Crash course conservation: Evaluating the effectiveness of Feather Friendly® markers and bird-safe murals in reducing bird-window collisions

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APBI 490D / CONS 495
The University of British Columbia

April 12, 2024

Cover Photo: UBC Brand and Marketing
The Spruce / Nisanova Studio
UBC Brand and Marketing

SEEDS Sustainability Program

ABSTRACT

Human-wildlife conflicts arise out of incompatibilities between the needs, goals, or activities of humans and wildlife, which result in real or perceived threats to either party. Such conflicts encompass not only direct confrontations between humans and wildlife, but also indirect consequences resulting from their impacts on the shared environment. Bird window strikes, or mid-flight collisions between birds and glass window features, are an example of such consequences. Estimated to upwards of 1.3 billion birds each year in North America alone,

bird-window collisions are one of the largest anthropomorphic threats to avian populations. With many bird species experiencing a widespread decline in abundance, diversity, and biomass, there is an urgent need to confront the sources of human caused mortalities in birds. The objective of this study was to identify which facades at IRSHDC, CIRS, and MTM may be considered high risk for window collisions, and to evaluate the effectiveness of existing Feather Friendly® window applications and bird safe murals on facades at IRSHDC and CIRS respectively. The results of our study revealed an 84.6% decrease in collisions at IRSHDC facade 1 following the application of Feather Friendly® Markers. We advocate for the application of Feather Friendly® Markers to other high risk facades on UBC campus, and for the continued monitoring of IRSHDC and MTM to better understand the long term effects of such prevention strategies.

Future research should analyze the large-scale impacts of collision prevention strategies, and address knowledge gaps in order to target areas of high mortalities and meet conservation goals.

TABLE OF CONTENTS

INTRODUCTION

Human-wildlife conflicts arise out of incompatibilities between the needs, goals, or activities of humans and wildlife (Madden, 2010) which result in real or perceived threats to either party (Long et al., 2020). Such conflicts encompass not only direct confrontations between humans and wildlife but also indirect consequences resulting from their impact on the shared environment. These interactions differ significantly across taxa and depend on spatial and urban contexts (Long et al., 2020), resulting in disproportionate costs to certain species and people (Schell et al., 2020). In this paper, I demonstrate how urban expansion and modern architecture have emerged as significant sources of human wildlife conflict as it relates to bird-window collisions, and how effective intervention strategies may be used to reduce the threat of this conflict.

Bird Window Collisions

Anthropogenic land use changes and human activities are increasing conflicts with wild birds. Within North America, research has shown that pollution from human activities (Kelly et al., 2014), predation by domestic cats (Loss et al., 2013), vehicle collisions (Trombaluk & Frissell, 2000), and window strikes (Klem, 1990; Loss et al., 2014) are the primary human-wildlife conflicts impacting wild bird populations (Long et al., 2020). The rapid expansion of urban areas in North America, and worldwide, is increasing opportunity for human-wildlife conflict, by pressuring wild animals to navigate a human-dominated landscape (Schell et al., 2020). Bird window strikes, or mid-flight collisions between birds and glass window features, are a devastating consequence of such pressures. Estimated to kill upwards of 1.3 billion birds each year in North America alone (Klem, 1990; Loss et al., 2014), the exact impact of bird window collisions on biodiversity loss is not yet fully understood (Cusa et al., 2015; Loss et al., 2014). With many bird species experiencing a widespread decline in abundance, diversity, and biomass (Rosenberg et al. 2019), there is an urgent need to address this considerable knowledge gap.

A combination of structural and environmental factors contribute to the magnitude of collisions at certain sites. Research has suggested that bird window collisions are a consequence of the transparent or reflective characteristics of glass, which cause glass barriers to reflect nearby habitat or to be mistaken as passable airspace by flying birds (Klem 1989, Klem et al. 2009). Architectural features such as the amount of glass (Bayne et al., 2012; Cusa et al., 2015; Hager et al., 2013; Klem et al., 2009; Zulian et al., 2023) and the building type (Machtans et al., 2013) have been correlated with increased incidents of window strikes. Described by Hager et al. (2017) as "mortality signature" of a building, the surface area of glass has been shown to positively influence the probability of collisions in all seasons (Zulian et al., 2023). Environmental features, such as whether the location is urban or rural (Bayne et al. 2012), and the proximity to nearby vegetation (Gelb and Delacretaz 2009, Klem 2009) and large landscape features (Cusa et al. 2015) such as greenspaces or forests (Hager et al., 2017) have also been found to influence the probability of collision, likely by increasing the number of birds available to collide with windows (Basilio et al. 2020, Bayne et al. 2012).

A variety of commercially available and do-it-yourself (DIY) prevention strategies have emerged in response to growing awareness of the consequences of bird window collisions. As most collisions are thought to occur due to the inability of birds to appreciate glass windows as permanent barriers, the primary focus of collision reduction strategies is to increase the visibility of glass to birds (Klem, 2009). This may be achieved by retrofitting facades with ceramic frit glass or adhesive films, incorporating UV properties, and increasing the opacity of exterior glass panes, among others (Klem, 2009). Commercially available adhesive films, such as the Feather Friendly® circular adhesive markers have been successful in reducing the risk of window collisions by up to 95% in some trials (De Groot et al., 2022). Additionally, creative options such as window murals have been praised for their success at both deterring window collisions and spreading awareness through community involvement (De Groot et al., 2021).

Bird Window Collisions at the University of British Columbia Campus

University campuses, often featuring park-like conditions, clusters of low and high rise educational buildings, and animal attractants such as litter, may be important sources of future research (De Groot et al., 2021). At the University of British Columbia, collision research conducted by students, staff, and community partners such as Environment and Climate Change Canada (ECCC) have been able to track collision dynamics across a number of buildings, identifying high risk buildings and facades, and updating estimates of bird mortalities at a community level. This report will build upon prior research collected by students and community partners (ECCC) at the University of British Columbia's West Point Grey campus. The aim of this study is to identify high risk facades at three low-rise academic buildings at UBC, and to evaluate the effectiveness of existing Feather Friendly® window markers and bird-safe murals featured at our study sites. It is hypothesized that facades treated with Feather Friendly® collision prevention technologies, such as murals or adhesive markers, will cause fewer bird window collisions when compared to traditional glass facades (De Groot et al., 2022). As reported in literature, facades with large, uninterrupted glass components (Klem, 1989), which are in close proximity to vegetation (Cusa et al., 2015) and bird attractants (Bayne et al., 2012), are expected to have the highest numbers of collisions, and will likely be positive targets for mitigation efforts.

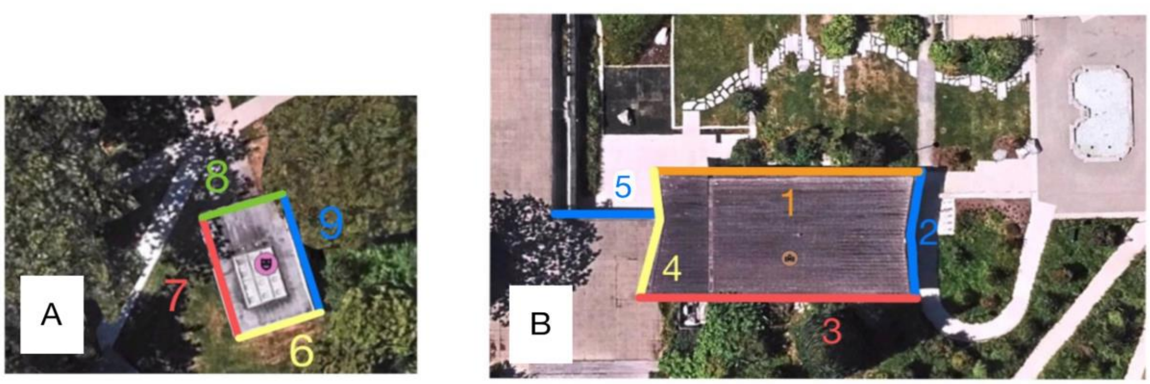
METHODS

Study Sites

This study took place at the University of British Columbia West Point Grey campus in Vancouver, British Columbia (49.2606°N, 49.2606°W), Canada, for 8 weeks (January 29–March 29) during the 2024 winter season. The UBC Point Grey campus is situated on the traditional, ancestral, and unceded territory of the Musqueam people. Located at the western tip of the Point Grey peninsula, the University of British Columbia's 420-hectare campus features a high diversity of flora and fauna, situated between the 2,000 acre Pacific Spirit Regional Park and the sandy beaches along the adjacent Strait of Georgia (De Groot et al., 2021). The UBC campus is characterized by low to mid-rise academic buildings and park-like landscaping, featuring over 18,000 coniferous and deciduous trees (UBC CCP, 2007), in addition to other vegetation and landscape features such as gardens and the neighboring UBC Farm.

Surveys were conducted at three low-rise academic buildings on the UBC campus: the Center for Interactive Research on Sustainability (height =4 stories, building footprint~ 18,000 m^2), the Indian Residential School History and Dialogue Centre (height= 2 stories, building footprint~ 1,980 m^2), and the Millenial Time Machine structure (height=1 story, building footprint~ 45 m^2).

Figure 1. ***Aerial views of MTM and IRSHDC with labeled facades***



Note. Aerial view of MTM with labeled facades 6-9 featured on left (A). Aerial view of IRSHDC with labeled facades 1-5 featured on right (B).

Figure 2. ***Aerial view of CIRS with labeled facades***

Carcass surveys

Surveys took place three times per week, starting the week of January 29th, 2024 for a total of 8 weeks. Two teams of two performed the carcass surveys, with Team A assessing the Centre for Interactive Research on Sustainability (CIRS), and Team B the Indian Residential School History and Dialogue Centre (IRSHDC) and Millenial Time Machine (MTM). A clean up was performed at each building the evening before the first survey, to remove any evidence of bird window collisions and ensure the data recorded was from our intended study period (Hager & Consentino, 2014). Surveys were conducted between the hours of 8am and 11am, to minimize the risk of scavengers removing evidence of collisions. As most collisions occur at dawn (Scott et al., 2023), the chances of evidence being removed by scavengers or maintenance workers increased as the day progressed. Further, carcass persistence trials conducted at UBC by De Groot et al. (2021) revealed the probability of carcass persistence on day 1 is 0.83, suggesting that over 15% of carcasses may disappear within the first 24 hours alone. Including these variables in our survey design are thus important to increasing the likelihood of carcass detection.

Evidence of window collisions was recorded using the Epicollect5 application and software. Prior to each carcass survey, the time, date, weather conditions, and initials of surveyors were recorded in the Epicollect5 application. Following the survey protocol established by Hager & Consentino (2014), the team of two would then independently survey for evidence of collisions, walking opposite directions along the building perimeter and searching within 2 meters of the building exterior. Three types of evidence were collected: feather smears, feather piles, and carcasses. Feather smears could be identified by feathers adhered to the glass facades, often associated with signs of dried blood, feces, or dust. Feather piles were defined as a minimum of 10 feathers located within a one meter radius. A carcass, or remains of the dead bird, may be found intact or partially scavenged (Hager & Consentino, 2014).

Evidence of feather smears, carcasses, or feather piles were first recorded independently. The survey team then discussed their findings, revisited collision points, logged data, and collected feather piles and carcasses. Evidence of smears, feather piles, and carcasses (intact or scavenged) were logged in the Epicollect5 app by attaching photos and descriptions of evidence and noting the facade on which it occurred. If an intact carcass was located, photos were taken of the ventral, dorsal, and lateral aspects to assist with identification (Hager & Consentino, 2014). After confirming and uploading data, evidence of window collisions were collected or removed so as not to be double counted. Feather piles and carcasses were placed into ziplock bags, labeled, and stored in the MCML 208 freezer to be used for later analysis. Feather smears were photographed, and then cleaned from the glass and composted. Feathers that were not included in feather piles were removed so as not to confuse data on subsequent days.

Carcass Persistence (CP) and Searcher Efficiency (SE)

Carcass persistence (CP) and searcher efficiency (SE) trials were conducted to inform potential biases due to scavenging or human error (Barrientos et al., 2018; De Groot et al., 2021).

The probability of detection may be influenced by many factors, such as the body mass of the bird (Barrientos et al., 2018) and abundance of local scavengers (Hager & Consentino, 2014), and such factors should be taken into account for the chosen study site. Carcass persistence (CP), or the probability of a carcass persisting at the site of the collision, was performed by placing a test carcass at a randomly chosen facade and measuring its persistence at that location (Hager & Consentino, 2014). The trial carcass had its hallux toe clipped to signal that it was a part of the trial. Surveyors would visit the trial carcass in the morning, noon, afternoon, and during scheduled surveys over a four day period, and confirm whether it was present or absent. Photos were taken for the first three days of scheduled visits. When the trial carcass was scavenged or removed from the site, the date, time, and location were recorded. If the carcass persisted beyond the carcass persistence trial, it would be noted during surveys, and the date of its eventual disappearance recorded. The searcher efficiency (SE) measured the percentage of carcasses located by surveyors (Barrientos et al, 2018), and was carried out by placing trial carcasses at unknown locations within the survey area, and recording if and when the carcasses were located.

RESULTS

Carcass Persistence (CP)

The results of the carcass persistence trials indicate high levels of opportunistic scavenging at the UBC campus. For instance, at the Indian Residential School History and Dialogue Centre (IRSHDC), a rufous hummingbird placed by facade 5 was removed leaving no evidence within 24 hours. The carcass persistence trial performed at the Centre for Interactive Research and Sustainability (CIRS) consisted of a golden crowned kinglet placed at facade 2 and a varied thrush at facade 4. The crowned kinglet persisted for 6 days, at which point the trial was suspended. The varied thrush was scavenged within 24 hours of placement, leaving behind evidence of a feather pile. The carcass persistence trial performed at the Millenial Time Machine structure (MTM) included a downy woodpecker being placed at facade 6 at 11:20 am. The carcass was recorded as present at noon, however by 5 pm had disappeared without a trace.

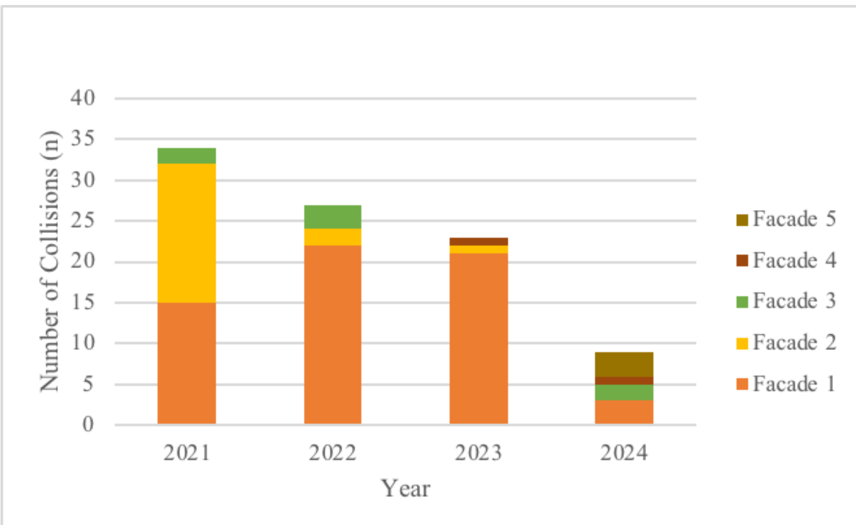
Searcher Efficiency (SE)

The SE carcasses included in this study were both located by the survey team, resulting in a 100% searcher efficiency rate. However, due to the limited sample size (n=2), and other factors contributing to carcass detection (Barrientos et al., 2018), this value may not be representative of the searcher efficiency rate at UBC. Research by De Groot et al. (2021) identified an searcher efficiency rate of 0.57 after conducting SE trials using 29 carcasses over 5 seasons at the UBC campus. As the searcher efficiency rate has been found to be unaffected by vegetation, season, and searcher experience (Barrientos et al., 2018), the SE score calculated by De Groot et al. (2021) may be standardized to other buildings across UBC and used in future data analysis and estimates.

Indian Residential School History and Dialogue Centre (IRSHDC)

Evidence of 9 collisions were recorded at IRSHDC during the 2024 winter carcass surveys. Of these collisions, 3 occurred at facade 1, 2 occurred at facade 3, 1 occurred at facade 4, and 3 occurred at facade 5, as illustrated in Figure 3. Evidence of the 9 collisions at IRSHDC were detected as feather smears. Over the 2021-2023 collision surveys, the field teams reported an average of 19 collisions per year at facade 1, resulting in the identification of facade 1 as a “high risk” facade. After presenting their recommendations to stakeholders at UBC, previous survey teams were able to persuade UBC to retrofit facade 1 with Feather Friendly® adhesive window markers. Facade 1 was treated with Feather Friendly® adhesive window markers prior to the 2024 winter surveys. A total of 3 collisions were recorded for facade 1 in 2024, as recorded in Table 1. The total number of reported collisions at facade 1 decreased by 85.7% when compared to 2023, or by 84.6% when compared to the average number of collisions across the other study periods (2021-2023). The annual number of reported collisions at facade 1 is illustrated as a line graph in Figure 4.

Figure 3. ***Annual Total Reported Collisions per Facade at the Indian Residential School History and Dialogue Centre (IRSHDC)***



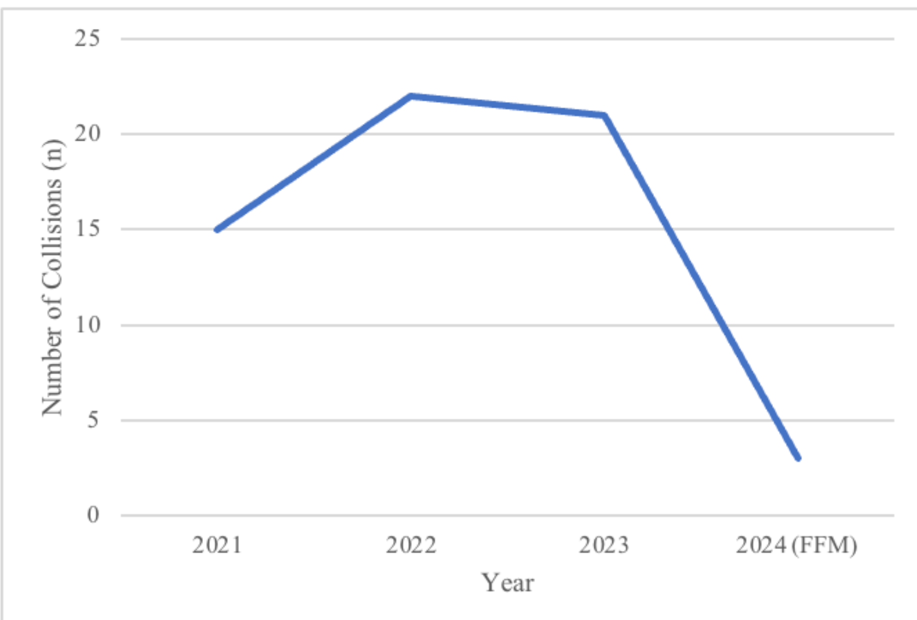
Note. Stacked bar graph depicting the annual total number of reported collisions at the Indian Residential School History and Dialogue Center (IRSHDC), by facade. The number of collisions (n) is measured on the y-axis, while the year is indicated on the x-axis. Facade 1 was depicted in orange, facade 2 in yellow, facade 3 in green, facade 4 in maroon, and facade 5 in brown, as indicated in the legend.

Table 1. ***Total Number of Reported Collisions at Facade 1 (IRSHDC) per Year***

Year	Number of Collisions (Facade 1)
2021	15
2022	22
2023	21
2024 (FFM)	3

Note. Table representing the annual number of reported collisions at facade 1 (IRSHDC) from 2021-2024. The application of the Feather Friendly® Markers at facade 1 is referenced as 2024(FFM) in the above table.

Figure 4. ***Annual Total Reported Collisions at Facade 1 at IRSHDC***



Note. Line graph depicting the annual total number of reported collisions at the Indian Residential School History and Dialogue Centre facade 1 for four years of collision survey data. The number of collisions (n) is reported on the y-axis, and the year represented by the x-axis. The application of Feather Friendly® Markers (FFM) is identified for the year 2024, in the above figure noted as 2024 (FFM), to allow comparison of annual total collisions before and after the application of FFM on facade 1.

Centre for Interactive Research and Sustainability (CIRS)

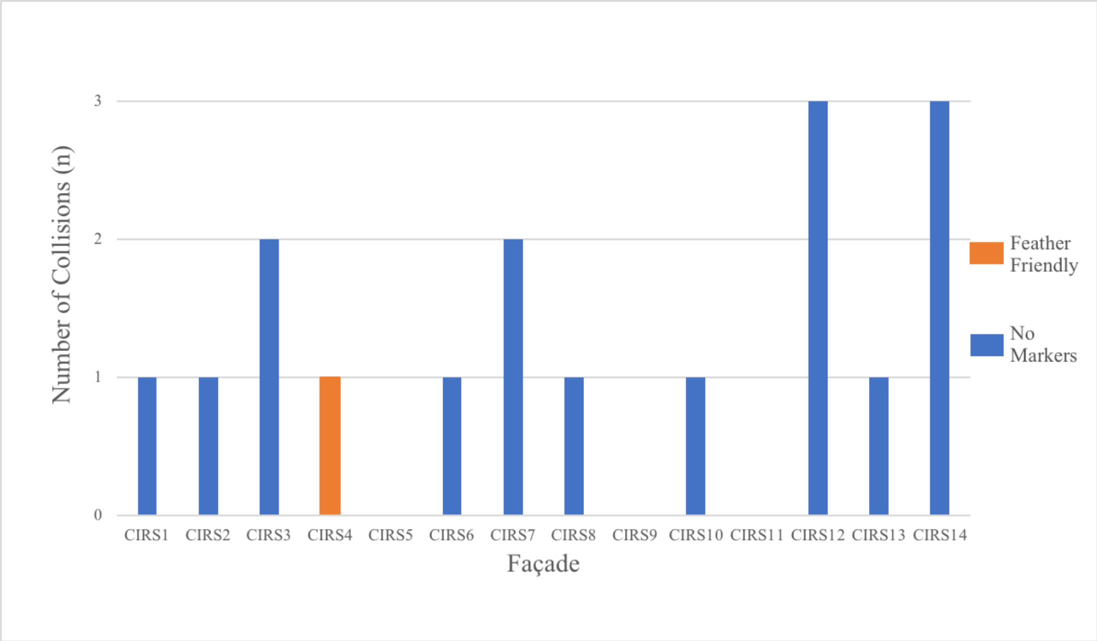
Evidence of 17 collision incidents were recorded at the Center for Interactive Research and Sustainability (CIRS) during this study. Of these collisions, 14 left were detected as feather smears, 1 left evidence of feather piles, and 2 were identified as scavenged carcasses, as described in Table 2. Two facades, 12 and 14, had evidence of 3 collisions each, and could be identified as high risk for bird window collisions. Facade 12 consists of large continuous glass panels, and serves as an entrance to the building with 2 sets of glass doors. Facade 14 borders the building's outdoor courtyard, and is the only facade described to be in direct contact with the proximate vegetation. Facades 3 and 7 each had evidence of 2 window collisions during this study period, and facades 1, 2, 4, 6, 8, 10 and 13 each had evidence of 1 collision. Three facades, 5, 8, and 11, had no evidence of collisions recorded during our study period. These three facades were characterized by the field team as concrete walls with small glass window components. The total number of reported collisions per facade are represented in Figure 5.

Table 2. ***Types of Collision Evidence and Number of Incidents Reported at CIRS in 2024***

Evidence of Collisons	Number of Incidents (CIRS)
Feather Smear	14
Feather Pile	1
Carcass	0
Scavenged Carcass	2

Note. Table displaying the types of collision evidence, and the number of incidents as reported at CIRS in 2024.

Figure 5. ***Number of Reported Collisions per Facade at the Centre for Interactive Research and Sustainability (CIRS) in 2024***



Note. Bar graph depicting the total number of reported collisions at CIRS in the 2024 survey period, per facade. As indicated in the legend, the blue bars represent the number of reported collisions with unmarked glass facades. The orange bar represents the number of reported collisions with facades marked by Feather Friendly® adhesive markers. At the Centre for Interactive Research and Sustainability (CIRS), facade 4 (noted as CIRS4 in the above figure) has been retrofitted with an adhesive window mural following bird safe building guidelines.

MTM

No evidence of bird-window collisions was found at the Millenial Time Machine structure, or MTM. Millenial Time Machine is characterized by 4 glass facades, with minimal visual interruption aside from a concrete door built into facade 8. It is situated on an elevated concrete platform which acts as a 1 to 2 meter buffer zone around the building. Facades 6, 7, and 9 at MTM are within 5m of nearby vegetation, including a mixture of grasses, medium height bushes, coniferous trees, and mature deciduous trees. It is situated just off of the Main Mall, a prominent transportation corridor for UBC students and animals on campus, and connected to additional vegetation via a gravel walking path.

DISCUSSION

The objective of this study was to identify which facades at IRSHDC, CIRS, and MTM may be considered high risk for window collisions, and to evaluate the effectiveness of existing Feather Friendly® applications and bird-safe murals.

IRSHDC

At the Indian Residential School History and Dialogue Centre (IRSHDC), the primary goal was to evaluate the effectiveness of the Feather Friendly® Markers (FFM) which were retrofitted to Façade 1 following the 2023 collision survey period. As this year was the first year of monitoring following the application of the Feather Friendly® markers, our group was in a position to make direct comparisons between collision rates before and after this treatment. As seen in Figure 4, evidence of collisions at Façade 1 was reported to decrease by 84.6% when compared to the average across the other survey periods. These results provide clear evidence supporting the success of this collision strategy in preventing collisions (De Groot et al., 2022), and support our hypothesis that collision rates would decrease following the application of Feather Friendly® Markers (FFM). Despite the observed success of the FFM, however, there was still evidence of 3 collisions at façade 1. Although adhesive window markers are effective at increasing the visibility of glass barriers to birds, and thus reducing the likelihood of window collision (Klem, 2009; De Groot et al., 2022), other factors may contribute to a bird’s ability to successfully avoid glass. For instance, factors such as species morphology and flight speed (Alerstam et al., 2007; Klem, 1990) may affect not only the bird's ability to sense the barrier, but also to change their flight path at the last second. From the results of our surveys at IRSHDC, we advocate for the treatment of high risk facades with Feather Friendly® adhesive window markers. Facade 5, with a total of 3 reported collisions in our survey period, may be a possible target for such efforts. Continued monitoring at IRSHDC will be helpful to confirm whether this building should be considered high risk for window collisions.

CIRS

At the Centre for Interactive Research and Sustainability (CIRS), our intention was to identify the facades that experienced the highest rates of collisions, and to make comparisons between traditional facades and the one treated with visual markers. Our hypothesis was that façade 4, which was treated with a bird-safe mural in 2019, would have lower rates of window collisions when compared to the building's other glass facades.

Our data suggests that CIRS may be a positive target for further mitigation efforts, such as the treatment of high risk facades with Feather Friendly® adhesive markers or murals. CIRS had the highest number of collisions of the three surveyed buildings, with evidence of 17 collisions collected during our survey period. In Canada, low rise commercial structures are estimated to kill 0.4 to 55 birds per building per year (Machtans et al., 2013). After adjusting our raw data to account for searcher efficiency and scavenging, it is likely that CIRS may represent a considerable risk for bird window collisions, and should be recommended for further attention. Of the collisions recorded at CIRS, however, only one occurred on the façade treated with a bird friendly mural (Façade 4). Two facades (numbers 12 and 14) could be deemed high risk, as they each had evidence of at least 3 window collisions. This evidence supports our hypothesis at CIRS that facades marked by collision deterrents would experience lower rates of collisions.

However, it would have been helpful to have collision data from prior years in order to analyze the direct impact of the bird-safe mural on bird window strikes on facade 4. Prior data would have been useful for comparison of collision frequencies at facade 4 before and after the treatment, rather than basing our assumptions on comparisons to the building's other untreated facades.

It is worth noting that for both IRSHDC and CIRS, the majority of collisions were detected as feather smears. Although smears do not provide direct evidence of mortality (Loss et al., 2014), they do provide evidence of a window collision, and should be factored into our understanding of collision risk at a given site.

MTM

At the Millenial Time Machine (MTM), our goal was to identify high risk facades, and determine whether the building should be a target for mitigation efforts. As previously discussed, there are many factors that influence the frequency of bird strikes at a given site, such as the surface area of glass (Zulian et al., 2023) and proximity to local vegetation features (Cusa et al., 2015) or other bird attractants (Bayne et al., 2012). MTM is characterized by continuous transparent glass facades, surrounded by grass and other vegetation, and within 50 m of water sources. These characteristics qualified MTM for observation as a potential high risk building.

As with our other buildings, we hypothesized that facades characterized by uninterrupted transparent glass would have more collisions than facades marked by bird safe window treatments.

To our surprise, there was zero evidence of bird window collisions detected during our study, which did not align with our hypothesis. Some possible limitations influencing our results may be high levels of scavenging, searcher efficiency, survey design, and the specific characteristics of this study site. For instance, previous research conducted at UBC reported high levels of scavenging on campus, noting that the probability of carcass persistence after 3 days was roughly 0.43 (De Groot et al., 2021). In this study, a carcass persistence trial conducted at MTM recorded the removal of a downy woodpecker within 6 hours of placement, leaving no trace of evidence. This observation has been reported in literature: research by Klem (2009) estimated that 25% of bird window collisions leave no evidence after 24 hours. Further, the design of our survey may have limited our ability to detect evidence. Given that carcass surveys were conducted 3 times per week with intervals of 1-4 days, there was likely an opportunity for carcass removal by scavengers between scheduled surveys. This limitation may be a possible reason why such limited evidence was found at IRSHDC and MTM, where the surveys were more often conducted on three sequential days, as opposed to CIRS, where surveys were largely standardized to Mondays, Wednesdays, and Fridays.

Finally, in addition to searcher efficiency and scavenging, building characteristics specific to MTM may contribute to the lack of evidence recorded during the study period. For instance, the elevated cement platform surrounding the perimeter of the building may assist in the detection of carcasses by scavengers. As scavengers such as coyotes and raccoons often forage at dawn and dusk (Grinder & Krausman, 2001), it is possible that carcasses were removed outside of surveying hours via opportunistic scavenging. Additionally, it was observed multiple times during our study period that on rainy days, facades 6 and 7 were observed to be coated with rain droplets. The combination of architectural features and weather events may have resulted in the removal of collision evidence from the glass facades. Combined with opportunistic scavenging by predators and non-perfect searcher efficiency, it is not as surprising to see such limited evidence at MTM. Due to the data collected through our study, we do not recommend MTM to be retrofitted with

Feather Friendly® markers, however would encourage future research to continue monitoring MTM for further signs of window collisions to better understand its threat to local bird populations.

CONCLUSION

Bird collisions with human structures is not a new problem. First described by Nuttall (1832), reports of bird strikes with buildings— communication towers, wind turbines, high-rises, residences, etc.— have since gained considerable attention from academics, city planners, architects, conservationists, and concerned citizens alike (Klem 1989). Growing awareness of this shared concern for bird-window collisions has led to an emergence in bird-safe window technologies that aim to increase the visibility of glass window elements to birds. This study investigated the effectiveness of mitigation strategies aiming to increase the visibility of facades at two high risk buildings on UBC campus: the Indian Residential School History and Dialogue Centre (IRSHDC) and the Centre for Interactive Research and Sustainability (CIRS). We hypothesized that facades treated with Feather Friendly® markers and bird-safe murals would have fewer collisions when compared to other traditional glass facades (De Groot et al., 2022).

The results of our study supported our hypothesis. At IRSHDC, we reported an 84.6% decrease in window collisions at facade 1 of IRSHDC following the application of Feather Friendly® Markers. At CIRS, the facade featuring a bird-safe window mural had evidence of fewer collisions than other untreated facades. However, no data had been collected prior to the application of this mural, limiting our ability to quantify its success. From these results we recommend Feather Friendly® adhesive window markers to be used on other buildings on UBC campus, and suggested to business and home owners as a means of reducing bird-window mortalities.

With many bird species experiencing a widespread decline in abundance, diversity, and biomass (Rosenberg et al., 2019), there is a critical need to understand and confront the sources of human caused mortality in birds. Future research should serve to address knowledge gaps in the literature, and remove temporal and geographic biases (De Groot et al., 2021; Loss et al., 2014). For instance, of the 100 species currently listed as vulnerable to window collisions, only 4 are species commonly distributed in the Pacific North-West (De Groot et al., 2021). As most research on window collisions has been concentrated in the eastern United States, there is a need for focused research in understudied regions (Loss et al., 2014). Additionally, to our knowledge there has yet to be any research analyzing the efficacy of bird safe projects on any appreciable scale. Data supporting the efficacy of such projects will be vital to updating estimates and tracking the impacts of collision related bird mortalities. Increasing accessibility to education and bird friendly resources, targeted mitigation to high-mortality areas, and further understanding of species level responses to bird window collisions will be crucial to reducing window collisions and achieving conservation goals.

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