An Investigation into the Degree and Reasons for Contamination of Outdoor Organic Waste Stations at the University of British Columbia

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Geography 371 with Siobhan McPhee

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Abstract

Throughout the University of British Columbia's (UBC) Vancouver Point Grey campus, outdoor organic waste bins have a considerably high contamination rate compared to the same waste bins located indoor. This has caused UBC Waste Management to send almost all of the waste to landfills, thereby hindering the university's waste reduction targets. Until the problem is solved, UBC Waste Management is reluctant to increase outdoor bins.

This UBC SEEDS research project investigates the contamination rate of outdoor organic waste stations on UBC's Point Grey campus. We focused on five key themes to contextualize our research: the UBC Zero Waste Action campaign, contamination, spatial distribution of UBC's outdoor food waste stations, user engagement and aesthetics of the bin landscape.

In terms of research methodology, we developed a waste audit to sort, measure and record the eight UBC "Sort It Out" outdoor waste stations. This was to observe which stations were the most contaminated, compare the weight of contamination to the total weight of waste and highlight the most frequent contaminants. We also designed a survey to understand user behaviour behind these bins. By isolating three of the eight most contaminated stations for surveying, this would help us understand the causes of contamination in the food scraps stream.

Our findings show that the outdoor food scraps stream had an average contamination rate of 10.22%, above the 5% threshold allowed for contamination. Plastic cutlery, recyclable coffee cups and recyclable food containers were the most frequent

contaminants. When respondents were asked what could be done to encourage more composting at UBC, 34.7% said more bins should be placed around campus and 26.5% said clearer signage would be beneficial.

Between our audit data and survey data, it appears that many bin users had no clear understanding on what composting is. Furthermore, there is a gap of knowledge between what users think they are doing and what they are actually doing (eg. putting compostable bowls in the garbage stream instead of food scraps stream). Overall, our survey data shows that users think composting is necessary for sustainability purposes, but the act of accurately diverting waste is undermined by a complexity of factors.

Suggestions for further efforts include intervention strategies to help distinguish items that are compostable and recyclable. More research should also be conducted to see if users are confused by what materials go in the bins and/or the signage on the bins. Judging by our survey data, there was a mixed feedback on the use of the stations, with some respondents saying it is easy to understand the signage while others were confused by it. Furthermore, more attention is needed on the labelling and design of take-out utensils and containers across UBC food vendors. Perhaps clearer labelling on which containers are compostable would help decrease contamination rates bin.

1. Introduction

Partnering with UBC SEEDS Sustainability Program, this study investigated the extent and reasons for high contamination rates of outdoor organic waste food stations across the University of British Columbia's (UBC) Vancouver Point Grey campus.

We examined the eight outdoor bins across campus, as shown in figure 1, including both BigBelly and UBC designed bins, pictured in figure 2a and 2b. UBC aspires to become a zero-waste community and subsequently in 2010, developed a Zero Waste Action Plan to move the campus towards this vision (UBC Sustainability, 2014). The plan's target is to treat all waste products and materials as reusable resources, especially focusing on organic waste, to achieve virtually zero garbage (UBC Sustainability, 2014). However, contamination of outdoor organic food waste stations is presenting a significant barrier to UBC achieving this vision (SEEDS, 2015). Presently, UBC Waste Management sends the majority of organic food waste to landfill and are disinclined to increase the number of outdoor stations until this has been resolved (SEEDS, 2015).

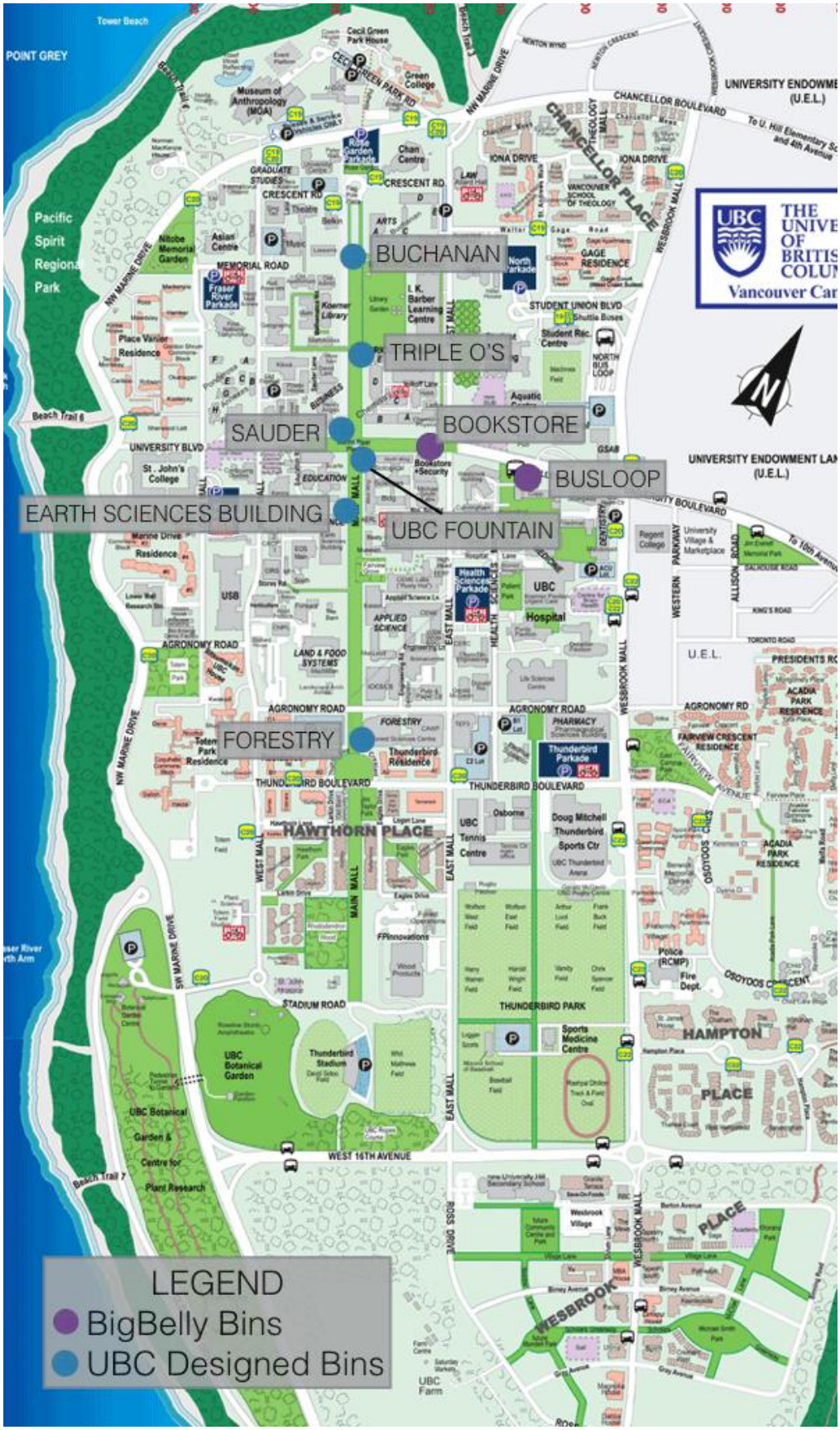

Figure 1. Map of Outdoor Waste Stations across Vancouver Point Grey Campus (by authors).

Figure 2a. UBC's Designed Three-Stream Station (UBC Sustainability, 2015).

Figure 2b. BigBelly Station (UBC Sustainability, 2015).

There is a limited amount of research on the causes and degree of contamination at university campuses; therefore, this report hopes to contribute to the knowledge gap and provide valuable information to help UBC succeed in becoming a zero-waste campus. Building upon past research (e.g. Hottle and Bilec, 2015; Common Energy UBC, 2014; Devlin, 2014;), we employed a waste audit to investigate the rate of contamination and administered a standardized survey on campus to explore potential reasons behind this contamination. The report examines five main themes: UBC's Zero Waste campaign, contamination, spatial distribution of UBC's outdoor food waste stations, user engagement and aesthetics of the bin landscape. First, we state our research questions; second, contextualize our research within the literature; third, outline our method; fourth, analyse our data and conclude with the significance of our research and future suggestions.

2. Statement of the Problem

UBC aspires to be a zero-waste community; however, the UBC SEEDS Sustainability program has identified a significant barrier to achieving the necessary waste reduction targets. Presently, contamination of outdoor compost stations is at an exceptionally high level, above the threshold level of 5%, and resulting in almost all of the organic food waste being sent to landfill (SEEDS, 2015; Fraser, 2015, pers comm., 18th September). This is a major issue for UBC, as their goal is to divert 80% of their garbage from landfill by 2020 (UBC Sustainability, 2014). Until this problem is addressed, UBC Waste Management is unwilling to increase the number of outdoor compost stations. As a result, this will potentially slow down the timeline to achieving a zero waste campus (SEEDS, 2015). Subsequently, this study aims to uncover the amount of contamination across UBC's eight outdoor compost stations and possible

reasons behind the high rates of contamination. Below we have stated out hypothesis and research questions.

By answering the following hypotheses and research question, this study aims to investigate the contamination of compost stations and characterize the reasons behind contamination.

Contamination hypothesese

H_o: There will be no contamination of organic waste in the outdoor 'Food Scraps' stations.

H_1: Contamination of organic waste in the outdoor 'Food Scraps' stations will be above the 5% threshold.

User behaviour research questions

To what extent is contamination affected by user behaviour, attitude, perceptions and knowledge?

How can this be influenced by the aesthetic of the landscape and spatial distribution of the 'Food Scrap' stations?

In order to answer these hypotheses and research questions and contribute to UBC achieving its zero-waste goals, our study will use a mix methodology approach, including a waste audit and surveys. Next, we outline how our study fits within the current literature.

3. Literature Review

3.1 UBC's Zero Waste Campaign

In 2010, UBC developed the Zero Waste Action Plan to drive the Vancouver Point Grey campus towards becoming a sustainable, zero-waste community. The university aims to divert 80% of its waste from the landfill by 2020, focusing on food scraps and recycling 'collection infrastructure' to make waste diversion systems user-friendly and accessible (UBC Sustainability, 2014).

Many post-secondary institutions in North America and Europe are increasingly aiming to become hubs of sustainable innovation and vehicles of environmental change (Finlay and Massey, 2012). As campuses are commonly the size of small municipalities, functioning with their own population and economic force, they have also become places that create large amounts of waste. Thus, there is an expectation for educational institutions to share the same environmental responsibility as governments and corporations (Zhang *et. al*, 2011). For UBC, the Zero Waste Action Plan is expected to boost the university's reputation as a leader in waste reduction, sustainable development and green economy (UBC Sustainability, 2014).

Despite the operational targets and strategies set up by UBC, contamination of food scraps and organic material are significant barriers in achieving zero waste objectives. Organic materials have low diversion rates and yet, make up the largest source of waste produced on campus (UBC Sustainability, 2014). Furthermore, the Zero Waste Action Plan extends to the entire UBC community, including the academic community, student and family campus housing, the University Neighbourhood Association (UNA) and businesses. (UBC Sustainability, 2014). Similar to other

Metro Vancouver municipalities (eg. North Vancouver and Richmond), the geographic locations of where housing and waste facilities are located play an important factor in contamination of residential and businesses food scraps (Metro Vancouver, 2015). Overall, the Zero Waste Action Plan is an aspirational target for UBC to become a place a sustainability and green innovation, but increasing organic diversion rates has been a proven challenge.

3.2 Contamination

The key component in our research will be to identify the composition and frequency of inorganic materials found in the outdoor compost streams throughout the UBC campus. According to UBC Sustainability (2014, p.16): "The key constraint on organic waste diversion currently is not processing capacity, but achieving source separation from the garbage stream**."** Therefore identifying contamination as a fundamental issue that needs to be addressed in order to improve UBC's waste management.

Research (e.g. Common Energy, 2014; Smyth *et al.*, 2010) conducted on waste characterization and contamination rates, suggests that proper sorting and recycling has the potential to divert significant amounts of garbage sent to the landfill every year from Higher Education institutions. Common Energy UBC (2014, p.8) stresses the same findings in their waste audit report: "Without even reducing the amount of waste produced or making infrastructural changes, UBC could reduce the amount of garbage sent to the landfill by 45% if UBC students and staff sorted out their waste correctly". Smyth *et al.* (2010) and Common Energy UBC (2014) both highlight the importance of conducting research on the characterization of waste composition and

its spatial variability in order to enhance the sustainability of an on campus waste management system.

The waste audit conducted by Common Energy UBC (2014) found that the 'Food Scraps' stream and the garbage stream both have significant potential to mitigate the amount of food scraps unnecessarily sent to the landfill. When the contamination rate is at a level of 5% (Fraser 2015, pers. comm., 18 September) in a food scrap stream, everything in that bin has to be sent to the landfill. The Common Energy UBC (2014) waste audit found that 11% of the materials within compost stations were sorted incorrectly, which means that contamination levels were more than double the rate acceptable for composting. Interestingly the same report found that 57% of the garbage stream audited was food scraps, suggesting that reducing contamination levels of waste streams is a fundamental area of improvement when working towards a Zero Waste campus.

3.3 UBC Outdoor Waste Station Spatial Distribution

The locations of waste diversion infrastructure, such as bins, can have varying impacts on its ability to encourage waste diversion from the landfill. Bulkeley and Askins (2009) and Levis *et al.* (2010) suggests that access to zero waste infrastructure, such as multiple stream bins, are the first steps in reducing waste; however, even with this infrastructure, it is subject to contamination because of user behaviour. Currently, UBC has Sort It Out bins in almost every building on campus and in eight outdoor locations (UBC Sustainability, 2014; Figure 1). This encourages the UBC community to sort their waste, because they are provided with the opportunity to separate their waste. Subsequently, due to the abundance of Sort It Out

Stations on campus, sorting your waste is becoming a "social norm" (Bryne and O'Reagan, 2014; UBC Sustainability, 2014; Long *et al.*, 2013). Bryne and O'Reagan (2014) emphasize the importance of creating positive social norms, because it will promote positive individual values, attitudes, beliefs and sense of responsibility towards waste reduction.

Some of the literature (e.g. Byrne and O'Reagan, 2014; Kaplowitz *et al.*, 2009) also points to poor composting being associated with structural difficulties, especially proximity, convenience and bin storage. Similarly, Kelly *et al.* (2006) found that positioning bins in more convenient places can significantly improve a person's composting behaviour. People will be more likely to accurately divert their waste if it is as convenient as just placing it in a garbage bin. UBC has accomplished this by ensuring that there are plenty of stations around campus, with the outdoor BigBelly and UBC designed waste stations located along Main Mall and University Boulevard. Both of these streets are considered popular pedestrian thoroughfares, whereas other less prominent walkways only offer garbage bins (e.g. Koerner Plaza). These outdoor single use garbage bins create inconsistent user-behaviour and contradict UBC's Zero Waste Action Plan (2010). Consequently, spatial distribution of organic waste stations plays a significant role in contamination rates; therefore, this should be considered in UBC's Zero Waste Action Plan.

3.4 User Engagement

The literature (e.g. Hottle and Bilec, 2015; Byrne and O'Regan, 2014; Stapleton *et al.*, 2001) indicates that the success of composting schemes, such as the one implemented by UBC, is greatly dependent on consumer engagement and behaviour. Subsequently,

studies focusing on university campuses, e.g. and Hottle and Bilec (2015), Kaplowitz *et al.* (2009) and Kelly *et al.* (2006), indicate that central to a successful university campus-wide recycling program are students' attitudes, behaviours, engagement and knowledge of the program and environment. In order to transform user behaviour and attitudes to pro-environmental and shift their lifestyle to a more sustainable one via recycling, studies (e.g. Byrne and O'Regan, 2014; Kaplowtiz *et al*., 2009) suggest that university recycling campaigns need to tackle students' internal motivations to recycle or compost.

Social components of composting and recycling (e.g. consumer awareness and education outreach) are complex and due to a lack of research, their effectiveness on changing consumer behavioural patterns are largely unknown (Hottle and Bilec, 2015; Long *et al.,* 2013). However, Byrne and O'Regan (2014) and Kaplowtiz *et al*. (2009) have shown that positive social pressures, such as friends and family influencing recycling behaviour, have enhanced community recycling habits of Limerick, Ireland and University of Michigan. Furthermore, Kaplowtiz *et al.* (2009) and Kelly *et al.* (2006) papers on North American universities show that scheme-specific information, via outreach programs aimed at students, would be beneficial to improving recycling behaviours.

Common Energy UBC (2014) executed a public waste audit on UBC campus in 2014, complete with an educational booth to further engage UBC campus users. This was very successful and discovered that students were not aware of where their garbage went and its subsequent impact on the environment. Consequently, Common Energy UBC (2014) suggested an education outreach program to reconnect consumers with their actions and the environment.

Consequently, the literature illustrates that the various interventions utilized to transform user behaviours to become more pro-environmental and sustainable, have varied consequences (Byrne and O'Regan, 2014; Kaplowtiz *et al*. 2009; Kelly *et al*.. 2006). There is a significant knowledge gap between lack of user engagement with a university recycling program and how to transform these consumer behaviours and attitudes towards a more active pro-environmental stance. Subsequently, this study aims to add valuable information and data to reduce this gap and improve UBC's contamination issue.

3.5 Visual Design of the Outdoor Stations

As aforementioned, consumer engagement plays an important role in the success of recycling programs at universities (Hottle and Bilec, 2015). Subsequently, bin signage is an effective way to encourage pro-environmental behaviours, as it provides consumers with behavioural cues, practical and persuasive information (Gifford and Reuven, 2011).

There have been a number of previous researches about bin signage that has taken place at UBC. These tell us that students believe simple and catchy designs will obtain most attention (Boyle et al. 2007 and Brown et al. 2007). We also learn that many students only spend minimal time diverting their waste and therefore signs must be very clear and visible (Brown et al. 2007). These are all very valuable information. Yet, it is important to note that most research has only been done on indoor compost bins. As we know that outdoor compost bins have a significantly higher rate of contamination, there is a strong necessity to understand why this difference is present

and whether or not an implementation on signage can be a method to decrease contamination rates of outdoor bins.

4. Methodology

4.1 Waste Audit

Looking at the Waste Audit Report from Common Energy UBC (2014), our team designed an audit using their model of measuring, sorting, and re-measuring the sorted waste. Before beginning our audit, it was imperative for our group to research UBC's Zero Waste Policies and Sort-It-Out guidelines, to ensure that each team member fully understood how the materials should be sorted. UBC contains eight outdoor waste stations, six with three streams (UBC Designed Sort It Out Stations: Garbage, Container Recycling and Food Scraps) and two with four streams (BigBelly: Garbage, Container Recycling, Paper Recycling and Food Scraps), which are identified in figure 1. Between October 13th and 16th 2015, we met at 5pm by the UBC Bookstore to audit the Food Scraps stream from each location, keeping track of the bin type. This allowed us to measure the effectiveness of the BigBelly model in comparison to the UBC Designed Sort It Out model. Due to the time frame, we were unable to explore contamination of recycling and garbage streams.

We collected the necessary items to conduct an audit; bodysuits and gloves for sanitary protection, one tarp, a flat scale, extra garbage bags, a container to help us weigh the material, computer spread sheets to record data, a camera to visually record data, and keys to access the outdoor waste stations. The spread sheet (Appendix, Figure 1) is designed to keep track of the data collected at each station. We recorded the station, total weight of the waste, the waste that was correctly sorted (Food

Scraps) and the rest (Container Recycling and Garbage). Furthermore, we recorded each contaminant; any item that did not belong in the Food Scraps stream, as it does not break down within 90 days; thereby, creating a profile of the contamination at each site. The green container (see figure 3) enabled us to accurately measure the large bag of Food Scraps on the flat scale. Upon arriving, we set up our audit: placed a tarp and scales on the ground and the container on top. Next, we put on our body suits and gloves. Then half of our team collected the waste, while the other half sorted the material.

Figure 3. Waste Audit Process (Authors' own)

Once we collected a bag, we recorded the location, placed on the scales and noted the total weight. As the container weighed approximately 5.6kg, we subtracted this number from the total amount weighed, which gave us the total amount of Food Scraps collected. This was recorded in our spread sheet. Next, we sorted through the material on the tarp and placed each item into its corresponding stream (Food Scraps, Recyclable Plastics, Recyclable Paper and Garbage). Notably, the Food Scraps stream includes food scraps as well as compostable containers from UBC Food Services and multiple other vendors on campus.

Once we had sorted through each bag, we measured the weight of the correctly sorted Food Scraps. Once again, subtracting the total weight of the container to obtain the true weight of the Food Scraps. We were then able to work out the weight of contamination for each bag, by subtracting the total Food Scraps weight from the original weight, as shown in the equation below:

Contamination (kg) = Original Bin Weight (kg) - Sorted Food Scraps Weight (kg)

The method of our data analysis is now described. For each station, we averaged the weight of contaminants by adding all of the contamination weights from one location, and dividing it by the total weight collected from that location. After this calculation, we divide the Contamination Rate for each location by four, to find the average level of contamination on a given day. During the week we spent auditing the Sort It Out Stations, on five occasions some bins (Buchanan, Sauder, UBC Fountain) had been emptied earlier than scheduled by UBC Waste Services and we were unable to collect data for these locations. We adjusted our calculations to reflect this:

Contamination Rate = (Contamination @ Location 1 (kg))/(Total Weight Collected @ Location 1 (kg))

Finally, we noted what percentage of contaminants belonged in Container Recycling or Garbage. This was done by counting how many contaminants there were in each bin and how many of them should have been diverted into a separate stream.

4.2 Survey

We chose to supplement our waste audit with survey data, in order to heighten our understanding of why contamination was ubiquitous across UBC BigBelly and UBC Sort It Out stations. Following advice from our SEEDS supervisors, we designed a survey that would complement our waste audit data with information on bin user behaviour (see Appendix, figure 2).

Data collection entailed six students administrating a 5 minute standardized structured survey across three of the eight bins (Triple O's, Sauder and UBC Bookstore). These bins were chosen due to having the greatest contamination rates and access to outdoor wifi; therefore, we assumed that these bin users would provide the best indicator of why contamination is prevalent across UBC. A sample size of 49 people on UBC campus was collected on 10th November 2015 between 12 and 2pm**.** This time was chosen, because it is one of the busiest times on campus, due to class changeover and people breaking for lunch. To obtain an accurate representation of UBC bin users, efforts were made to interview various people including age, gender and occupation, whether they were a UBC student, member of staff or visitor (McLafferty, 2010). Of

our sample, 91.8% were students and staff, 53.1% and 46.9% were women and men respectively, and the age group 17-21 dominated, shown below.

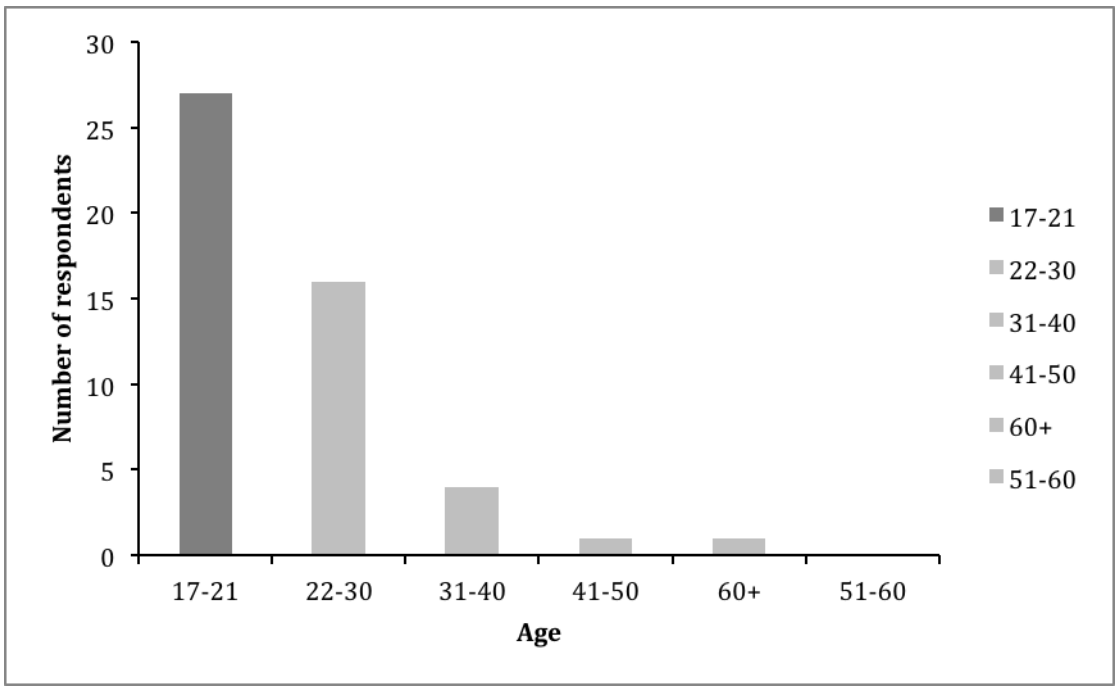

Figure 4. Respondents' age distribution.

We employed the simple random sampling technique to select respondents, because there is an equal probability of that individual being chosen (McLafferty, 2010). Our interviews were standardized to minimize bias, attain the respondent's 'true' viewpoint and ensure accuracy in processing the data (Bryman *et al.*, 2012; May and Williams, 2010). To acquire quick facts and unperceived information about the respondent's perceptions and interactions with composting at UBC, our survey contained diverse question types (Dunn, 2010; Frankel and Denver, 2000).

The survey questions ranged from closed, including likert scale, to open-ended. Closed questions provided the advantages of acquiring pre-determined data, which reduces the potential for interviewer error and answers are easily analysed (Bryman *et*

al., 2012). However, open-ended questions allowed the interviewer the acquire a deeper understanding of the interviewee's perceptions, attitudes, experiences, behaviours and interactions surrounding composting at UBC. (McLafferty, 2010). To create a strong survey, we therefore followed advice from Bryman *et al.* (2012) and Mclafferty (2010) to include a mixture of both.

To encourage people to be interviewed, we tried building rapport with them through an introductory statement, as advised by (Bryman et al., 2012). This included asking their consent to be interviewed and second, introducing ourselves and our research. Despite interviews being difficult to secure, they allowed the respondent to be guided through questions and the recording of field notes (May and Williams, 2010). This enabled us to create a scene in which reality is 'mirrored', as our field notes involved noting the scene and characterizing the individual, including any non-verbal gestures (Emerson *et al.,* 1995). Furthermore, our notes provided insight into correlation between how the respondent perceived their composting aptitude correlates and their actual aptitude.

5. Data Analysis

5.1 Contamination

One of the significant patterns that emerged when analysing our waste audit data was that on average, all of the outdoor Food Waste streams had a contamination rate above the 5% threshold, with our average being 10.22%. As aforementioned, the Common Energy UBC (2014) waste audit found that 11% of the materials in the Food Waste streams were incorrectly sorted. Therefore, our results correlate with Common Energy UBC (2014) findings and subsequently confirm, that achieving source

separation is a priority. This aligns with UBC Sustainability (2014), who believe it is crucial for source separation to be improved, in order to reduce the current (2013-2014) waste diversion rate of 61% and achieve the target 80% diversion target by 2020.

In terms of composition and frequency, the contaminants identified were largely dominated by three major groups: recyclable plastic cutlery, recyclable coffee cups and recyclable food containers. These findings suggest that bin users are confused between compostable items and recyclables. Based on our observations, it is evident that users mis-sort these items, most probably due to similarities in design, form and use of materials that look alike. Data from our survey highlights that 27.7% of the respondents did not know how to sort out compostable food containers, with 21.3% choosing to recycle them instead of composting. Recyclables constituted 52.6% of all the recorded contaminants, with 46.8% of these being cutlery, cups or containers. The remaining 47.4% of the items were identified as garbage, and for this group, no significant patterns emerged.

When comparing the waste audit data to the survey data, the results suggest a gap between what people think they are doing and what they are actually doing, in terms of sorting their waste. As shown in figure 5, 40.8% of the respondents sorted the hypothetical plastic cutlery incorrectly, of which, 0% of respondents said that they would put the item in the Food Scraps stream. This contradicts the waste audit data, in which 19% of the total contaminants detected was plastic cutlery. Coffee cups show a similar pattern; 12.2% respondents incorrectly sorted the hypothetical coffee cup, of which, only 4% of respondents said that they would put the item in the Food Scraps

stream. Again, this contradicts the waste audit data, which shows that 16% of total contaminants were coffee cups. Consequently, the UBC community illustrates that there is a gap between perceived ability and reality, corresponding with the field notes we took during our survey.

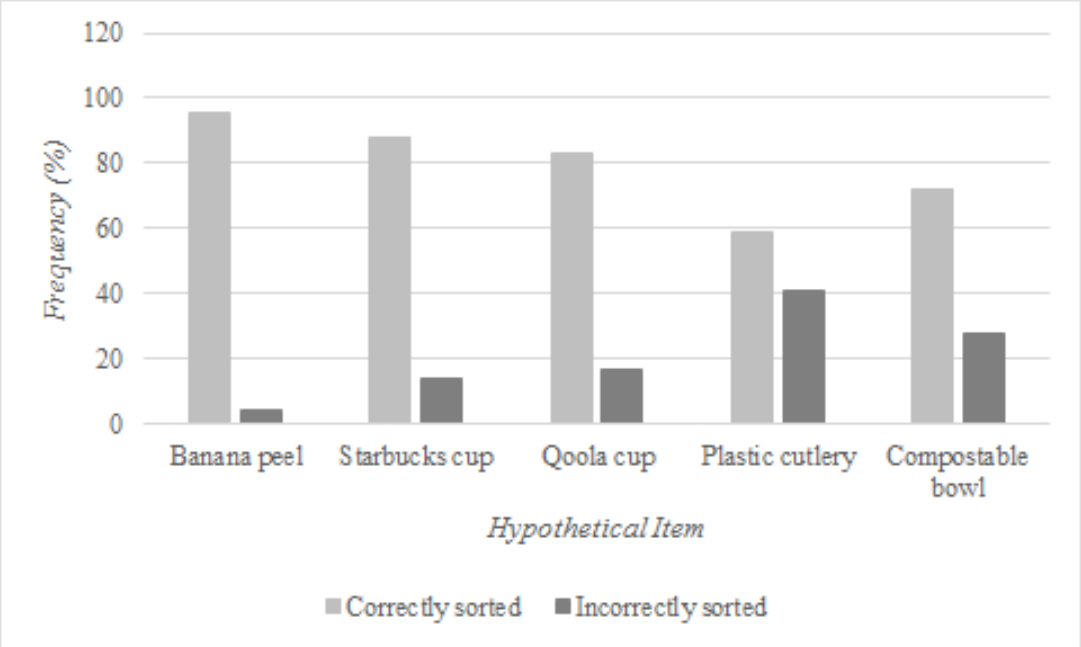

Figure 5. Hypothetical sorted items according to survey question 4 **(**see Appendix, figure 2)

5. 2 UBC Outdoor Waste Station Spatial Distribution

Our waste audit determined which bins on campus are subject to the most contamination; the most polluted bin is located near the Triple O's on Main Mall and Agriculture Boulevard, with an average contamination rate of 15.61% everyday (Figure). Understanding that the UBC In-vessel composter can only accept under 5% daily contamination, this proves to be a problem. In total, five locations were found over this threshold: The Trolley Bus Loop, Triple O's on Main Mall, The UBC Fountain on Main Mall near the Biology Building, Forestry and Sauder School of

Business (Figure 1). The bin with the least contamination was located near the Earth Sciences Building with an average daily contamination rate of 5.5%.

In our qualitative research survey, we also asked respondents the question, "What, if anything, would encourage you to compost at UBC?" and 34.7% of people recommended more bins on campus. Currently the bins are concentrated near the centre of campus close to the UBC Fountain. This is strategic because it has high volumes of pedestrian traffic, there are gaps between the Earth Science Building and Forestry and between the Triple O's and Buchanan, as shown in Figure 1. There also remain no Sort It Out Stations on other university thoroughfares such as Lower Mall, Agronomy Road, or West Mall.

5.3 User Engagement

User engagement is analysed to explore the links between UBC's high contamination rates of food scraps and bin users' attitudes, behaviours, knowledge and perception to composting and UBC's Zero Waste Campaign. The survey data aligns with the literature (e.g. Hottle and Bilec, 2015; Common Energy UBC, 2014; Kaplowtiz *et al*., 2009; Kelly *at al.,* 2006), implying that the success of UBC's campaign is largely reliant on consumer engagement and behaviour, of which much is lacking in terms of composting.

Although approximately 80% of bin users expressed their pro-environmental behaviour by declaring that they compost, when asked to define 'composting' many were uncertain. Respondents replied with ambiguous answers ranging from "not sure" (Respondent 19) to "throwing away stuff according to the labels" (Respondent 1) and

"making use of food waste and other organic materials instead of just throwing it away" (Respondent 22). This evidently shows that consumers lack understanding of composting, which supports Common Energy UBC's (2014) finding, that students have deficient knowledge and awareness of composting.

However, despite the majority of respondents not fully understanding what composting was, users believed that composting was important for our planet's health and part of a sustainable lifestyle (see table 1). This correlates with more than 80% of respondents agreeing that they enjoy composting, because it contributes them to leading a pro-environmental lifestyle (see figure 6). Furthermore, more than 50% said they composted elsewhere (see figure 6). These results are incongruous with studies by Kaplowitz *et al.*, (2009) and Byrne and O'Regan (2014), because UBC bin users appear to have strong moral convictions for composting and positive pro-environmental behaviour, which should create low contamination rates across UBC stations, rather than high contamination rates.

Table 1. Respondents reasons for composting.

Factors Important to respondents	Per cent of responses (%)	Number of respondents
Sustainable lifestyle	***95.8***	***46***
Reduce amount of waste to landfill	**77.6**	**38**
Positive environmental impact	**69.4**	**34**
Composed material is useful for gardening	36.7	18
Municipal law	26.5	13
Bin signage	24.5	12
UCB's Zero Waste campaigns	10.2	5
Other	0	0

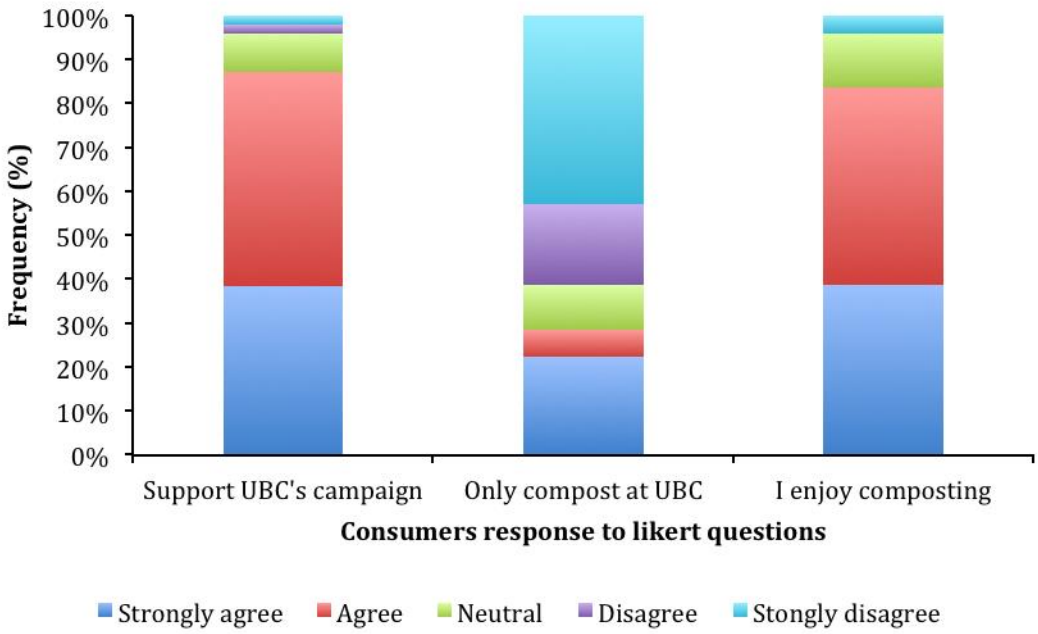

Figure 6. Respondents' responses to the likert Question 9 (see Appendix, figure 2).

Notably, there is a discrepancy between respondents' answers regarding UBC's Zero Waste campaign. When asked why users compost, just 10.2% said it was an

important factor whereas more than 80% agreed that supporting UBC's Zero Waste campaign by composting was important to them.

These results imply that UBC bin users have strong moral convictions for composting, because a pro-environmental lifestyle is important to them. Echoing Hottle and Bilec (2015), the social components of composting are complex and this study indicates there are underlying social factors, other than moral motivations, driving contamination across UBC. This will be explored next.

5.4 Visual Design of the Outdoor Waste Stations

To understand the correlation between signage and user's ability to accurately divert waste, we first looked at the characterization of the contaminant. This showed the impact signage has on the contaminants placed in the bins. Secondy, we analysed our survey results to see if signage helped people divert their waste properly. The survey results also contained respondents' comments on bin signage and their overall impression about UBC's Zero Waste campaign.

While looking at the characterization of contaminants, disposable paper cups appeared most often, despite a sign of a paper cup on the recycling bin. This is significant to identify, as disposable cups have a large contribution to the total weight of contaminants.

In our survey, respondents were asked where to put their waste between food scraps, recycling bins and garbage bins. Due to time constraints and weather conditions, some respondents were not surveyed in front of stations. Figure 5 below shows how

often each item was diverted accurately or inaccurately. Plastic cutlery and compostable bowls had especially high rates of inaccuracy in bin placement. Despite "plastic" being written on the recycling stream, there was no visual of plastic cutlery, which could explain why plastic cutleries were inaccurately placed. In contrast, visuals of compostable containers are depicted on the compost bin and had lower contamination rates compared to plastic cutlery. These figures show that visual signage might have an impact on lowering contamination rates.

When asked how users could encourage more composting at UBC, 26.5% of responses said improvements of signage. Most the responses stated that clear signage will help encourage composting efforts while others stated that placing the signs at a higher location would make it more visible. Some suggested creating signs with physical items that belong to the bin for better understanding. These responses show that signage plays an important role in clarifying the sorting of items for the UBC community.

6. Significance of proposed research

Understanding the driving forces of contamination and its physical make up is significant because it can lead to less waste in the landfill. Landfills produce chemicals that are detrimental to the environment, such as high quantitates of Methane Gas ($CH_4(g)$) and Leachate (Themelis and Ulloa, 2007; Lo, 1996). Methane Gas is considered to be twenty times more potent than Carbon Dioxide ($CO_2(g)$), while Leachate is considered 'Garbage Juice' or any liquid that has dissolved while in the landfill and has the potential to seep into the land, and thus can pollute ground water (Lo, 1996; Lema *et al*, 1988). One example of this can be e-waste, which has

substances such as mercury and arsenic, which is not only dangerous for our environment but also humans. Reducing the amount of organic material entering the landfill is critical because organic matter does not break down in landfills because it is an anaerobic environment thus lacking oxygen necessary for matter to break down (Lema *et al,* 1988). If organic material ends up in the landfill due to poor sorting behaviour, it will only contribute to the creation of methane gas and leachate.

Furthermore, this research project will aid in understanding the underlying reasons behind the high contamination rates across UBC and contribute towards UBC's Zero Waste Action Plan. An array of studies (e.g. Angelique & Quimby, 2011; Kelly *et al*, 2006; Geller, 1989) correlate to the survey and waste audit data, regarding factors influencing contamination rates. In addition, the aforementioned scholars believe and support the idea that behavioural change is a pivotal factor that could potentially improve the rate of food waste composting habits.

The waste audit that we conducted only focused on the food-scraps stream; nevertheless, the results suggest that the level of education and outreach are key determinants in a bin user's ability to properly divert their waste. Common Energy UBC (2014) found Food Scraps contamination rate was estimated at 11%. Because the contamination rates cannot exceed 5%, the food-scraps stream contributed directly to the increase in material arriving at the landfill. Our results found that the average contamination rates was 10.22%, demonstrating that there was a reduction in the contamination by 0.78%. In the next section we outline potential interventions or other research opportunities which will work towards lowering contamination rates below the 5% threshold to further decrease the amount of waste being sent to the landfill, and thus polluting our environment.

7. Future Research Directions

Based on our waste audit data, survey results and literature review, we have arrived at a set of potential solutions that can help UBC maximize their waste efforts. These suggestions aim to guide future research on the topic of increased waste diversion by targeting the social and spatial factors that influences waste sorting habits.

We recommend a future intervention that helps the UBC community distinguish items that are compostable and recyclable. Both our waste audit data and our survey data show that people are either confused or do not understand the difference between compostable and recyclable. For instance, some of these items are visually similar and are accompanied with symbols (eg. a green leaf) to indicate the items as recyclable or compostable; however, there is no explication on which one is which. By having the UBC community understanding which items are compostable or recyclable, this will reduce the frequency of recyclables that end up in the compost stream, which will further decrease contamination rates.

Furthermore, we suggest more research on whether bin users are more confused by the *products* that go in to the bins or the *design* of the bin itself. When asked about the functionality of UBC's Sort It Out campaign survey respondents had mixed feedback, saying that the stations are easy to use (42.9%) and have clear signage (38.8%), but at the same time 22.4% find the stations confusing. To add to this, clearer signage was second on the list, after more bin locations, when people were asked which initiatives would encourage them to compost more at UBC. Drawing on our field notes, the same patterns appear: a number of respondents found waste sorting at UBC

complicated and confusing, but said that signs are clear. These contradictions indicate that something other than signage is creating confusion. Based on our observations during the waste audit, the apparent inconsistency regarding labelling and design of take-away utensils and containers across UBC food vendors, is one major reason for high contamination rates in the outdoor food scrap stream.

Research by Byrne and O'Regan (2014) and Kaplowtiz *et al*. (2009) has suggested that the creation of social norms can have a positive impact on waste diversion. These norms are created through the presence of friends and family taking action which reflects these values. A potential intervention could be gathering a large group of leaders on campus, such as Residence Advisors (RAs), and educating them about the impacts of landfills and contamination and asking them to disseminate this information to their residents. UBC has approximately 9,400 students living on campus, and Residence Advisors must meet with each of their residents throughout the academic year, giving them the opportunity to reach a large pool of people and passing on the education and knowledge they have received, hopefully encouraging more students to be aware of the waste they produce.

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Appendix 1.

Table 1: Waste Audit Data

Bin Location	Date	Total Weight (kg)	Weight Compost (kg)
Bus Loop	October 13th	6.2	5.6
Book Store	October 13th	10.4	9
Triple O's	October 13th	4.2	3.2
EOSC	October 13th	9.6	9.4
Sauder	October 13th	8.8	7.6
UBC Fountain	October 13th	4.8	4.6
Buchanan	October 13th	3.4	3.2
Bus Loop	October 14th	5.6	5.2
Book Store	October 14th	5	4.8
Triple O's	October 14th	-	-
EOSC	October 14th	4.6	4.4
Sauder	October 14th	5.4	4.4
UBC Fountain	October 14th	8.6	7.2
Buchanan	October 14th	5	4.8
Bus Loop	October 15th	3.2	3
Book Store	October 15th	3	3
Triple O's	October 15th	5.4	5
EOSC	October 15th	3.8	3.2
Sauder	October 15th	4.8	4.6
UBC Fountain	October 15th	-	-
Buchanan	October 15th	4.6	4.2
Bus Loop	October 16th	3.8	3
Book Store	October 16th	2.4	2.2
Triple O's	October 16th	-	-
EOSC	October 16th	3	3
Sauder	October 16th	-	-
UBC Fountain	October 16th	-	-
Buchanan	October 16th	1.8	1.6

Figure 1. Survey

a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

Department of Geography, Faculty of Arts

Master Questionnaire

Hello, I am a student at University of British Columbia and I am researching people's composting habits at UBC for my geography course. More specifically, I am looking at the factors affecting people's composting habits at this bin.

I would like to ask you a few questions about your visit today; these should take about 5 minutes to answer. If you feel uncomfortable at any time, please feel free not to answer the question. All answers will be entirely anonymous.

Thank you very much for your time.

Start of Survey

First, we'd like to ask you a few general questions about where you are from and if you have used this bin before.

1. Do you work or study at UBC?

◯ Yes (goto1A) ◯ No (goto1B)

1A. Would you mind telling me at which faculty you study/work at?

1B. Would you mind telling me where you are visiting from?

2. Do you compost?

◯ YES ◯ NO

3. How would you define composting?

4. We will now show you 5 items, please could you identify if they go in the compost, recycle or garbage bin?

Banana peel:

◯ Food scraps

◯ Container recycling

◯ Garbage

Starbucks cup:

◯ Food scraps

◯ Container recycling

◯ Garbage

Qoola cup:

◯ Food scraps

◯ Container recycling

◯ Garbage

Plastic cutlery:

◯ Food scraps

◯ Container recycling

◯ Garbage

Compostable bowl:

◯ Food scraps

◯ Container recycling

◯ Garbage

5. Why would you compost? (check all that apply) ***Interviewer: show options to interviewee as prompt if necessary.***

☐ Sustainable lifestyle ☐ Reduce amount of waste ☐ Municipal requirement
☐ Composted material useful for gardening ☐ Positive environmental impact
☐ Bin signage ☐ UBC's campaign ☐ Sustainable lifestyle

☐ Other (please specify)

6. What did you put in the bin today?

Prompts: cutlery, starbucks cup, frozen yogo

6a. Did you put these items in the compost, recycle and/or garbage bin?

7. How would you describe UBC's composting campaign to a friend who has never visited before?

☐ Easy ☐ Clear signage ☐ Food waste and compostable paper only ☐ Green bins

☐ Confusing ☐ Poor signage ☐ Complicated ☐ Don't know ☐ Didn't know there were any regulations ☐ Other

8. What, if anything, would encourage you to compost more at UBC?
Prompts: Clearer signage? Clear stickers on items? More bin locations? Social media campaign? Composting event? If your friends composted and tweeted would this encourage you?

9. On a scale from 'Disagree Strongly' to 'Agree Strongly', how do you feel about the following statements (please choose one for each question):

9A. Supporting UBC's Zero Waste Plan by composting is important to me.

. Disagree Strongly Disagree Neutral Agree Agree Strongly

9B. I compost at UBC, but nowhere else.

Disagree Strongly Disagree Neutral Agree Agree Strongly

9C. I enjoy composting, it makes me feel good leading a more environmentally friendly lifestyle.

Disagree Strongly Disagree Neutral Agree Agree Strongly

Market Survey

Demographics

Finally, I'd like to you ask you a few questions about you. If at any point you feel uncomfortable with a question, please feel free not to answer.

10. What is your gender?

◯ Male ◯ Female

11. What is your age range?

◯ 17-21 ◯ 22–30 ◯ 31–40 ◯ 41-50 ◯ 51-60 ◯ 60+ ◯ Prefer Not to Say

Thank you very much for your time today, your answers will help us to understand the factors affecting the rate of compost contamination of the UBC's outdoor bins.

Personal Notes/Reflections

For interviewer to complete at end of the survey.

17. Place of interview:

18. Date and time of interview:

19. Name of interviewer:

20. What are your own reflections on the interview (*student to complete*)
Prompts: what went well & what didn't? Did anything that the respondent said strike you as surprising or unusual? Is there anything that they didn't say which you expected them to say? How might you get better results from the next respondent?

Table 2. Survey Results

Respondent	Time	UBC student/ faculty and employee	Department	Do you compost?	Place of Interview	What is your gender?	What is your age range?
Respondent 1	11/13/2015 13:32	Yes	accounting	Yes	Tim Hortons	Female	22-30
Respondent 2	11/10/2015 14:45	Yes	Arts	Yes	Sauder	Male	17-21
Respondent 3	11/10/2015 14:55	Yes	Arts	Yes	Sauder	Male	17-21
Respondent 4	11/10/2015 15:11	Yes	Arts	Yes	Sauder	Female	17-21
Respondent 5	11/13/2015 13:14	Yes	arts	Yes	Tim Hortons	Male	17-21
Respondent 6	11/13/2015 13:17	Yes	Arts	No	Tim Hortons	Female	17-21
Respondent 7	11/13/2015 13:44	Yes	Arts	Yes	Tim Hortons	Female	17-21
Respondent 8	11/13/2015 18:08	Yes	Arts	Yes	Nest	Female	22-30
Respondent 9	11/16/2015 18:35	Yes	Arts	Yes	Geography building	Female	17-21
Respondent 10	11/12/2015 12:10	Yes	Arts	Yes	Bookstore	Female	22-30
Respondent 11	11/12/2015 12:57	Yes	Arts	Yes	Bookstore	Male	22-30
Respondent 12	11/12/2015 13:18	Yes	Arts	Yes	Bookstore	Male	22-30
Respondent 13	11/10/2015 14:57	Yes	Commerce	Yes	Tim Hortons	Female	17-21
Respondent 14	11/10/2015 15:05	Yes	Commerce	Yes	Sauder	Female	17-21
Respondent 15	11/10/2015 15:12	Yes	Commerce	Yes	Sauder	Female	17-21
Respondent 16	11/12/2015 13:40	Yes	Commerce	Yes	Sauder	Male	22-30
Respondent 17	11/12/2015 15:14	Yes	Commerce	Yes	Sauder	Male	17-21
Respondent 18	11/13/2015 13:07	Yes	Commerce	Yes	Tim Hortons	Female	17-21
Respondent 19	11/13/2015 13:33	Yes	Commerce	Yes	Tim Hortons	Female	17-21
Respondent 20	11/12/2015 12:35	Yes	Commerce	Yes	Bookstore	Female	22-30
Respondent 21	11/12/2015 13:31	Yes	Commerce	Yes	Sauder	Female	22-30

Respondent 22	11/12/2015 12:32	Yes	CTLT	Yes	Bookstore	Female	41-50
Respondent 23	11/10/2015 14:34	Yes	Engineer	Yes	Sauder	Male	17-21
Respondent 24	11/13/2015 18:01	Yes	Engineering	No	Nest	Male	22-30
Respondent 25	11/13/2015 13:40	Yes	Engineering	Yes	TH	Female	17-21
Respondent 26	11/13/2015 13:34	Yes	Engineering	Yes	Nest	Male	17-21
Respondent 27	11/13/2015 13:20	Yes	English	Yes	TH	Female	17-21
Respondent 28	11/10/2015 14:56	Yes	Exchange Student	Yes	Tim Hortons	Female	17-21
Respondent 29	11/13/2015 19:20	Yes	Enrollment services	Yes	Nest	Female	31-40
Respondent 30	11/13/2015 12:03	Yes	Forestry	Yes	Geography building	Male	17-21
Respondent 31	11/10/2015 15:02	Yes	MBA	Yes	Tim Hortons	Male	22-30
Respondent 32	11/13/2015 13:10	Yes	Music	No	TH	Male	22-30
Respondent 33	11/10/2015 15:02	Yes	Pharmacy	Yes	Bookstore	Male	22-30
Respondent 34	11/12/2015 13:12	Yes	Pharmacy	Yes	Bookstore	Male	22-30
Respondent 35	11/10/2015 14:24	Yes	Private TA	No	Triple Os	Male	22-30
Respondent 36	11/13/2015 22:01	Yes	Psychology	No	N/A	Female	17-21
Respondent 37	11/10/2015 15:04	Yes	Sauder	No	Tim Hortons	Female	17-21
Respondent 38	11/10/2015 14:39	Yes	Sauder	Yes	Sauder	Male	17-21
Respondent 39	11/10/2015 14:50	Yes	Science	Yes	Sauder	Female	17-21
Respondent 40	11/10/2015 15:00	Yes	Science	Yes	Sauder	Male	22-30
Respondent 41	11/10/2015 15:17	Yes	Science	Yes	Sauder	Male	22-30
Respondent 42	11/13/2015 13:02	Yes	Science	Yes	Tim Hortons	Female	17-21
Respondent 43	11/13/2015 13:05	Yes	Teacher	Yes	Tim Hortons	Female	31-40
Respondent 44	11/10/2015 14:30	No		No	Triple Os	Female	17-21

Respondent 45	11/10/2015 14:32	No		No	Sauder	Male	31-40
Respondent 46	11/10/2015 14:44	No		Yes	Bookstore	Male	60+
Respondent 47	11/10/2015 15:12	No		Yes	Sauder	Male	17-21
Respondent 48	11/12/2015 12:20	No		No	Bookstore	Male	31-40
Respondent 49	11/13/2015 13:01	Yes		Yes	Tim hortons	Female	17-21

Table 3: Contamination Rates at each outdoor waste station

Location	Contamination rate total (%)	Daily Average* (%)	Percentage of recyclables
Bus Loop	44.12	11.03	37.5
Bookstore	25.79	6.45	50
Triple O's	31.22	15.61	46.6
EOSC	22.22	5.55	50
Fountain	20.45	10.22	50
Forestry	53.33	13.33	64.7
Sauder	36.33	12.11	69.4
Buchanon	29.69	7.42	52.7

Table 4. Respondent's definition of composting

Respondent	How would you define composting?
Respondent 1	throwing away stuff according to the labels
Respondent 2	Organic material
Respondent 3	Food scraps you don't eat
Respondent 4	Not throwing everything in garbage
Respondent 5	putting decomposable food/stuff into a compost
Respondent 6	Putting food in designated places
Respondent 7	Anything that we can eat
Respondent 8	Unfinished food and food waste
Respondent 9	Follow the instructions on bin, just sorting it out
Respondent 10	recycling leftover food
Respondent 11	Recycling food

Respondent 12	Not wasting food by putting into the garbage, make it into something useful
Respondent 13	Food waste into green bin - unsure
Respondent 14	
Respondent 15	
Respondent 16	Not putting food into garbage, using it for soil
Respondent 17	Breaking down of food into material that can be reused
Respondent 18	To make recycling easier
Respondent 19	Not sure
Respondent 20	Breaking down of food
Respondent 21	Putting food into compost....?
Respondent 22	making use of food waste and other organic materials instead of just "throwing it" away
Respondent 23	Breakout of inorganic material
Respondent 24	Separating food scraps and other paper bag etc from other garbage
Respondent 25	I know things that can be composted and places them in compost!
Respondent 26	sorting of organic waste, not wasting food that we have no use for, reuse the resource, sustainability
Respondent 27	Not sure
Respondent 28	don't know
Respondent 29	where food scraps go, where the signs tell me where to put my food scraps
Respondent 30	bringing food scraps back into soil
Respondent 31	using biodegradable stuff to compost
Respondent 32	separating organics
Respondent 33	Breaking down organic material
Respondent 34	Putting food into composting instead of garbage
Respondent 35	Putting organic waste in food scraps
Respondent 36	Recycling food and other organic material to convert it to be efficient
Respondent 37	Processing food for fertilizer
Respondent 38	Putting organic materials in to the reuse for fertilizer
Respondent 39	Returning the things that come from the earth to the earth
Respondent 40	Biodegradable
Respondent 41	Making sure Organic waste goes right place
Respondent 42	leftover food scraps place in compost
Respondent 43	own compost bin at home
Respondent 44	Food scraps use it for soil stuff
Respondent 45	Recycling organic material
Respondent 46	Recycling food finish
Respondent 47	Didn't know what it was.
Respondent 48	Making use of leftover food into something else (eg. soil)
Respondent 49	Recycling