AVIAN WINDOW STRIKE MORTALITY AT AN URBAN OFFICE BUILDING

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Abstract—During 2005, NYC Audubon's Project Safe Flight program led a citizen science project to study avian collisions at one of Manhattan's worst bird-collision sites. Over the course of that year, 251 birds were documented to have collided with the six-story office building, 90% of which were found dead. Most of these collisions occurred during daytime hours, and almost all involved passage-migrants during spring and fall migration. Higher strike rates were documented along the glass surfaces that reflected densely vegetated areas than along surfaces opposite less-vegetated areas. Because structures with similar glass and vegetation characteristics are numerous and widely distributed, it is likely that such structures collectively represent a threat to migratory bird populations, especially given that several species involved in collisions are also on the US Fish and Wildlife Service's list of Species of Management Concern. Possible solutions to this problem include netting and glass etching which can eliminate the reflectivity of windows. Other solutions include the development of a new type of glass that is transparent to people but visible to birds.

For more than a century, human-built structures have been known to pose hazards to migratory birds (Klem 1989). After habitat loss and fragmentation, collisions with such structures probably pose the greatest human-related threat to bird populations (Klem et al. 2004), including several species that are listed on the US Fish and Wildlife Service's *Species of Management Concern* and the Audubon Watchlist (Shire et al. 2000). Estimates of avian mortality from collisions with glass throughout the United States range from 100 million (Dunn 1993) to one billion (Klem et al. 2004) birds per year. To date, bird collision research has focused mostly on nocturnal collisions at non-urban sites, especially communications towers (e.g., Avery et al. 1976, Shire et al. 2000). Reflective and transparent glass surfaces have also been implicated in lethal daytime collisions by resident and migratory birds (Klem 1989, 1990). Although collision data collected from urban sites such as Toronto, Chicago, and New York have not yet been published in scientific, peer-reviewed journals, substantial anecdotal evidence suggests that plate glass is involved in large numbers of daytime collisions in urban areas, especially during the periods of spring and fall migration.

NYC Audubon's *Project Safe Flight* (PSF) has been monitoring bird collisions in New York City since 1997. In 2005, PSF conducted a year-long study at the Morgan Processing and Distribution Center (Morgan Mail), a six-story office building in Manhattan known to kill large numbers of birds each year (Figure 1). The purpose of the study was to document the frequency, timing (especially day vs. night), and physical context of collisions at this site. Specifically, we sought to test two hypotheses: (a) that day-time collisions are responsible for most of the bird mortality observed at this site; and (b) that the frequency of daytime collisions is highest along those portions of the exterior glass surface that reflect large amounts of nearby vegetation.

METHODS

The Morgan Mail building is a six-story office building where relatively high numbers of bird collisions have been recorded since 2002. The building is located in Manhattan between 28th and 29th Streets and between 9th and 10th Avenues (40° 45' 02" N, 73° 00' 01" W). During 2005, when the present study was conducted, the building's exterior was made up of windowless concrete walls for the first two stories and 440 large, reflective glass panels (each 2.3 m by 1.3 m) covering approximately 75% of the remaining four stories (the "windows" actually mask an interior-concrete wall). All exterior walls ran straight from the base of the building to the rooftop, with no major outcrops or ledges that could prevent colliding birds from falling to the street level. The southern perimeter of this building (247 m) faced a row of short street trees that did not reach the building's window line. Opposite the building, on the south side of the street, was a row of large street trees (mostly London Plane trees, *Platanus x acerifolia*), many of which were over 20 m tall and reached to the top of the six-story structure. Beyond this row of trees extended a rectangular 1.42-hectare urban park (Chelsea Park) with more tall trees (again, mostly London Plane trees), some of which were also reflected in the building windows. The vegetation at this park was not uniformly distributed; whereas the eastern portion of the park included many large trees, the western portion of the park – amounting to slightly less than half of the entire park – was much less vegetated, partly due to the fact that most of the space was taken up by a large ball-field covered with artificial turf. The building's position in relation to its surroundings is shown in Figure 2.

Figure 1. Dead Golden-crowned Kinglet,
Morgan Processing and Distribution Center, Manhattan, New York.
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Figure 2. The Morgan Processing and Distribution Center, Manhattan, New York.

To quantify the number of collisions at the site, we relied on methodology developed by other researchers, in which a strike is registered when a dead or injured bird is found at the base of the building (Klem 1989, 1990; Dunn 1993; O'Connell 2001; Klem et al. 2004). The southern perimeter of the building was monitored throughout the spring (late March to early June) and fall (late August to early November) migration periods of 2005. Daily monitoring was discontinued after collision numbers dropped substantially at the end of each migration season. Periodic monitoring during the non-migratory season indicated that strike rates remained low during these periods. All study participants walked the route slowly, looking for dead or injured birds from the base of the building to the gutter at the street side. This study was overseen by Yigal Gelb, Program Director at NYC Audubon, with assistance from Nicole Delacrétaz, PSF Program Manager. Training orientations were conducted to ensure that all study participants followed the same methodology.

In order to determine as precisely as possible when collisions occurred over the course of a day, a three-day study was conducted from October 18th to October 20th**,** 2005, in which participants monitored the building exterior during the following time periods: 6:45-7:15, 9:00-9:30, 12:00-12:30, 15:00-15:30, and 19:00-19:30. For the purposes of this three-day study alone, the building's western perimeter, extending from 28th to 29th Street (58m), was also monitored. This perimeter, which had no tall trees adjacent to it, served as a qualitative control for the presence/absence of vegetation. Sunrise during this study was approximately at 7:10, with Civil Twilight at approximately 6:45, and sunset was approximately at 18:10 EDT. Weather conditions during the three-day study were generally favorable, with little to no cloud cover throughout the study period.

A more general test of whether the frequency of window strikes was associated with the amount of adjacent vegetation was performed during spring and fall 2005 by recording the locations of collision victims along the building's southern perimeter. As noted above, the eastern portion of the southern perimeter faced more tall trees than did the western portion. We divided the southern perimeter into approximately equal halves and counted the number of trees in each half that reached up to the fifth and sixth floors along the sidewalk opposite the building. There were 12 such trees along the eastern half (referred to as "vegetated" below) and four trees along the western half (referred to as "less-vegetated" below). The positions of dead and injured birds found at the base of the building were carefully noted and assigned to one or the other of these two sections. In some instances, especially during the spring, volunteers were not able to record the locations of dead and injured birds. Data from these days were not included in the statistical comparison of collisions along the vegetated vs. less-vegetated sections (Binomial goodness-of-fit, two-tailed; SPSS 12.0.0 for Windows, release Sep. 2003).

RESULTS

During 2005, 251 birds of 54 different species were documented to have collided with the Morgan Mail building, and 90% of these were found dead. Almost all birds were found during the periods of spring and fall migration, and 92% of all collisions involved species whose occurrence at this site consists exclusively of passage-migrants. The top five species found were Dark-eyed Junco (*Junco hyemalis*) 27; Ruby-crowned Kinglet *(Regulus calendula*) 24; Golden-crowned Kinglet (*Regulus satrapa*) 23; White-throated Sparrow *(Zonotrichia albicollis*) 11; and Ovenbird (*Seiurus aurocapillus*) 10. Complete data for 2005 are presented in Table 1.

During the three-day study, 28 birds of 13 different species were documented to have collided with the structure, 23 of which were found dead (82%). Dead and injured birds found during the three-day study were distributed among monitoring periods as follows: 6:45-7:15: 6 birds; 9:00-9:30: 13 birds; 12:00-12:30: 7 birds; 15:00-15:30: 2 birds; and 19:00-19:30: 0 birds. Of the total number found, 27 were found along the variably vegetated southern perimeter, and only one was found along the un-vegetated western perimeter that served as our control.

Among the 144 individuals whose collision locations were mapped during 2005, strike frequency differed significantly between the vegetated (105) and less-vegetated (39) halves of the southern perimeter (Binomial test, $Z = -5.42$, 2-tailed, $P < 0.0001$).

Table 1. Dead and injured birds observed at the Morgan Processing and Distribution Center, Manhattan, New York during 2005.

Species	Scientific Name	Number
Dark-eyed Junco	*Junco hyemalis*	27
Ruby-crowned Kinglet	*Regulus calendula*	24
Golden-crowned Kinglet	*Regulus satrapa*	23
White-throated Sparrow	*Zonotrichia albicollis*	11
Ovenbird	*Seiurus aurocapillus*	10
Northern Parula	*Parula americana*	9
Black-capped Chickadee	*Poecile atricapilla*	8
Hermit Thrush	*Catharus guttatus*	7
Mourning Dove	*Zenaida macroura*	7
Black-and-white Warbler	*Mniotilta varia*	6
Gray Catbird	*Dumetella carolinensis*	6
Wood Thrush	*Hylocichla mustelina*	6
Black-throated Blue Warbler	*Dendroica caerulescens*	5
Common yellowthroat	*Geothlypis trichas*	5
Yellow-bellied Sapsucker	*Sphyrapicus varius*	5
Fox Sparrow	*Passerella iliaca*	4

Species	Scientific Name	Number
House Wren	*Troglodytes aedon*	4
Magnolia Warbler	*Dendroica magnolia*	4
Swainson's Thrush	*Catharus ustulatus*	4
Brown Creeper	*Certhia americana*	3
Canada Warbler	*Wilsonia canadensis*	3
Northern Flicker	*Colaptes auratus*	3
Red-breasted Nuthatch	*Sitta canadensis*	3
Red-eyed Vireo	*Vireo olivaceus*	3
American Redstart	*Setophaga ruticilla*	2
Bay-breasted Warbler	*Dendroica castanea*	2
Blue-headed Vireo	*Vireo solitarius*	2
Connecticut Warbler	*Oporornis agilis*	2
House Sparrow	*Passer domesticus*	2
Indigo Bunting	*Passerina cyanea*	2
Nashville Warbler	*Vermivora ruficapilla*	2
Northern Waterthrush	*Seiurus noveboracensis*	2
Pine Warbler	*Dendroica pinus*	2
Rock Dove	*Columba livia*	2
Ruby-throated Hummingbird	*Archilochus colubris*	2
Scarlet Tanager	*Piranga olivacea*	2
Veery	*Catharus fuscescens*	2
Wilson's Warbler	*Wilsonia pusilla*	2
Winter Wren	*Troglodytes troglodytes*	2
American Woodcock	*Scolopax minor*	1
Baltimore Oriole	*Icterus galbula*	1
Blackburnian Warbler	*Dendroica fusca*	1
Blue-winged Warbler	*Vermivora pinus*	1
Brown Thrasher	*Toxostoma rufum*	1
Chipping Sparrow	*Spizella passerina*	1
Marsh Wren	*Cistothorus palustris*	1
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	1
Song Sparrow	*Melospiza melodia*	1
Swamp Sparrow	*Melospiza georgiana*	1
Worm-eating Warbler	*Helmitheros vermivorus*	1
Yellow Warbler	*Dendroica petechia*	1
Yellow-bellied Flycatcher	*Empidonax flaviventris*	1
Yellow-breasted Chat	*Icteria virens*	1
Yellow-rumped Warbler	*Dendroica coronata*	1
Unidentified warbler		2
Unidentified bird		14
Total birds		**251**
Total species		**54**

DISCUSSION

The data from the three-day study provide important support for our hypothesis that daytime collisions occur at high frequency at this site. Although intensive monitoring was not conducted throughout the night, no collisions were found to occur during the 19:00-19:30 inspections, which were approximately one hour past sunset. Furthermore, fewer collisions were documented during the 6:45 inspections, which monitored the building at daybreak, compared with the daytime inspections of 9:00 and 12:00. Finally, because the 6:45 inspections were conducted at daybreak, some of the collisions detected then might best be considered daytime collisions, a conclusion also supported by the observation that birds found at this time were not more likely to show signs of desiccation or damage caused by scavengers than were those collected later. Although it remains possible that some nocturnal collisions were not detected because the victims were completely removed by scavengers, the three-day study conclusively demonstrates that daytime collisions occurred at a high frequency at this site. This result is not surprising because two of the factors usually involved in nighttime collisions were missing from this site: this was a low structure, compared with skyscrapers and communication towers which are usually involved in nighttime collisions (Avery et al. 1976, Ogden 1996, Shire et al. 2000, Gauthreaux and Belser 2003); and no light was emitted from this building (the glass surfaces were not really windows, but merely covered a concrete wall). The distribution of collisions across time periods observed during the three-day study, with most collisions occurring during morning and late morning hours, was consistent with findings at other low structures (Klem 1989).

The near-absence of collisions (only one of 28) along the completely un-vegetated western perimeter during the three-day study supports our hypothesis that the presence of vegetation near windows is an important factor influencing daytime collisions. Furthermore, our comparison of vegetated vs. less-vegetated sections of the southern perimeter throughout 2005 revealed a statistically significant disparity in collision rates of about five to two—very similar to the corresponding numbers of tall trees adjacent to each of these sections.

Our findings suggest that strike rates are much higher where glass surfaces reflect nearby vegetation than where they do not. Where nearby vegetation is limited in extent, even extensive glass surfaces may produce only a few collisions per year; but where this factor is prominent and "mirrored glass exteriors" face "forested patches" (O'Connell 2001), high collision rates, on the order of several hundred collisions per year, can be expected. In cases where reflective window panels face vegetated areas, we propose a two-step process that results in daytime collisions. First, vegetation attracts birds to the site (Klem 1989, 1990, Klem et al. 2004). Second, once there, the birds perceive reflected images of vegetation in the windows as continuous vegetation, leading them to collide with the solid glass barrier.

Most of the bird species involved in collisions at the Morgan Mail building occur at this site exclusively as passage-migrants. The large number of migrants involved in collisions during spring and fall supports Klem's finding (1989) that the most numerous species involved in collisions are those present at the greatest numbers near the site at any specific season. It is no secret that the number of birds in New York City peaks during migration seasons, as demonstrated by the large quantities of migratory birds observed in many of the City's parks, such as Central Park and Prospect Park.

Given that many structures exhibit the characteristics documented in the building studied here, it is likely that such structures collectively pose a threat to migratory bird populations. This is especially true given the fact that several of the species involved in collisions are on the US Fish and Wildlife Service's list of *Species of Management Concern*. Sadly, this threat is only likely to increase as we continue to use more glass to construct our buildings, and as urban and suburban centers continue to expand into rural landscapes where many migratory birds can be found during spring and fall.

SOLUTIONS

There are several retrofitting options that can reduce bird collisions at existing structures that incorporate glass in proximity to vegetation: Window etching, also known as sandblasting, eliminates the reflections of habitat in the windows by reducing the reflective quality of the glass. This method can be used to create patterns that both reduce reflectivity and allow the birds to perceive the glass as a solid barrier. Unless the entire window surface is etched, patterns should take into account Klem's findings which recommend un-etched surfaces to be no larger than 2x4 inches in order to prevent birds from flying into the glass (Klem 1990). NYC Audubon is currently helping Morgan Mail find a long-term solution to their bird collision problem. Window netting is another option which reduces bird collisions by placing a tight net a few inches away from reflecting window panels. This net allows birds to bounce off the net, preventing them from colliding with the glass surface. Other retrofitting options include placing exterior sun-shades and blinds, placing non-reflective film over the windows, such as Toronto's Fatal Light Attraction Program's (FLAP) CollidEscape film, painting over the glass, or growing vines in front of it (Sloan 1997-2001). NYC Audubon is currently leading the *Bird-Safe Glass Working Group*, an initiative to create a new type of glass which would be visible to birds but not to the human eye.

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