Carleton College Waste Habits

An Analysis of Carleton College's East Side Dormitories' Waste Habits

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Math 215: Introduction to Statistics

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Introduction

As the first college to own a utility grade wind turbine in the country, Carleton College ranks as one of the greenest colleges in the U.S. To continue the success of Carleton's role as a leader in sustainability and environmental issues, it is important to analyze and assess students' trash habits. Carleton began its effective sustainability program, Carleton Composts, in 2007. Since then, recycling and composting at Carleton has seen a large increase in participation among students. However, not all Carleton students dispose of trash correctly. We hope that by studying Carleton's trash habits, we will be able to discover whether or not students dispose of their waste in the correct bins, if they over-fill bins, and which dormitories have the best and worse waste habits. We hope that our analysis will give students something to learn from.

Methods

Our data on Carleton's trash habits was provided by student custodial worker, Jackson Van-Fleet. Data was collected on the morning of Saturday the 18th of May, 2013 from 5 dormitories on the East side of the Carleton College campus (excluding Watson and Goodhue). For each trash bin, several observations were recorded. The first observation recorded for each bin was the type of receptacle (garbage, recycling, compost). The location of the bin was specified by the dorm building, floor number, and floor type (substance free or regular) it was located in. The fullness of each bin was recorded as a fraction rounded to the nearest quarter. For each bin, items from the visible top layer were observed and a bin was marked as either contaminated or not contaminated depending on whether or not students saw items that did not belong in that particular bin.

Results: Our interpretation of the data began with a simple exploratory data analysis on bin fullness and contamination

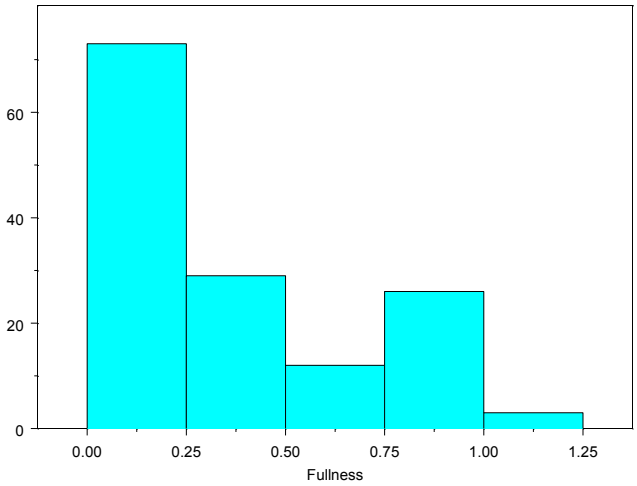

Figure 1. Distribution of Bin Fullness

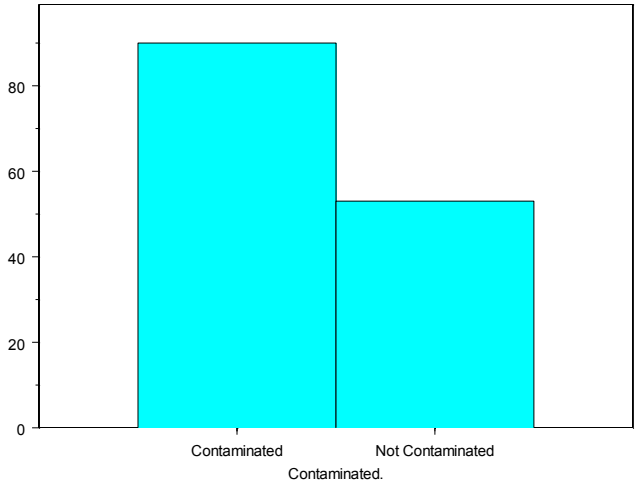

Figure 2. Distribution of Bin Contamination

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The distribution of bin fullness (Figure 1) is uneven and heavily right-skewed. The number of bins that are contaminated is greater than the number of bins that are not contaminated (Figure 2).

Next, we looked at contamination proportion and average fullness grouped by dorm building.

Table 1. Contamination Proportions and Average Fullness Grouped by Dorm Building

	Cassat	Evans	James	Myers	Nourse	Total
Proportion Contaminated	0.839	0.469	0.739	0.545	0.542	0.622
Fullness Mean	0.524	0.305	0.467	0.561	0.521	0.474
Fullness SD	0.35	0.296	0.356	0.313	0.337	0.338

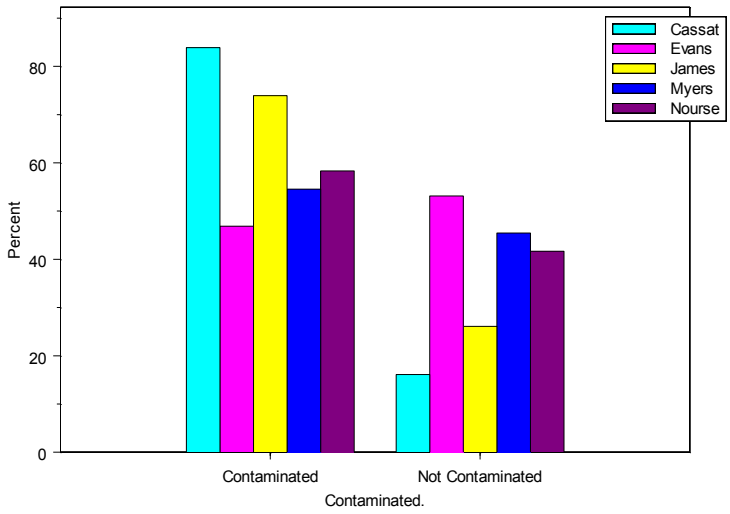

Figure 3. Proportions of Contaminated Bins Grouped by Dorm Building

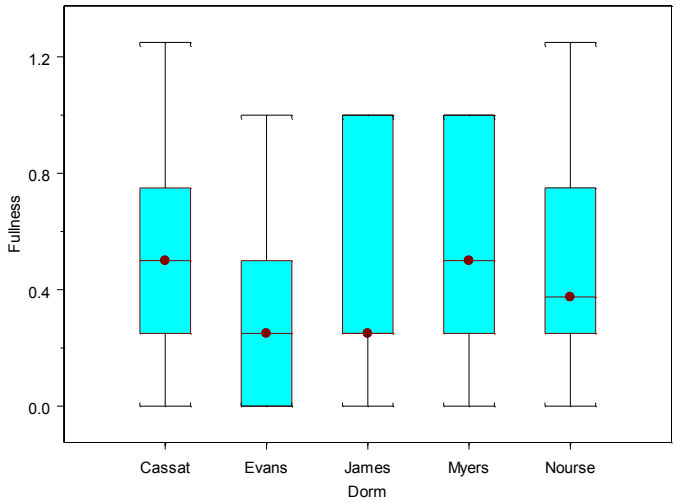

Figure 4. Distributions of Fullness Grouped by Dorm Building

Bins in Cassat and James appear to be more contaminated than bins in the other dorm buildings (Figure 3). A Chi-Square test shows that there is evidence for an association between dorm building and contamination at the 1% significance level ($p = 0.004$). The median bin fullness is between 0.3 and 0.5 for each dorm building, and the spread of bin fullness is about the same for each dorm building (Figure 4).

We then looked at contamination proportions and average fullness grouped by floor type.

Table 2. Contamination Proportions and Average Fullness Grouped by Floor Type

	Substance Free	Regular	Total
Proportion Contaminated	0.565	0.642	0.622
Fullness Mean	0.652	0.440	0.474
Fullness SD	0.335	0.329	0.338

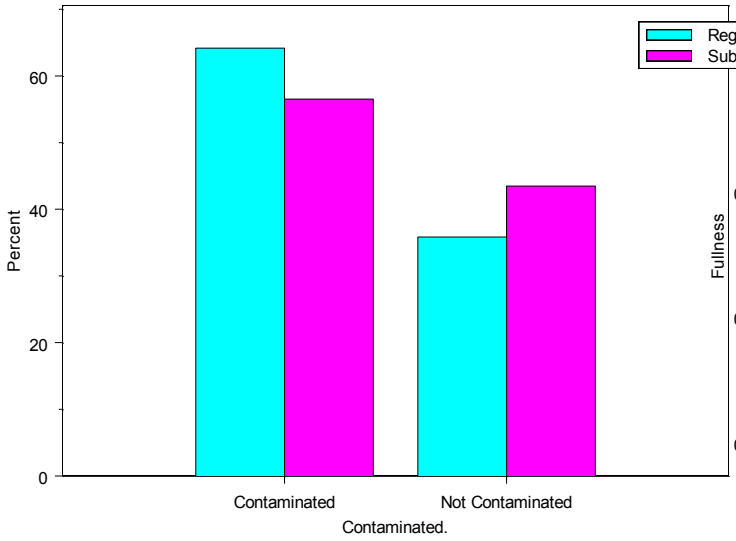

Figure 5. Contamination Proportions Grouped by Floor Type

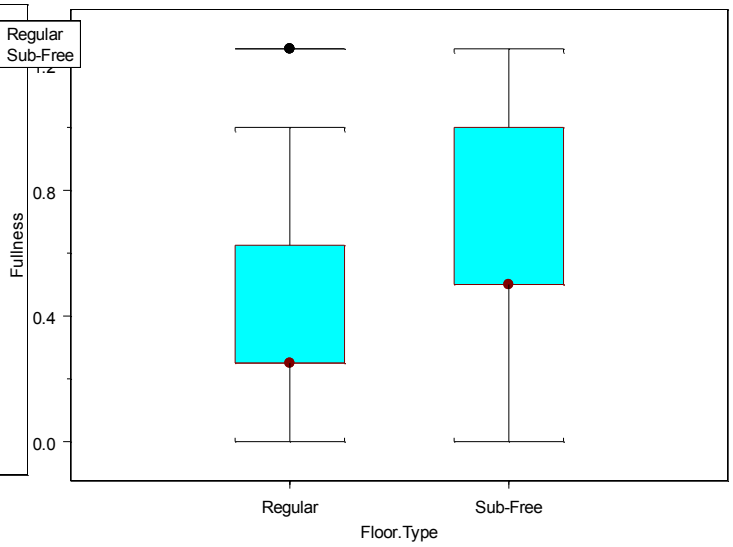

Figure 6. Distributions of Fullness Grouped by Floor Type

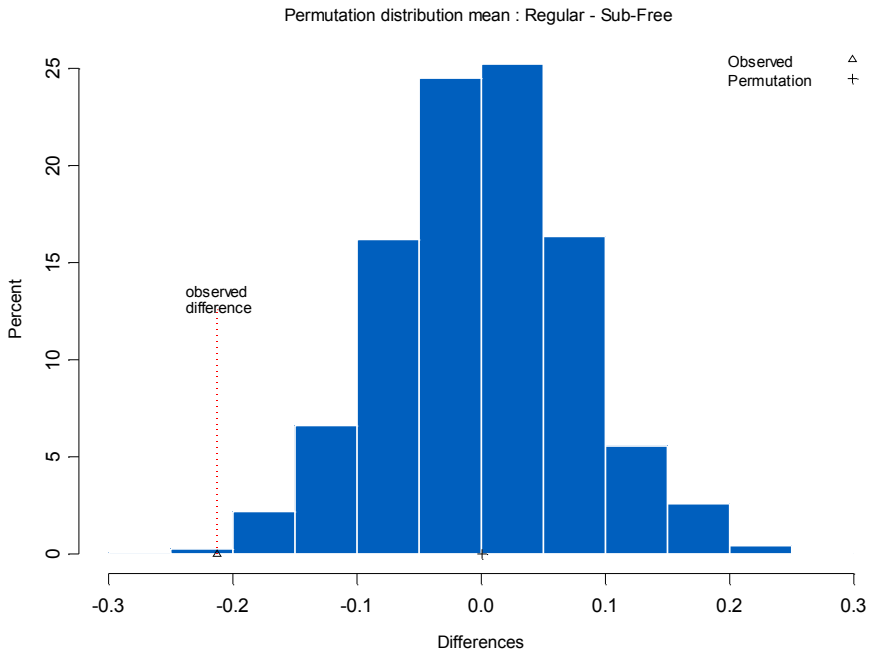

Figure 7. Sampling Distribution for Fullness vs. Floor Type

The proportion of contaminated bins on regular floors appears to be greater than the proportion of contaminated bins on substance-free floors (Figure 5). However, with 95% confidence, there is no evidence that the contamination proportion for regular floors is different from the contamination proportion for substance-free floors. The distribution of fullness is heavily right-skewed for both floor types (Figure 6). The mean fullness of bins on substance-free floors is greater than the mean fullness of bins on regular floors (Table 2). A permutation test confirms (p=0.001) that bins on substance-free floors are, on average, more full than bins on regular floors at the 1% significance level (Figure 7).

We then looked at contamination proportions and average fullness grouped by floor number.

Table 3. Contamination Proportions and Average Fullness Grouped by Floor Number

	Floor 1	Floor 2	Floor 3	Floor 4	Total
Proportion Contaminated	0.737	0.513	0.594	0.676	0.622
Fullness Mean	0.579	0.506	0.375	0.412	0.474
Fullness SD	0.354	0.378	0.284	0.288	0.338

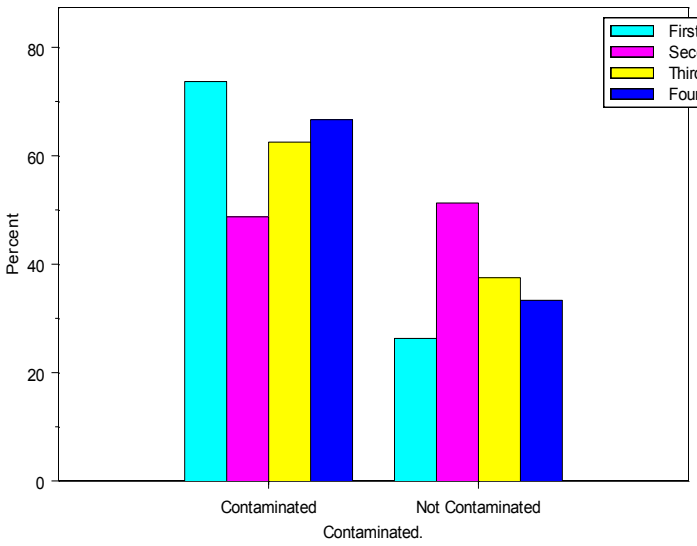

Figure 8. Contamination Proportions Grouped by Floor Number

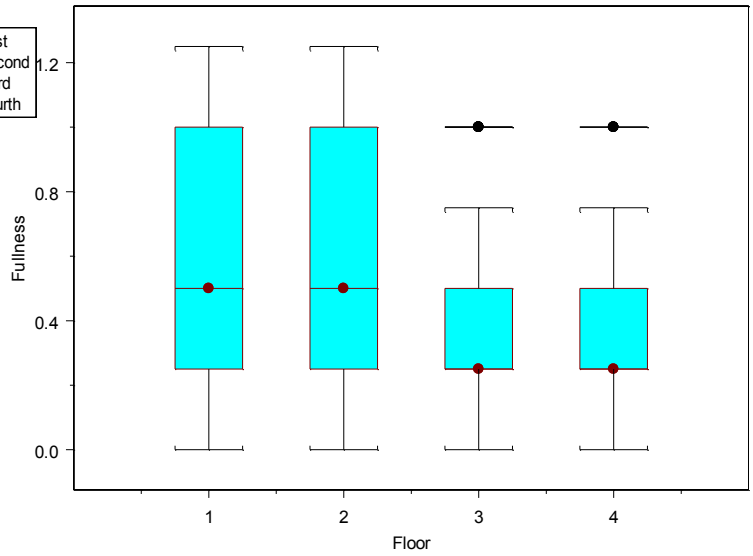

Figure 9. Distributions of Fullness Grouped by Floor Number

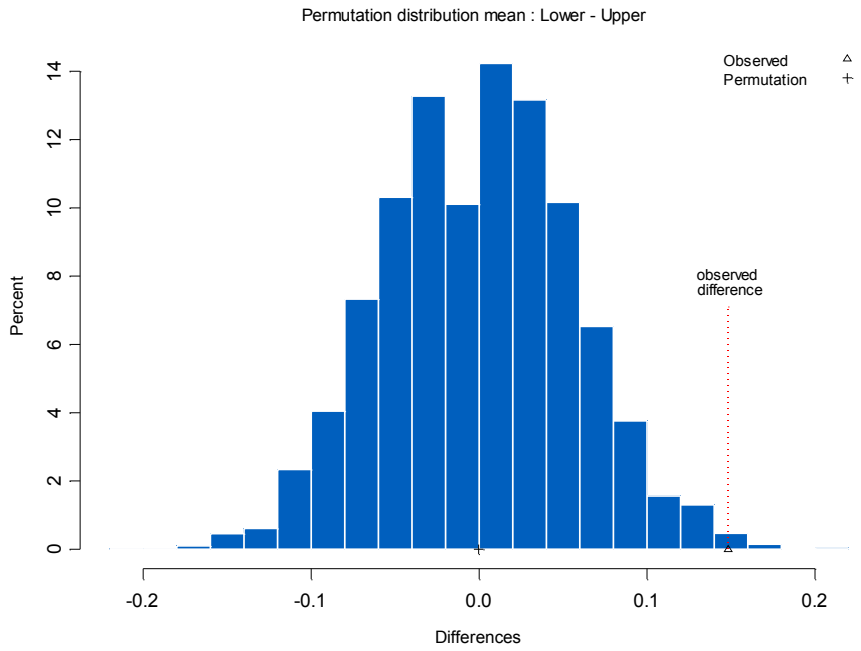

Figure 10. Sampling Distribution of Fullness vs. Upper/Lower Floors

The relationship between floor number and contamination proportion (Figure 8) shows that the first floor in general has the highest proportion of contaminated bins while floor two has the lowest. However, a Chi-Square test confirms the null hypothesis at the 10% significance level ($p = 0.134$) meaning we do not have sufficient evidence that there is a statistically significant difference in contamination between floors. The mean (Table 3) and median (Figure 9) fullness of bins is greater for the two lowest floors than it is for the two highest floors. A new variable was created (UpperLower) which separated floors by grouping (Lower is the first two floors while Higher is the upper two). A permutation test confirms ($p = 0.0056$) that bins on lower floors are, on average, more full than bins on upper floors at the 1% significance level (Figure 10). The distribution of fullness is more heavily right-skewed for the two lowest floors than for the two highest floors (Figure 9).

Lastly, we looked at the contamination proportion and average fullness grouped by receptacle type.

Table 4. Contamination Proportions and Average Fullness Grouped by Bin Type

	Garbage	Recycling	Compost	Total
Proportion Contaminated	0.922	0.383	0.421	0.622
Fullness Mean	0.520	0.446	0.408	0.474
Fullness SD	0.340	0.357	0.253	0.338

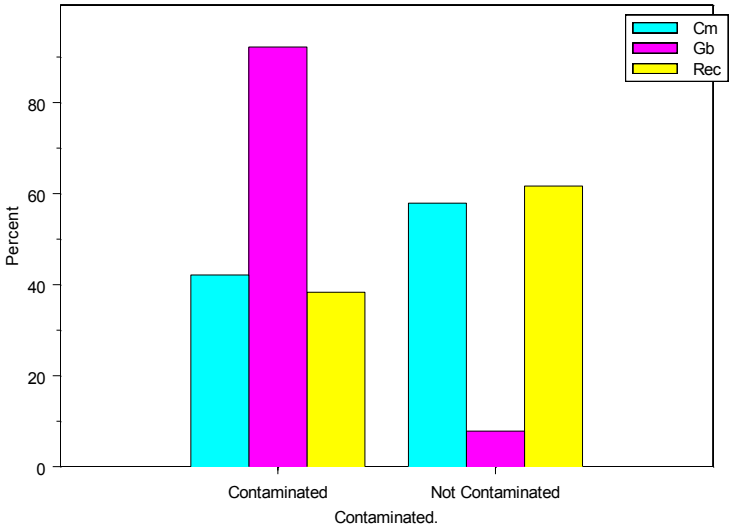

Figure 11. Contamination Proportion Grouped by Receptacle Type

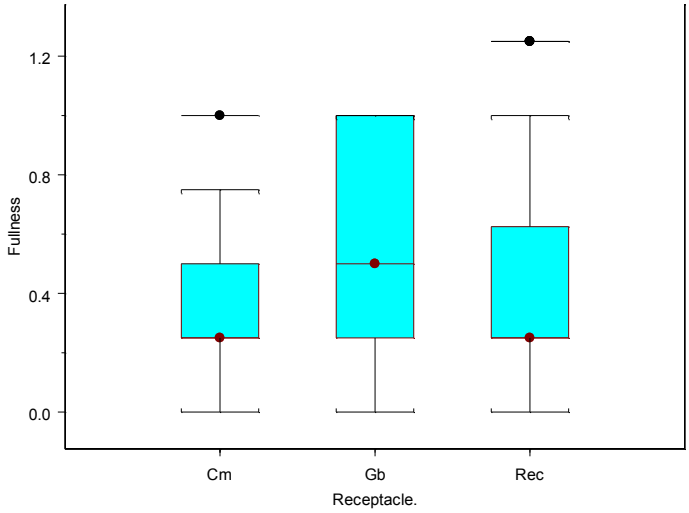

Figure 12. Distributions of Fullness Grouped by Receptacle Type

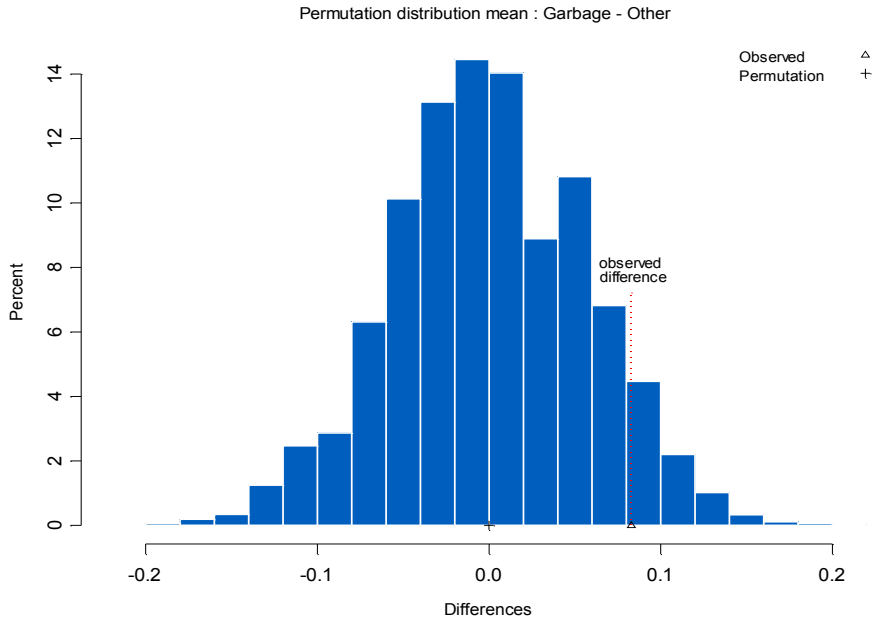

Figure 13. Sampling Distribution for Fullness vs. Garbage/Other Receptacles

Figure 11 shows that the proportion of contaminated garbage bins is much greater than the proportion of contaminated recycling bins and compost bins. A Chi-Square test shows that there is evidence for an association between contamination and receptacle type at the 1% confidence level ($p \approx 0$). The mean (Table 4) and median (Figure 10) fullness is greater for garbage bins than for recycling and compost bins. Bins were separated into a new variable grouping (Garbage and Other) in order to determine if there was a difference between the Garbage and the other two bins. A permutation test confirms ($p = 0.081$) that garbage bins are, on average, more full than other receptacle types at only the 10% significance level (Figure 13). The distribution of fullness is right skewed for each receptacle type (Figure 10).

Discussion:

Significant findings and Conclusions:

Our data essentially is comprised of an analysis of bin fullness, and contamination grouped first by dorm building, floor type, floor number, and bin type. We had several assumptions going into this analysis most were confirmed but we also found that there were some unexpected conclusions to be drawn from the data

We did not expect there to be a significant difference in dorm trash contamination, after all it would seem intuitive that students are somewhat randomly placed and that with over 200 students in each dorm there could not be one dorm where students are unaware of what trash belongs in what bin. Ultimately, we saw a large difference in dorm trash contamination. A Chi Square test of association allowed us to reject the null hypothesis (that all dorms contaminate trash equally). Table 1 then shows us that 84% of Cassat bins and 74% of James bins are contaminated compared to 47% in Evans, and about 54.5% in both Myers and Nourse.

One association that Mr. Van Fleet expected from experience was that Substance Free floors would show significantly higher fullness levels than regular floors. On average, bins from substance free floors were 65% full while bins from regular floors were only 44% full. We performed a permutation test

to see if this difference was significant and discovered that substance free floors produce more trash than regular floors ($p = 0.001$).

Our analysis on floors overall—floors 1, 2, 3, 4 across all dorms—was not expected to yield any significant results for either contamination or fullness. A Chi-square test of association between contamination and across all floors and confirmed the null hypothesis that there was no association between floor and contamination ($p = 0.13$). However, after creating a new variable that separated floors by the categorization of Upper (3 and 4) or Lower (1 and 2) we performed a permutation test that revealed that bins from lower floors, are on average more full than bins from upper floors ($p = 0.0056$). Floors 1 and 2 are on average 58% and 51% full, respectively while Floors 3 and 4 are only 38% and 41% full, respectively (Table 3). We postulate that this has something to do with Lower floors getting more traffic than upper floors. Students walking through a dorm as well as those who reside there might deposit their trash on those floors.

The final piece of analysis we did was on contamination and fullness by bin type. We found that 92% of garbage bins were contaminated compared to only 38% and 42% of recycling and compost bins respectively (Table 4). This is very obviously significant and a Chi square test confirmed that we could reject the null hypothesis that bins are equally contaminated ($p \approx 0$). All three bins seemed to have relatively similar fullness levels (Table 4). After separating the three bin types into a new variable grouping of Garbage and Other we saw that we could confirm that garbage bins were fuller than the other two types of bins. However we could only confirm this at the 10% significance level ($p = .081$) so this association is not as strong as others in our analysis (Figure 13).

Conclusions:

We conclude that student's trash habits vary by dormitory and floor level according to the past of least resistance. That is to say that Cassat and James Hall have higher trash contamination levels because students pass through one dorm to get to another (James has a tunnel that leads into Cassat). Furthermore, lower floors are surely higher traffic as well, so a student that is passing through a dorm and happens to have some trash may simply throw it out as he or she is passing through.

Our most significant findings however concerned contamination and fullness analyzed according to floor type and especially bin type. Substance free students produce significantly more trash perhaps because they spend more time on their floors together. Substance free floors tend to be somewhat insular communities on campus (we postulate) and thus when other students may be off in the townhouses at parties that involve alcohol, substance free students may enjoy staying on their floors and spending the evening together as a community within the Carleton community. That means that all the waste that they produce (pizza boxes, soda bottles, homework scraps etc.) for an evening will remain on their floor. Even more interesting is the fact that contamination and fullness levels for trash bins are significantly higher than those of recycling or compost bins. We suspect that we found these results because students are either careless or unsure of what belongs in the compost and in the recycling bins and treat the garbage bins like a catch all.

It is also important to note that students have trash and recycling bins in their room. However, we suspect that not all students discriminate between these two bins and that many treat them both as trash bins and thus empty all the trash, recycling and compostable items that they accumulate in their rooms into the trash to avoid the hassle of emptying their trash properly.

Ultimately it would seem that despite our efforts, we as a community have a lot to work on towards sustainability. Clearly students are not well educated enough on either the importance of sorting through their waste and being sure to put waste in the proper bin or on what kind of waste goes in which bin. Either way it is the recommendation of these two students that the administration look into some new strategies for waste management education.

Limitations of our study:

The data for our study was collected entirely by student workers, it slowed down their fellow workers and none of those collecting the data were professionals. Furthermore, notation methods for different data differed according to who was collecting the data. Nevertheless, a large amount of data was collected and perfectly useful analysis was performed.

However, there were a few general limitations to the data beyond the general amateur nature of the data collectors. First of all, only five dormitories were observed, this omits the remaining five dorms, and all of the town houses that are not cleaned by student workers as well as all non-academic buildings. So our data really can only give us conclusions as to the nature of five east side dorms and not the entire campus's trash habits.

With 143 observations for only one day of data, analyzing 10 days' worth of data (student custodial workers clean all 10 Saturdays of a term) represents well over 1000 observations to analyze. It was not within our means to perform this analysis as none of the data had been transferred to electronic spreadsheets before we approached Mr. Van Fleet. Furthermore, even if we analyzed every Saturday of a term, we still wouldn't have a complete picture of Carleton students' consumption and waste habits as dorm bins are emptied daily.

There were also some problems with the measurement of trash fullness. It was recorded only as a fraction when ideally measurements would be more precise. Volumetric measurements would have been perfect. Furthermore, we could not account for the difference in the size of bins in each dorm. Some dorms have enormous industrial size bins while others have only small cupboard sized bins but more of them. This means that a full bin in one dorm might only equal half of a bin in another dorm this certainly introduced some error into our fullness measurements that we could not account for.

Recommendations for future analysis:

The perfect future study would account for all of these problems and more. Ideally trash statistics should be recorded daily according to a clear set of guidelines and then entered into a spreadsheet on a weekly basis. Then at the end of each term extensive statistical testing would be performed on each variable measured and give a better picture of which students, in which context are producing the most trash and contaminating bins with the wrong kind of trash.

Additionally, it would be interesting to record the content of the trash bins. This would answer questions left by our analysis. What do Carleton students throw out the most? Are they aware that every

packaging item from the Sayles café (straws, utensils, to-go containers etc.) are compostable? If so what factors contribute to students' inability to throw away their trash in the right bins?

Some academic buildings have introduced trash pods composed of 3 uniformly sized bins (garbage, recycling, and compost of course). These pods display what items should and should not be thrown in each particular bin within the pod. It would be fascinating to see if the introduction of these new pods which are surely expensive has had an impact on Carleton's sustainability efforts.

Despite these limitations and the vast possibilities for future research, our data analysis provides a jumping off point for student/custodial/administrative collaboration on improving Carleton's sustainability record. We can only hope that someone picks up where we and Mr. Van Fleet have left off.