization and Recycling Programs

- Convenience

The convenience score indicates the respondent's perceived level of convenience for proper waste and recycling behavior. Out of a maximum possible 'convenience score' of 10, the average respondent received a score of 6.3. The maximum score received was 10 and the minimum was 1. When asked whether there are enough recycling bins on campus to encourage proper recycling behavior, 48% of respondents indicated yes, there are enough bins. 45% believed there are not enough bins, and 6% indicated they have not noticed or do not know (see Figure 28 in Appendix). When asked, "why do you choose to recycle?" 32% of respondents indicated because it was convenient on campus (see Figure 25).

In the attitudes section of the survey, 55% of respondents disagreed or strongly disagreed with the statement that "recycling is inconvenient". 20% agreed or strongly agreed with the statement, and 25% were neutral (see Figure 29 in Appendix). Another convenience statement, which read, "the costs and hassles of recycling outweigh its benefits", indicated agreement or strong agreement from only 4% of respondents. Alternatively, 82% of respondents either disagreed or strongly disagreed with the statement, implying that they believe the benefits are at least equal to the costs of recycling (see Figure 30 in Appendix). I included this statement with the convenience score because activity that is considered costly or a hassle can also be considered inconvenient or undesirable based on the amount of effort involved.

- Moral value

Moral value, both on an individual and collective level, was scored out of a possible 17 points. The maximum score received by a subject was 16, while the minimum score was four. When asked why one chooses to recycle, only 1% of respondents reported because they

somehow personally gain by doing so (see Figure 25). This response, however implies extrinsic, personal value and I did not include a response for intrinsic value in the survey.

Four statements in the attitudes section refer to one's moral values of recycling and proper waste management; two focused on personal moral value and two on communal moral value. The first statement read, "It is my personal responsibility to recycle". 92% of respondents either agreed or strongly agreed to this statement. Only 2% disagreed or strongly disagreed that it was his or her personal responsibility to recycle (see Figure 31 in Appendix). Another statement included in the attitudes section revealed that 91% disagree or strongly disagree with the idea that "it makes no difference whether I recycle or not". Only one respondent strongly agreed with the statement. 3% agreed and 6% were neutral regarding the difference their recycling behaviors make (see Figure 32 in Appendix).

The next two statements were with regard to the communal moral value of recycling behavior. One stated that, "recycling programs should not be optional, but required of communities". Respondents supported this statement less strongly, but 64% still either agreed or strongly agreed that recycling should be required of communities. 18% disagreed or strongly disagreed, and another 18% were neutral (see Figure 33 in Appendix). The next statement read, "I believe it is human's responsibility to keep the natural environment clean and healthy". 91% of respondents either agreed or strongly agreed with this statement, and 2% disagreed or strongly disagreed (see Figure 34 in Appendix).

- Environmental value

This independent variable indicated that a person's waste and recycling behavior was influenced by his or her value of the environment. Out of a possible score of nine, the maximum

score received by respondents was nine as well, with a minimum of two. When asked why one chooses to recycle, 81% of respondents indicated because they value how recycling benefits the environment and society (see Figure 25).

In the attitudes section, I included two statements to identify the respondents' level of environmental value. The first statement read, "I believe in the environmental benefits of recycling". Ninety-five percent of respondents agreed or strongly agreed with this statement. This is the strongest level of agreement among all the attitudinal statements. Only four respondents disagreed or strongly disagreed, implying that they do not believe in the environmental benefits of recycling (see Figure 35 in Appendix). The second statement read, "recycling does not do much to help the environment". Eighty-nine percent of respondents disagreed or strongly disagreed with this statement. Only 2% agreed with the statement, and one person strongly agreed with it (see Figure 36 in Appendix).

- Social norms

This independent variable implies a person's waste and recycling behavior is influenced by the norms of society. Out of a possible score of six, the maximum score received by respondents was also six and the minimum was zero. When asked how one's recycling habits compare to those of their peers, 51% of respondents indicated that they recycle more than their peers. Thirty-nine percent believed they recycled about the same as their peers, while only 4% believed they recycled less (see Figure 37 in Appendix). Further, when asked why one chooses to recycle, only 8% of respondents indicated because they see others recycling (see Figure 25). In the attitudes section of the survey, one statement read, "I would recycle more if I knew it was a widely valued practice by my community". Only 26% either agreed or strongly agreed with

this statement, while 33% disagreed or strongly disagreed. 41% of respondents stated they were neutral (see Figure 38 in Appendix).

Regression Results

Once I generated a score for the dependent behavior variable and each of the five independent variables, I used linear regression to determine which factors motivate a person's waste behavior. Three independent variables were found to be statistically significant in contributing to the score of one's waste behavior. A result is considered statistically significant if it is unlikely to have occurred by chance. Knowledge and awareness had a significance of .002, moral value had a significance of .045, and social norms had a significance of .001. This means that the scores from the independent variables and the behavior variable show correlations that are so strong that there is only a .2%, 4.5%, and .1% chance, respectively, that they occurred at random. Figure 39 demonstrates the linear regressions table created by SPSS software to show the three significant motivators of waste behavior. Both knowledge and moral value had positive correlations to behavior, meaning that one's behavior is directly influenced by his or her waste knowledge and moral value. In other words, a person who is more knowledgeable about waste and recycling and feels a greater sense of moral value in recycling and waste management is more likely to participate in proper waste and recycling behavior. On the other hand, social norms demonstrated a negative correlation, which means that one's waste behavior has an inverse relationship to his or her self-reported obedience to social norms. These results imply that one who is defiant of the social norms regarding waste is more likely to participate in better waste and recycling behavior than one who adheres to social norms.

Significance value for independent variables

Model		Unstandardized Coefficients		Standardized Coefficients	t	**Significance**
		B	Std. Error	Beta		
1	(Constant)	8.373	.834		10.034	**.000**
	answers_score	-.201	.130	-.100	-1.548	**.123**
	knowledge_awareness*	.198	.064	.206	3.085	**.002**
	convenience_value	.026	.072	.023	.367	**.714**
	moralvalue_score*	.120	.060	.155	2.017	**.045**
	envirovalue_score	-.017	.105	-.013	-.167	**.867**
	socialnorms_value*	-.318	.097	-.196	-3.280	**.001**

Figure 39: Significance Test Using Linear Regression

2. *What characteristics of the respondents are associated with these motivators of waste behavior?*

After identifying the three significant motivational factors that contribute to a person's waste behavior, my next step was to determine whether any personal characteristics correlate with these three motivators of behavior. We can create more effective waste programs on campus by determining which groups of people need to be most targeted for improved behavior. In this part, I examined knowledge, moral value, and social norms as dependent variables to determine what personal characteristics contribute to these significant motivators of waste behavior. The characteristics I used as independent variables were campus role (student, faculty, staff, etc), residential location (if a student), class year (if a student), and gender. I used chi square tests to compare the variables and determine which characteristics influence motives of behavior. In my results, I found one's role on campus to have the greatest correlation with one's motivation to behave. Additionally, within the student group of campus members, I found class year to be a significant characteristic in influencing a person's motivation for his or her behavior. Gender proved varying results so no conclusions could be made as to whether one's gender

influences motives of waste behavior. Student's residential location also proved no significant influence.

Role on Campus

I found one's role on campus to be significantly correlated with all three significant motivators of behavior (knowledge, moral value, and social norms). Though there was no correlation between campus role and the overall knowledge score, I found a significant relationship with one of the knowledge questions. When asked about per capita waste generation on campus, 45% of administration and staff answered correctly with 2-4 lbs/person (2.6 lbs precisely), while 33% of facilities staff, 28% of professors/faculty, and only 24% of students answered correctly (see Figure 40). In addition to knowledge, one's campus role was also associated with one's moral value and social norms, however this association was with the entire score of the variable and not just individual questions. Regarding moral value, professors and faculty reported the highest average moral value score of 14.6 out of 17, while students had the lowest average score of 12.6 (see Figure 41). Students had the lowest social norm score as well, receiving an average score of 1.8 out of 6, whereas facilities staff members received the highest score of 2.6 (see Figure 42). When comparing one's campus role directly to waste behavior, students were also found to demonstrate the least proper waste practices with regard to one question about consumer behavior. When asked whether one actively chooses to use or purchase recyclable materials, 58% of faculty and professors reported that they did, while only 15% of students responded affirmatively (see Figure 43). In general, among all roles on campus, students demonstrated the lowest influence by the three significant motivators of waste behavior as well as demonstrate the least proper waste behavior overall.

Class Year

Within the student body at Bucknell, I found significant correlations between one's class year and one's level of waste and recycling knowledge for two of the knowledge questions asked in the survey. When asked about the potential recovery rate for Bucknell's waste stream, 34% of juniors answered correctly that 20-30% (26.3% precisely) of campus waste has the potential to be recovered. 30% of sophomores and 24% of freshmen answered correctly, while only 7% of seniors were correct (see Figure 44). Another knowledge question asked which campus building had the highest waste density. 68% of sophomores, 60% of freshmen, and 52% of juniors correctly responded with Dining Services (see Figure 45). The senior class had the lowest correct response rate, with 43% of respondents answering correctly.

Gender

Gender proved to be significantly correlated to knowledge for two knowledge questions, though results for the more knowledgeable gender varied. For the knowledge question that asked about per capita waste generation, 31% of females correctly answered with 2-4 lbs/person, while 26% of males answered correctly (see Figure 46). For the next knowledge question, which asked about campus' recycling rate, 39% of males correctly responded with 10-20% (18.5% precisely), while 26% of females responded correctly (see Figure 47). Because males were more knowledgeable for one question, and females were more knowledgeable for the other, I could not conclude that gender is correlated with one's level of waste and recycling knowledge.

E. Campus Survey Conclusions

What are the motivators that influence waste behavior?

Results from my survey demonstrate that there are three significant motivators that contribute to one's waste behavior. The first is knowledge, with a statistical significance of .002. Responses to the five questions about Bucknell's waste stream demonstrate a lack of overall knowledge or awareness of campus waste (the average respondent answered only 28% of questions correctly). Most responses to these questions also demonstrate that campus members perceive Bucknell's waste stream to be in worse condition than it actually is, by overestimating the daily per capita waste generation and potential recovery rate for recyclables. However, most respondents underestimated Bucknell's recycling rate, perceiving it was higher than in actuality. Despite lack of knowledge of the University's waste stream, most respondents reported an adequate level of procedural knowledge about proper disposal of materials. Over half of respondents indicated they recycle because they know how to do so. Respondents indicated they were confident in recycling most materials on campus (72% of the listed materials types). This strong significance value implies that people who are more knowledgeable about waste and recycling are more likely to practice proper waste behavior. The influence of knowledge on behavior is also widely supported by scholarly literature, as noted previously by Schultz.

Moral value was determined as another motivator of waste behavior, with a significance value of .045. The attitudinal statements about the moral value of recycling and waste minimization demonstrated much stronger responses toward statements of personal value than communal value. These results imply that campus members express strong support of the concept of human responsibility to behave properly, yet are more hesitant to support requirements or policy that would demand accountability from human society. Overall, these data tell us that those who feel a stronger sense of moral (individual or communal) value toward

recycling and waste minimization are likely to practice proper waste behavior as well. Much of the literature as discussed previously explains the connection of positive human attitudes to positive behavior.

The third variable that is linked to waste behavior is social norms, with a significance value of .001. This shows the strongest association to waste behavior among all other independent variables tested, however it is a negative correlation, meaning that social norms have an inverse relationship with waste behavior.

This statistic implies that those who deviate from the social norm are more likely to participate in proper waste behavior, while those who adhere to the social norm of waste and recycling behavior are more likely to practice less proper waste behavior. The average score for this variable was lower compared to other variables, implying an overall low influence of this motivator on one's waste behavior. When asked how one's recycling behavior compares to their peers, 51% of respondents reported to recycle more, whereas only 4% reported to recycle less. This demonstrates a common perception that the campus community believes their behavior to be better than their peers. Further, only 8% of respondents reported they recycle because they see their peers recycling. I speculate that respondents report low influence from social norms and from their peers because they believe they behave better than the average or norm. It can be deduced that the inverse relationship between social norms and waste behavior is caused by this overestimation of one's behavior. People report to deviate from the social norm because they behave *better* than the norm. This supports the conclusion that reported deviance from the social norm leads to better waste behavior.

What individual characteristics correlate with these motivators of waste behavior?

In addition to researching the motivations of waste behavior, I further investigated whether individual characteristics of campus members have a correlation to these motivators. Of all the characteristics I tested for, only an individual's role on campus correlated with all three of the most motivators of waste behavior. Students demonstrated the least knowledge regarding per capita waste generation, while administrators and staff members were most knowledgeable. Students also received the lowest scores for both moral value and social norms. Professors and faculty had the highest moral value score, while facilities staff received the highest social norms score. Among each of the three motivators of waste behavior, students were the campus group that received the lowest score, meaning they are the least influenced by these motives to behave properly regarding waste and recycling. Additionally, students reported the least proper waste behavior regarding the active purchase or use of recyclable materials. The previously mentioned study by Kelly et al. supports these results, demonstrating that faculty and staff often have more positive attitudes and behavior regarding recycling.

A student's class year also correlated with motivators of waste behavior, but only with the knowledge variable. Regarding responses for Bucknell's potential recovery rate and the highest waste-dense building, the senior class was the least correct in answering these questions (7% correct and 43% correct, respectively). This implies that seniors are the least knowledgeable class year at Bucknell. In the past several years, Bucknell has increased its efforts to address the underclassmen, especially freshmen, in incorporating sustainable practices in their lifestyle. I speculate that the lower level of waste knowledge among seniors is caused by nonexistence of these educational programs when the seniors entered Bucknell. As the underclassmen matriculate

and become juniors and seniors, they will maintain the knowledge they gained as freshmen and increase the overall knowledge among all class years.

I found no significant correlations between gender and residential location, and the motivators of waste behavior. Two knowledge questions were significantly correlated to one's gender, though results differed regarding the more knowledgeable gender. Because both genders have equal access to waste information and recycling opportunities, it is reasonable to believe that influence by motivators of behavior would not differ by gender. Additionally, residential locations on campus are all provided relatively equal access to information and recycling opportunities, which is a likely cause for why no correlation existed between residential location and the motivators of waste behavior.

CONCLUSIONS

Parts 1 and 2 of my thesis aim to observe waste behavior from two different perspectives. The waste audit took an objective approach and made a direct observation on the campus' waste stream, while the campus survey took a more exploratory approach and used self-reported responses to explain the causal factors that determine the waste stream's characteristics. I found several similarities and discrepancies between both methods of investigating waste behavior on campus. In general, self-reported behavior about waste composition was consistent with observed behavior through the waste stream's composition. However, I found a discrepancy between self-reported and observed waste behavior regarding the campus groups that need to be targeted for waste programs.

The small portions of recyclable materials found in the waste stream correspond to respondents' self- reported behavior regarding of recycling frequency by material type. Paper

and plastic were reported to be recycled by the strongest majority of campus members, 90% and 91%, respectively. Looking back at the results from the waste audit, only 11% of the waste was recyclable paper and 4% was recyclable plastic. These are relatively low percentages, indicating that reported behavior and actual behavior are consistent. Fewer respondents reported recycling glass, cardboard, and aluminum (68%, 64%, 59%, respectively). These materials made up even smaller portions of the waste stream (1%, 5%, and 2%, respectively). Because glass, cardboard, and aluminum are less commonly used on campus, they would naturally show up less frequently in the waste stream, which contributes to their small proportion.

Organic waste made up the largest proportion of Bucknell's waste stream. Factoring both preparation food waste and post-consumer food waste, I believe that reported and observed behavior is reasonably consistent. 85% of respondents reported they consumed almost all (80-100%) of the food they purchase on campus. Only 5% of campus members reported consuming anything less than 60% of the food they purchase. The waste audit, however, identified organic materials as making up almost one-quarter of all campus waste. Of the waste that is not accounted for by respondents' self-report of food consumption, the remaining organic material comes from food preparation. Because organic waste made up smaller portions of campus dumpsters where food is not prepared, the larger proportions of organic material in food-prep locations (the Bison, fraternities, etc) can be accounted for by this preparation. I conclude that self-reported behavior regarding organic material is consistent with the observed results of organic waste behavior from the waste audit.

Despite this consistency in waste behavior regarding materials types, I found inconsistent results regarding the group of campus members that need targeting for recycling and waste management programs. Results from the waste audit determined the least waste-efficient

buildings to be the Carpenter Shop and Cooley Hall, based on their high potential recovery rate and high waste density. Both had potential recovery rates above 40% for recycling diversion alone, and above 50% when compost diversion was included. When measuring their pounds of waste generated per square foot, they were also the second and third most waste dense buildings, respectively. The majority of campus members who use these facilities, however, are staff and not students. This means that staff members are more likely to contribute to the corresponding dumpsters. This information would therefore imply that staff members are the main contributors to campus' inefficient waste stream. Alternatively, the buildings in which the majority of their use is by students, such as the library, gateways, and classrooms, have a very low waste density. Additionally, the corresponding dumpsters to these buildings all have potential recovery rates for recycling below 20% (other than McDonnell). This would imply that students are not the main contributors to the waste stream's inefficiency, since the dumpsters of the buildings used most often by students are rather efficient. Given these direct observations from the waste audit, I can conclude that students actually participate in better waste practices than do staff members.

When compared to responses from the waste survey, this conclusion regarding better waste behavior among students is inconsistent. Using statistical analysis, I found that students are less knowledgeable about campus waste than staff and report a lesser sense of moral value in proper waste management and recycling practices than do faculty. Additionally, students reported to be the least likely to participate in proper waste behavior. Among all campus groups, students were the least responsive in affirming that they actively use or purchase recyclable products. Based on these results, I can conclude that students are the least influenced by the motivators of waste behavior (knowledge, moral value, and social norms). Additionally, I determined students' self-reported waste and recycling behavior to be worse than that of faculty

and staff. Though, based on my above conclusions from the waste audit, I cannot conclude that students *actually* participate in worse behavior. My waste audit findings imply that staff members overestimate their level of proper waste and recycling behavior, as they report high levels of positive behavior and influence my recycling motivators, although their actual participation in proper behavior is low. Students, on the other hand, tend to underestimate their level of proper waste and recycling behavior, as they report less positive activity and influence by recycling motivators, yet demonstrate more proper waste behavior.

One explanation for this discrepancy may be that the University has made significant efforts to encourage proper waste and recycling behavior by targeting its students. For this reason, residence halls and classroom buildings are equipped with many of the necessary means (labeled recycling bins, signs, etc) to encourage this behavior. Because staff-dominated buildings have not been targeted as strongly, waste and recycling resources are less accessible and their waste stream becomes less efficient than those with the appropriate resources.

Overall, results from the waste audit and campus survey were relatively optimistic regarding Bucknell's solid waste stream. Compared to other schools I researched, Bucknell's waste stream is much more efficient by having a potential recovery rate below 50%. This is consistent with responses to survey questions that demonstrated campus members' support for and participation in recycling practices. However, Bucknell's performance in Recyclemania demonstrates that per capita waste generation is much higher than at other colleges and universities in the country. I speculate that Bucknell's low recycling rate is caused not by low recycling behavior, but by high overall waste generation, which lowers the relative percentage that is recycled. From this I conclude that, in addition to the issue of *quality* (or composition) of waste, there is an even greater issue regarding the *quantity* of waste that needs to be tackled.

Based on observations of Bucknell's community, I suggest two explanations for this pressing issue regarding high waste generation. First, Bucknell campus members tend to be of high socio-economic status, compared to other colleges in the country. This is supported by financial aid data, which shows that a lower percentage of Bucknell students (50%) qualify for financial aid than the national average (66% +). Bucknell tuition is also above the national average, meaning that more students can afford a higher tuition than the average student at a college with an average tuition. Consumption increases when one has more disposable income. New products can be bought frequently, rather than reusing older ones. As consumption increases, eventual waste generation increases alongside as products are disposed of to purchase new ones. I believe that this is one reason why Bucknell's per capita waste generation is higher than other colleges.

Additionally, my findings from the campus survey demonstrate that most campus members perceive their waste behavior to be better than that of their peers. They overestimate their personal behavior, while underestimating the behavior of the entire community (as observed by responses to knowledge questions about Bucknell's waste stream). Because of this perception, campus members may feel that they already behave in the correct way and do not need to change their practices. This mentality allows people to feel satisfied with their current behavior, which is actually more wasteful than one perceives it to be. For this reason, the community feels less incentive to minimize waste generation or increase recycling behavior because they believe they already participate in this behavior more so than the average person. While I do not have data regarding self-perceived waste behavior at other universities to make a comparative conclusion, I do believe that this is a contributing factor to Bucknell's high level of waste generation.

SUGGESTIONS TO IMPROVE BUCKNELL'S WASTE STREAM

Current Campus Programs

Bucknell has already demonstrated several ways in which it can minimize waste and increase recycling. The Bostwick Marketplace Cafeteria has been particularly successful in employing practices to reduce waste that would otherwise go to landfill. In an interview with John Cummins, Director of Dining Services, he explained several ways in which Bucknell's dining facilities have begun to implement more effective methods of waste reduction. This year, Bostwick Cafeteria has gone completely trayless. This has reduced excess food waste by up to 150 pounds per day. Bucknell has also signed a 3-year contract to send all its cafeteria food waste to a local farmer in Milton to have it converted into compost. Because the farm benefits from the nutrients in the food waste, there is no charge for this service. Not only has this transition to compost reduced Bucknell's landfill load by almost 850 lbs per day, but the university saves money by avoiding a landfill tipping fee for the cafeteria food waste.

In addition to reuse and reduction in food waste, Bertrand Library has implemented several programs to reduce and recycle paper waste. Library printers now require a password before printing off a document so the computer user is more responsible for what he or she is printing. Bins have been located throughout the library for not only recycling paper, but for recyclable bottles and cans that come from the Library cafe.

In February of this year, Waste Management Systems (WM) met with Bucknell's Facilities Department to determine how to assess the waste stream and create effective changes to make it more efficient. One of the programs currently in discussion is switching Bucknell's

recycling to a single stream. This would require new receptacles around campus to capture all recyclable materials that can be processed at WM's recycling facility. By installing a program like this at Bucknell, a much larger portion of the waste stream could be captured and diverted to recycling. Facilities anticipates a waste diversion rate of as high as 80% of the total waste stream.

Comparison to Programs at Other Universities

Future recycling and waste minimization programs at Bucknell can be positively influenced by what has been done at similar universities. I investigated environmental programs at Oberlin College, Middlebury College, Colgate University, and Lafayette College to determine whether comparable programs could be installed on our campus. Because these schools are similar in size, academic rigor, and geography, it seems reasonable to believe that successful programs for them would likewise be successful for us.

- Oberlin College

Similar to Bucknell, Oberlin offers a competitive academic environment and is located in a small town setting. It values the benefits of a small campus and a low student to professor ratio. In May 2004, Oberlin's Environmental Policy Advisory Committee (EPAC) created a document listing its campus' environmental policy regarding energy use, transportation, construction, consumption, and more (Oberlin Policy Advisory Committee). Within its section titled, "Purchasing, Reuse, and Disposal", the document states that "sustainability is achieved in part by eliminating the concept of waste, which means that material byproducts from one process become useful inputs for other processes (OPAC 2004:13)." The policy highlights several objectives, some of which include minimizing consumption by reducing and reusing materials,

selecting materials with low environmental costs, monitoring purchasing, disposal, and recycling activities, and facilitating compliance of the Oberlin community with College policy (OPAC 2004: 14).

Oberlin believes that, in order to accomplish any of the above-mentioned goals, educating the campus community about waste and recycling issues is an important first step. "Oberlin College's environmental policy will succeed only to the extent that students, faculty, and staff, and the larger community with which it interacts adopt a culture of environmental stewardship (OPAC 2004: 17)." The university has adopted several programs to encourage proper consumptive and disposal behavior, some of which include programs at freshman orientation to discuss materials use goals, policy that encourages faculty involvement in research and proper behavior, and signage that explains policy objectives (OPAC 2004: 17).

Of the waste that accumulates on college campuses, products from dining services contribute a sizeable portion through the food and food packaging it distributes. Oberlin's Campus Dining Services works on ways to incorporate sustainability into food consumption and disposal (Campus Dining Services). A group called CDS Recyclers employs students to help initiate waste-reduction projects and educate the campus about how to reduce consumption and waste. CDS has already terminated the sale of bottled water in any of the campus' facilities or vending machines in an effort to reduce the oil used and carbon dioxide released by manufacturing and transporting the bottles. CDS is "currently working on a composting plan for post-consumer food waste, expanding the reusable container program, as well as conducting waste and energy audits." Bucknell could benefit through several of the CDS programs listed above, given that so much of our campus waste comes from dining locations as well.

Though Oberlin has not posted its recycling and waste data either on their university website or through the Recyclemania website, the policies and programs the school has created demonstrate its motivation for creating a more sustainable campus environment. Creating campus groups, such as CDS Recyclers, which strive to educate the public through the employment of students and staff, is an important part to achieving the university's goals to minimize consumption and increase resource efficiency.

- Middlebury College

Middlebury is another liberal arts college with a similar size and academic agenda compared to Bucknell. Middlebury has the reputation of being an environmentally conscious school and has implemented many programs that reduce human impact on the campus environment. It is through these programs that the college has been able to divert over 1.5 million pounds of its campus waste from the landfill, and instead handle it at their 5,700 square foot Material Recovery Facility ("Recycling and Waste Management at Middlebury"). This translates to 64.3% of the campus waste being composted or recycled and diverted from landfill in 2009. Middlebury has constructed another facility just four miles away that composts all food waste from their campus kitchens. Bucknell has discussed constructing its own facilities for waste diversion, though little progress has been made in the realization of any project.

With regard to individual recycling habits, Middlebury offers similar opportunities to Bucknell for encouraging recycling among its students. Each dorm room is equipped with a blue (recycling) bin and a grey (trash) bin. All recyclable materials are put in the blue bins, which are used in the same way as Bucknell's blue bags that are used for recycling in the dorm rooms. When the bins become full, they are taken out to the building's recycling station, where the grey

bin is emptied into the trash, and the blue bin is sorted by recyclable material into the corresponding receptacles. At Bucknell, each residential building is assigned a recycling shed and dumpster to use for discarding room waste. ("How to Recycle").

Middlebury has competed in Recyclemania for the past several years, and ranks generally high in several of the categories. The school's recycling rate of 42.9% in 2011 placed it 44th out of the participating 288 schools in the Grand Champion category. Comparatively, Bucknell ranked 225th, with a recycling rate of 19.34%, less than half of Middlebury's recycling rate. Middlebury ranked high as well in the Per Capita Classic, in which an average of 23.5 pounds of recyclable materials were collected per person each week. The College ranked 46th out of 363 participating schools for this category. Bucknell's per capita recycling average of 18.8 pounds still trails behind Middlebury with regard to recycling behavior (RecycleMania).

Despite success in these two categories, Middlebury did not rank as high in the Waste Minimization category, which measures the amount of total solid waste (both trash and recycling) generated per person. They ranked 122nd out of 180 schools total, with an average of 54.8 pounds of waste generated per person throughout the competition weeks. These results imply that, while Middlebury is successful in its efforts toward recycling, the school could still improve upon its efforts for reducing consumption or reusing materials so overall waste is minimized (RecycleMania). Similarly, Bucknell's low ranking of 170th in this category demonstrates the need to promote reduction and reuse methods before recycling as a means of effectively reducing the school's environmental impact.

- Colgate University

Colgate University, another east coast liberal arts school, has developed a Sustainability

and Climate Action Plan, which discusses the implementation of several future projects that will help limit consumption and landfill waste. The university highlights the importance of source reduction as an initial strategy for achieving environmental sustainability. “Preventing unnecessary materials and packaging from entering the university in the first place, offers the first important strategy in reducing Colgate’s landfill waste… Focusing on source reduction is important because it reduces labor and time and reduces greenhouse gas emissions through less waste entering, and therefore, leaving the university (“Waste Minimization and Recycling”)”. With the materials that must necessarily be consumed, Colgate stresses the importance of purchasing reusable or recyclable products to minimize the amount of waste send to landfill.

Between 2008 and 2010, Colgate was successful in diverting 150 tons of waste from landfill. Campus programs that focused on recycling education and reducing material consumption contributed to this waste diversion. Colgate also proposed several new programs that would help reduce their ecological footprint. By 2013, the school plans to implement and pre- and post-consumer composting program. They anticipate composting up to 130 tons of organic materials each year, which will save the school money by avoiding extra tipping fees for food waste disposal at the landfill. Bucknell’s new composting program provides similar benefits to the University.

In 2009, a group of faculty and staff created the Green Office Program, which intended to “foster sustainable behavior in the workplace by providing educational resources, generating excitement, and raising awareness around issues of sustainability in the work environment (“Behavior-Change Programs”)”. Within this program are activities such as reusing/redistributing used office equipment and supplies, establishing smaller paper margins to reduce paper use, and reducing junk mail (“Waste Minimization and Recycling”) The Green

Living Program has a similar goal of fostering sustainable practices, but within student life instead of the office setting. Activities in this program include establishing eco-reps that encourage sustainability around campus, installing energy monitoring systems in student housing, and establish Eco-Olympics and RecycleMania as well-supported events during the school year ("Behavior-Change Programs"). Bucknell's eco-reps program provides mentors and role models within the residence halls, but has yet to expand much influence onto the rest of campus.

Based on RecycleMania's 2011 results, Colgate ranked 247th in the Grand Champion category, with a recycling rate of 16.5%. This figure is slightly lower than Bucknell's recycling rate of about 19%. Colgate ranked better in the Per Capita Classic as 120th out of 363 schools. Each Colgate student recycled an average 13.1 pounds during the competition weeks. Bucknell students, by comparison, performed slightly better again by recycling an average 18.8 pounds. Within the Waste Minimization category, Colgate placed 156th out of 180 schools. The school's students, on average, generated 79.3 pounds of overall solid waste during the competition weeks. This figure is actually better than that of Bucknell, which averaged 97.2 pounds of waste per student (RecycleMania). While Colgate has made a significant effort to provide waste minimization and recycling programs on its campus, it is evident from RecycleMania results that further implementation and motivation for sustainable behavior will be necessary to accomplish the goals they have set out.

- Lafayette College

Lafayette, a small college located in Pennsylvania, shows several initiatives toward sustainable waste management practices. The school has incorporated their Recycling Program

across all campus activities to collect recyclable materials as well as pre- and post-consumption food waste. Specific activities within the program include “Green Move In” and “Green Move Out” in which cardboard, packaging material, and furniture is picked up from dorms at the beginning and end of each semester. In 2011, Lafayette was able to donate over 11,000 pounds of items to local charity organizations through its “Green Move Out” event. (“Green Move Out”). Because Bucknell generates the most waste during the first and last months of the semester (see Figure 42), it would be beneficial to provide a similar program on our campus that would seek to reuse or recycle so many discarded items.

In addition to recycling materials, Lafayette also makes an effort to divert food waste from landfill. Three “Earth Tubs” collect food waste, food packaging, and cutlery from the school’s dining facilities and turn it into compost. The Grounds Department then uses the compost for campus landscaping. There are several other programs Dining Facilities has adopted to minimize their landfill waste. Cups, containers, and bags are all made out of biodegradable material to be composted. Bucknell has yet to switch from plastic and non-recyclable paper products to biodegradable utensils in its ‘take-out’ dining locations. By purchasing fresh produce from four farm locations, Lafayette is able to reduce packaging material and transportation costs (Recycling Brochure). Bucknell also supports the local community by using nearby farms as food sources for campus. Dining Facilities at Lafayette further hopes to convert 100% of its waste for compost and reuse on the college campus. Similar to Bucknell, Lafayette’s cafeteria has become trayless in an effort to reduce unnecessary food waste (“Dining Services”).

Future Suggestions Based on Waste Behavior Results

Direct observation of Bucknell's waste behavior through the campus-wide waste audit helped identify several issues that exist within the community's waste stream. Based on the audit results, we can identify which locations need to be most targeted, based on high waste density and potential recovery rate. In terms of waste density, the Bison and Carpenter Shop generated the most waste per square foot. Buildings that deal with dining, facilities work, or athletics should be targeted specifically in programs to reduce waste. Buildings that correspond to dumpsters with high potential recovery rates should also be especially targeted for recycling programs. Audit results show that half of the waste generated by the Carpenter Shop could be diverted by recycling practices. Cooley Hall and the Computer Center also have high potential recovery rates, both above 30%. These results indicate that Facilities, Administration, and lab/science locations on campus should be addressed first in the creation of new recycling programs.

In addition to locations that require special attention, certain categories of waste should also be especially targeted. Audit results reveal that the largest overall components of waste were organic material (24%), non-recyclable paper (23%), and non-recyclable plastic (20%). None of these categories have the potential to be recovered through recycling. Therefore, new programs could focus on minimizing, overall, the presence, use, and therefore, disposal of these materials. For example, the majority of non-recyclable paper came in the form of waxed paper cups and paper towels. New waste minimization programs could reduce the presence of these materials on campus, such as by switching to automatic hand dryers in bathrooms, or requiring reusable beverage containers as alternatives for 'to-go' cups in the Bison and other food locations. Programs with similar objectives could be applied to the minimization of compost and non-

recyclable plastic as well. Smyth's results from her waste audit study at UNBC demonstrated similar conclusions and she made similar program recommendations that focused on addressing the largest waste compositions. Because a larger proportion of UNBC's waste stream was recyclable material, Smyth's recommendations emphasized minimization through diversion of recyclables. Bucknell could make improvements in further diverting recyclable materials, however, the majority of materials found in the waste stream were non-recyclable and therefore the University must follow an altered course of action regarding minimization.

After determining *what* issues to address for new programs through the waste audit, it is necessary to then determine *how* to address these issues (what methods/tactics to use) and *which* campus groups to address. These last two questions were answered through the campus survey, which focused on discovering the motives of waste behavior and personal characteristics that influence these motivators. Knowing what motivates a person to recycle can help determine the best methods and approaches for new programs. Additionally, knowing what respondent characteristics influence these motives will identify the groups on campus these programs must target. Based on results from the campus survey, I found three significant motivators that are associated with waste behavior: knowledge, moral value, and social norms. Ideally, these motivators could be utilized to create waste programs that would encourage recycling and waste management practices. Several of the studies I researched suggested that increased signage of recycling information with diagrams and pictures would facilitate knowledge retention and influence proper behavior. Other ways colleges have increased recycling knowledge is by incorporating the subject in coursework "as part of their efforts to communicate recycling information and increase environmental awareness (Kaplowitz 2009: 614)". Bucknell's new College Core Curriculum includes an 'Environmental Connections' requirement, in which

Students will analyze, evaluate, and synthesize complex interrelationships between humans and the natural world ("Tools for Critical Engagement")".

With the idea that everyone, to an extent, is equipped with moral values, one approach may be to emphasize the ethical and moral importance of recycling. Guest speakers could come to campus and discuss humanity's responsibility for maintaining a healthy society. Many forms of media could cover the topic as well, such as pamphlets, newspaper articles, flyers, etc. Vicente and Reis illustrate the importance of creating programs geared toward this value so that "citizens assimilate the idea that everyone is a waste producer and therefore 'recycling…is up to everybody' (145)".

Though social norms were found to have an inverse relationship with proper waste behavior, I conclude that this deviance from norms is caused by respondents' perception of behaving better than what they interpret the norm to be. I suggest to still publicize the social norm of the overall value of recycling on campus. Examples would include displaying statements around waste and recycling bins that say "95% of Bucknell's campus members believe in the environmental benefits of recycling" or "90% of Bucknell's campus members report to routinely recycle when using a recyclable product" By exposing that valuing recycling is the norm, I speculate that people will maintain their urge to be better than their peers and continue to increase proper recycling and waste practices, rather than deviate by stopping such practices.

Through my survey, I also found several individual characteristics that were either directly related to waste behavior, or related to the above-mentioned motivators of waste behavior. Faculty and professors are more likely to actively choose to recycle than students. Therefore, students should be targeted directly in encouraging proper waste behavior. One's position on campus also proved an association with one's adherence to social norms and one's

human value. Both cases revealed students to show the least compliance or influence by these two motivators. This means that future waste programs should especially target students, using methods that would increase their moral value of recycling or their adherence to the practice as socially normal behavior.

Within the student body, the senior class in particular was the least knowledgeable about Bucknell's waste stream. Over the years, Bucknell has made efforts to provide information to incoming freshmen about proper waste behavior. Thus, it is possible that seniors were not provided the same resources that freshmen and underclass now have access to, causing their level of knowledge to be lower. It makes little sense to target a class year that only has a short amount of time left to make an impact on Bucknell's waste stream. Thus, further encouragement of increasing knowledge among incoming students seems to be the best approach, as these students eventually matriculate into upperclassmen and seniors. Gender was also associated with responses to certain knowledge questions, however results were split (more males answered one question correctly, while more females answered another question correctly), therefore it does not seem necessary to target a specific gender group in promoting recycling and waste knowledge.

Because I determined the greatest issue of campus waste to be its large quantity overall, programs should be installed that emphasize waste reduction primarily. Diversion of recyclable material would be effective in reducing the overall waste stream by up to about 25%. However, 75% of the waste stream would still remain, which could only be addressed through minimization efforts. I attribute high consumption of products and materials to the campus' large quantity of waste. Therefore, programs should address the consumption side as an initial step toward ultimately reducing waste generation. If fewer products are consumed and used, there

will naturally be fewer products to then dispose of. These programs would likely require a great amount of effort because it would entail changing the community's attitude not only about waste practices, but consumption practices for products before they are even considered waste. With the proper resources and methods discussed above, I believe Bucknell has the ability to change the mentality of its campus members to eliminate and divert as much as possible from the University's waste stream.

BIBLIOGRAPHY

1. "Behavior-Change Programs." *Colgate University's Sustainability and Climate Action Plan*. Colgate University. Web. Feb. 2012. <https://sites.google.com/a/colgate.edu/2011-2015-sustainability-and-climate-action-plan/behavior-change-programs>.

2. Bratt, Christopher. "The Impact of Norms and Assumed Consequences on Recycling Behavior." *Environment and Behavior* 31.5 (1999): 630-53.

3. Campus Dining Services. "CDS Recyclers Corner." *Oberlin College Housing and Dining*. Oberlin College, 24 Jan. 2011. Web. Feb. 2012. <http://www.oberlin.edu/cds/social/recyclers.html>.

4. De Young, Raymond. "Recycling as Appropriate Behavior: A Review of Survey Data from Selected Recycling Education Programs in Michigan." *Resources, Conservation, and Recycling* 3 (1990): 253-66.

5. "Dining Services." *Facilities Planning and Construction*. Lafayette College. Web. Feb. 2012. <http://facilitiesplanning.lafayette.edu/sustainability/csi/food-service/>.

6. "Dining Services Waste Practices." Personal interview with Hallie Kennan. 21 June 2011

7. El-Mogazi, Dina. *A Comprehensive Environmental Assessment of Bucknell University*. Rep. Bucknell University Environmental Center, 2007. Web. June 2011. <http://www.bucknell.edu/Documents/EnvironmentalCenter/Assessment%20Report%20final.pdf>.

8. El-Mogazi, Dina. Earth Week Waste Audit. 21 Apr. 2011. Raw data. Bucknell University, Lewisburg

9. Fenco MacLaren Inc. *Waste Audit Users Manual: a Comprehensive Guide to the Waste Audit Process.* Winnipeg: Canadian Council of Ministers of the Environment, 1996.

10. “Green Move Out." *Green Move out*. Lafayette College, 2012. Web. Feb. 2012. <http://sites.lafayette.edu/gmo/>.

11. Kaplowitz, Michael D. et al. "Garnering Input for Recycling Communication Strategies at a Big Ten University." *Resources, Conservation, and Recycling* 53 (2009): 612-23.

12. Kelly, T. C. et al. "University Community Responses to On-campus Resources Recycling." *Resources, Conservation, and Recycling* 47 (2006): 42-55.

13. Kinnaman, Thomas. "Examining the Justification for Residential Recycling." *Journal of Economic Perspectives* 20.4 (2006): 219-32.

14. Mason, I. G. et al. "Implementation of a Zero Waste Program at a University Campus." *Resources, Conservation, and Recycling* 38 (2003): 257-69.

15. Middlebury Recycling. "How to Recycle." *Recycling and Waste Management*. Middlebury College. Web. Feb. 2012. <http://www.middlebury.edu/offices/business/recycle/howtorecycle>.

16. Middlebury Recycling. "Recycling and Waste Management at Middlebury." *Recycling and Waste Management*. Middlebury College. Web. Feb. 2012. <http://www.middlebury.edu/offices/business/recycle>.

17. Oberlin Policy Advisory Committee. *Oberlin College Environmental Policy*. Oberlin College, May 2004. Web. Feb. 2012. <http://oberlin.edu/sustainability/about/OCEnvironmentalPolicyMay2004.pdf>.

18. Pedrick, Merritt. Yearly Refuse Through 2009. 2009. Raw data. Bucknell University, Lewisburg.

19. Pedrick, Merritt. Materials Values. 2011. Raw data. Bucknell University, Lewisburg.

20. RecycleMania. 2011 Full Competition Rankings. 2011. Raw data. South Carolina. 2012 <http://recyclemaniacs.org/scoreboard/past-results> .

21. Schultz, P. W. "Knowledge, Information, and Household Recycilng: Examining the Knowledge-Deficit Model of Behavior Change." *New Tools for Environmental Protection: Education, Information, and Voluntary Measures*. Washington, DC: National Academy, 2002. 67-82.

22. Smyth, Danielle P, Arther L. Fredeen, and Annie L. Booth. "Reducing Solid Waste in Higher Education: The First Step towards 'greening' a University Campus." *Resources, Conservation, and Recycling* 54 (2010): 1007-016.

23. "Tools for Critical Engagement." *College of Arts & Sciences*. Bucknell University. Web. 25 Mar. 2012. <http://www.bucknell.edu/x56899.xml>.

24. United States. Environmental Protection Agency. Solid Waste and Emergency Response. *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2010*. US EPA, 2010. Web. Mar. 2012. <www.epa.gov/wastes>.

25. Vicente, Paula, and Elizabeth Reis. "Factors Influencing Households' Participation in Recycling." *Waste Management and Resources* 26 (2008): 140-46.

26. "Waste Minimization and Recycling." *Colgate University's Sustainability and Climate Action Plan*. Colgate University. Web. Feb. 2012. <https://sites.google.com/a/colgate.edu/2011-2015-sustainability-and-climate-action-plan/waste-minimization-and-recycling>.

27. Wheeler, Stacy E. *"Garbage on the Green" - A Waste Audit Event at the University of North Florida, March 8, 2007*. Rep. 2007.

APPENDIX

Figure 5: Average value of recyclable materials

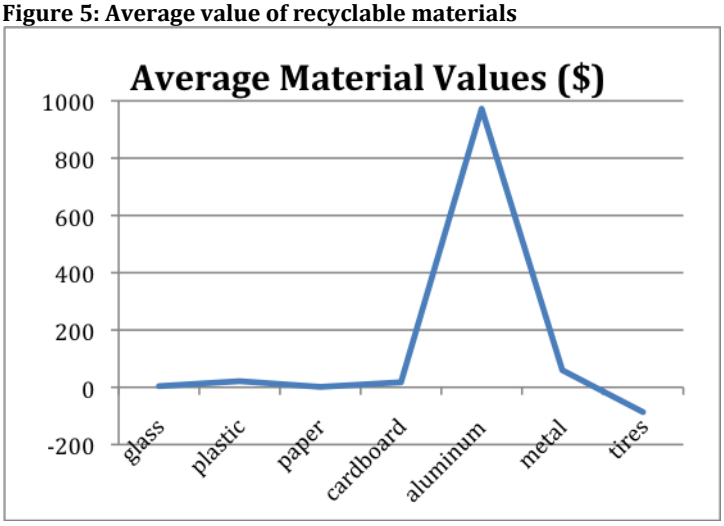

Figure 10: Template 1 - Audit Data Recording Sheet

Location #1 Date of Audit

Total Weight:

Material	Weight (lbs)	Volume (gallons)	Comments
Total measured			

Figure 15: Responses to Purchasing Recyclable Materials Over Non-recyclable Ones

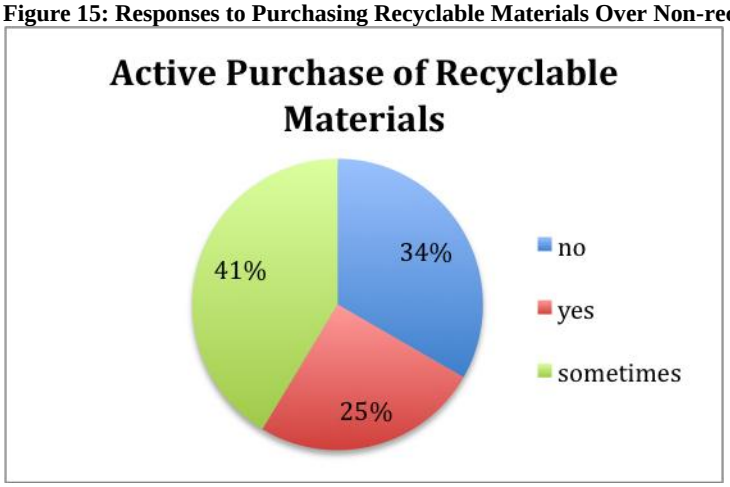

Figure 16: Responses to How Often one Recycles a Recyclable Product

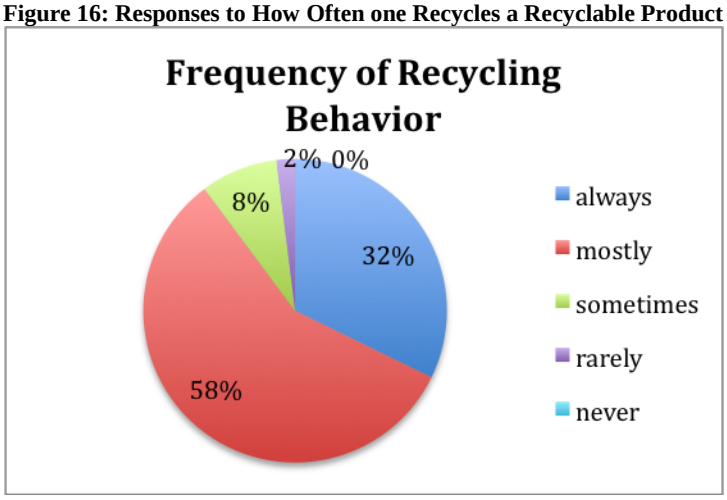

Figure 19: Responses of Percent of Purchased Food Actually Consumed

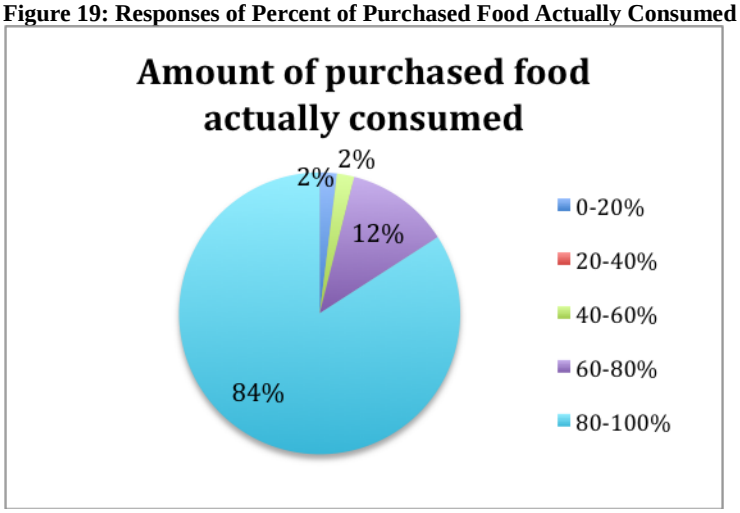

Figure 20: Responses to "How many pounds of waste are generated per person each day at Bucknell?" (* marks correct response)**

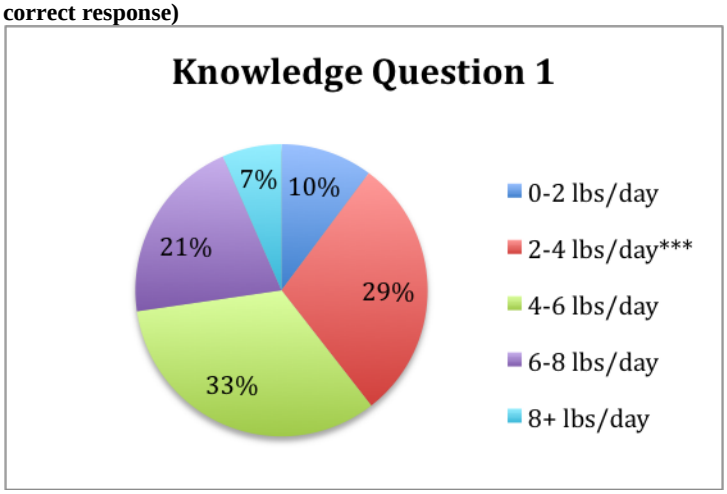

Figure 21: Responses to "What percent of Bucknell's discarded waste do you think has the potential to be recycled on campus?" (* marks correct response)**

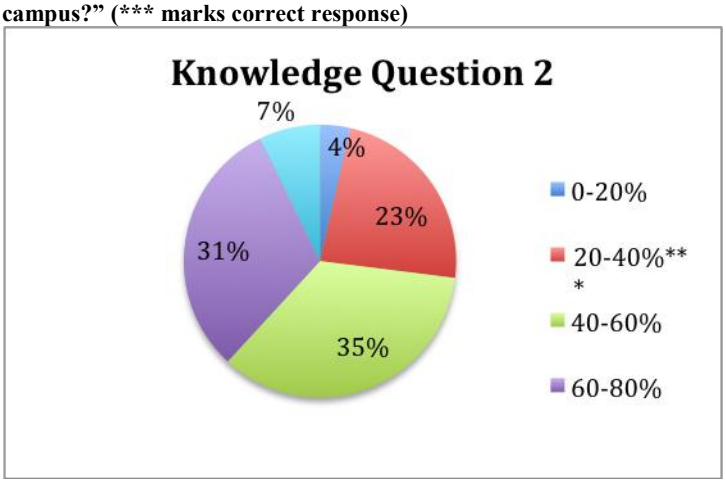

Figure 22: Responses to "What do you think is Bucknell's recycling rate?" (* marks correct response)**

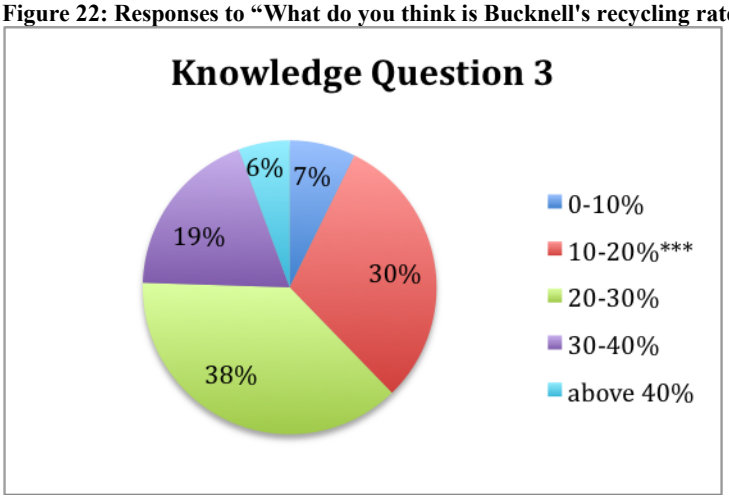

Figure 23: Responses to "What material do you think makes up the largest component of Bucknell's waste stream?" (* marks correct response)**

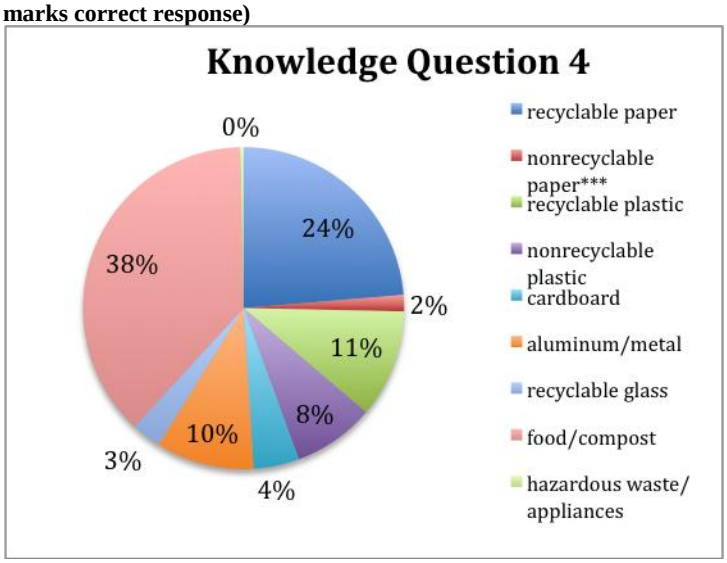

Figure 24: Responses to "Which campus building type do you think generates the most waste per square foot?" (* marks correct response)**

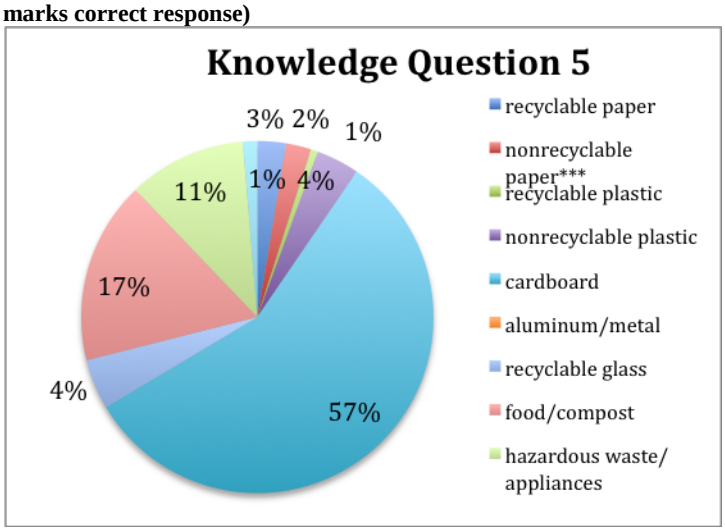

Figure 26: Reactions to "If I knew how to recycle properly, I would recycle more"

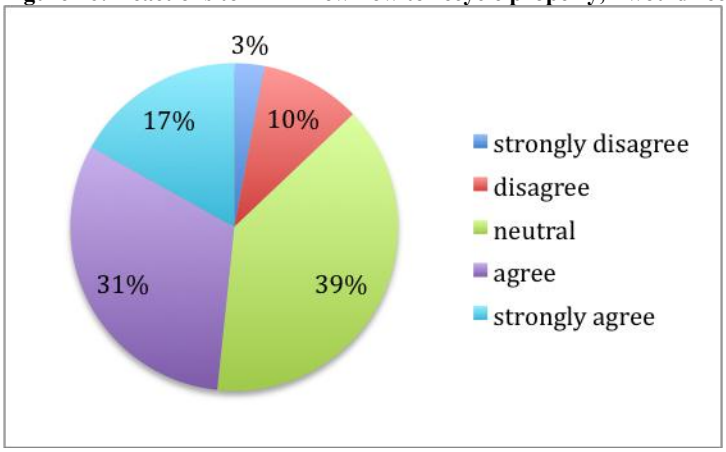

Figure 28: Responses Regarding Whether There are Enough Recycling Bins to Encourage Recycling

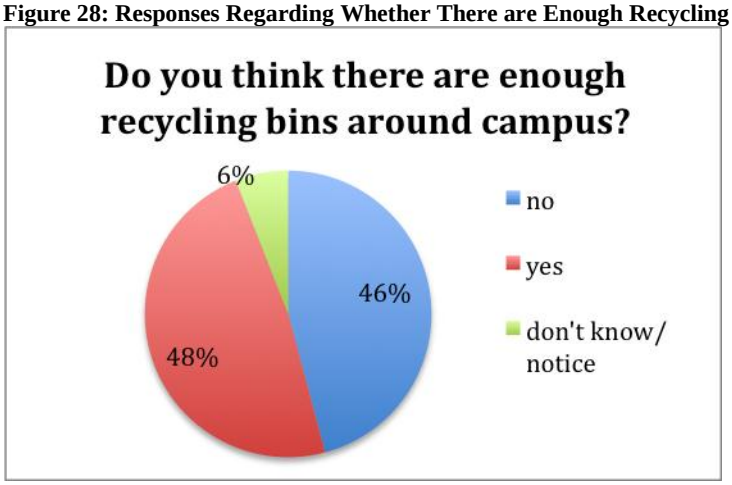

Figure 29: Reactions to "Recycling is inconvenient"

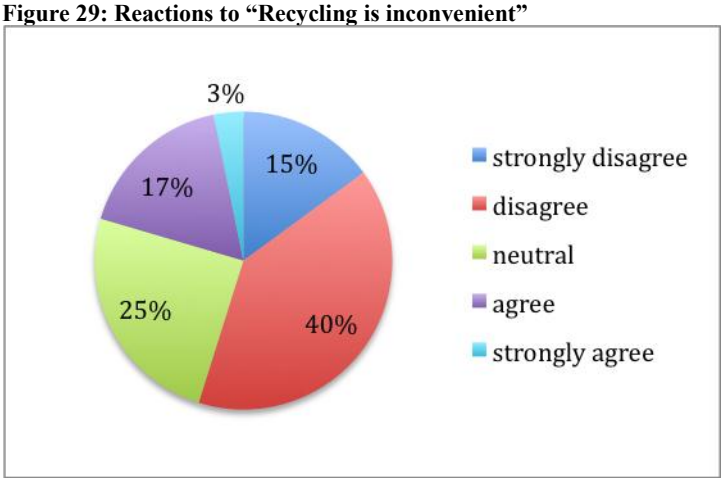

Figure 30: Reactions to "The costs and hassle of recycling outweighs its benefits"

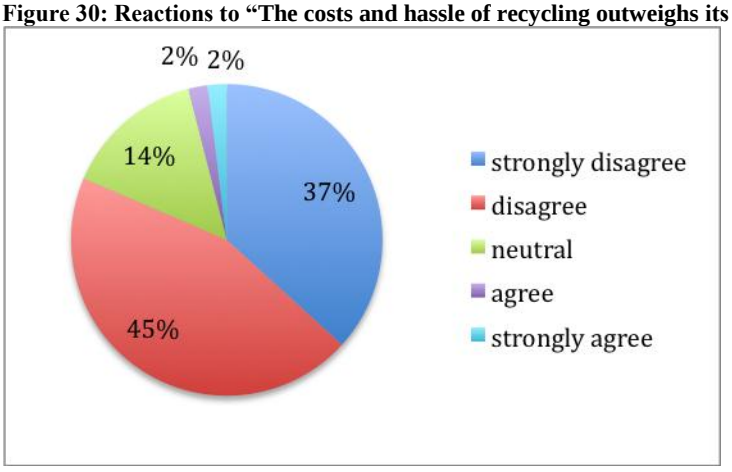

Figure 31: Reactions to "It is my personal responsibility to recycle"

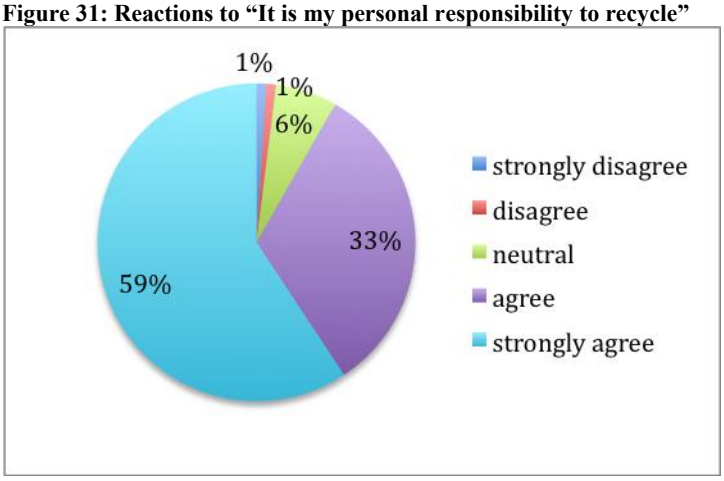

Figure 32: Reactions to "It makes no difference whether I recycle or not"

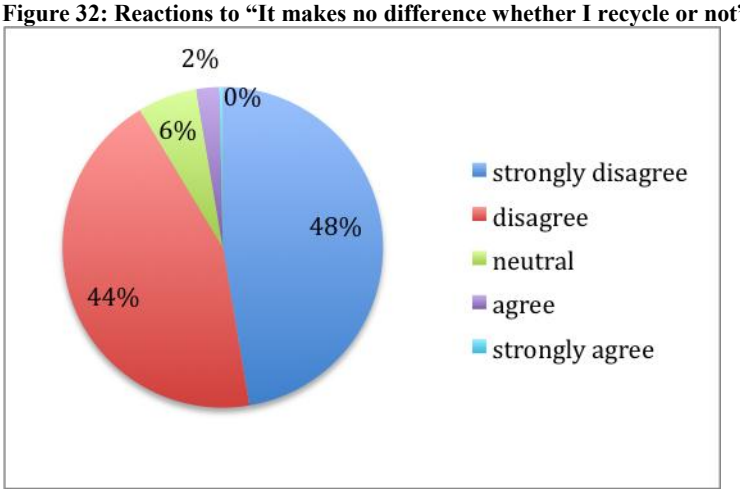

Figure 33: Reactions to "Recycling programs should not be optional, but required of communities"

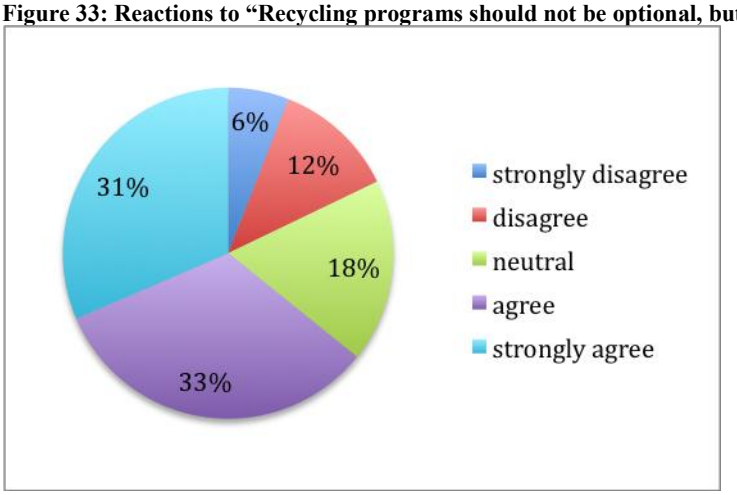

Figure 34: Reactions to "I believe it is human's responsibility to keep the natural environment clean and healthy"

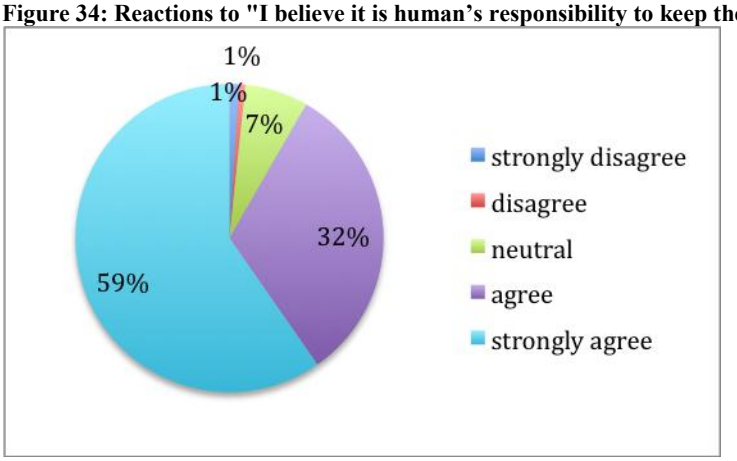

Figure 35: Reactions to "I believe in the environmental benefits of recycling"

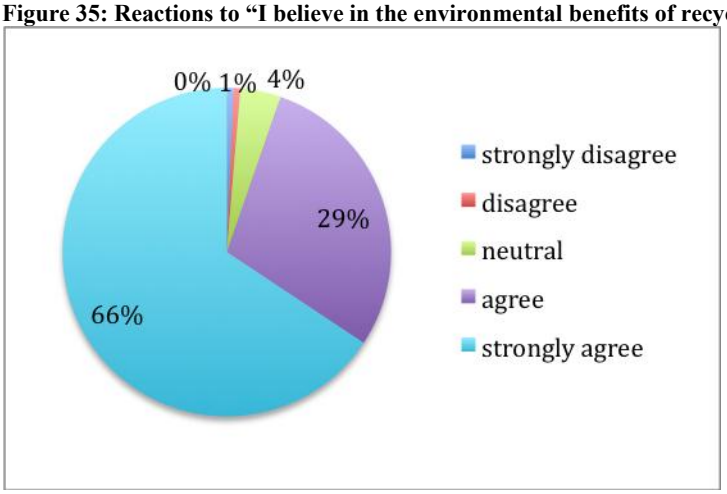

Figure 36: Reactions to "Recycling does not do much to help the environment"

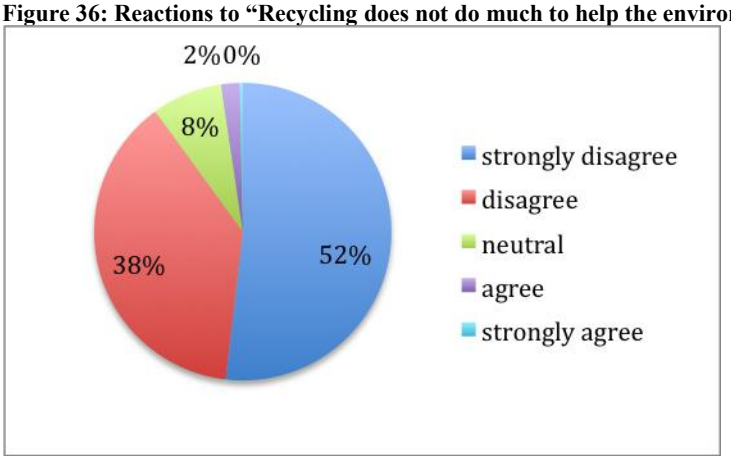

Figure 37: Responses to How One's Recycling Behavior Compares to Peers

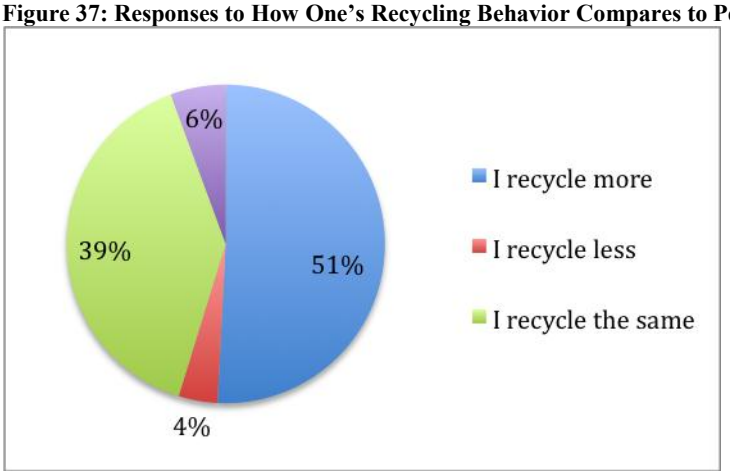

Figure 38: Reactions to "I would recycle more if I knew it was a widely valued practice by my community"

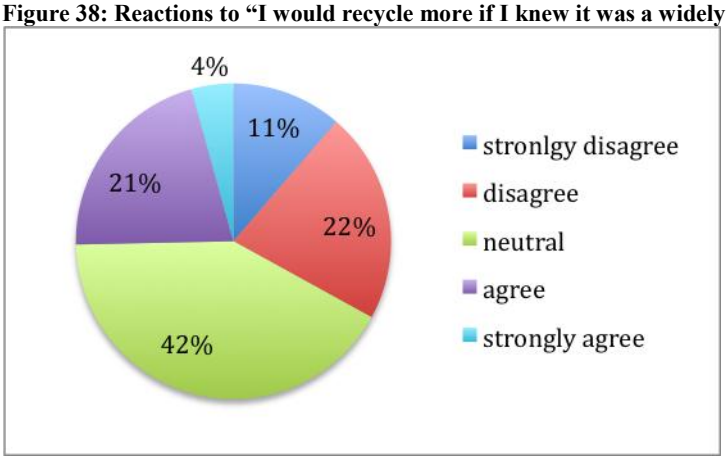

Figure 40: Chi Square Test for Campus Role vs. Knowledge Question 1

		How many pounds of waste are generated per person each day at Bucknell?		
		wrong	correct (2-4 lbs)	Total
What is your position at Bucknell?	student	143	46	189
	professor/faculty	26	10	36
	administrator/staff (non-facilities)	36	29	65
	facilities staff	8	4	12
Total		213	89	302

Chi-Square Tests

	Value	df	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	9.703[a]	3	**.021**
Likelihood Ratio	9.268	3	.026
Linear-by-Linear Association	7.473	1	.006
N of Valid Cases	302		

Figure 41: Chi Square Test for Campus Role vs Moral Value

		What is your position at Bucknell?				
		student	professor/faculty	administrator/staff (non-facilities)	facilities staff	Total
moralvalue_score	4.00	0	0	1	0	1
	6.00	1	0	0	0	1
	7.00	6	0	1	0	7
	8.00	7	0	1	0	8
	9.00	5	1	2	1	9
	10.00	14	1	3	0	18
	11.00	18	0	5	0	23
	12.00	46	4	7	1	58
	13.00	21	3	8	3	35
	14.00	23	2	11	1	37
	15.00	19	8	13	2	42
	16.00	27	16	13	4	60
Total		187	35	65	12	299

Chi-Square Tests

	Value	df	**Significance**
Pearson Chi-Square	49.150[a]	33	**.035**
Likelihood Ratio	52.512	33	.017
Linear-by-Linear Association	10.376	1	.001
N of Valid Cases	299		

Figure 42: Chi Square Test for Campus Role vs Social Norms

		What is your position at Bucknell?				
		student	professor/faculty	administrator/staff (non-facilities)	facilities staff	Total
norms_value	.00	7	9	7	0	23
	1.00	30	4	8	2	44
	2.00	58	10	26	5	99
	3.00	59	9	16	2	86
	4.00	27	3	7	2	39
	5.00	5	0	1	1	7
	6.00	1	0	0	0	1
Total		187	35	65	12	299

Chi-Square Tests

	Value	df	**Significance**
Pearson Chi-Square	29.061[a]	18	**.048**
Likelihood Ratio	25.716	18	.106
Linear-by-Linear Association	2.448	1	.118
N of Valid Cases	299		

Figure 43: Chi Square Test for Campus Role vs Behavior

		Do you actively choose to purchase/use recyclable materials or products over non-recyclable ones?			
		no, I don't pay attention to its recyclability	sometimes	yes, I actively choose recyclable ones	Total
What is your position at Bucknell?	student	84	75	28	187
	professor/faculty	0	15	21	36
	administrator/staff (non-facilities)	14	28	23	65
	facilities staff	1	7	4	12
Total		99	125	76	300

Chi-Square Tests

	Value	df	**Significance**
Pearson Chi-Square	51.965[a]	6	**.000**
Likelihood Ratio	61.108	6	.000
Linear-by-Linear Association	25.959	1	.000
N of Valid Cases	300		

Figure 44:Chi Square Test for Class Year vs Knowledge Question 2

		What percent of Bucknell's discarded waste do you think has the potential to be recycled on campus (but is thrown away rather than recycled)?		
		wrong	correct (26.27%)	Total
If you are a student, what class year are you?	freshman	38	12	50
	sophomore	35	15	50
	junior	29	15	44
	senior	43	3	46
Total		145	45	190

Chi-Square Tests

	Value	df	**Significance**
Pearson Chi-Square	11.239[a]	3	**.011**
Likelihood Ratio	13.178	3	.004
Linear-by-Linear Association	2.975	1	.085
N of Valid Cases	190		

Figure 45: Chi Square Test for Class Year vs Knowledge Question 5

		Which campus building type do you think generates the most waste per square foot?		
		wrong	correct (dining services)	Total
If you are a student, what class year are you?	freshman	20	30	50
	sophomore	16	34	50
	junior	21	23	44
	senior	26	20	46
Total		83	107	190

Chi-Square Tests

	Value	df	**Significance**
Pearson Chi-Square	6.424[a]	3	**.093**
Likelihood Ratio	6.477	3	.091
Linear-by-Linear Association	4.028	1	.045
N of Valid Cases	190		

Figure 46: Chi Square Test for Gender vs. Knowledge Question 1

		How many pounds of waste are generated per person each day at Bucknell?		
		wrong	correct (2-4 lbs)	Total
What gender are you?	Other	0	2	2
	male	83	29	112
	female	131	58	189
Total		214	89	303

Chi-Square Tests

	Value	df	**Significance**
Pearson Chi-Square	5.620[a]	2	**.060**
Likelihood Ratio	5.727	2	.057
Linear-by-Linear Association	.426	1	.514
N of Valid Cases	303		

Figure 47: Chi Square Test for Gender vs. Knowledge Question 3

		What do you think is Bucknell's recycling rate (the percent of overall waste that actually gets recycled)?		
		wrong	correct (18.5%)	Total
What gender are you?	Other	2	0	2
	male	68	44	112
	female	139	48	187
Total		209	92	301

Chi-Square Tests

	Value	df	**Significance**
Pearson Chi-Square	7.006[a]	2	**.030**
Likelihood Ratio	7.478	2	.024
Linear-by-Linear Association	1.879	1	.170
N of Valid Cases	301		

Figure 48: Data on Monthly Waste Generation at Bucknell