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Student Research Report

Birds on Campus: Assessing Sources of Unintentional Feeding to Inform Policy and Campus Design

Understanding Trash Foraging Practices in Bird Populations on the UBC Vancouver Campus

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Abstract

Unintentional food sources such as waste provide an additional and constant food source for many birds. However, the issues of unintentional feeding and its effects on birds received limited attention. Alternative food sources may be associated with lower in quality (Pollock et al. 2017) and favour certain behavioral patterns over others (e.g opportunistic and generalist feeders) (Chamberlain et al., 2009). Hence, we stress that understanding the impacts of unintentional food (litter, food scraps, overfilled trash-bins) sources to birds in The University of British Columbia (UBC) campus is important for developing actionable recommendations that relate to the conservation of avian biodiversity through fostering habitats that offer optimal nutrition that support a diversity of avian populations in the campus. This project will assess the potential impacts to birds from unintentional food sources on the UBC Vancouver campus and identify populations most likely to be impacted by these risks. We first conducted a literature review to synthesize previous research on the impacts of unintentional food sources to birds and their potential impacts to the avian biodiversity. We then conducted observations of unintentional feeding on the UBC Vancouver campus to examine potential bird foraging activities on waste. Based on the initial findings from the literature review and observations, we conducted three qualitative, semi-structured interviews with UBC waste management and a UBC ornithologist to understand the prevalence of litter on campus (where does it occur, what type of litter is it, is it on the ground or in overfilled trash cans, etc) and how this affects UBC's bird populations both directly and indirectly. Our findings indicated that unintentional feeding sources (e.g., loose litter) are prevalent on campus which support a growing crow and seagull population. The direct physiological and indirect ecological effects of unintentional feeding in urban settings are little understood - our findings corroborated this broader pattern in the literature. Though, there is evidence of increased corvid populations negatively impacting campus aesthetics, avian

abundance and wellbeing of other avian populations, and the spread of waste that become food sources for other opportunistic mammals. We provide a series of recommendations to reduce unintentional feeding on campus that are primarily guided by structural changes and behaviors nudges to minimize the spread of trash at the source. Our study highlights an important research gap that we hope receives more attention when considering campus bird diversity.

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1. INTRODUCTION

Urbanization has significantly altered the feeding and foraging environments of wildlife, both in terms of type and availability of food. Avian species are among those that have been seriously affected by the urban food environments. One way that birds have been impacted by urbanization has been the availability of anthropogenic waste, which has constituted an alternative and constant food source for urban birds. Feeding and foraging on trash can have both positive and negative effects on birds, as for gregarious foragers (i.e. forager species tending to form a group with others of the same species) it allows for a competitive advantage, whereas for some it considerably limits the availability of food, all the while posing concerning health risks from pathogenic infections for all species.

UBC is an expanding urban environment, and while trash cans are prevalent around campus, the constant presence of people means that litter is an ongoing issue. UBC has been conscious of the impacts of urbanization on birds, but mainly through the lens of limiting building collisions. As such, the linkages between urbanization and foraging behavior of birds remains a largely unexplored area. Our research aims to address this gap by studying trash foraging and feeding instances of the bird population at UBC Vancouver campus. The approaches applied in this research focus on identifying the frequency and locations of birds feeding on trash on UBC campus by undertaking observations, employing a simple spatial analysis and conducting interviews with experts on waste management and ornithology. We acknowledge the observations and spatial analysis applied in this study are not comprehensive and with limited scope, as such a more thorough investigation of these issues are required.

The purpose of this research is to provide the initial considerations for understanding and reducing the instances of trash foraging and feeding, from which further research on the bird-trash nexus can be generated.

2. LITERATURE REVIEW

2.1. Urbanization and Avian Biodiversity

In 2018, the United Nations outlined that by 2050 more than two-thirds (68%) of the world's population will live in urban areas (as compared to today's 55%), naturally leading to an increase in not only the number, but also the size of urban areas (United Nations, 2018 p.10). This growth in urban populations and areas will have serious consequences on biodiversity, as both the biotic and abiotic environments are altered, with the most notable changes coming from habitat fragmentations, transformations in vegetative covers, and the increased presence of people (Hensley et al., 2019). Birds are not exempted from the challenges posed by urbanization (Shanahan et al., 2014; Di Pietro, Mantoni and Fattorini, 2020). Isaksson (2018) has shown that birds are significantly impacted by four key stressors that can be observed globally; chemical pollution, noise pollution, artificial light at night and human presence. Focusing specifically on the influences of increased human presence, Shanahan et al. (2014) see human induced habitat destruction and fragmentation as significant alterations to feeding and breeding resources, as they have limited the availability of traditional food sources and generated new, and more constant, alternatives through anthropogenic litter. The presence of such alternative food sources have been found to create opportunities for some species, while putting increasing pressure on other species, both directly and indirectly (Shanahan et al. 2014). As such, when considering

avian species diversity and well-being in urban areas, the alterations to feeding behavior must be critically considered.

2.2. Waste and Avian Health

As mentioned, among the range of changes caused by urbanization, the alterations to food supply abundance (i.e indirect food sources at areas of waste treatment, collection, and transfer) have posed one of the most notable pressures on bird well-being and richness (Chace and Walsh, 2006). These unintentional food sources, such as rubbish, provide an extra and constant food source for many birds. Some bird species such as kelp gull in an inland refuse dump in Patagonia (Frixione et al, 2012) , white stolk in Poland (Kruszyk and Ciach, 2010) and black kite in Rome (Giacomo and Guerrieri, 2008) were found to use rubbish as a dependable food source. However, Marzluff (1997) indicates that the impacts of urban food sources vary across species, with some benefitting from them, while others facing increasing stress, both directly and indirectly. One notable example of this dichotomy is the unique ability of gregarious foragers to disproportionately exploit anthropogenic food sources, thus leaving less resources for songbirds and less adapted foragers, and thus also increasing the occurrences of stealing eggs from nests (Marzluff, 1997). The indirect effects of alternative food sources is also highlighted by Isaksson (2018), who states that waste disposal systems could have significant impact on avian population composition between urban adapter species and exploiter species within an urban area. Commonly, when resources increase, the exploiters can outcompete the adapters, changing the composition of bird populations. For instance, urban adapter species, such as

crows, increase most rapidly in urban areas where anthropogenic food sources are easily located, rich, and concentrated (Marzluff et al., 2001).

Furthermore, the difference in individual species's ability on feeding supplement food also give rise to intra-and interspecies competitions that could have impact on the composition of bird populations. For instance, the extend to which juveniles Herring Gull fed on high and low quality of food from rubbish tip is correlated to the degree of competition from adults (Monaghan et al., 1986). Larger gull species (Great black-backed gulls) have higher feeding success in undisturbed rubbish than other smaller gull species (Greig et al. 1986).

Wildlife foraging on rubbish may improve the size of population abundance but may also increase the risk of infections with pathogens because the presence of pathogens in rubbish dumps is very common (Plaza and Lambertucci, 2017). However, there are limited studies exploring the causal relationship between birds supplement feeding and the impacts to their health. Some studies found that wildlife in touristed areas such as crows, house sparrows, rock iguanas, foxes, sparrows and sea turtles had increased cholesterol levels as a result of feeding on supplement food in urban landscapes (Townsend et al., 2019). However the impacts of elevated cholesterol to their health, fitness and competitive ability remain undiscovered.

Hence, exploring the impacts of unintentional food sources such as rubbish to the health of birds and to the composition of bird populations is important for developing actionable recommendations to conserve avian biodiversity especially in urban landscapes.

2.3. University of British Columbia Bird Population

The University of British Columbia (UBC) is home to a staggering array of bird species ranging from migratory songbirds to year-round settlers such as seagulls, white stolk, and crows.

Increasing pressures of urbanization on and adjacent to campus have created unique challenges for birds, including adapting to alternative food sources that result from unintentional feeding. Campus initiatives to encourage survival of UBC's bird populations have often focused on fatalities that result from collisions with buildings, yet opportunities for increasing nutritional food sources and reducing unintentional feeding of garbage remain largely unexplored. This is, in part, a result of the limited empirical information about unintentional feeding behaviors. Therefore, there is a need to understand the relationship between UBC birds and patterns of feeding on alternative food sources such as trash. Doing so will inform opportunities for campus policies to encourage structural modifications on campus that promote food sources of optimal nutrition to reduce harmful impacts on scavenger species and foster species richness.

3. RESEARCH SCOPE AND QUESTIONS

Our research questions are motivated by the limited empirical information about unintentional feeding behaviors on UBC campus. Therefore, there is a need to understand the relationship between UBC birds and patterns of feeding on alternative food sources such as trash. Specifically, this project was guided by three research questions:

1. *How often and where do birds feed on unintentional food-sources at UBC?*
2. *What are the potential risks to birds from unintentional (trash-based) food-sources on the UBC campus?*
3. *How can UBC standards or campus-design be improved to foster habitats with optimal nutrition for birds and higher avian biodiversity on campus?*

4. METHODS

This research was conducted by three young women with international backgrounds as a part of a graduate level course on socio-ecological systems, RES510. The initial stages of our research included group discussions with our SEEDs coordinators (Ben Scheuffler), SEEDs partners (Penny Martyn, Tamas Weidner), as well as our course organizers (Dr. Leila Harris and Dr. Sameer Shah). These conversations helped us identify common research interests between the group and the partners, which aided us in tailoring the research to provide relevant and useful information and recommendations.

We chose to utilize observations around UBC Vancouver Campus and interviews to achieve the objectives of our research. Observations, and the spatial data that was generated from them, allowed us to identify instances of exposed waste and the interactions of birds with such waste. Hence, we were able to address objective 1: frequency and location of feeding and foraging. Interviews with both waste management and ornithologist went towards achieving our second objective, as we were able to obtain information on how birds influence the prevalence of trash (waste management) and the potential implications of waste to birds (ornithologist). Both of these methods were supported by an extensive literature review in order to meet our third objective: creating recommendations to limit the amount of unintentional food sources for birds.

4.1 Ethics

The project was designed in accordance with the UBC Research Ethics Board applications for RES510 and all three group members completed the TCPS 2.0 CORE ethics training. Each interview was held online in consideration of COVID-19 and all interviewees

signed a consent form prior to the interview (Appendix C). Anonymity and confidentiality of participants were ensured throughout the research process and results presentation.

4.2. Data collection

Data for this research were collected via qualitative semi-structured interviews and observations of incidents of trash feeding within our study context on campus. Daily observations were conducted over the period of two months for approximately 20 minutes per day within our study area to observe the disposed waste condition, potential unintentional food sources, and bird feeding behaviour. All incidents of trash feeding were captured via photographs or video to demonstrate birds feeding on trash. Additionally, photo evidence was documented of particular waste material over time to get a better sense of how long it took litter on campus to be consumed by birds. Photographs and videos were captured using an iPhone 11 Pro Max which recorded the time, date, and spatial coordinates of unintentional feeding on campus.

We also conducted three online, semi-structured interviews with Building Operations' Waste Management personnel in Municipal Services of UBC (n = 2) and an urban ornithology expert on campus (n = 1). Participants were identified through recommendations from partners and based on relevance to our project. In particular, we selected waste management personnel and ornithologists, as the former held relevant knowledge about the type, location and prevalence of trash on campus (as well as observations of birds), and the latter provided in-depth information about the avian population and their behavioral patterns on campus. To invite participants, we approached individuals by email, wherein we provided an overview of our study and invitation to participate via an interview. All interviews were conducted via Zoom and lasted from 30-45 minutes, where they were recorded for transcription and subsequent analysis. Two separate interview guides were prepared for ornithologists and UBC waste management

participants to better understand trends in causes and areas of waste on campus, direct and indirect effects on avian biodiversity, and opportunities for mitigating unintentional feeding sources on campus. (Appendices A and B). All interviews were transcribed for subsequent analysis.

4.3. Data analysis

From the site observations, the coordinations of the locations where bird unintentional feeding activities were sighted were plotted on a trash receptacles distribution map provided by UBC Waste Management team. The relationship between the number of sightings and the number of trash bin designated within an area was analysed. The interview transcript analysis involved a combination of mixed deductive and inductive in-vivo coding processes: deductive coding analyzed data according to predetermined topics (e.g birds feeding on trash), and inductive coding identified emergent themes that were not predefined but were relevant to our research interest (e.g rodents feeding on trash). Each researcher coded and analyzed the interview transcripts individually, then compared results through peer debriefing and theme matching processes. To account for biases, the researchers worked as a team to regularly cross-check our analyses and ensure that the study was not inordinately influenced by any one researchers' perspective.

5. RESULTS

5.1. Spatial observations

Observations of bird feeding behaviors were undertaken between the period of October 1st and December 1st on the UBC campus. When making observations, we focused on three criteria:

1. Where on the UBC campus does rubbish often occur?
2. Are birds carrying or feeding on the rubbish?
3. Are there other ways in which birds are interacting with rubbish?

5.1.1 Food and Trash on Campus

We noted that food-related trash on campus was often in the form of food containers (e.g wraps, boxes, bags, etc) (Figure 1). On multiple occasions the food containers still had remnants of food in them (figure 2), in which cases we also observed birds interacting with the trash. While it was more rare to notice open food waste around campus, we did see such occurrences on a few instances (Figure 3). Open food waste, however, seemed to be a result of accidental spills or drops, as seen again in figure 3 with the french fries. As such, we suspect that open food waste was less prevalent on campus precisely because of its accidental nature, whereas leaving containers behind was understood to be a more deliberate form of littering, possibly due to perceived absence of trash bins (Chaudhary, Polonsky and McClaren, 2021).

Figure 1. *Pictures of food containers left around campus (Personal Photographs)*

***Figure 2**. Pictures of food remnants among trash around UBC campus (Personal Photographs)*

***Figure 3.** Pictures of open food waste around UBC campus (Personal Photographs)*

5.1.2 Birds attempting to feed on trash

The next area of concern for our observations was the occurrences of birds feeding, or attempting to feed, on trash. During our observational periods, it was common to see birds carrying or eating trash, with the most common species being crows and gulls[1]. We noticed that consumption behavior happened with both open food waste (as seen in middle picture of Figure

[1] This is the extent of our identification of species as we are not familiar with identifying specific crow and gull types in nature.

4), as well as packaged food items (left picture Figure 4). With open food waste, we were able to observe birds actually eating the discarded waste, whereas with packaged food items we witnessed the birds carrying them around and attempting to access the food by either pecking or scratching the item. Later in the observational period, we started to notice possible linkages between feeding on trash and foraging behaviors, as birds would be seen to systematically go through trash items to find food. On one instance, we noticed a crow peck at, pick up and examine a row of coffee cups, food wrappers and drink bottles that had been left in a row on the concrete wall at the UBC bus loop. We connected such foraging behavior to the prior occasions of birds feeding on trash, inferring that birds had incorporated trash foraging behaviors as a result of the possible sources of food that trash has previously provided (Benmazouz et al., 2021).

Figure 4. *Birds feeding, or attempting to feed, on trash at the UBC campus (Personal Photographs)*

5.1.3 Bird interactions with trash

The last component of our observations was to identify whether birds interacted with trash in other ways than just feeding. In particular, we noticed that birds had a role in the

prevalence of exposed trash around the campus. When bags of trash were left next to bins[2], birds had a tendency to tear them open and spread the insides around, resulting in spreading of trash around campus (Figure 5). On a few occasions, we also spotted birds tearing open bags of food (Figure 4, middle picture), which resulted in more open food waste.

Another interesting interaction was noted earlier in the fall, as we saw birds observing and approaching groups of people eating outside (Figure 6). While not specifically a bird/trash interaction, we believe it was an important observation to point out, as it indicates to the associations birds are building between people, trash and food.

Figure 5. *Trash on Main Mall from a trash bag that had been torn open by seagulls (Personal Photograph)*

[2] We believe this was done because the trashbags did not fit through the holes of the bins.

Figure 6. *A seagull observing a group of students eating outside*

5.1.4 Spatial representation of observations

In order to understand the spatial patterns in our observations, we mapped instances of bird/trash interactions (indicated by red dots). This map was combined with a map showing the type and location of trash bins on the UBC campus[3](indicated by green and blue dots). Combining these two maps showed, not only a pattern in our observations of birds/trash interactions, but also the relationship between such interactions with trash bin prevalence (figure 7). From this map, we can see that bird/trash interactions were most often observed around the UBC bus loop and green turf (indicated by the red circle). Notably, the UBC bus loop and the green turf were also areas with an identifiable absence of trash bins. Hence, based on such spatial patterns, we recognize the area surrounding the UBC bus loop and green turf as sites of

[3] The map locating UBC trash bins was provided by UBC Waste Management

significant importance for our recommendations concerning trash foraging and feeding activities of birds.

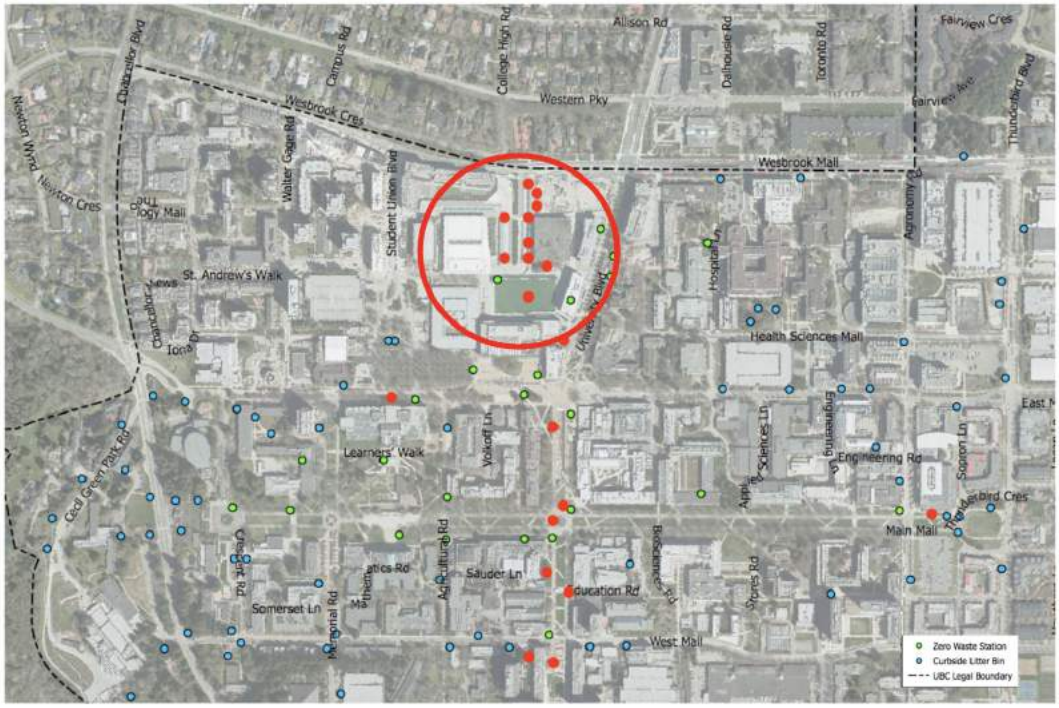

Figure 7. *A map depicting the occasions of trash foraging and feeding by birds (red) and the locations of trash bins (green/blue) (Adapted from UBC Waste Management Spatial Analysis of UBC trash cans)*

5.2. Interview findings

5.2.1 Birds foraging on exposed waste on campus

Findings from interviews with UBC waste management personnel and a campus ornithologist indicated that, indeed, the two species that take the most advantage of trash feeding on campus are the Glaucous-Winged Gull (*Larus glaucescens*) and the American Crow (*Corvus brachyrhynchos*), which aligned with findings from our observations.

One waste management staff underlined this view, stating the frequent incident of birds feeding on trash and that has been a constant challenge to them:

"I see it all the time, I can't even tell you how many times, I see it all the time, I don't even sense about that, I don't count how many times. It happens very frequently… we chase them away and try to clean up the mess."

Our ornithologist expert added by saying:

"Both [crows and seagulls] nest on campus and around individual buildings on campus. And you'll see both near trash can, you know, consuming food scraps and litter that had been left out. You'll see both around students or people that are eating lunch and trying to get food from people when people are there."

The participants also described how the birds seem to know where to look for food (exposed waste) and what type of sources they can target. He noticed the most common feeding behaviour of birds is that they would look for take-out bags, pull them apart to forage the food inside, leaving a messy ground to be cleaned up. This can happen with or without any human contacts, suggesting the birds have adapted to foraging on urban landscapes.

5.2.2 Causes of exposed waste on campus

Exposed waste refers to waste that filled in opened-top bins, waste that spilled on the ground from overfilled bins or loose litters that left unattended. The waste management department in UBC operates from Mondays to Fridays, and waste collection staff works on morning and afternoon shifts. They have scheduled check-ups on trash bin conditions up to four to five times a day. he department would arrange additional shifts at nights and weekends to manage extra loads of waste during sunny days, weekends or on special occasions, such as having big events on campus. Therefore, the staff participants claimed that the weekends and overnight temporal gaps are not the potential causes of exposed waste from overfilled bins. They pointed out the three main causes of exposed waste are: first, littering of waste by consumers on

places that are not designated for waste disposal (i.e loose litters) such as on the ground, around the trash bins, on the flower beds, table and chairs; second, the fact that outdoor trash bins on campus are predominantly opened-top bins which are easily accessible by birds and rodents; and third, in some areas, the plastic lids of closed-top bins are frequently chewed and destroyed by squirrels, leaving the waste exposed and accessible by birds, as detailed by one of our waste management experts:

> *"Not only birds, squirrels do feed on garbage. They would chew the plastic lids of the dumpsters and climb into them. My drivers have actually been startled by them jumping out at them when they try to move the dumpsters and have them emptied. So that's a rule of thumb to kick the dumpsters before the drivers try to move the bins to make sure whatever is in it come out otherwise they may get bitten by them."*

5.2.3 Direct effects of trash feeding on bird populations

Findings from our interview with an ornithology expert indicated that there were several direct effects of trash feeding on UBC crowns and seagulls (Table 1). Primarily, increased trash feeding sources have led to increased populations of crows and seagulls on campus. According to our expert,

> *"And so they're [seagulls] a species that have been able to take advantage of..[trash feeding]. And so that human derived food has allowed their populations to become quite large in these urban areas. And the same thing is true for crows."*

While our expert indicated that unintentional food sources on campus, such as waste, likely do not provide the most optimal nutritional value, *"...it's [unintentional food sources] easy and acceptable from the birds perspective"*. Our interviewee went on to describe the

potentially reduced life spans of birds who feed on trash, but also a key challenge in discerning direct effects because these effects on bird physiology are understudied.

5.2.4 Indirect effects of trash feeding on bird populations

Interestingly, when asked to describe the broader indirect effects of trash feeding on bird diversity and urban ecology, our expert eluded to the need for more research in this area. For instance, potential interspecies competition can result from unintentional feeding on campus, including stressing out other species to the point where they surrender potential space for nesting. To demonstrate this potential effect, our participant said:

> *" I think the fact that there's lots of crows makes it harder for the Ravens that do live around here, the crows are always pestering and chasing and being aggressive towards ravens and crows use their social behavior to be aggressive to Ravens."*

Additionally, the participant indicated that *"you could hypothesize that the crows will eat eggs and other songs of songbirds"*, but also warned that they felt *"that concern is usually overblown, at least in the absence of data"*. Other unintended effects that our participant highlighted were that urban birds behavioral patterns are shifting toward low fear response of humans, resulting in increased human-crown interactions, as corroborated with our observations. To illustrate this effect, the participant described this aggressive behavior:

> *"that also manifests as lots of human crow interactions in the breeding season, where the crows are defending their nest and doing so by swooping down on people and that sort of thing."*

While these indirect effects were reported by our participant, they highlighted that identifying these indirect effects is challenging because limited data exists to support these claims, highlighting an important research gap in the context of urban social-ecological systems.

In addition to birds, the participant highlighted additional considerations of mammalian populations that take advantage of trash feeding on campus. These findings were corroborated by UBC waste management. In particular, racoons, squirrels, rodents, and coyotes are opportunistic and generalist feeders. Our participant warned about the risks of human-coyote interactions with increased waste on campus, a finding corroborated by observational studies (see Figure 8). Our participant described:

> *"There's an opportunity for there might be a couple ecological arguments to bolster the pre-existing human concerns that you could throw those in? I think probably the wildlife component that has the most direct consequences are coyotes because of the coyotes on campus. I don't know how many there are right now. But certainly in the last year or two, there's multiple individuals that are not scared of people that are getting food from trash in different places, presumably, and are walking next to people on campus. And so those are the ones that, you know, there's the potential for a kind of more direct human wildlife conflict that we certainly like to avoid with them, but from the bird perspective."*

Figure 8. *Coyote seen on campus (Personal Photograph)*

5.2.5. Current practice to reduce exposed waste and future recommendations

The issue with loose litters has been a constant battle to the waste management team. Loose litters increased recently as a result of reduced dine-in seatings in restaurant which in turn dramatically increased the volume of take-out food during Covid-19 pandemic. The short-term solution employed by the team is to increase ground keeping on loose litters. The team is also gradually replacing outdoor open-top bins with indoor sorting stations that support sorting of multiple streams of waste which also block the accessibility of rodents and birds. Plastic lids that are chewed by squirrels are replaced in a timely manner. According to our waste management interviewees, the team recognised changing plastic lids to durable material such as metals could be a potential long-term solution however, metal lids are less economical and relatively heavier and pose safety risk to staff who have to frequently lift the trash bins.

To overcome some of the challenges highlighted around unintentional feeding on campus, our ornithologist expert provided a few recommendations. Primarily, they indicated taht improved structural design of trash cans to prevent birds, small mammals, and coyotes from accessing trash would limit the amount of scavenger birds on campus and reduce the amount of waste that is spread by birds on campus. Further, the participant recommended mitigating the spread of waste at the source by encouraging students, staff, and faculty to limit occurrences of littering campus. Finally, to promote bird diversity in the face of increasing urban bird presences on campus, our expert suggested increasing opportunities for songbirds to use as habitat:

> *"The key thing is their habitat. If you know, having more birds on campus was more of a priority. There are things like putting up mess boxes to help out chickadees and things like that. It would be an effort that might increase populations of certain bird species."*

Table 1. Findings from interview with ornithologist that describe the direct and indirect effects of unintentional feeding on UBC bird populations, the current challenges around this problem, potential solutions, and additional considerations

Theme	Code
Problem	Aesthetic concerns
	Areas where unintentional feeding occurs
	Birds spreading trash around
	Crow-human interactions
	Food sources are less than optimal nutrition
Direct effects	Crows eating trash
	Crows tearing up grass
	potentially reduced life spans
	Growing population
	Gulls eating trash
	Increased gulls and crow nests on campus
Indirect effects	Urban birds becoming more used to human presence
	Crows stealing songbird eggs
	Interspecies competition/interactions
	Lack of data to understand indirect effects
Challenges	Unknown effects of unintentional feeding on physiology
	Unknown indirect effects
	Creating opportunities for songbirds to nest
Solution	Encouraging less littering on campus
	More secure trash cans
	Removing food sources on campus
	Trash has sufficient nutritional value for birds
Additional problems/challenges	Other mammalian species taking advantage of supplemental feeding

6. IMPLICATIONS

Our findings showed that trash feeding on UBC campus is prevalent primarily among scavenger bird species such as the American Crow and Glaucous-Winged Seagull, but also several mammalian species such as rodents, racoons, squirrels, and coyotes. Our findings suggest that trash feeding occurs opportunistically in areas with large amounts of trash which tend to coincide with areas exhibiting high levels of student traffic (e.g., UBC Bus Depot and Main Mall). A growing urban bird population on campus resulting from increased unintentional feeding sources (e.g., loose litter) can have effects on campus aesthetics, bird diversity, urban bird physiology, and human-wildlife interactions.

Our observations and interviews highlighted growing incidents of human-bird interactions on UBC campus. Increasingly, crows and seagulls are becoming more used to human presence and, at times, even aggressive towards humans, a phenomena corroborated in the literature (Kövér et al., 2018). This finding is corroborated in the empirical literature which has demonstrated corvids behavior in urban contexts becoming more habituated as a result of increased unintentional food sources placed near high concentrations of human activity in cities (Benmazouz et al., 2021). Empirical evidence has long suggested that aggression is likely a result of nest persecution by humans in urban areas (Knight et al., 1987). Further, our results show that crows and seagulls effectively spread waste around campus, an undesirable human-bird interaction from a campus planning perspective (ornithologist interview participant, 2021), one of the primary reasons why crows are considered a nuisance by city goers (Clucas and Marzluff, 2012). Thus, it is important to limit human-bird interactions to mitigate possible negative human-corvid interactions on campus.

While there are observed direct implications for birds (e.g., increased urban bird populations on campus, more human-bird interactions), there were many indirect implications that were unknown by our ornithologist expert. These findings alluded to a potential research gap in the effects of growing urban bird populations on other bird species in urbanized social-ecological systems. Despite skepticism from our ornithologist expert, there is some evidence in the literature that crows, in particular, reduce songbird populations through nest predation (Marzluff, 1997). While crows are not the dominant nest predators in urban landscapes (these are typically cats, racoons, and raptors) (Marzluff et al., 2011; Stracey, 2011), rapidly increasing crow populations have spurred concerns about more substantial nest predation in urban areas (Frost, 2013). Indeed, some studies have indicated that high crow abundance in cities

has homogenized urban bird fauna, decreasing richness or abundance of other bird species primarily through nest predation (Biadun, 2005; Diquelou et al., 2016; Evans et al., 2009; Rush et al., 2014). Thus, the effects of growing crow populations in urban contexts are not fully understood and warrant further research attention. Additionally, further attention should be directed to mammalian species feeding on trash on campus (e.g., coyotes, squirrels, racoons, etc) due to the risk of human-wildlife conflicts.

7. LIMITATIONS

While our study highlighted an important issue related to urban birds on campus, this was not without several limitations.We did our best to apply a social-ecological lens to the study design, data collection, analysis, and interpretation of findings. Though we were largely constrained from drawing too many conclusions due to a low sample participant size. In total, we reached out to seven individuals for interviews who were selected based on their expertise relevant to our study. However, we interviewed three individuals, only one of which was considered an ornithological expert. As a result, we learned a lot about the causes and effects of unintentional feeding on campus, but from a very limited scope. It is likely that if we had a larger sample size we would have extracted more nuanced perspectives and have been able to identify patterns across interviews that did or did not align with findings in the literature.

A major motivation of our study was to learn about the indirect effects of a growing urban bird population on other bird populations on campus. It was difficult to draw conclusions around these questions because we only conducted one ornithological expert interview and also because this is largely an understudied topic in the literature. A recent global literature review of corvids in urban environments indicated that a primary research gap is related to the negative

consequences of corvids on other urban bird assemblages (Benmazouz et al., 2021). Without an understanding of these indirect effects on other bird populations, it is difficult to make management decisions for corvids in urban environments .

A final limitation to our study was its narrow spatial and temporal focus for our observations. Our observations largely remained within the North Campus area and thus almost no findings are presented from South Campus. Moreover, observations were most often done between 7am-9am and 3pm-6pm, which might have skewed the findings of our observations towards the schedules of waste management. In other words, our observations might have indicated less litter than actual based on whether we consistently conducted them right after waste management inspections. Further, if we had been able to conduct more longitudinal observations, it is likely we would have been able to better distinguish patterns of when, where, and which food sources were most pertinent to seagull and crows on campus.

8. RECOMMENDATIONS

Based on the results of our research and anchored from the viewpoint that unintentional feeding on trash by birds may potentially have negative impact on birds populations on campus, we collated three key recommendations for further consideration:

1) *Increasing the number of waste disposal sites around the observed problem areas (UBC bus loop)*

From our interviews, it became apparent that our observations of birds eating and spreading trash were not isolated instances, but rather a common occurrence around campus, specifically around the UBC bus loop. Unsurprisingly, this was also an area with the most

amount of litter and the most glaring absence of trash bins. Hence, we recommend that more bins are installed in the UBC bus loop, as Al-mosa, Parkinson and Rundle-Thiele (2017) have indicated that less litter occurs in areas with more trash cans. By limiting the presence of exposed litter, we believe the instances of birds feeding and foraging on trash can be reduced. Furthermore, ensuring that future expansion projects of UBC consider the sufficient availability of trash bins, we suggest the creation of a people-to-bin ratio[4]. In other words, a certain number of bins must be installed based on the possible number of people in the area.

Our second recommendation builds on our first, but instead focuses more on socio-cognitive solutions to reducing the instances of birds feeding on trash:

2) *Utilizing social incentives and education campaigns to limit littering and promote proper waste disposal practices by campus population, and community-based education program to prevent human-wildlife conflict*

As indicated by UBC waste management team, take-out food was the major type of waste and source for unintentional animal feeding. We recommend to introduce incentive to help reducing take-outs on campus, such as Bring-Your-Own-Container (BYOC) program. Restaurant operators may give discount which is saved from reduced take-out packaging to customers who BYOC and refuse using disposable take-out packaging.

We also propose that anti-littering campaigns or initiatives to be created to promote awareness of the potential negative impacts on birds and other wildlife. Such initiatives could be done through signage or messages on trash bins encouraging people to properly dispose of their waste, which has been shown by Reiter and Samuel (1980) to reliably reduce the amount of litter

[4] This idea was suggested to us as a possible consideration in our initial conversations with waste management executives if it was found that UBC areas

in comparison to areas with no signage. Because social norms are a power driver of human behavior, we believe that appropriate nudges such as signage could be used to activate more environmentally friendly norms (Byerly et al., 2018; Grilli et al., 2021). Thus, effective information signages have the potential to limit the amount of trash on campus, and subsequently reduce trash feeding behavior of birds.

Furthermore, we propose community-based programs that aim to address human-wildlife conflict, with goals in educating people about how to avoid attracting wildlife to forage on unintentional food sources at property, changing behaviors that serve to attract wildlife and what to do should a wildlife approach or feed on trash. We believe such programs could create co-existence that is important for humans and wildlife co-adapt to living in shared landscapes (Madden, 2004). Example of such a program we can learn from is the Bear Smart Community Program in British Columbia (Davis, et al., 2002).

Lastly, we believe that the findings from this research offer important starting points for expanding the considerations of avian populations on campus, but warrants a significant broadening of scope. Hence, our last recommendation goes as follows:

3) *Incorporating citizen-science methods to expand the temporal and spatial scope of observations and data collection.*

By including a citizen science program, either through involving students, waste management employees, or bird-enthusiast clubs, the ability to collect data on bird unintentional feeding on campus would be significantly enhanced. Citizens on campus can use mediums such as smartphones to help collect bird unintentional feeding data such as location and time of sighting, type of trash being foraged, bird species and bird behavior. The results could be useful

to yield important information and potentially help UBC waste management team to discover exposed waste. The program can also help to raise awareness among UBC citizens on the social-ecological impacts of human actions on bird populations.

9. CONCLUSION

Our research aimed to understand the unintentional food sources that exist for birds on the UBC campus, as well as how birds might interact with such food sources. Even though the scope of our research is limited, we believe that feeding and foraging on trash was a common occurrence on campus, specifically around the UBC bus loop. We also believe that while all the litter on campus was of anthropogenic origins, birds played a significant role in spreading it out. Such occurrences not only make it more challenging to limit exposed waste on campus, but also promote the opportunistic feeding practices of other wildlife, such as coyotes, as trash is made more available to them. Moreover, we noted that persistent feeding on trash may increase the amount of human-bird interactions by influencing stronger associations between people and food. As such, our recommendations centered around reducing the occurrence of litter on campus, both through infrastructure and socio-cognitive opportunities. Furthermore, our research alluded to a possible gap in understanding the implications of trash feeding behaviors of growing urban bird populations within wider social-ecological systems. Our findings simply scratched the surface of this larger issue, and thus we believe future studies should expand on our research by broadening its temporal and spatial scope. With that being said, our research has the potential to highlight the growing need to consider trash feeding and foraging practices in the context of UBC, as the campus area is surrounded by, and consistently expanding to, natural wildlife habitats.

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APPENDICES

Appendix A. Interview guide for ornithologist expert

Topic	Questions
Avian Population on campus	● We are thinking a lot about scavenger birds on campus and their potential feeding patterns on unintended food sources such as trash. Which scavenger birds are most common on campus ○ where do they most often congregate? ● How have species dynamics changed on campus over time (or remained the same)?
Optimal nutrition for birds	● What man made food is nutritional to birds that can be found in the urban environment such as the UBC campus? Which sources are least nutritional (e.g., rubbish)? ● Do you think UBC campus offers suitable food sources for birds? If not, how could these be improved? a diverse array of species on campus?
Impacts of unintentional feeding on birds	● Can you share your opinions on the potential impacts of unintentional feeding to birds on campus? ● In which ways does unintintential feeding negatively impact bird species on campus? ○ Are there positive effects of unintentional feeding on some species? - What are the bird species that are likely to be impacted the most (negatively and positively) by unintentional food sources? ● Will unintentional food sources change bird feeding behaviour? How? ● What are the indirect effects of unintentional feeding on multiple bird species on campus (such as intra- and inter-species competition)?

	● What are the impacts of removal of unintentional food sources on campus to the populations of birds? ● Do you have concerns about unintentional feeding of birds on the UBC campus? ○ Are there primary areas of concern on campus?
Opinions and values	● What do you think we can improve on our waste management in ways that would limit unintentional feeding on campus? ● Why do you think structural fixes to prevent unintentional bird feeding are not as common as those for other species such as bears and rodents (e.g., sealed trash cans in national parks)? ● Should we provide nutritional supplements to birds on campus? How and why? ● Do you have any questions for us or anything that we did not get to that you would like to share?

Appendix B. Interview guide for UBC waste management personnel

Topic	**Questions**
Exposed Waste	● Can you broadly describe how the waste on campus is being managed? Are there any gaps between times and spaces? ● Which areas are more prone to exposed waste? ● Why are there exposed waste? ● What is the most common waste on campus?
Bird Feeding On Trash	● Did you receive report regarding bird feeing on waste? Or any other issues regarding birds to waste management? ● How often do you see bird feeding on waste?

Bird Feeding Behaviour	● How do birds feed on trash? ● Can you describe how they feed on trash?
Impacts to operations and potential solutions	● Does bird feeding on trash disturb operations in waste management? ● How do you solve the problems caused by bird feeding on trash? ● Would you say having more close-top bins can reduce animal feeding on garbage? ● Are there any current or future program aims to reduce as much exposed waste as possible? ● What are the current practises in place to reduce animal such as rodents feeding on waste?

Appendix C. Consent form for employees of UBC Waste Management and UBC ornitologist

UNINTENTIONAL BIRD FEEDING

Institute for Resources, Environment & Sustainability

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Vancouver, BC Canada V6T 1Z4

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Fax: (604) 822-9250

Website: www.ires.ubc.ca

Principal Investigators:
Dana Johnson, Elina Eronen,
Kah Mun Wan
UBC, IRES

Co-Investigator
Dr. Leila Harris
Professor, IRES
Professor, Institute for Gender, Race, Sexuality and Social Justice

October XX, 2021

Interview – Understanding Trash Foraging Practices In Bird Populations on The UBC Vancouver Campus

Dear Collaborator,

We are graduate students with the Social Ecological Economic Development Studies (SEEDS) Program at the University of British Columbia, which is investigating the prevalence of litter on campus and the potential impacts to avian biodiversity via trash foraging practices on campus. Working with Dr. Leila Harris at UBC, we are contacting you about participating in an interview about your experience with the waste management on campus and potential bird foraging activities on waste. We are writing to request your participation in the interview in the near term.

This letter provides more information about the project and, in accordance with UBC Ethics Review Board norms, includes a consent form that needs to be signed and returned to us before the focus group can take place.

UNINTENTIONAL BIRD FEEDING

Study Objectives:
The objective of this project is to identify risks to birds from feeding on unintentional food sources (litter, food scraps, overfilled trash-bins) on the UBC Vancouver campus. The project aims to evaluate the prevalence of litter in hotspots and the negative (or positive) patterns in bird feeding behaviors on campus that may negatively impact local avian populations via trash foraging; and determine actionable recommendations that relate to the conservation of avian biodiversity through fostering habitats that offer optimal nutrition in the campus.

Our specific aim with this interview is to better understand the prevalence of litter on campus, type of exposed waste and bird feeding patterns on waste. As such, we will be asking you questions related to your experience in waste management on campus.

Study Procedures:
You are being invited to participate in this research project because of your experience as an employee of the Building Operations' Waste Management team in Municipal Services of UBC who provides waste management service to the UBC campus community. All participants must be over 18 years old at the time of the study. The interview will be conducted in person, preferably in October or November 2021—we will arrange the interview to suit your availability. During the interview you will be asked a range of questions related to the goals of this research project. The interview will require approximately thirty minutes to one hour of your time. We will aim to write up the results of the study in a short article later this fall.

You may decline to consent or withdraw from the study at any time without consequence.

Confidentiality:
Interviews will be audio-recorded and transcribed for qualitative analysis. The interviews and your identity remain confidential at all times. No information that discloses your identity is released or published. However, research records identifying you may be inspected in the presence of the investigator or his or her designate by representatives and the UBC Research Ethics Board for the purpose of monitoring the research. However, no records that identify you by name or initials will be allowed to leave the investigators' offices. The data records will be kept on a computer hard disk that will be accessible only by password. Pursuant to UBC policy, the data will be kept in storage for five years after the completion of the study. At the end of the five years, the records will be destroyed. The completed research report will be stored in a public open-access library on the SEEDS website (SEEDS Sustainability Library).

If you are interested in participating in the interview, please let us know at your earliest convenience.

Contact for information about the study:
If you have any questions or desire further information with respect to this study, you may contact **Dana Johnson** at Dnjohns2@student.ubc.ca , **Elina Eronen** at eeronen@student.ubc.ca, **Kah Mun Wan** at carmenwk@student.ubc.ca.

Contact for concerns about the rights of research subjects:
If you have any concerns about your treatment or rights as a research subject, you may contact the Research Subject Information Line in the UBC Office of Research Services at 604-822-8598.

Please sign the enclosed consent form if you agree to participate in the interview. You can return the signed form via email to the above address. Upon receipt of this we will contact you to arrange a time for the interview at your convenience. You may withdraw from the study at any time without consequence.

We look forward to hearing from you.

Regards,

Dana Johnson, Elina Eronen and Kah Mun Wan for Leila Harris

Graduate students, Institute for Resources, Environment & Sustainability, UBC

Social Ecological Economic Development Studies (SEEDS) Program

CONSENT FORM

Re: Interview, Impacts of Unintentional Feeding to Birds on UBC Campus (University of British Columbia)

Please return to carmenwk@student.ubc.ca with a signed copy.

Consent:
Your participation in the interview is entirely voluntary and you may refuse to participate or withdraw from the research project at any time without consequence.

Your signature below indicates that you consent to participate in this study and that you have received a copy of this consent form for your own records.

_____
Subject Signature Date

_____
Printed Name of the Subject above

Institute for Resources, Environment & Sustainability

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Our specific aim with this interview is to better understand the avian population on campus and the potential impacts of trash foraging practice to the population and composition of bird species on campus. As such, we will be asking you questions related to your expertise in avian population on campus.

Study Procedures:
You are being invited to participate in this research project because of you are an employee in UBC who have undertaken research related to birds or have involvement with protecting avian population on campus. All participants must be over 18 years old at the time of the study. The interview will be conducted in person, preferably in October or November 2021—we will arrange the interview to suit your availability. During the interview you will be asked a range of questions related to the goals of this research project. The interview will require approximately thirty minutes to one hour of your time. We will aim to write up the results of the study in a short article later this fall.

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