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Reducing bird-window collisions at a botanical garden: The effect of bird-friendly artwork and dirty windows

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With up to 42 million dying each year due to window strikes, evaluating the effectiveness of mitigation strategies is a must to protect vulnerable bird species. One of the most effective strategies is the application of decals to the outside surface of a window. Commercial products, such as Feather Friendly® bird deterrent film, use a grid pattern of small dots that helps reduce visual obstruction for humans. However, bird-friendly artwork has been suggested as a strategy that combines effectiveness and aesthetic appeal, but has not been critically evaluated. Dirty windows too, are suggested as being effective, but little research exists to support these claims. This study performed bird collision monitoring at the UBC Botanical Garden before and after the application of bird-friendly artwork to the Pavilion, and during a time where dirt was allowed to accumulate on the windows at the Garden Centre. Monitoring was performed 4 times a week for 8 weeks during February and March. Building facades were searched for collision evidence, such as carcasses, feather piles, and feather smears. The reduction in collisions was dramatic; collisions decreased from 11 to 0 at the Pavilion, and from 84 to 3 at the Garden Centre. The results of this study support the use of bird-friendly artwork and dirty windows as management strategies for bird collisions, but also support student engagement in identifying collision hotspots and informing mitigation. Continued monitoring of the garden is suggested. Future research is needed to quantify the level of dirt on a window and how that effects collision risk, as well as research into public perception of dirty windows. Overall, the results of this study are promising for the future of birds at the UBC Botanical Garden.

INTRODUCTION

Every year, as many as 42 million birds are killed every year due to window collisions in Canada, making bird-window collisions one of the leading causes of human-wildlife conflict (Machtans et al. 2013). Human-wildlife conflict refers to situations where the needs of wildlife and the needs of humans oppose one another and lead to negative consequences for one or both species (Mekonen 2020). Here, human interests in expansive glass architecture causes significant mortality among birds, with some species being particularly vulnerable (De Groot et al. 2021).

What makes glass so deadly is that birds are not only unable to perceive glass as a solid object, but can also be tricked by the reflection of vegetation or sky. As a result, birds attempt to fly through the glass pane but collide instead. Thus, the glass area and glass proportion of a building or façade has been well studied as a significant predictor of bird collisions (Borden et al. 2010, Hager et el. 2013, Cusa et al. 2015, Ocampo-Peñuela et al. 2016, Loss et al. 2019, Riding et al. 2020). In addition, the relationship between glass cover and collision risk is non-linear; Klem et al. (2009) calculated a 32% increase in collision risk for only a 10% in glass proportion.

In order to reduce avian mortality caused by windows strikes, there has been significant research into possible mitigation strategies and their effectiveness. One such strategy is the application of decals to the outside surface. Commercial products, such as Feather Friendly® bird deterrent film have demonstrated a remarkable ability to reduce collisions (Brown et al. 2019, Brown et al. 2021, De Groot et al. 2022). The study by De Groot et al. (2022) demonstrated a 95% decrease in collision risk for buildings retrofitted with Feather Friendly® markers. While this type of strategy has limited effects on the aesthetic appeal of treated windows, given the low surface area covered, circular markers are not particularly pleasing to the eye or engaging to the public. The use of bird-friendly art, on the other hand, has just these qualities. However, research into the effectiveness of bird-friendly art is limited; in a study by Rossler et al. (2015) looking the effectiveness of different bird-deterrent patterns, the researchers chose to include an "coral" pattern. The results indicated this pattern was highly effective, but the authors did not include any discussion on this pattern. Thus, there is a significant gap in the literature and further investigation is warranted.

Another mitigation strategy that has received little attention is dirty windows. A study in Poland reported reduced collisions at glass bus shelters covered with dust or graffiti compared to clean bus shelters (Zyśk-Gorczyńska et al. 2020). Another study using citizen science reported increased collisions at homes with recent window cleaning (Żmihorski et al. 2022). However, given the limitations of the aforementioned studies, more research is still needed to investigate the effects of dirty windows.

The main objectives of this study are to: (1) investigate the effects of bird-friendly artwork on collision incidence and (2) determine if dirty windows are an effective mitigation strategy.

MATERIALS AND METHODS

Study Site

The study location was the UBC Botanical Garden at the University of British Columbia Point Grey campus in Vancouver, BC, Canada. Two buildings were selected: the Garden Centre and the Pavilion. Facades were labelled from 1-19 with 1-15 being at the Garden Centre and 16-19 being at the Pavilion (Figure 1). Prior to the start of the study, bird-friendly artwork was applied the windows of the Pavilion (Figure 2). In addition, the glass panes at the Garden Centre had not been washed, allowing algae and dirt to build up on the surface.

Figure 1. Satellite photographs of the Garden Centre (A) and the Pavilion (B) with labelled facades

Figure 2. Artwork applied to the windows of the Pavilion at the UBC Botanical Garden

Data Collection

Prior to beginning the survey, a clean up day was held to remove any evidence of previous collisions. Monitoring was performed in pairs, four times a week from January 28th, 2022, to March 29th, 2022. Monitoring was performed in the mornings and was concluded by 10:00 am each day. Weather conditions were recorded using the Weather Bureau Sky Condition Codes prior to the start of each monitoring period. The glass area for each façade was determined by measuring the length and width of each glass pane in a façade using a standard tape measure. Pictures of each façade were also taken.

Surveyors searched for three types of collision evidence: carcasses, feather piles, and feather smears, A feather pile was defined as 10 or more feathers within a 1 m diameter circle, while a feather smear was defined as a feather attached directly to a glass pane. Surveyors walked in opposite directions around each building and searched for evidence within 2 m of windows. If evidence was found, the location (building and façade #) was recorded, but no information was shared between surveyors until both had completed their passes around the building. Afterwards, surveyors returned to any evidence to record additional details and remove the evidence.

For a carcass, three photographs were taken: a dorsal view, ventral view, and lateral view. The condition of the carcass (intact, partially scavenged, or decomposing) was recorded, as well as a description of the carcass and species (if known). For a feather pile, feathers were counted if there were <15, otherwise feather counts were estimated as >20, >50, or >100. For both a carcass and a feather pile, the evidence was collected in a resealable plastic bag a labelled with a unique code, which includes the date, building code, façade # and species (if known). In the event that a feather smear was found above a carcass or feather pile, it was not counted as a separate collision but was added to the comments of the carcass or feather pile. Carcasses and feather pile were then delivered to Krista De Groot for species ID and storage of the evidence.

All data and photos were uploaded to a shared Google Drive by the end of the day with a data entry for each façade, even if no evidence was found, and an entry for each separate collision. Photos were named with the unique code corresponding to the evidence found. One member of the pair uploaded the data, while the other checked for errors.

Carcass Persistence

Two carcasses, each with a clipped hallux, were procured for the carcass persistence trial, which commenced on March 17th, 2022. Due to a misunderstanding, both carcasses were placed at the Garden Centre instead of one at each study building. A random number generator was used to choose the façade location for each carcass. When the carcasses were placed, a photograph was taken and labelled with carcass ID (date, building code, façade # and species). The substrate the carcass was placed on was recorded, and the visibility of the carcass was ranked from 1 (very visible) to 5 (very difficult to see). The carcasses were placed a 1:45pm on the first day, checked 4:30pm later that day, and every morning thereafter for four days. The first carcass, a Black-capped Chickadee, was placed at façade 10, on top of shrubs/ground cover, with a visibility of 2. The second carcass, a Red-breasted Nuthatch, was placed at façade 4, on top of shrubs/ground cover, with a visibility of 4.

Data Analysis

Pre-existing data from 2021 was obtained for a comparison of collisions between years. In 2021, monitoring occurred from February 2nd, 2021 to March 26th, 2021 using the same protocol as described above. Evidence was totaled for each year and the percent decrease was calculated. Data was also grouped by building and year to look at building specific trends. The data for 2021 and 2022 was then combined to compare collisions by façade. Finally, Pearson's Correlation Coefficient (*r*) between collisions in 2021 and façade glass area was determined in R, using the tidyverse R package. Residuals indicated data was normally distributed.

RESULTS

Collision Data

During the 2021 monitoring period, a total of 95 collisions were observed, with 84 occurring at the Garden Centre and 11 occurring at the Pavilion. During the 2022 monitoring period, only 3 collisions were observed, all at the Garden Centre (Figure 3). This represents an decrease of 100% and 96% from 2021 to 2022 for the Pavilion and Garden Centre, respectively. Combining both years, most collisions at the Garden Centre occurred at façade 6 and 9, followed by façade 3, 5 and 7 (Figure 4). These five façades account for 55% of all collisions at the Garden Centre. At the Pavilion, 64% of collisions occurred at façade 17. The correlation between façade glass area and the number of collisions was significant ($r = 0.53$, $p = 0.02$) (Figure 5). However, the number of collisions at certain façades differed largely from what would be expected given the glass area. Façade 6 had just as many collisions as façade 9 despite having a third of the glass area. Similarly, facades 3 and 5 have a higher number of collisions than would be expected. Façade 4, on the other hand, has very few collisions despite having a large glass area.

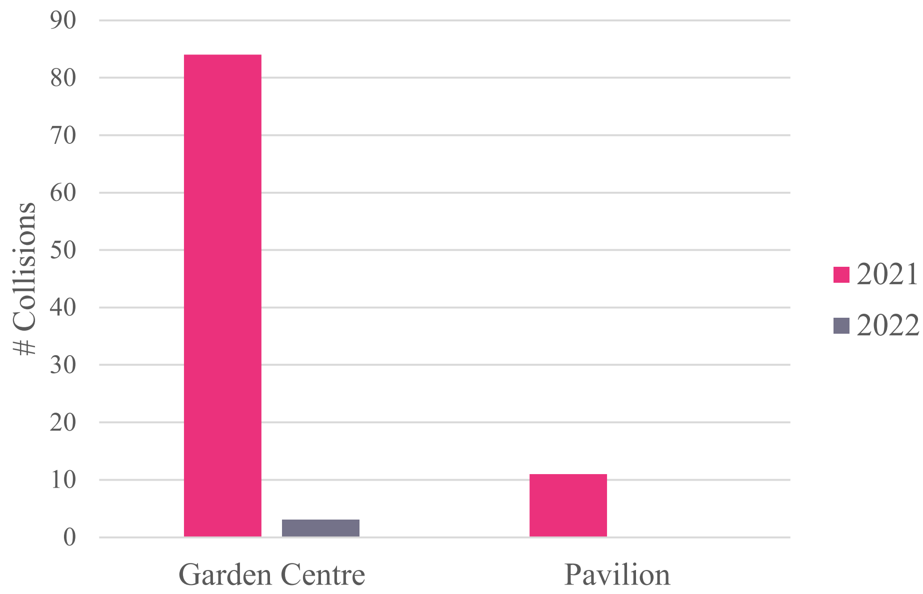

Figure 3. A comparison of the number of bird collisions observed at the Garden Centre and Pavilion between the 2021 and 2022 monitoring periods

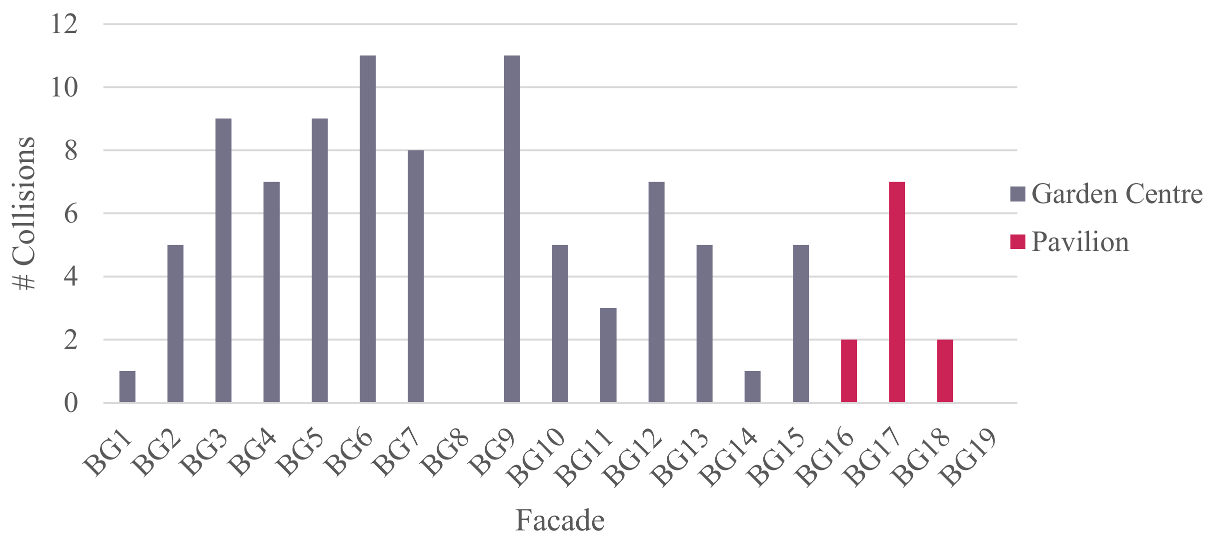

Figure 4. Total number of bird collisions observed at each façade, combining 2021 and 2022 data

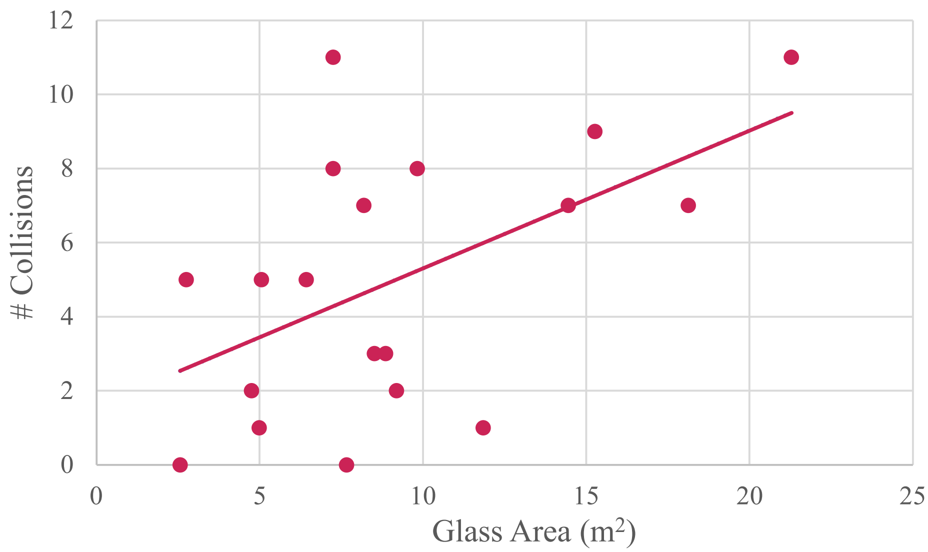

Figure 5. Relationship between the total number of collisions observed at the glass area of each façade

Carcass Persistence

Persistence varied for each carcass (Table 1). The first carcass was partially scavenged between 3 and 19 hours after being placed, while the second carcass remained intact during the whole trial.

Table 1. Timeline of carcass persistence

Date & Time:	03/17/22 13:45	03/17/22 16:30	03/18/22 08:30	03/19/22 10:00	03/20/22 10:00	03/21/22 09:00
Carcass 1	Placed	Intact	Partially Scavenged	Partially Scavenged	Partially Scavenged	Feather Pile
Carcass 2	Placed	Intact	Intact	Intact	Intact	Intact

DISCUSSION

Glass Area

In this study, we were able to confirm that glass area and the number of collisions is significantly correlated at the UBC Botanical Garden, much like previous research (Cusa et al.

2015, Loss et al. 2019). However, certain façades had more or less collisions than would be expected based on their glass area. One of the reasons for this is that glass area is just one risk factor; other variables exert a significant influence on collision risk as well, such as the proximity of vegetation (Klem et al. 2009, Loss et al. 2019). As a result, other factors are likely contributing to the uneven collision risk at facades with similar glass area.

Bird-friendly artwork

This study confirms the effectiveness of bird-friendly artwork as a bird-deterrent measure as bird collisions at the Pavilion have decreased by 100% following the application of artwork to the windows. These findings are consistent with what would be expected from the literature on pattern spacing. The maximum spacing for a pattern to be effective is 10 cm vertically and 5 cm horizontally (Rossler et al. 2015). In addition, any markings need to be at least 0.2 cm wide in order to be recognizable to birds (Rossler et al. 2015). Beyond these spacing requirements, the specifics of a pattern are less relevant. Since the artwork was designed with these spacing guidelines in mind, it fits all the requirements needed to effectively create a visual barrier for birds.

One of the benefits of this study is that it shows bird-collision reduction in a real-world scenario. While flight tunnels can be an effective tool to evaluation the effectiveness of window treatments, the factors that influence collision risk are very diverse (Brown et al. 2019). Flight tunnels are also unable to replicate reflections, which are also known to contribute to collisions (Sheppard 2019). Reflections also vary internal lighting, external lighting, and the angle of view (Sheppard 2019). Studying mitigation strategies applied to real buildings incorporates the context-specific variables of a building or façade, which strengthens generalizations from the data.

Dirty Windows

Collisions at the Garden Centre dramatically decreased from 2021 to 2022, likely due to the effects of dirty windows. Presumably, the glass panes along the boardwalk would be more opaque after a year of dirt accumulation and algal growth. By decreasing the transparency of the windows, birds are less likely to see habitat behind the glass and would instead see a solid barrier. Secondly, dirty windows may also be less reflective, meaning birds are less likely to see habitat reflected in the glass (Zyśk-Gorczyńska et al. 2020). As a result, dirty windows help remove the factors that cause birds to fly into glass windows: transparency and reflection.

Our results confirm the findings of Zyśk-Gorczyńska et al. (2020), who found significantly less evidence of collisions at glass bus shelters with dust on the glass than those with clean panes. Similarly, a study by Żmihorski et al. (2022) found that homes without recent window cleaning reported less bird collisions than homes with recent window cleaning. However, our study is the first to make comparisons between years for the same glass panes.

Carcass Persistence

In the present study, carcass persistence varied considerably; one carcass lasted for less than 19 hours while the other persisted for more than four days. Direct comparisons to published studies are limited as numerous variables account for differences in carcass persistence between sites. However, many studies also report large variation in carcass persistence, much like our results (Kummer et al. 2016, Riding and Loss 2018, De Groot et al. 2022). In addition, a study reported that 40% of scavenging events in a carcass persistence trial left remains after the first scavenging event. This supports the results of carcass 1, which was left partially scavenged for some time before being removed.

Limitations and Future Research

Our study has several limitations that should be addressed. First is searcher efficiency; it is likely that at least some evidence was missed. Evidence, such as feather smears, may be less visible on dirty windows (Zyśk-Gorczyńska et al. 2020). In addition, the observer detection probability for carcasses can be quite low for some buildings. In one study, the detection probability ranged from 4% to 70% for different buildings, an important factor being the substrate a carcass was on (Loss et al. 2019). Searcher efficiency tends to be higher on artificial substrates as carcasses are less camouflaged (Riding and Loss 2018). Since the boardwalk is surrounded by shrubs and ground cover on either side, this likely reduced the chances we would detect a carcass at the Garden Centre. In contrast, the Pavilion has artificial substrate within 2 m of the windows, thus the detection probability there was likely quite high. However, due to a misunderstanding, a carcass persistence trial was not held at the Pavilion, so no conclusions can be made about whether a carcass might have been removed prior to surveyors having a chance to detect it.

Another factor contributing to missed evidence is that several observations were made by only a single surveyor. On these days, a partner was unavailable, which increased the probability that evidence would be missed. Since our analysis did not account for these biases, the actual collision counts may be higher than reported. Future studies should consider including searcher efficiency trials and using the results to estimate true collision counts.

A second limitation is that we are unable to quantify the difference in opacity of glass panes between 2021 and 2022. Without an image comparison or data from the previous year, we are unable to conclusively say that the reduction in collisions was because the glass was dirtier. Future research should be performed with a more robust study to test the effects of dirty glass. A future study could perform year-round monitoring for several years after the windows are cleaned to observe changes in collision rates. It would also be helpful to have some quantitative measure of the opacity of the glass panes. Finally, control areas could be cleaned as used as comparisons for changes in yearly collision rates not due to the dirty glass.

Future research should also investigate the public perception of dirty windows at the UBC Botanical Garden. While our results may show promise that dirty windows reduce collisions, the practicality of this mitigation strategy for a public place of business may depend on how dirty windows affect an individual's experience at the garden. Such a study may also wish to investigate whether education on the reasoning behind the dirty windows influences public perception.

Management Implications

The results of this study inform on several management strategies. Firstly, bird-friendly art is effective at reducing window strikes, which makes it an excellent mitigation strategy for any building. Public buildings, such as university campuses and botanical gardens, may especially benefit from the aesthetic effects of bird-friendly art, as well as the ability of art to inform the public. Design competitions can also be used to help engage the public with preventing window strikes. Overall, our results support the recommendations made in bird-friendly design guidelines to retrofit existing buildings with artwork.

Secondly, dirty are an effective strategy to mitigate bird collisions. Homeowners and building managers alike should consider ceasing window cleaning, or at least reducing the frequency to allow dirt to accumulate. Dirty windows should also be added to bird-friendly design guidelines, and public awareness campaigns should emphasize dirty windows as a free and easy mitigation strategy.

Finally, this project supports the use of student engagement to identify collision hotspots and inform mitigation. Previous studies have also helped garner support for bird-friendly retrofits; at Duke University, a collision monitoring survey identified a particularly deadly building on campus, and with the help of the student body, the researchers convinced the university to take action (Ocampo-Peñuela et al. 2016). Bird deterrent filmed was applied to the windows of this building. In our study, student research and engagement with the UBC Botanical Garden is helping to bring in changes that reduce the number of bird collisions. If the UBC Botanical Garden were to apply bird deterrent film to the glass panels of the boardwalk instead of allowing dirt to accumulate, the film should be applied to façades 3, 5, and 6 to minimize costs. Altogether, businesses and universities should be encouraged to engage with research on bird collisions and apply mitigation strategies to identified hotspots.

CONCLUSION

Overall, this study shows promising results for reducing bird collisions at the UBC Botanical Garden. Collisions at the Pavilion were reduced by 100% after the application of bird-friendly artwork, and collisions at the Garden Centre were reduced by 96% after an additional year of dirt accumulation. Performing this study in a real-world scenario strengthens our results and supports the use of bird-friendly artwork as a mitigation strategy. Our results also suggest that allowing windows to become dirty effectively reduces window strikes. Future research with a more robust study is still needed to confirm these results, as well as continued monitoring of the UBC Botanical Garden.

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