THE POTENTIAL FOR AN

OUTDOOR RECYCLING PROGRAM

AT

University of Waterloo

AN ANALYSIS

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An Analysis of the

Potential for an Outdoor Recycling Program

at the University of Waterloo

for

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1.0 Abstract

The University of Waterloo prides itself as being a leader and model for environmental sustainability in the community. The University's environmental initiatives, research, and active participation in on-campus environmental awareness and development are recognized world wide. It would come as a surprise then that the University of Waterloo does not have an outdoor recycling program on campus. Recyclable materials are being thrown out on campus in alarming quantities. How could this happen? A post-secondary intuition that is at the forefront of environmental creativity and thought lacks arguably the main component in any good environmental program… recycling! In this project, we set out to answer the question: Will an outdoor recycling program work on campus? The need for an outdoor recycling program is first assessed. We would design a sampling method that would best gather the information we needed. Implementation of that design occurred through a number of waste audits of various outdoor locations on campus. Analysis of our findings concluded that an outdoor recycling program is required and feasible, however, not without further research.

2.0 Introduction

Outdoor recycling on campus falls into the goals of WATgreen, which include creating a sustainable campus. The problem that is being addressed in this greening the campus project is the lack of outdoor recycling bins present on the University of Waterloo campus. With a quick glance into a garbage bin around campus, a student would notice that a large amount of recyclables are ending up in the outdoor garbage bins. These recyclable materials are entering

the local landfill because the University lacks an outdoor recycling program. This has led to the development of the research question for this project: Will outdoor recycling work on campus?

2.1 Definitions

The important terms used over the course of the project are defined here:

Recyclables: PET, clear glass, aluminum cans, fine paper and newsprint.

Garbage: Anything not classified as recyclables. Mostly items like compostables, cardboard, and other items normally found in garbage. It also includes other recyclable materials that are not currently recycled on campus.

Visitor (Supporting Actor): An individual who is not a student or a staff member that is on campus semi-regularly. An example would be someone who uses the sports complex once a week.

Visitor (Shadow Actor): An individual who is not a student or a staff member that is on campus irregularly. Someone who comes to watch a play once every few years would be an example.

Shadow Actors: Those individuals who are not involved in the problem at hand but are affected by what happens for some reason (Murphy, 2003).

Core Actors: Those individuals who are constantly and intensely involved in the problem at hand (Murphy, 2003).

Supporting Actors: Those individuals who could exert a significant effort to decisions but are less involved (Murphy, 2003).

2.2 Actors

Core Actors

University Students: Students are constantly contributing to the amount of garbage on campus. There are students on campus 24 hours a day and therefore garbage is being produced and thrown out constantly.

Professors/Staff: Like students, University staff are on campus for great amounts of time. They also produce and throw always garbage while on campus, therefore contributing to campus garbage levels.

Supporting Actors

Administration: The administration influences the on-campus waste through their control over the economic aspects. Administration influences garbage pick-up times, locations and dates. They are also in control of the amount of money which is allotted for garbage disposal on campus.

Visitors: Visitors on campus influence the campus garbage levels by producing, or bringing their own garbage to the university and disposing of it in campus bins.

Maintenance Staff: The maintenance staff influence waste by disposing of it. Ground crews collect waste from campus garbage bins for disposal thus regulating the levels in the cans on campus. They are in control of the disposal of the campus garbage.

Shadow Actors

The City of Waterloo Community: Waste from the campus influences the city by contributing to the levels of garbage brought to and contained within the city's designated landfill.

Visitors: People who visit campus once or twice a year influence the campus garbage levels slightly; nonetheless, it is still an influence. They dispose garbage in the campus cans while they are visiting the university.

2.3 Goals and Objectives

Through our research and analysis of outdoor garbage bins on campus, we will show whether or not there is a need for outdoor recycling containers. We believe that recycling bins will significantly decrease the amount of recyclables that end up in the garbage cans. Ultimately, by comparing and analyzing our research data, we will show if there is a potential need for an outdoor recycling program at the University of Waterloo and determine the feasibility of implementing the program. Primarily, by sampling selected garbage bins on campus and the contents within them, we will form an accurate model of the materials, both non-recyclable and recyclable, that make up the outdoor garbage component at the University of Waterloo.

Secondly, by sampling a selected area on campus known as our "control group" (which will be discussed later in detail), we will develop a model for the potential of outdoor recycling containers to operate and determine to what extent they are operating successfully.

Finally, through careful comparison and analysis of both sets of data, we will show how well an outdoor recycling program will work when implemented across campus. Simply stated,

the objective of this project is to discover whether or not an outdoor recycling program at Waterloo is feasible and whether it will be successful in reducing the amount of recyclables currently ending up in outdoor garbage bins.

3.0 Literature Review

A previous study was conducted in April of 2001 with the goal of reducing wastes going to the landfill from outdoor garbage bins on the University of Waterloo campus. To reach their goal, this group identified types and proportions of wastes in garbage bins by looking at several different sites. The methods of this project involved a visual audit by looking in the opening at top of garbage bins, and then using pokers to uncover the trash at the bottom of the bins (Becker et al., 2001). The group would then call out what they saw and recorded their findings. The group put recycling bins beside garbage bins and audited them three times for a period of a week (Becker et al., 2001). This greening the campus project was determined by our group to have several flaws and as a result we have decided to build only on the previous group's objective. We feel that the previous research on campus of the issue of outdoor recycling has been inconclusive. The use of percentages in this project to express the data collected was felt by our group to be a vague and inappropriate way to represent the data for their project.

Another study that has influenced the proposed study was also conducted by students at Waterloo and found that the use of signage indicating what type of material to be placed in a specific recycling bin was not successful (Fisher et al., 1998). This study further found that people believe recycling is important but 75% of people found recycling inconvenient (Fisher et al., 1998).

Students at the University of South Carolina found in an audit of their campus that 29% of waste was paper, 11% was other waste and 11.5% was glass (Becker et al., 2001). This information will be important to consider and could possibly be confirmed through our proposed project. The findings at the University of South Carolina demonstrates the need to consider what type of recycling bins should be used when considering the implementation of outdoor recycling.

The system that will be looked at and analyzed is outdoor waste on the University of Waterloo campus. The boundary will be Ring Road, which surrounds the main section of the campus within the area known as South Campus. The analyzed inputs will be wastes and recycling that is thrown into the garbage bins. The outputs will be all wastes, which goes to the Erb St. Landfill, and all recyclables, that goes to a local recycling plant. The limits of the system are that people might not make the effort to make sure that the items they throw away end up in the right place. Garbage might end up in the recycling containers and recycling might end up in the garbage bins.

There are five main actors in this system: Management at the University (who deal with spending money and deciding what kinds of waste management practices are going to be used), the Students, Staff, Visitors and the Grounds Crew who collect the waste and recycling.

The Grounds Crew will be helping out the Auditors by labeling the bags that have been selected for the audit as well as putting the garbage in a location in which the audits can take place. The Auditors will relay their research on to the University of Waterloo through the Greening the Campus and Community course (ERS 250). Management, if and when presented with the research findings, will decide the course of action to take or if any will need to be taken.

4.0 Sampling Method

For the purpose of this particular research project, a stratified random sampling method was used. This type of probabilistic sample is defined as "the division of a subject into interest groups and then sampling randomly within each stratum" (Palys, 2003). This is demonstrated through our division of the campus into north and south as well as within the boundaries of Ring Road and how we randomly sampled random cans within this boundary.

4.1 Data Collection Methods

Step 1: Establishing Boundaries and Control Group

Before we decided what garbage cans we should use, we established boundaries for our audit. Our first boundary is Ring Road. We observed that the majority of students are on the main campus during the day, therefore the most garbage would be found in cans on the main campus as opposed to on the other smaller college campuses. Also, we thought that it would be easier to pick cans that are relatively close together to make it easier for the maintenance crew. Therefore, auditing bins at the college campuses were not an option.

Another boundary came about because of the division of the campus into North and South by the maintenance crew; we elected to audit the cans in the South Campus area because we assumed this to be the busiest area of the campus.

Step 2: The Walk Around

The group's first task was to identify all the garbage cans on campus so that we could randomly pick the cans we would use from all cans on campus. We split into two groups; one would locate can on the South side and the other on the North. We each took a campus map and marked each can on the map in the appropriate location. In total 64 cans were located.

Step 3: Random Generation

Each can was assigned a number from 1-64 in no particular order. The group had to randomly generate twenty cans from the 64 that were identified on campus. This was done in Microsoft Excel. We opened a spread sheet and used the code =**rand () * (64-1) +1** which gave us the numbers of our twenty cans.

Step 4: The Control Group

We established a control group on campus. Our control group was the recycling bin located beside two garbage cans under the biology link. This decision was based on the fact that we had noticed recycling bins in that area for awhile. We made the assumption that other students had noticed the placement as well and would place their recyclables in the recycling bins rather than in the garbage cans. We decided to retrieve the contents of the two garbage cans every Monday of the audit to see what kind of impact the presence of the recycling bin is having on the contents of the adjacent garbage cans. We then would be able to compare the amount of recyclables in the control group garbage cans to that of the campus-wide garbage cans to see if the presence of recycle bins would be beneficial.

Step 5: Talking to Les Van Dongen, Plant Operations

The next step was to make an appointment with Les Van Dongen who is one of the lead hands in the Plant Operations sector of the University. We met with him and asked him to randomly pick ten cans from our twenty randomly picked cans. He then told us of the campus was divided into two and the collection days for the two halves differed. We then concluded that South Campus should be our main area of interest and asked him to choose ten cans for us to audit. We then assigned numbers to the cans for identification purposes. To further help the identification we gave him stickers for the garbage collectors to write the identifying number on. Therefore, when we conducted the audits, we are able to tell the bags apart and from which locations they came.

Step 6: The Data Sheets

In order to perform the audits and keep our data in order we created data sheets. These sheets outline all elements of each bag collected: initial weight, count, weight of all recyclables identified in the bag, and the final weight of the bag's remaining contents. See the Attachments section for a s sample of the data sheets used.

Step 7: The Audits

1. *The Garbage is Dropped Off at the ES Loading Dock*

   The maintenance crew that normally picks up and disposes of the campus garbage agreed to drop off our specific bags of garbage at the ES loading dock every

Monday and Friday around 12:00pm. It was agreed that this was the most convenient location for the maintenance crew and also provided an out-of-the-way location for us to do the audit. It was also convenient that there is a large dumpster and recycle bins located in the dock, which enabled us to quickly and easily dispose of the garbage once the audit was completed.

2. *Initial Weighing of Each Bag*

Each bag was weighed initially to get the weight of the bag including all the recyclables contained within the bag. It was weighed using a spring scale which was attached to the top of the bag, and the bag hung to register the weight.

3. *Open and Go Through the Bag*

Each bag was opened one at a time as to not mix up the contents. The contents of the bag were separated into four groups: PET, glass, aluminum and newsprint. These are the recyclable groups that the University currently recycles. Once all the recyclables were removed, the remaining litter was classified as garbage.

4. *Weigh and Count Different Types of Recyclables*

After the recyclables were separated and grouped accordingly, the various groups were first counted and then weighed. They were then emptied into their proper recyclable bins at the loading dock.

5. *Re-weigh Bag*

The bag with the left over garbage was then re-weighed. This is to determine the approximate amount, or weight, or the recyclables that were contained within the bag and to give a final weight of the garbage from that particular garbage can.

6. *Dispose of Garbage*

Once the remaining garbage was weighed, it was disposed of into the adjacent dumpster located at the loading dock area.

7. *Record Data*

All the information that was found during the audit of each garbage bag was simultaneously recorded on the data collection sheets.

5.0 Results

Over our audit period, recyclables are found in the garbage frequently. Of the forty bags audited (which excludes the control group because they were only audited twice), plastic was found 80% of the time, glass was found 72.5% of the time, aluminum cans were found 87.5% of the time and paper was found 55% of the time in the ten garbage bins.

How this was calculated:

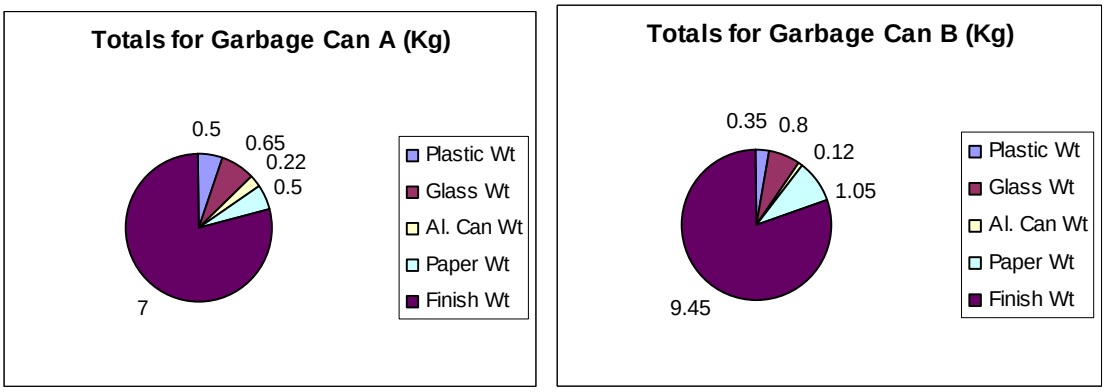
4 audit days x 10 bins =40 bags total

The total average weight by percentage for each day data was collected shows a range from 75-79% of the garbage content being non-recyclable material on campus. The total average

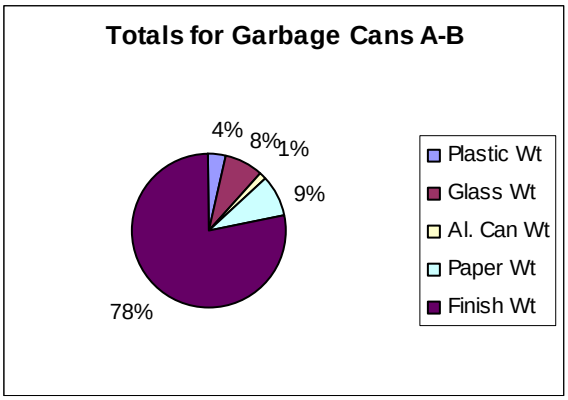
weight of the ten locations audited over the two weeks is 77%. It is important to know what these percentages amount to in terms of weight because of the importance of weight in the economics of recycling. The total average weights for each audit day of the ten locations audited, had a range of 21.3-30.7 kg. The actual range of individual garbage bags over the two week auditing period ranged between 0.4 kg to 12.5kg, refer to raw data.

Looking at the control group:

The total average weight of control group A, as shown in chart 5, was found to be 7kg of garbage while recyclables all together totaled 1.87 kg. In contrast the total average weight of control group B was found to 9.45 kg and the total of all recyclable together was 2.32 kg, this data is shown below.



The total average weight as a percent for both A and B was 78% garbage, 4% plastic, 8% glass, 1% aluminum cans, and 9% paper, as seen below.



When you look at cans 1-10's total average weight 50% of the cans had less than 78% garbage and 50% had more than 78% garbage in the cans. 70% of bins 1-10 had 70% more 8% glass compared to the control group, and 30% has less than 8% of glass in the bins. 50% of the cans had less than 4% plastics, 30% had more than 4% plastics in the cans and 20% had the same amount of plastic as the control group. 90% of the cans had more than 1% of aluminum cans in the garbage cans and 10% of the cans were the same as the control group.

5.1 Statistical Analysis

We used counts to measure 'use' of the garbage cans, based on the assumption that each item counted as one unit of 'use'.

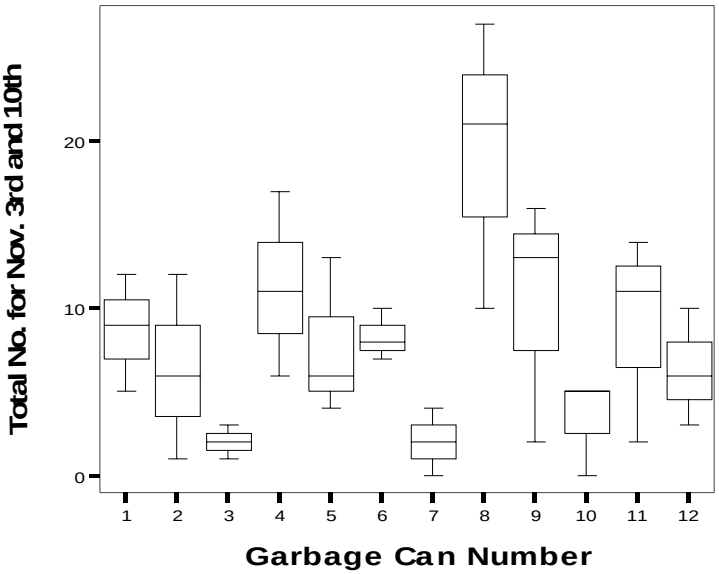


Figure 1: Box plots showing the distribution of recyclable items in each garbage can

The box-plots above show the total number of recyclables found in each garbage can on the November 3rd and 10th combined, the days that the A and B cans were audited. The software used to create this graph only allowed only the use of numeric categories, therefore, for the purposes of the statistical analysis graph A and B are 11 and 12, respectively. From this we see that the means of the A (11) and B (12) are different from each other. 'A' has a relatively high amount of recyclables while 'B' has a low number of recyclables. We cannot account for this discrepancy, however it means that depending on which can in the control are you use for comparison, the results will differ. Using 'A' will suggest that the presence of recycling bins in that area seems to be ineffective. The use of 'B' will suggest that the presence of recycling bins does reduce the amount of recycling ending up in the garbage. It is important to point out that the

number of trials is quite small and, in this case, audits were only conducted twice, making statistical inference difficult.

Figure 2 shows the relationship of each of the bags to the mean number of all recyclable items found in each bag, as well as the 95% confidence intervals. The confidence intervals are wide because the number of audits conducted was too few to make the results as precise as they should be for proper inference. However from this graph we can see that approximately half of the cans contained recyclables that were higher than the mean. One of these cans is can ‘A’, which further shows that the data collected cannot lead to a statistically sound conclusion on the effect of recycling bins on the garbage cans placed in close proximity.

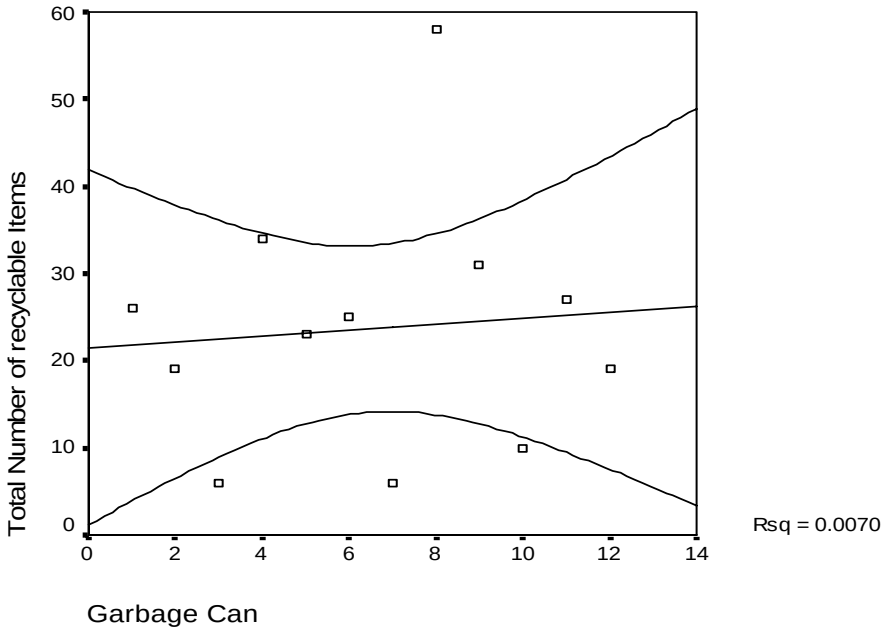


Figure 2: Scatter plot showing the total number of recyclables found in each bag

Table 1: Statistics comparing the recyclables found in all cans.

	Type of recyclable			Statistic	Std. Error
Total No. of recyclables in all cans for Nov. 3rd and 10th	Al. can	Mean		10.09	1.776
		95% Confidence Interval for Mean	Lower Bound	6.13	
			Upper Bound	14.05	
		Std. Deviation		5.890	
		Minimum		2	
		Maximum		21	
	glass	Mean		4.09	1.022
		95% Confidence Interval for Mean	Lower Bound	1.81	
			Upper Bound	6.37	
		Std. Deviation		3.390	
		Minimum		0	
		Maximum		10	
	plastic	Mean		10.73	2.085
		95% Confidence Interval for Mean	Lower Bound	6.08	
			Upper Bound	15.37	
		Std. Deviation		6.915	
		Minimum		1	
		Maximum		27	

Table 1 compares the various amounts of recyclables found in all cans. From the means one would be inclined to deduce that plastics are the most numerous recyclables found in the garbage due to the fact that they have the highest means but Figure 2 shows that this is probably due to the presence of a significant outlier and we should instead conclude that aluminum cans

are more in number. The standard deviations are high and again due to the limited amount of data we cannot make any inferences from this as we will most likely be far off the mark.

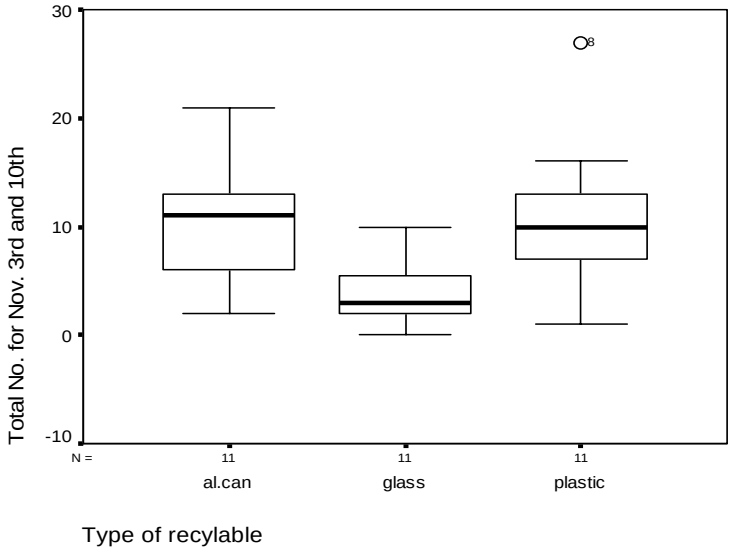


Figure 3: Box plots showing the total amounts of each recyclable type.

Aluminum cans seem to be more prevalent.

Weight measurements have been used in economic and other analyses, as mentioned above counts we used here because of their assumed relationship to ‘use’.

6.0 Economically Important Data

The total amount of waste and recycling collected on campus costs the university approximately $250,000 annually. The waste is charged in two different ways. The first is by service or how many times a week the dumpsters are emptied. This exact amount is kept

confidential because the University, and their present contractor Capital Environmental, do not want other companies to know the amount of their winning bid. It is sufficient to say the lift charge, or how much its costs per time the trucks lift and dump the dumpsters is very low, even less than $10 a lift. The second is by weight or how many tones of garbage which is charged at the Region of Waterloo landfill when the trucks are emptied. The tonnage charge is $47.50/metric tonne for waste.

Recycling is separate from the waste charges. Recycling costs on campus are about $30,000 per year for the pickups alone, not including the $100 fee per cart. Fortunately the University gets a good return on certain recyclables. For example, the University of Waterloo gets about 75% of all the $769.99/tonne for cans and plastic, $47.00/tonne for glass and $104.00/tonne for newsprint. In total, recycling costs about $697.70/month for about 8 tonnes of cans, plastic, glass and newsprint.

Compare the recycling to the waste, and it would be 8 x $47.50 = $380.00 for the weight. There are 270 kgs/cubic yard of materials, which means that a 4 cubic yard bin would have to be emptied daily for about 8 days (10x8 for the service). So, $380.00 + $80.00 = $460.00 for all the recycling to go directly in the trash garbage. In conclusion, for the same materials that cost $697.70 to be recycled, would cost $460.00 to be disposed of with the garbage.

If the amount of recyclables ending up in the outdoor garbage were collected in outdoor recycle bins, the University would receive more money on their return. Based on our findings, the total weight of all recyclables from cans 1-10, over the two weeks, is 31.14 kg. When calculated, 31.14 x 26 weeks (because audited for 2 weeks) is approximately 809.64 extra

kilograms per year in addition to the recyclables gathered from inside buildings on campus. The following chart demonstrates the totals for each sampling day, minus the treatment group.

Totals

Date	Nov 3-03	Nov 7-03	Nov 10-03	Nov 14-03	Total
Start Wt	44.1	38.7	29.9	40.2	152.9
Plastic #	58	34	40	37	145
Plastic Wt	2.25	1.35	1.3	1.375	5.425
Glass #	17	26	8	23	69
Glass Wt	4.25	4.04	2	5.65	14.49
Al. Can #	54	33	25	40	135
Al. Can Wt	1.08	0.66	0.5	0.8	2.7
Paper Wt	2.55	2.15	1.8	1.75	6.7
Finish Wt	30.7	26.25	21.3	29.8	91.6
Difference	3.27	4.25	3	0.825	10.485

If the total weight of each individual recyclable is multiplied by 26 weeks of the year, it gives the weight of each individual recyclable over the whole year.

Plastics	= 5.425 x 26	= 141.05 kg/yr divided by 1000	= 0.141 tons/yr
Glass	= 14.49 x 26	= 376.74 kg/yr divided by 1000	= 0.376 tons/yr
Alum. cans	= 4.525 x 26	= 117.65 kg/yr divided by 1000	= 0.118 tons/yr
Paper	= 6.70 x 26	= 174.20 kg/yr divided by 1000	= 0.1742 tons/yr

The total amount of recyclables found in the outdoor garbage over one year would be 0.81 tones in the selected 10 garbage cans alone. This would barely increase the already accumulated 8 tones of recyclables that cost the University $697.70 per month. But because the

University receives 75% of the money received per ton of recyclables, and this would increase the tonnage of recyclables which the return is based on.

7.0 Discussion

Recommendations

The Outdoor Recycling project is just the beginning in what could potentially be a very large study. Only twelve out of a couple of hundred, if not more, garbage bins were audited over a period of two weeks and to fully implement an outdoor recycling program at the University of Waterloo, a full study (every bin) over every season (spring, winter, fall, summer) needs to be completed.

We have also included in this project the economics behind the garbage and indoor recycling operation but have not done a full study on how the economics would work in regards to fully implementing an outdoor recycling program on campus. Therefore, it would be essential to look at the cost both in labour and material to implementing an outdoor recycling program.

Assumptions

A number of assumptions were made throughout the entire process of the audit. First, we assumed this type of study would be representational of a common community found anywhere within Canada. We made this assumption based on the fact that there are a number of different ethnic, religious, and age variances on campus. The community on campus can also be thought

of as a system. For instance, there are a number of restaurants and business at the University of Waterloo as well as residences, lecture halls, offices, and other facilities.

Second, from our visual observations of our initial walk-about, we assumed that there was no outdoor recycling program on campus. There are in fact two recycling bins located outside of the Biology 1 and Earth Sciences building as well as one located near the Dana Porter library, but there are no recycling bins located outside a building anywhere else on campus. Therefore to confirm our assumption we spoke with Patti Cook.

Third, we assumed that not everyone on campus recycles; therefore, there will be recyclables in the outdoor garbage bins across the campus. This assumption was confirmed through casual observation of student behavior.

Our final assumption was in relation to the weather. We assumed that seasonal conditions (rain, snow, cold, etc.) would make people stay indoors more; therefore the amount of garbage and recycling in the garbage collected would be less than on days when seasonal conditions favor being out-of-doors. In the spring term, there will be more garbage and more recyclables ending up in the garbage than at the end of the fall and throughout the winter term.

7.1 Limitations

Over the course of our study we encountered many limitations which had an effect on our outcome. First, time was a definite limitation. We had two weeks to do the audits and generate enough information to compile conclusions based on the data we collected in that time frame. An audit which spanned longer than two weeks, perhaps a month, would have been more favorable.

Weather was a factor because it determined the amount of garbage found in the cans. If the weather was wet, cold or generally undesirable then the garbage amounts were likely to be lower than they would be if the weather was sunny, warm and dry. Also, on wet days the garbage inside the cans was wet and increased the total weight of garbage. This had the most significant impact on newsprint which increased in weight the most when wet.

The number of bags collected by the grounds crew was also a limitation. They were unable to collect all the required bags on the first day of the audit due to time constraints, which therefore limited our data collected for that day.

The accuracy of the scale was not always constant. The scale would have a tendency to stick and would not always provide accurate measurements.

Another problem that we had not anticipated was the fact that the University was divided in half by Plant Operations, and in order to make things less complicated for the grounds staff, we had to choose one half or the other. We chose South Campus because we made the assumption that it was the busiest.

8.0 Conclusions

It is arguable that our collected data and comparisons do not fully reflect a model of what is in campus garbage containers nor the full extent of the impact that placing recycling bins next to them has on people's recycling behavior. The extend of our research has, however, indicated that locating recycling bins next to outdoor garbage bins on the University of Waterloo campus will in fact divert recyclable materials from ending up in campus garbage bins.

We discovered a multitude of limitations during the course of our research but the one that most affected our study was time. With more time, more data could have been collected thereby allowing us to triangulate our results and thus forming a more accurate model of the recyclable components of campus garbage bins.

At first glance, the economics of implementing an outdoor recycling program on campus does not seem to warrant it. We've recognized that whereas economics are typically calculated and formulated on an annual or quarterly basis, our research and in particular our audits were only conducted over a two week time frame. A much larger project consisting of larger samples over a longer time span would provide the data required in order to accurately calculate the economic gains and/or losses of having such a program.

Ultimately, the limited scope and size of our project did answer our question: Will outdoor recycling work on campus? Yes. To discover to what extent it would actually work and the full economic impact it would have to the University of Waterloo would set the basis for further studies in this area. We have, through our research and this report, clearly demonstrated that the need for an outdoor recycling program is real and that it can work. Our questions as it pertains to recycling at the University have been answered. And in the process of answering that question, others abound. Our hope that this study sets a firm foundation upon which other studies in the area of outdoor recycling on campus can be done.

9.0 Bibliography

Works Cited:

Becker Belinda, Elizabth Louie, Nick Mcgrath, Jessica Piette. 2001. A waste audit of outdoor garbage cans.
http://www.adm.uwaterloo.ca/infowast/watgreen/projects/library/w01outdoorgarbages.html

Fischer, Craig, Kent Keeler, Cheralynne Kennedy, Melissa Kovacs, Rebecca Pollock and

Murphy, Stephen. 2003. Issue Analysis and Problem Solving for Environmental Studies 1: ERS 100 Course Reader. Pg. 35-37.

Palys, Ted. 2003. Research Decisions: Quantitative and Qualitative Perspective. Cited in: Chapter 6 Sampling: Pg. 134 .

University of South Carolina. Unknown. Solid Waste Reduction and Recycling, University of South Carolina. http://www.fmc.sc.edu/recycle/Ea96swrr.htm. Cited in: Belinda Becker, Elizabth Louie, Nick Mcgrath, Jessica Piette. 2001. A waste audit of outdoor garbage cans. http://www.adm.uwaterloo.ca/infowast/watgreen/projects/library/w01outdoorgarb ages.html

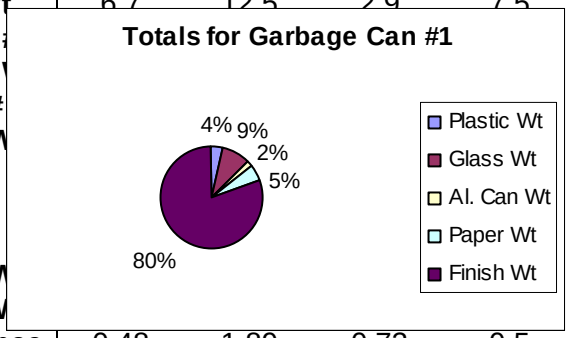
White, David. 1998. Recycling study in ES 1 and 2: An evaluation of contamination and litter problems.
http://www.adm.uwaterloo.ca/infowast/watgreen/projects/project_records/recyclees1.html

10.0 Attachments

Observational charts:

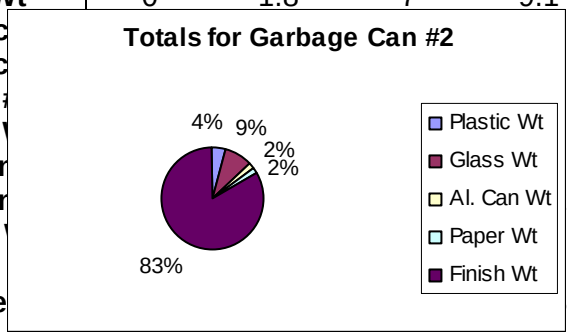
Garbage Can #1

Date	Nov 3-03	Nov 7-03	Nov 10-03	Nov 14-03	Total
Start Wt	6.7	12.5	2.9	7.5	29.6
Plastic #					24
Plastic W					1
Glass #					14
Glass Wt					2.35
Al. Can #					25
Al. Can Wt					
Paper Wt					0.5
Paper Wt					1.35
Finish Wt					20.8
Difference	0.48	1.89	0.73	0.5	3.6



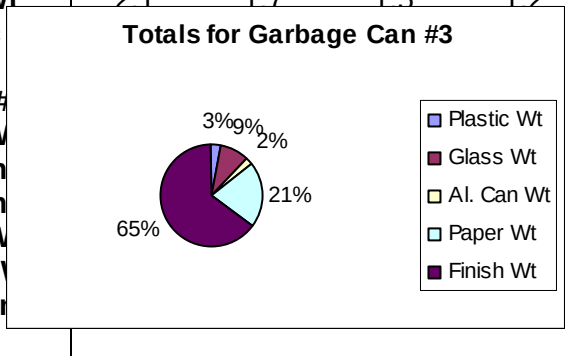
Garbage Can #2

Date	Nov 3-03	Nov 7-03	Nov 10-03	Nov 14-03	Total
Start Wt	0	1.8	7	9.1	17.9
Plastic #					19
Plastic W					0.7
Glass #					7
Glass Wt					1.45
Al. Can #					16
Al. Can Wt					0.32
Paper Wt					0.25
Finish Wt					13.35
Differe					1.83



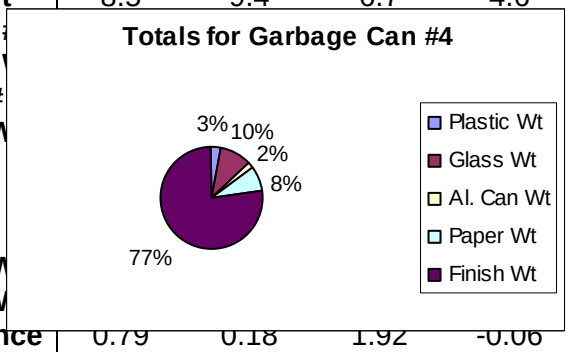
Garbage Can #3

Date	Nov 3-03	Nov 7-03	Nov 10-03	Nov 14-03	Total
Start Wt	2.1	1.7	1.5	1.2	6.5
Plastic #					5
Plastic W					0.225
Glass #					7
Glass Wt					0.65
Al. Can #					7
Al. Can Wt					0.14
Paper Wt					1.45
Finish Wt					4.5
Differer					-0.465



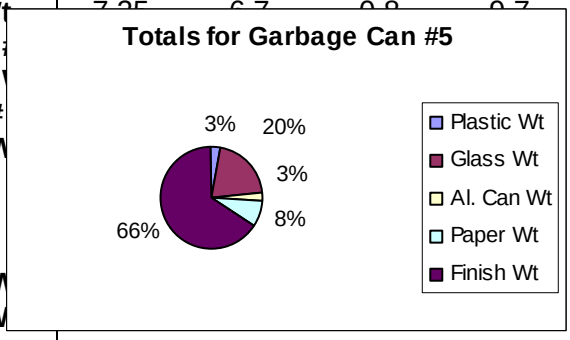
Garbage Can #4

Date	Nov 3-03	Nov 7-03	Nov 10-03	Nov 14-03	Total
Start Wt	8.5	9.4	6.7	4.6	29.2
Plastic #					27
Plastic W					0.9
Glass #					11
Glass W					2.6
Al. Can					26
Al. Can Wt					
Paper Wt					0.52
Paper W					2.1
Finish W					20.25
Difference	0.79	0.18	1.92	-0.06	2.83



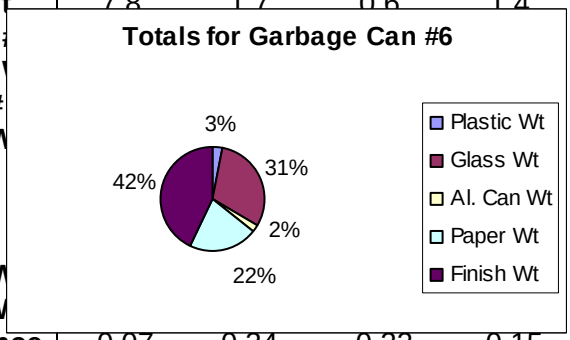
Garbage Can #5

Date	Nov 3-03	Nov 7-03	Nov 10-03	Nov 14-03	Total
Start Wt					24.45
Plastic #					18
Plastic W					0.8
Glass #					15
Glass W					5.2
Al. Can					32
Al. Can Wt					
Paper Wt					0.64
Paper W					2.15
Finish W					16.7
Difference	-0.09	0.33	-1.42	0.14	-1.04



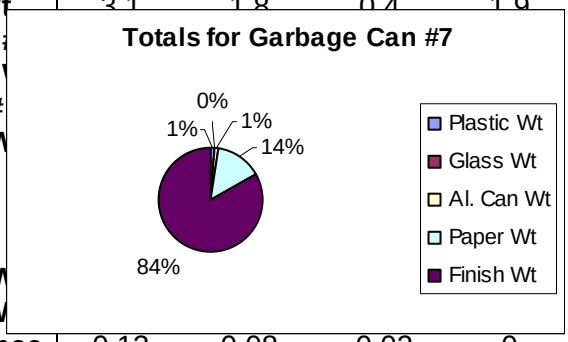
Garbage Can #6

Date	Nov 3-03	Nov 7-03	Nov 10-03	Nov 14-03	Total
Start Wt					11.5
Plastic #					10
Plastic W					0.35
Glass #					13
Glass W					3.55
Al. Can					11
Al. Can Wt					
Paper Wt					0.22
Paper W					2.53
Finish W					4.95
Difference	-0.07	0.34	-0.22	-0.15	-0.1



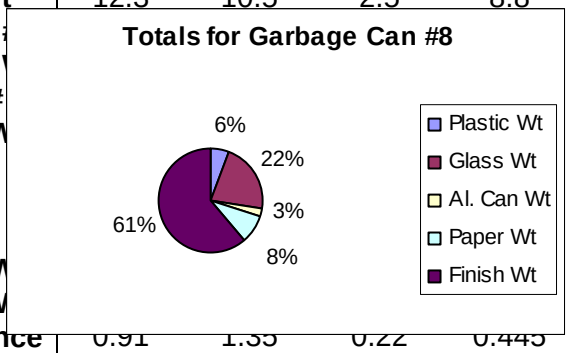
Garbage Can #7

Date	Nov 3-03	Nov 7-03	Nov 10-03	Nov 14-03	Total
Start Wt	3.1	1.8	0.4	1.9	7.2
Plastic #					4
Plastic W					0.1
Glass #					0
Glass Wt					0
Al. Can #					3
Al. Can Wt					
Paper Wt					0.06
Paper Wt					1
Finish Wt					5.85
Difference	0.13	0.08	-0.02	0	0.19



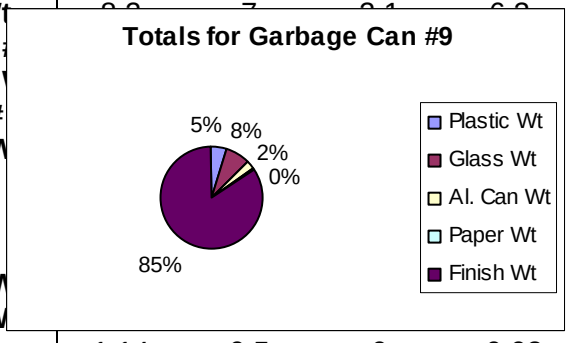
Garbage Can #8

Date	Nov 3-03	Nov 7-03	Nov 10-03	Nov 14-03	Total
Start Wt	12.3	10.5	2.5	8.8	34.1
Plastic #					54
Plastic W					1.725
Glass #					29
Glass Wt					6.89
Al. Can #					43
Al. Can Wt					
Paper Wt					0.86
Paper Wt					2.55
Finish Wt					19.15
Difference	0.91	1.35	0.22	0.445	2.925



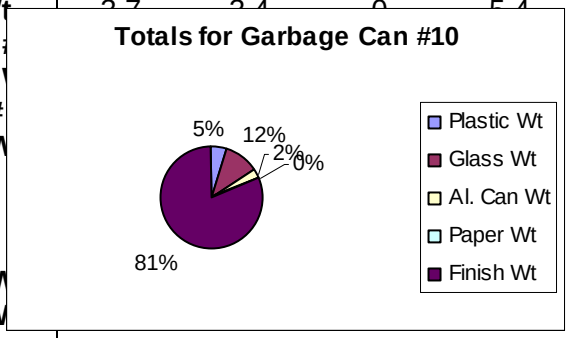
Garbage Can #9

Date	Nov 3-03	Nov 7-03	Nov 10-03	Nov 14-03	Total
Start Wt					23.6
Plastic #					27
Plastic W					1.1
Glass #					8
Glass Wt					1.8
Al. Can #					27
Al. Can Wt					
Paper Wt					0.54
Paper Wt					0.1
Finish Wt					18.45
Difference	1.14	0.5	0	-0.03	1.61



Garbage Can #10

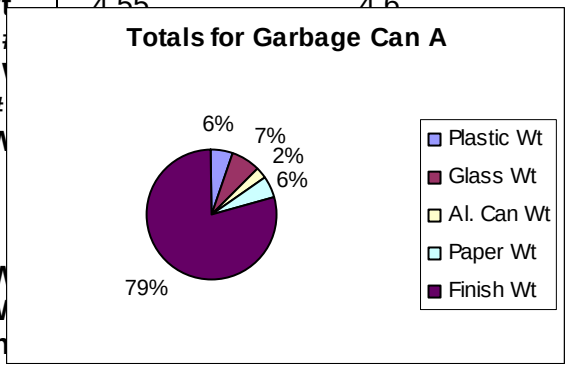
Date	Nov 3-03	Nov 7-03	Nov 10-03	Nov 14-03	Total
Start Wt	2.7	3.4	0	5.4	12.5
Plastic #					12
Plastic W					0.575
Glass #					4
Glass W					1.35
Al. Can					14
Al. Can Wt					
Paper Wt					0.28
Paper W					0
Finish W					9.5
Difference	0.15	0.29	0	0.355	0.795



Control Group

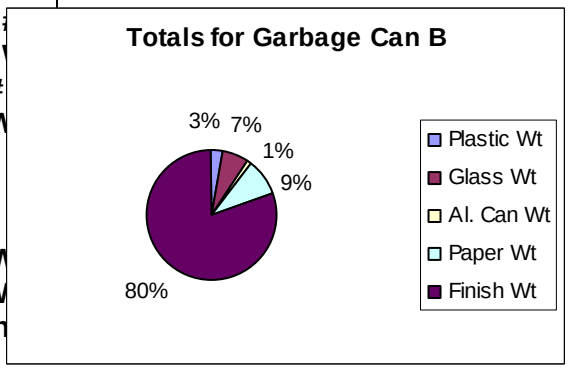
Garbage Can A

Date	Nov 3-03	Nov 10-03	Total
Start Wt	4.55	4.6	9.15
Plastic #			14
Plastic W			0.5
Glass #			2
Glass W			0.65
Al. Can			11
Al. Can Wt			
Paper Wt			0.22
Paper W			0.5
Finish W			7
Differen			0.28



Garbage Can B

Date	Nov 3-03	Nov 10-03	Total
Start Wt	3.45	8.9	12.35
Plastic #			10
Plastic W			0.35
Glass #			3
Glass W			0.8
Al. Can			6
Al. Can Wt			
Paper Wt			0.12
Paper W			1.05
Finish W			9.45
Differen			0.58



Totals

Date	
	Nov 3-03
	Nov 7-03
	Nov 10-03
	Nov 14-03
	Total
Start Wt	
	44.1
	38.7
	29.9
	40.2
	152.9
Plastic #	
	58
	34
	40
	37
	169
Plastic Wt	
	2.25
	1.35
	1.3
	1.375
	6.275
Glass #	
	17
	26
	8
	23
	74

Glass Wt

4.25
4.04
2
5.65
15.94

Al. Can #

54
33
25
40
152

Al. Can Wt

1.08
0.66
0.5
0.8
3.04

Paper Wt

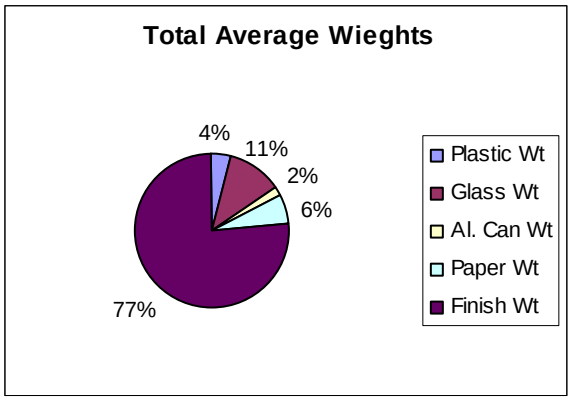
2.55
2.15
1.8
1.75
8.25

Finish Wt

30.7
26.25
21.3
29.8
108.05

Difference

3.27
4.25
3
0.825
11.345


Total Average Wieghts
4%
11%
2%
6%
77%
Plastic Wt
Glass Wt
Al. Can Wt
Paper Wt
Finish Wt

Sample data sheets

Outdoor garbage bins:

Date that the garbage was collected:
Location #:
Initial wt of bag: wt after:
Other comments:

# of plastic objects		Wt of all plastics	
# of glass objects		Wt of all glass	
# of paper objects		Wt of all paper	
# of aluminum cans		Wt of all aluminum cans	

Date that the garbage was collected:
Location #:
Initial wt of bag: wt after:
Other comments:

# of plastic objects		Wt of all plastics	
# of glass objects		Wt of all glass	
# of paper objects		Wt of all paper	
# of aluminum cans		Wt of all aluminum cans	

Control group data:

Gabage bins:
Date data was collected:
Location #:
Initial wt of bag: wt after:
Comments:

# of Plastic objects		Wt of all Plastics	
# of glass objects		Wt of all glass	
# of paper objects		Wt of all paper	
# of aluminum cans		Wt of all aluminum cans	

Location #:
Initial wt of bag: wt after:
Comments:

# of Plastic objects		Wt of all Plastics	
# of glass objects		Wt of all glass	
# of paper objects		Wt of all paper	
# of aluminum cans		Wt of all aluminum cans	

Campus map with bin locations: