UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Accessibility and Contamination:

A Mixed-Methods Study of How Location May Affect Green Bin Contamination at UBC

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Research Strategies in Human Geography

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Abstract

This research report is written in collaboration with the Social Ecological and Developmental Studies (SEEDS) sustainability program at the Vancouver campus of the University of British Columbia (UBC) in Vancouver, BC. The research and data collection are conducted under the guidance of SEEDS representative Bud Fraser.

The study explores the waste management practices at UBC through the assessment of waste bin contamination levels of 47 waste bins located at the South of UBC. Given the multi-faceted importance of reducing green bin contamination, this research report examines the problem of contaminated green bins across the UBC campus. Specifically, we attempt to answer whether there is a relationship between green bin accessibility and their level of contamination. 'Accessibility' is explored from two perspectives: 1) the relative location of green bins to building (front/back), and 2) green bin proximity to pedestrian pathways. As of April 2020, SEEDS do not have a comprehensive database of locations and quantities of waste bins. This is one of the deliverables of our project, and perhaps what will be of most use.

Using the methods of geographical information science (GIS), this research problem is explored through the creation of a database, two maps, and a spatial analysis of these maps. Overall, there were no major findings in support of a relationship between green bin contamination and accessibility. However, green bins located in remote locations (in the back of buildings; further from pedestrian pathways) tended to have lower rates of contamination.

Notably, the findings and research of this report have been significantly reduced by the unprecedented circumstances of COVID-19. Consequently, we were unable to collect and analyze data collected from our additional, originally intended research methods: semi-structured interviews of the UBC operational waste management staff and an ethnographic waste-collection ride-along.

Introduction

The Social Ecological and Developmental Studies (SEEDS) is responsible for the operations of the UBC's composting program. The SEEDS waste bin project is a collaborative effort between SEEDS and UBC students, and a way for SEEDS to monitor its composting operations and ensure that they are operating smoothly (Composting | Building Operations, 2020). The objective of this research is to find whether waste bin locations affect the level of waste bin contamination, using the methods of green bin data collection and spatial analysis (ArcGIS) to create a database for SEEDS and facilitate in the optimization of green bin placement.

On a campus scale, the regulations of green bins at UBC intended to prevent contamination are not fully effective. The green bins studied in this research project are located in the outdoor area and intended for the professional, pickup truck collection of the waste only. According to SEEDS, contamination is increasingly an issue at the UBC campus as non-professional pedestrians are found to use these bins to dispose of personal waste items (UBC SEEDS, 2020). These items are often non-compostable and may cause the green bin compost being sent to landfill rather than used for compost. Furthermore, the SEEDS composting program is a part of UBC's commitment to zero waste. According to UBC Building Operations, most – but not all - buildings participate in the composting program. To reach the target of zero waste, it is therefore crucial to ensure organic waste collection at *all* locations (Composting | Building Operations, 2020).

Notably, the study of waste contamination is important on a national scale as well. In Canada, the idea of rigorous waste management became near inevitable in 2018, after China made drastic changes in their national environmental policies. Known as the National Sword Policy, China cut waste imports by close to 98% and declared it would no longer serve as "the dumping ground of the world" (Hook & Reed, 2018). In Canada, China's policy triggered a waste management crisis: Prior to 2018, Canada had exported more than 50% of its waste to China for processing under near-nonexistent standards of contamination that allowed Canadian plants to accept high levels of contamination.

Following the implementation of the Sword Policy, however, contamination standards rose, and Canadian waste imports were cut by near 98% (Jarvis & Robinson, 2019). Unexpected and unannounced, Canadian waste management plants found themselves overwhelmed and with low capacity to properly sort and recycle contaminated waste. Furthermore, China's policy had created a global ripple effect of waste requirements (Jarvis & Robinson, 2019). Consequently, large portions of Canadian waste ended up in landfills.

More than two years after the initial shock of the National Sword Policy, much of Canada's recyclable waste continues to end up in landfill. This is of importance as landfills have shown to have significantly negative impacts on the environment. As recently highlighted by UBC Sustainability, landfills release significant amounts of methane into the air, causing air, water and soil pollution (UBC Sustainability, 2020). Given the global and national shifts in waste management practices, the harmful consequences of landfills and the increasing intolerance for contamination, we therefore stress the importance of the study of contamination and attempt to answer whether there is a relationship between green bin accessibility and their level of contamination at UBC.

Literature Review

Today, waste-management initiatives are observed across university campuses worldwide (Sima & Balteneanu, 2019; Gallardo et al. 2019; Smyth & Booth, 2010). In our research, we define waste management as the activity involved in the transportation of waste from point A to point B. It may contain a series of activities ranging from transportation to sign-posts or deliberate placement of waste bins. Contamination is defined as the presence of a non-organic matter within an organic waste bin and used as a measure of waste management efficiency. Although less visible, Moessinger (2000) notes contamination as a form of disorder: "a functional breakdown (…) in the pursuit of an important goal" (pp.102). Amongst the numerous challenges to the creation of more efficient waste management systems amongst universities, the especially large size of some North American universities is mentioned as a challenge to the effectiveness of university waste management by several scholars (S. S. & Khandelwal 2017; Ebrahimi & North 2017). In the instance of UBC, improving waste-management systems is a complex process only further challenged by the physical size of its land parcel: As of 2019, the UBC Vancouver campus is estimated to be approximately 400 hectares (The University of British Columbia 2019).

In response, several scholars point to the efficiency of a standardized system to identify highly efficient universities and examine their habits/processes. For instance, Ebrahimi & North (2017) studied the implementation of a standardized grading criterion. Dubbed the "Green Report Card", the grading criterion was implemented amongst 17 large U.S Universities and included a survey and follow-up interviews with the participating universities. According to the authors, high-scoring universities all followed systemized waste management plans that focused on the efficient use of space.

Notably, the study also found a collaborative use of internal resources. For instance, one of the highest scoring universities, Appalachian State University, cleverly expanded their recycling program by commissioning a group of graduate students with the task of using their knowledge of campus to identify the most optimal location of campus waste bins. Through their research, the students recommended more sorting stations and all stations be marked with recycling guidelines (stickers/infographics). These recommendations were followed: 6 years later, Appalachian State University had reduced its waste to landfill by more than 36 tons (Ebrahimi & North).

In their study of a large Canadian university, the University of Northern British Columbia, Smyth et. al. (2010) follow a similar approach. Much like Ebrahim and North (2017), their conclusion suggests room for improvement in the strategies already implemented by the University of Northern British Columbia. The factor of size and space is given greater attention than the piece by Ebrahim and North, and the authors specifically use location-based strategies such as maps to track and identify the location of garbage, recycling, and compost waste bins and their level of contamination. Both studies find a correlation between the two.

Furthermore, Smyth et. al. expand scholarly discourse even further by including the assessment of not only the location of waste-bins but the materials that were thrown away in these waste bins. This was done through a sample of waste materials which were separated into 12 primary waste categories and 24 secondary waste categories. As a result, the focus moves from waste-management in space alone, to include what materials were thrown away and how much.

Described as 'underlying mechanisms' by Smyth et. al., the importance of including the composition of waste bins in the study of waste management systems has been highlighted by several scholars and often stretch beyond the physical, to include perspectives of interaction between society and waste management systems (Saleem et. al. 2018; Edjabou et. al. 2015; Wheeler 2014; Gallardo et. al. 2019) As stated by Saleem et. al., understanding peoples' (re: students and staff) attitudes toward waste should be a crucial component in the long-term, sustainable waste-management practices of universities. (Saleem et. al. 2018) This is also expressed in the SEEDS itinerary, in which they suggest testing the viability of possible solutions such as moving highly contaminated waste bins to less accessible locations, alluding to the habit of convenience and proximity in the interaction between waste bins and people (UBC Social Ecological Economic Development Studies 2019).

Within this aspect of waste management, scholarly conversation is clear: Resolving the issue of contamination must include gaining an understanding of the underlying mechanisms that prevent current waste-management systems from operating efficiently (expressed by SEEDS as the contamination of organic-waste bins across campus). Which mechanism to focus on, is however contested amongst scholars. While some, such as Wheeler (2014), argue waste contamination as a reflection of general attitudes of the public towards recycling, others, e.g. Gallardo et. al. (2019) argue for environmental structures and more tangible solutions, such as reducing the serving size at university cafeterias.

As a third alternate to the aforementioned scholarly perspectives, Bolaane (2006) criticizes the literature on waste management as too saturated by human-centered approaches. According to Bolaane, more attention should instead be given to institutional structures and their failures to implement and maintain viable waste management systems. As an example, Bolaane highlights the ways in which knowledge of waste and management systems tend to be limited amongst the very same municipalities behind waste-management schemes; As they do not understand waste, they are not able to create efficient systems to manage it. Bolaane argues that this not only limits participation amongst the general population but leads to the failure of waste management initiatives (in our case, contaminated bins). A similar notion is also found by Howell (2015), who in his study of the waste management system of Maui, found a lack of knowledge around waste as one of the leading causes for the development of a viable environmental infrastructure of the island. For Maui, this resulted in a doubling of costs related to waste management, to which its private consumers took most of the burden.

Relating the article specifically to waste management at UBC, Bolaane's perspective makes an interesting contribution to our research problem of waste contamination in compost bins.

For instance, while there may be signs that discourage the general population from utilizing waste bins belonging to UBC buildings, the aforementioned findings support the idea of physical intervention (i.e. removing waste bins from visible location) as an efficient strategy to prevent contamination. Bolaane however, seems to suggest that there must also be knowledge and awareness amongst the institutions behind the waste management systems. Through a Bolaane lens, it therefore seems highly relevant to include interviews with members of the UBC building operations.

Although the argument of Bolaane on the limited knowledge of municipalities is fair in that it devests public contribution to a solution, it cannot be assumed that the study represents every municipality. A guide for solid waste management planning, provided by British Columbia's Ministry of Environment (2016), lays the groundwork for waste management with the aim of helping regional districts create plans to meet their local goals. Recommended practices include human-centered approaches such as informational strategies aimed at changing behavior and informing decisions, e.g. better labelling of products and recycling bins as well as other forms of public recognition (British Columbia Ministry of Environment, 2016).

The British Columbia Ministry of Environment also stresses the importance of an effective waste management plan as a proven way to reduce the amount of solid waste that requires disposal in a region (British Columbia Ministry of Environment, 2016). Ebrahimi and North (2017) reach a similar conclusion, as they in their study of university waste management systems found that large scale universities with systemized waste plans were the most effective and efficient.

Because UBC’s building operations are on a similar scale to that of a small city, we find it reasonable to apply the suggestions in the Solid Waste Management Plan to the SEEDS Waste Bin Inventory project. For example, a method used to evaluate effectiveness includes implementing weight scales for better disposal data, which SEEDS is already planning to carry out (British Columbia Ministry of Environment, 2016). As the detailed plan of the BC Ministry of Environment has proved to implement long-term change, it may serve as a guide to improve UBC’s waste management system.

Ultimately, waste management is important and must be further understood to support a sustainable future on campus. A standardized system involving location, tracking and

weighting waste bins can be a useful tool in waste management as laid out by SEEDS (2019), as well as Ebrahimi and North (2017). Furthermore, the literature also highlights education as valuable: As seen in the BC Ministry of Environments study, a detailed education strategy was crucial in making change last (British Columbia Ministry of Environment, 2016).
In all, continued education on waste and how to ultimately reduce it is necessary for any successful outcome. If we choose to adopt some of the BC Ministry of Environment's suggestions, we could have the opportunity to make a lasting impact on UBC's current waste management system.

If people on campus participate in a collective action to sort their individual organic debris and garbage, waste sites could have the opportunity to minimize the contamination within green bins. Maintaining awareness is imperative in this regard, as contamination of the green bins results in the entire bin contents being sent to the landfill (British Columbia Ministry of Environment, 2016), a consequence that holds environmental implications such as landfill gas (Maletz, R., Dornack, C., Ziyang, L. 2018). In addition, this material (organic or the recyclable material contaminating the organic bin) cannot be composted or recycled (Buildingoperations.ubc.ca, 2020). Nevertheless, the debate of whether the extent of contamination is people's attitudes and lack of knowledge, or if it is a matter of physical accessibility to waste bins is still a contested issue and requires further research (Bolaane, 2006; Ebrahimi and North, 2017).

UBC does have a Zero Waste Action Plan in place, and UBC Building Operations approach is focusing on integrating organic waste bins in strategically located outdoor areas, as well as hallways, lobbies, lounges and easily accessible places for peoples' convenience (Buildingoperations.ubc.ca 2020). This solution requires community participation and a shared consciousness around individual waste. The notion of "Zero Waste" originates at the source and gives the individual the responsibility of being accountable for their debris. Utilizing the strength of a sense of community as a sustainable solution is therefore a viable option to reduce the contamination of green waste bins.

As noted by Kallianos (2018) in his study of the waste management of Athens as it crumbled under the Greek-government debt-crisis, disorder within waste management is never planned for and hard to account for when designing a waste management system. To create a system that is sustainable in the long term, Kallianos argues that they must also understand the underlying motivations and behaviors of its users (or misusers).

This notion is mentioned by Guzman and De Souza (2018), who argue that institutions like UBC can increase the stabilization of their programs involving human to non-human interactions by understanding the social relationships within its social mix. By conducting interviews with UBC building operations, our group hopes to determine the stability of these social relationships and explore whether this has an effect on how waste is viewed.

These final reflections from Kallianos (2018) and Guzman and De Souza (2018) require knowledge outside of what is obtainable from a geodatabase alone. For our project, we therefore accompany the geodatabase with one-on-one interviews with UBC building operations staff to gain insight into how waste is viewed. It is essential to gauge a better understanding of the public's attitude on waste management because it will give us a better understanding of how humans interact with non-human objects like waste bins.

Methodology & Study Design

For our study of UBC waste management, we focus solely on the green waste bins; specifically, how accessible these bins are to people on campus and whether this accessibility correlates with their level of contamination. The UBC campus is an estimated 400 hectares (The University of British Columbia 2019). Due to constraints in time, examining all of campus would simply be impossible. Hence, the very first step in our research strategy was to split campus into two equal pieces (North and South). This was done in collaboration with SEEDS Group 1, and we chose the South side as our ‘unit of observation’.

As a first step in our study design, we used a hierarchical arrangement to describe how our information was collected. The unit that our group focused on was the UBC Vancouver's South campus and broke it down to each academic, operational, and recreational building within that region of campus. Further, we found a mix of quantitative and qualitative research methods to provide the best insight on our research topic. Our quantitative methods included a green bin inventory for all of the buildings on the south side of the UBC campus, and the analysis of the relationship between location and contamination. Our qualitative methods were split into interviews with UBC waste management employees and a ride along with employees to firsthand observe the process of waste collection of green bins. Ideally, the qualitative data we would get from interviews would help regulate patterns and correlations that are in our quantitative data, thereby resulting in an insightful analysis of the relationship between green bin contamination and accessibility. Due to COVID-19, these interviews were not conducted.

The green bin waste inventory was done following a visual audit method created and assigned to us by SEEDS. In accordance to the audit instructions, group members visually assess each green bin by looking into the bin, applying a score, and using this score to assign a 1-5 level of contamination. Using this method, 1 indicates bins with no visible contamination' and 5 indicates 10 or more pieces of non-compostable material. The audit was valuable as it helped us maintain a consistent rating throughout the entire green waste bin inventory.

As specified by SEEDS, the audit also included a sample of photos of the green bins contents that were being assessed. These are intended to supplement the pure data of the database by providing a visual example of what different levels of contamination in green waste bins look like. In hindsight, one of the limitations of conducting a sorting and contamination visual audit is that it only allows for a surface level view of the green bin contaminants. This restricts any further study of the contaminants and leaves us unable to control variations (i.e. waste weight) and patterns between the bins (i.e. count of most common types of contaminants) for a more accurate analysis.

Along with rating the green waste bin's contamination at each location and taking photos, our group also collected further quantitative data, such as green bin geo-coordinates. Our group also identified whether green bins were located at the front or back of its respective building. Using the Schaeffer waste bin collection app given to us by SEEDS, we logged this quantitative data directly into a GIS table from which we would later use to create maps and identify patterns of contamination and accessibility.

Following our findings in the literature review on how people's attitudes and behaviors influence contamination, we planned for an interview and ride-along to understand these things better. Choosing waste management employees as our source, we hoped to better identify weaknesses within UBC waste management's system. As mentioned previously, our targeted participants for this research were employees working for UBC waste management.

These interviews were structured to be short semi-structured interviews. The interviews consisted of 10 questions roughly separated into three sub-categories: 1) contaminated locations on campus, 2) personal observations made while working with waste about the UBC waste management system and observed attitudes to waste, and 3) improvements based on their observations and personal cultures/attitudes towards waste. Following is a sample question of each category:

1	Which 3 buildings on campus do you find to be the most contaminated, and what factor do you think makes these buildings more contaminated than others?
2	Based on the waste you collect; how would you describe UBC students' attitudes to waste?
3	If you had free rein, how would you improve current waste management practices on campus?

These types of questions were created with the aim of encouraging employees to share their "on the job" experiences and their opinions on potential improvements in UBC waste management's operations. We attempted to formulate these questions in a neutral manner. This was done in regard to ethical consideration; specifically, and awareness that we were conducting these interviews on behalf of their employer. They were planned to be non-mandatory, with all participants kept anonymous by not giving any personal information and by not having to report whether or not they chose to participate in them.

Along with conducting interviews with waste management employees to gain qualitative insight into waste bin contamination, our group also planned to take an ethnographic approach to acquire the data sufficient for this research. In this approach, one or more member from our group would attend a 'ride-along' with one of UBC's waste management crews responsible for the waste collection of the green bins in study. The purpose of this ride-along is to observe the experience of management employees. This approach is unique as it would allow our group to collect more quantitative data about the internal cultures of UBC's waste management operations. Furthermore, it would also improve the accuracy of our bin inventory assessment, as we repeat our methods when the crew collects the green waste.

Unfortunately, we were not able to complete the semi-structured interviews or ride-along that were planned to take place in the final part of our process, the timing of our methods collided with the COVID-19 outbreak which shut down all non-essential services. In an attempt to collect at least some qualitative data, we re-formatted our interview questions into a survey. Phone interviews were suggested, but surveys were more flexible and given the unprecedented times, therefore, the favorable choice.

Replacing our interviews with a survey will compromise part of the personal angle we were originally aiming at as it does not allow the interviewer to ask specific follow-up questions. This may limit our aim to use these interviews as a way to gain insight into the individual experiences of waste management employees. However, we had already lost all chance of our ethnographic component and adapted in a last attempt to still acquire some qualitative employee data.

Analysis of Findings

The deliverables for this project are as outlined in the *UBC SEEDS Sustainability Program: Research Project Description Form*. They are divided in two main groups: The first deliverable is a table and/or map identifying bin location and inventory; the second deliverable is a specific assessment of the green bins, specifically the ranking of their level of contamination from 1-5 and percentage fullness. The latter deliverable has an array of sub-deliverables, including but not limited to the contamination rating of the green bins, sample photographs of some of the bin storage areas, and the assessment of green bin contamination factors (visibility/accessibility). As the SEEDS project is a collaboration between SEEDS and the UBC Geography department, students are encouraged to further the project through using the research methods studied in the *GEOG 371 Research Methods in Human Geography* course. As explained in the methods section above, this second section of our research was cut short. Under COVID-19, our survey has yet to receive any responses.

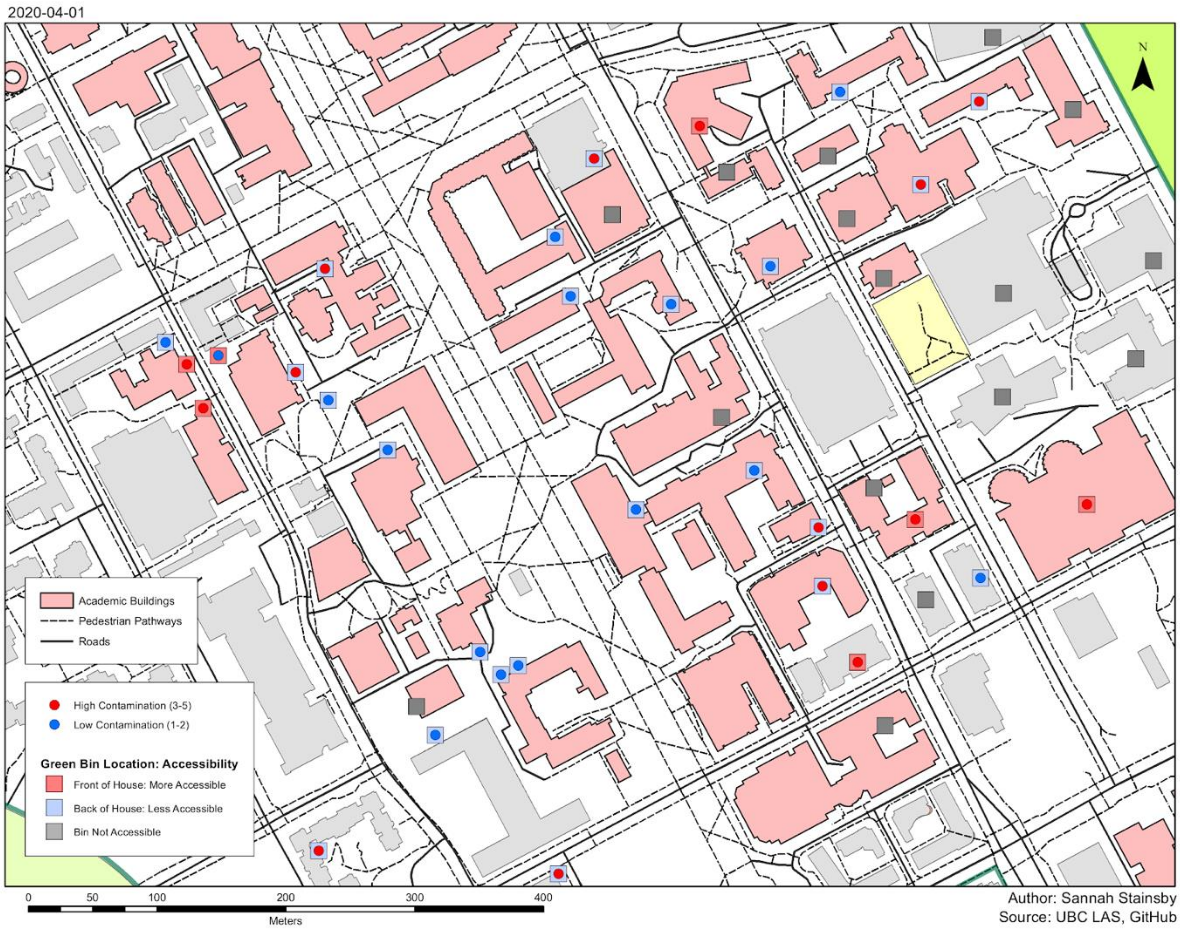
Ultimately, the main goal of this study is to use the collected waste bin data to create a database, using either GIS or excel. Ideally, this database will be continually added to and updated, even after the completion of this project. The idea behind the project is to assist

SEEDS in future waste management strategies and in this way contribute to reduce green bin contamination at the UBC Vancouver campus. The completed database is to be available in an external location determined by SEEDS.

Starting with an analysis of the literature, the cause of green bin contamination seems to be divided in two parts. The first, and most supported notion is that contamination is a result of people's behavior, namely poor attitudes to waste and/or a lack of knowledge about the importance of recycling (see e.g.: Wheeler, 2014; Gallardo, 2019). The second notion is that green bin contamination is a result of waste management systems; scholars view contamination as an issue rooted in the spatial/organizational elements of waste management, i.e. bin design, portion size and the internal bureaucracies of waste management companies (re: Bolaane, 2006; Ebrahimi & North, 2017). Further, it seems that scholars who study the behavioral perspective tend to use qualitative research methods, e.g. interviews, in their studies on waste; while scholars in favor of the systematic perspective, however, use more qualitative research methods, e.g. the “Green Report Card” by Ebrahimi & North (2017). As mentioned, we were intended to conduct our analysis on the basis of results obtained through a mixed use of methods. However, we were not able to conduct the ethnographic ‘ride-along’ and interviews with waste management.

To assess the research question of whether accessibility to green bins influences the level of contamination we created a total of four maps. These maps consist of two main maps (1.1 and 2.1) and two simplified versions of the main maps (1.2 and 2.2). In all of the maps, the geolocation of green bins is marked by a square and/or circle. Due to the limited sample size and areal size of our ‘unit of study’ (campus South side), we chose not to include an official regression or other statistical method to quantitatively test the relationship between our data/variables. This decision was prompted by our attempt to create a heat map in which clusters of contamination (‘hot spots’) could be easily identified. However, a test for spatial autocorrelation showed no evidence of spatial clustering of contamination; therefore, a heatmap would likely be unfruitful and was decidedly dropped.

The first map tests the relationship between bin accessibility and level of contamination by visualizing ‘accessibility’ as “front of house” (red square) and “back of house” (blue square) and “not accessible” (grey square) (Appendix 1). This approach was decided from our own observations made collecting the waste bin data, in which we noticed that some of the bins were not accessible and that bins located behind buildings tended to have lower levels of contamination than bins located at the front of buildings. Level of contamination is illustrated by assigning each level of contamination with a color and marking that waste bin's location with the respective colored 'point'. Due to the number of points, and number of subcategories in each point, we were unable to determine whether or not there was a relationship between level of contamination and accessibility. We created a second map:



Map 1.2: Relationship between bin accessibility and contamination, simplified as front/back and high/low respectively.

In the second map, depicted above, we simplified the contamination scale, with a group of five units (level of contamination, 1-5) to a group of two (level of contamination, high/low) where high contamination is illustrated by a red dot and blue contamination is illustrated by a blue dot (Map 1.2; Appendix 2). The accessibility variable (front/back of house) is unchanged. Our observations are gathered on the next page, Table 1:

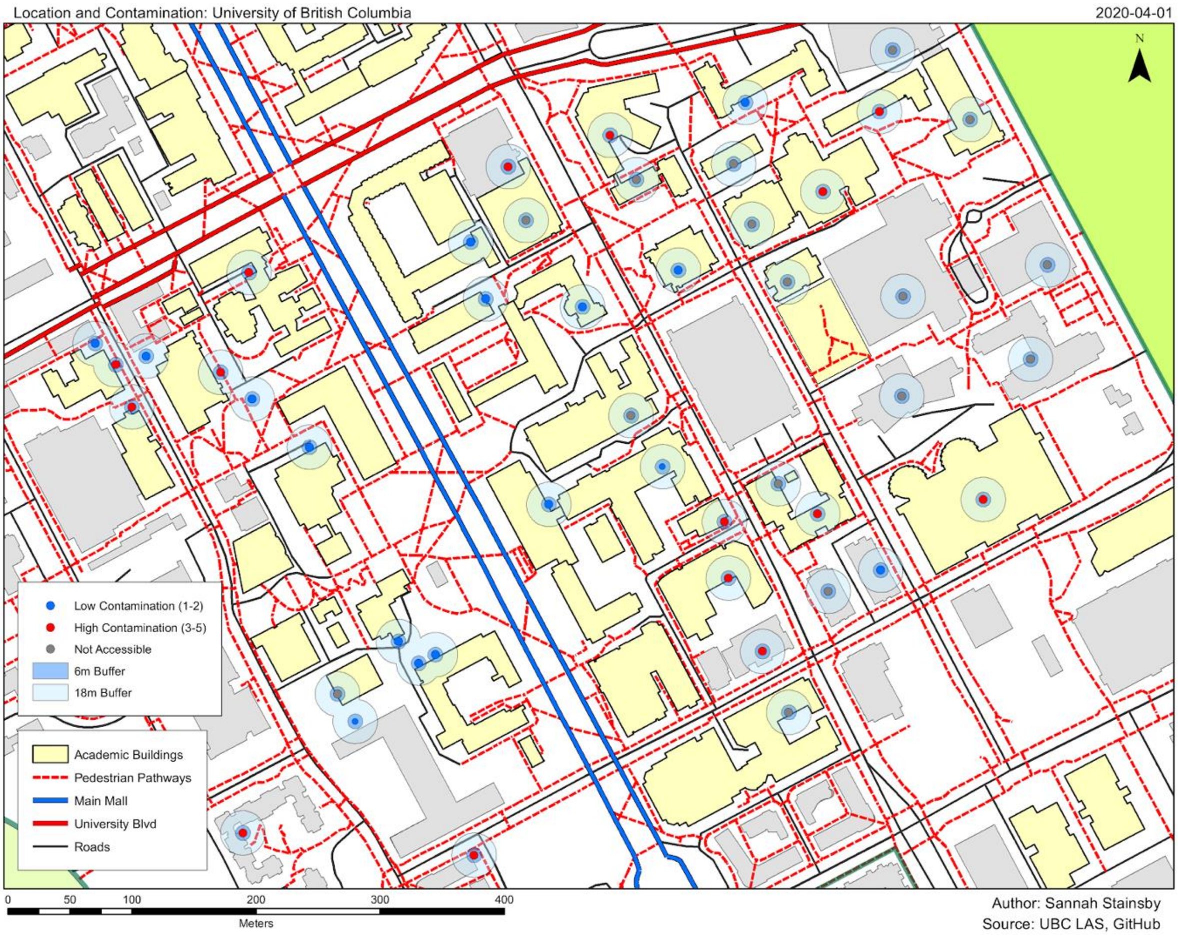
	Front of Building	*Back of Building*
High Contamination	6	9
Low Contamination	1	15

Table 1: Count of the various combinations of green bin location and level of contamination.

From the table, we find some support to our initial assumption: It appears that the majority of bins located at the back of buildings have a low level of contamination. Similarly, the reverse seems to be the case when examining the distribution of low contamination in bins located at the front of buildings, as there is only one bin that meets the low contamination criteria. Therefore, a general theme observed from the map is that there are more low contamination bins and that the majority of these bins, with the exception of 1, are located at the back of buildings.

However, the table also highlights the most important theme of our data collection: Its limited sample size, which for several reasons makes it impossible to draw any credible conclusions from our data set. When attempting to add or do calculations, the numbers are quick to turn confusing and contradictory. For instance, the map shows an almost even distribution of high versus low contaminated green bins in which low contaminated bins make the majority by less than 2%. Yet, only 22% of the bins are located at the front of buildings (Pie Chart, Appendix 3). This leaves a total sample size of 7 for bins located at the front of the house and a sample size of 24 for bins at the back. While these are both below the recommended $n => 30$ of any statistical analysis, we can therefore only suggest that there seems to be a trend of low contamination in bins located at the back of buildings. Due to a sample size of 7, we chose not to make any suggestions of a trend for waste bins at the front of buildings.

These findings lead us to our second set of maps. Although we were unable to determine any relationship between accessibility and contamination through the study of bin placement relative to front/back building, we attempted to refine our understanding of the influence accessibility may have on the contamination of green bins. In reference to the literature that sees contamination as a flaw of human behavior, we therefore continued our spatial study by creating a map of level of contamination relative to proximity to pedestrian pathways (Appendix 4).



Map 2: Relationship between proximity to pedestrian pathways and level of contamination, with level of contamination simplified as high/low (Appendix 5).

To illustrate this, map 2 shows all pedestrian pathways of the campus Southside with the lines of Main mall and University Blvd, the two busiest pathways on campus, distinguished as extra thick in red and blue. Proximity is represented by buffers of 6 (darker blue) and 18m (lighter blue) Euclidean distance. As our literature found that contamination to be a spontaneous act, we chose short distances that would not break too much off the pathways. Assuming it takes 1 second to walk 1 meter, these two buffers could be reached with high to moderate ease. Following the initial assumption of SEEDS, we expect bins with buffers that intersect with pathways to have high levels of contamination and bins of the opposite to have low contamination.

Albeit we were not able to find any support for this claim either. In the examination of our map, the level contamination appears to have a random relationship to proximity of pathways. Further, our map shows several areas that contradicts this claim. In the example below from lower Main Mall for instance, we observe two minor clusters of low contamination bins (Main Mall left, blue circle) and high contamination bins (Main Mall right, red circle).

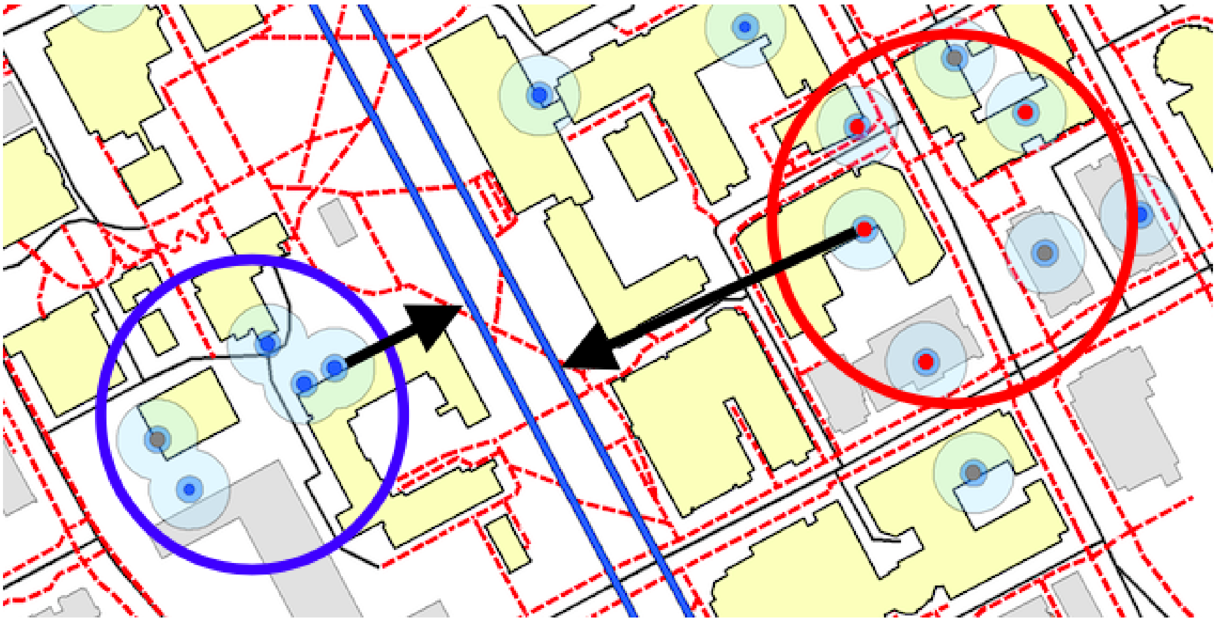


Figure 3: A closer look at Map 2 shows conflicting evidence to our claim.

If accessibility in the form of proximity to pedestrian pathways had an influence on level of waste bin contamination, we would expect the bins to the left of Main Mall, with the shorter black arrow indicating shorter distance, to be red indicating high contamination and vice versa. Yet, several areas of the map show the opposite.

Overall, the analysis of our maps and the maps themselves carry several limitations and possible sources of error. Beyond the mentioned issue of a limited sample size, the choice of what contamination levels to include as 'high' and what levels to include as 'low' may be disputed in both maps as well. In map 2, there is also the choice of buffer size as well as the choice of University Blvd. and Main Mall as the two busiest pathways; these were both based on our personal knowledge of campus space. Lastly, it may also be criticized that a third map illustrating the relationship between maps 1 and 2 was not created, as the possibility that the findings shown in figure 3 from map 2 are influenced by the relative location of the bins (i.e. front/back).

Significance of Proposed Research

After our investigation of the correlation between locations of waste bins and contamination rates, we found that highly trafficked pedestrian areas do not seem to influence the level of contamination. However, green waste bins located in the back of the house are less contaminated than green waste bins in front of the house. Therefore, the UBC waste management team can consider moving the front of house waste bins to the back.

Furthermore, signage should be put up near the green waste bins. As mentioned above, British Columbia's Ministry of Environment suggests that informational strategies encourage the public to recycle and reduce the contamination level (2016). Since students, staff or visitors might be unaware that these outdoor green waste bins are not for public use, putting up a warning sign or informational signage can remind them that they should throw waste in the sort it out station instead. For instance, a sign of “Not for Public Use” can be put up on the lids of the green waste bins or even set railings around the green waste bins.

Moreover, we believe it is important to solve the problem of contamination in the green waste bins at its source, which is sorting the waste. During the investigation of the green waste bins, we found that plastic was the major source of contamination in the green waste bins. For instance, plastic food containers, biodegradable and compostable plastics bags. These items might be confusing for the public to determine how it should be recycled. Since in the backboard of the food scraps bins in the sort it out station or on the lid of the green waste bins, it only shows the image of the container’s outline with text to illustrate “soiled and compostable paper” (UBC Sustainability, 2020). However, people might think plastic containers were included in the food scrap bins based on the image. On the other hand, since some composting facilities are able to compost biodegradable and compostable plastic bags, people might assume UBC in-vessel composting facilities can do so as well.

Yet, this is not the case. UBC in-vessel composting facility was unable to compost biodegradable and compostable plastics, and thus biodegradable and compostable plastics were supposed to be thrown into the garbage bins. Therefore, to prevent people sorting the waste incorrectly, "Text-based Sorting Guide" and the link of "A-Z Recyclepedia" should be placed beside the sort it out stations and the green waste bins for people to refer to when they are confused about how to recycle the waste (UBC Sustainability, 2020). Also, posters showing that any form of plastics (including plastic food containers, biodegradable and compostable plastic bags) is not compostable can be put up near the green waste bins and sort it out station to remind the public.

Future Research Directions

In this research project, we faced several challenges that have restricted our investigation to study more about the contamination of the waste bins; the main challenge being COVID-19, now declared a global pandemic. Under a 'state of emergency', we obliged to stay home and avoid as much human contact as possible. As a result, we were unable to conduct personal interviews with the members of the UBC waste management group.

However, we highly recommend that future research benefit from the opportunity to conduct interviews and an ethnographic ride-along with UBC waste management employees. In the case of both methods, we find reason to believe they would have greatly enriched our analysis. This is not only as they would give detailed insight into the UBC waste management operations, but because the in-depth waste employee perspective is one that we did not see represented in either the literature or UBC online sources; it can only be obtained from current conversations with current workers.

Of the two methods, we are especially curious to see future research include an ethnographic ride-along with the waste management crew. This 'observer-as-participants' methodology allows researchers to gain a more detailed observation of contamination in practice, and an understanding of how it may be influenced by its contexts. Chatting with the participants might help identify the specifics of these contexts and help prioritize these factors; they have been working with waste for much longer than the researchers.

On the other hand, a more precise assessment of waste bins contamination can be used in future research to further investigate this study. Due to time and labor limitations, we chose to measure the contamination level through the waste auditing guidelines provided by SEEDS. As previously touched on, the method of visual auditing may, however, produce less accurate results. Since the level of contamination was determined visually, only the top layer of the waste was considered. Thus, future research should attempt to employ a "full waste audit" with i.e. variables such as "bin fullness" measured by weight rather than a visual approximation.

Furthermore, future researchers can extend our research by expanding the sample size of the study to include the North side. In our analysis, the limited sample size was the main factor that prevented us from drawing reasonable conclusions and confidently solving our research problem, whether bin accessibility affects its level of contamination. This should be attainable once we, the two waste management SEEDS groups, have standardized and merged our findings into one geo-database.

Lastly, the "Significance of Proposed Research" portion found non-compostable plastic (plastic food containers, biodegradable and compostable plastics bags) to dominate green bin contamination non-compost materials. Therefore, we recommend a future study that accounts for the influence of nearby restaurants, grocery stores, sports arenas or other types of facilities. Given the observed trend, there is reason to suspect that these types of facilities may have an influence on waste bin contamination. It may therefore be useful to investigate not only the relationship between attitudes/behaviors of people at UBC towards waste, but to also examine how these attitudes/behaviors under the influence of different activities connected to location (e.g. walking to class down Main Mall versus walking to the UBC AMS Nest to have beer at The Pit Pub after watching a Thunderbird hockey game).

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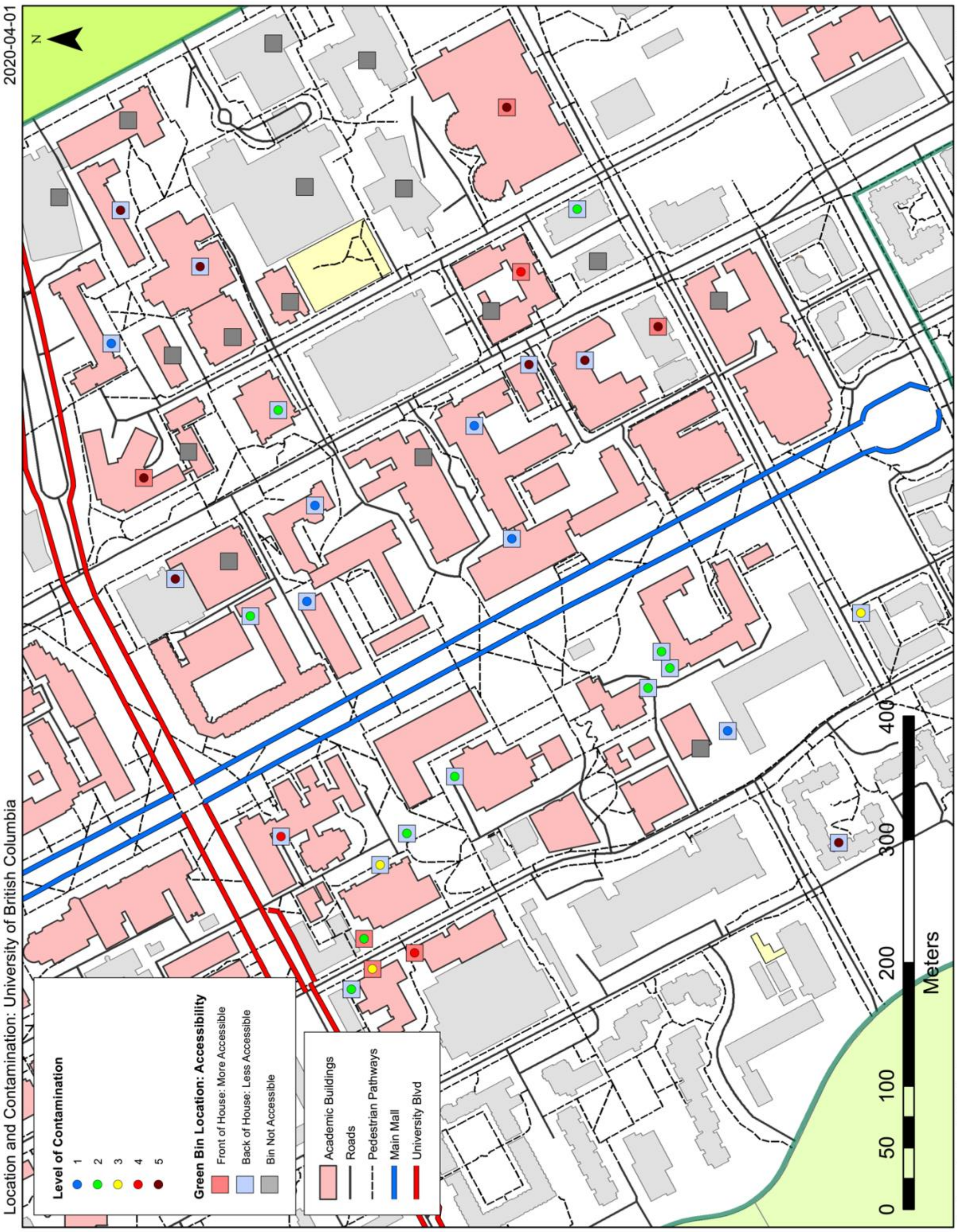
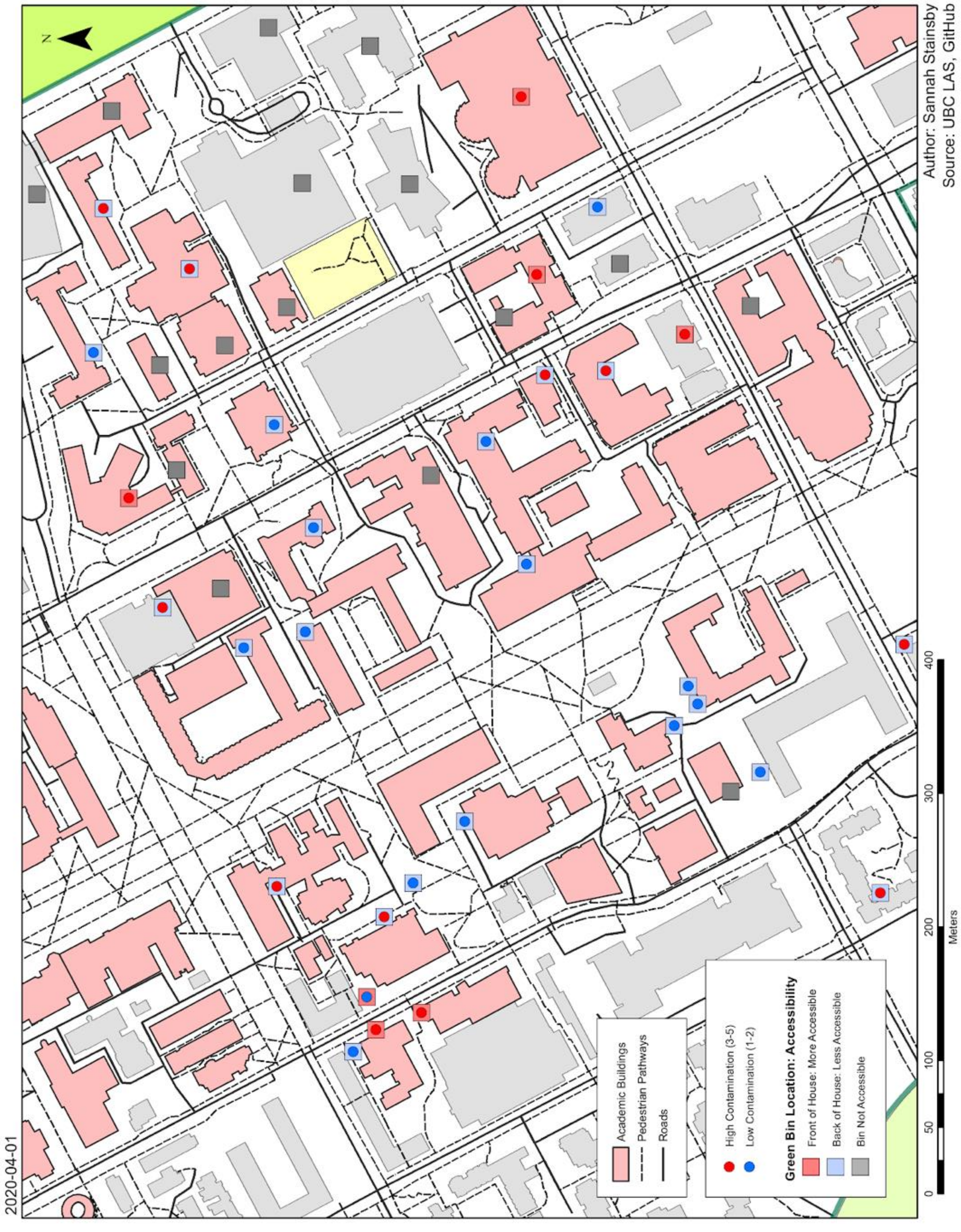
Appendices

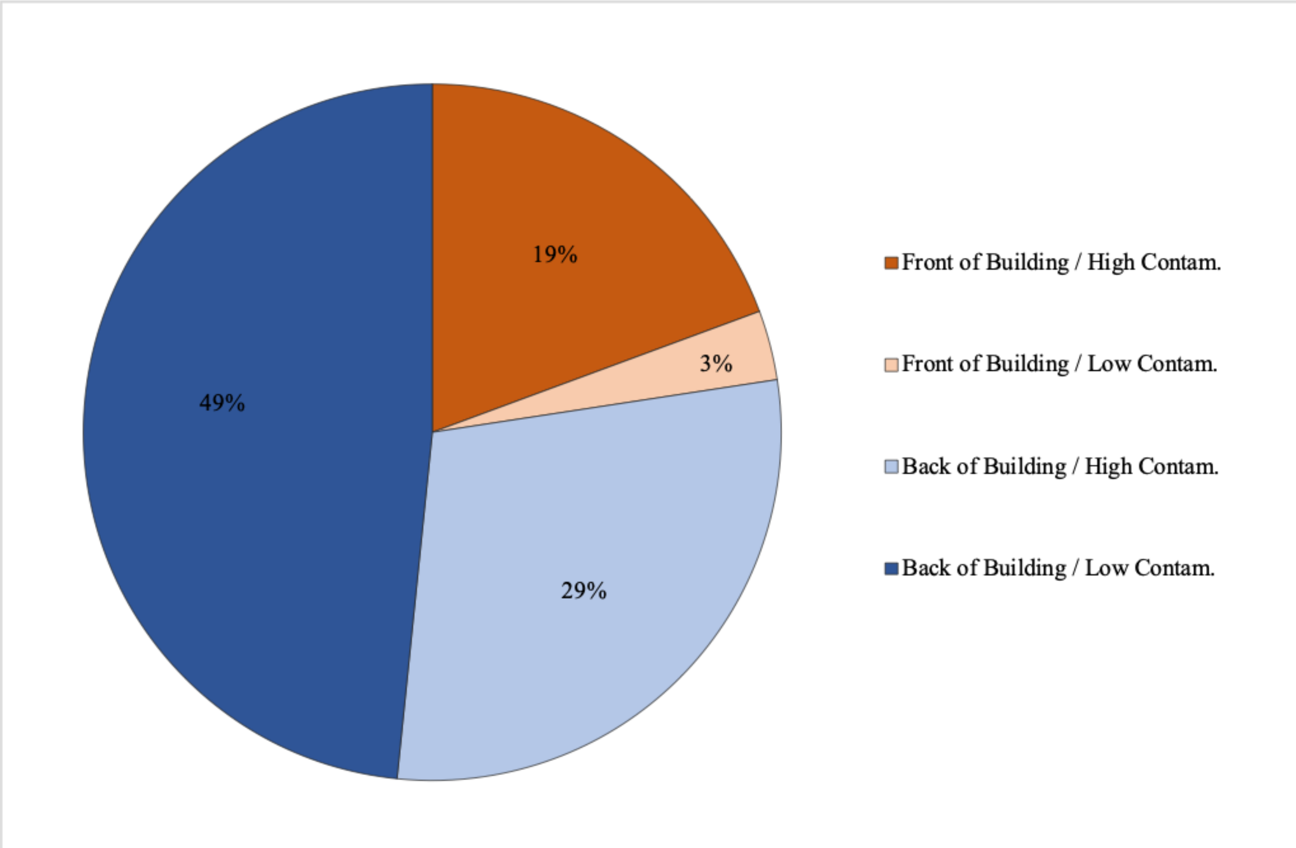
1. Map 1.1: Green Bin contamination (lvl. 1-5) and Green Bin Accessibility (Front/Back of house).



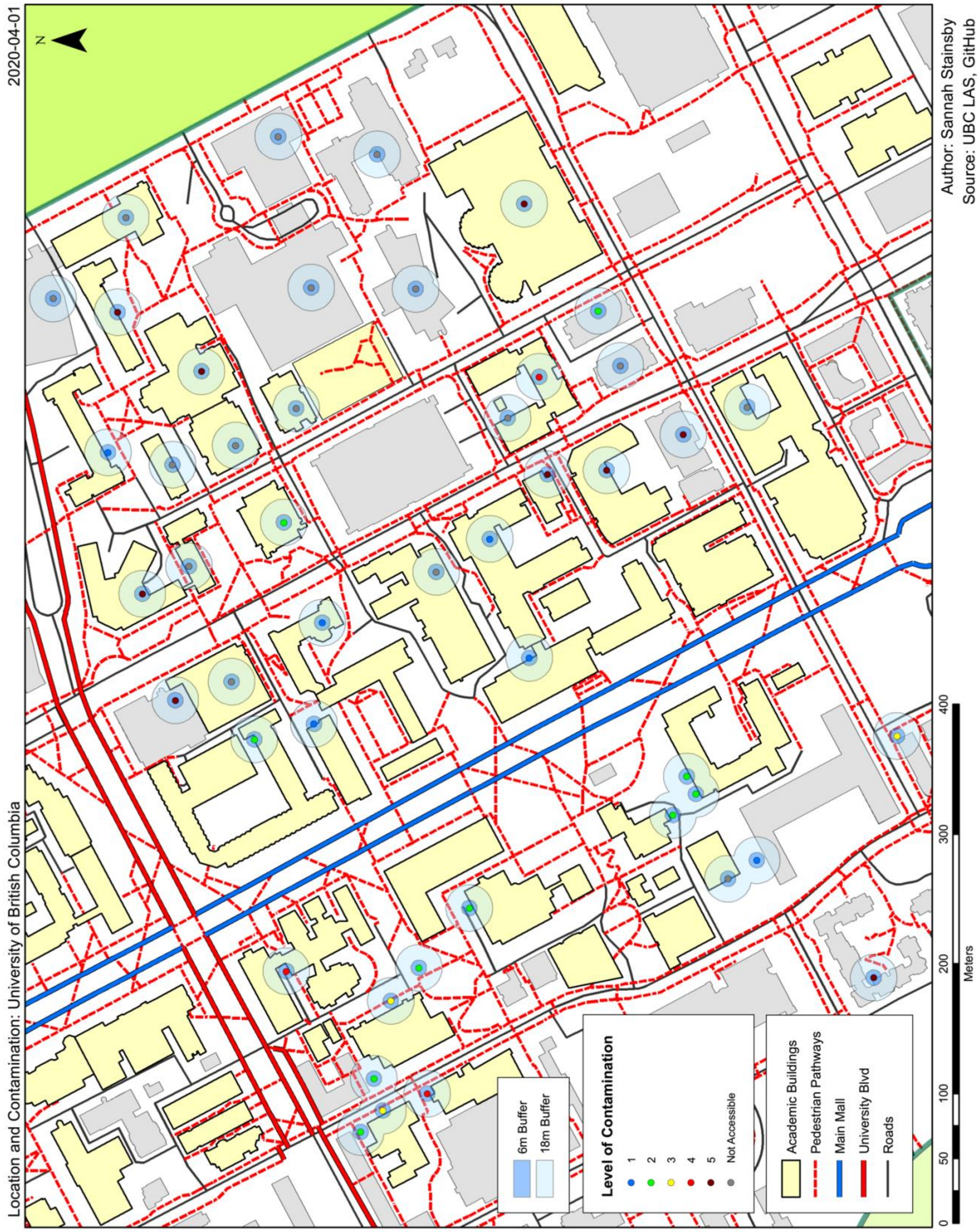
2. **Map 1.2:** Green Bin contamination Simplified (High/Low) and Green Bin Accessibility (Front/Back of house).



3. The result of too small sampling size:



4. Map 2.1: Green Bin Contamination (lvl. 1-5) and Proximity to Pedestrian Pathwa



5. Map 2.2: Green Bin Contamination Simplified (Front/Back) and Proximity to Pathways.