Journal of Service Learning in Conservation Biology 1:1-9

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Survey of songbird mortality due to window collisions on the Murray State University campus

Abstract Bird collisions involving mirrored and reflective windows are most likely due to the illusion of habitat or open sky mirrored on the glass panes. The inability of birds to perceive clear windows as a physical barrier can also result in window collisions, especially when indoor plants and open space are visible from the outside. Because avian predators and scavengers have been known to regularly visit accident-prone collision sites for stunned or dead birds, the evidence of window strike problems may be removed before the severity of the mortality factor is realized. Concern regarding bird window collisions at Murray State University arose due to a number of songbird deaths caused by window strikes in 2002, and the abundance of reflective and tinted windows located across campus. To determine the approximate avian mortality caused by window collisions at Murray State, transects were established along a variety of buildings on campus and fatalities were recorded over a 10-week period. Buildings with highly reflective and invisible windowpanes were found to be more hazardous to birds than buildings with smaller, recessed and less reflective windowpanes. The results of the mortality survey and possible preventative actions were submitted to building supervisors as part of a Service Learning Project through the Department of Biological Sciences.

Introduction

Bird populations are impacted by a variety of human-induced pressures including pesticide poisoning, predation by domestic cats, and like many other wildlife species, habitat destruction and degradation. Although the high mobility of avian species moderates some habitat-associated stresses, human structures and communication technology is replacing what once was open sky with an increasingly complex obstacle course of cell phone towers, power lines, and glass-plated buildings. The U.S. Fish and Wildlife Service estimates that between 40 and 50 million birds are killed annually in communication tower collisions and over 98 million are killed in glass window collisions (USFWS 2002). Although strikes have been documented for decades, biologists have recently predicted that bird kills may often go unnoticed and likely outweigh many of the more publicized losses of birds (Ogden 1996). The cumulative impacts of bird mortality due to tower and window collisions is currently unknown, but the possible implications on the 200 bird species already in decline in the United States have initiated research on migration and flight behavior, the avian visual system, and collision consequences for Environmental Impact Statements (USFWS Office of Migratory Bird Management 20003).

Collisions with glass windows are potential hazards for birds during the day and night because of failure for birds to 1) see glass panes, or 2) recognize glass panes as barriers. Mirrored and reflective glass can give the illusion of open sky, trees and vegetation during the day resulting in blind collisions. Clear windows can also result in blind collisions during the day, portraying an obstacle-free pathway to indoor space or house plants, as well as light-induced collisions during the night. Collisions occur at night when lights in or on a building attract and disorient birds, resulting in collisions or exhaustion. The 350 species of nocturnally migrating songbirds are particularly prone to light induced collisions during periods of poor visibility and bad weather, when attempts to improve navigation by reducing altitude can result in fatal crashes. Klem (1989) concluded that the frequency of window strikes is not significantly correlated to season, time of day, weather, bird sex, age or residency status, or window size, height and orientation. Factors that increase the density of birds, such as bird feeders, natural food sources, water supplies, and perching habitat can lead to an increased frequency of collisions with nearby windows.

Calloway County is located in Kentucky's eastern gulf coastal plain, supporting 114 local bird species and providing stopover habitat to countless more passing through during the annual spring and autumn migration periods (KYFWIS 2003). Founded in 1922, Murray State University's main campus consists of 73 buildings of varying ages and architectural styles. While Georgian bars and clear glass panes are typical of most of the older buildings, some of the more modern buildings contain windows with tinted and reflective glass. Glass walkways also stretch between four of the residential colleges and connect Pogue Library to the Lowry Center. In previous years, the high frequency of collisions occurring at the walkways caught the attention of both students and faculty (T. Kind, S. White pers comm). This study was implemented in order to estimate the severity of window collisions on campus, and identify the buildings and locations causing the greatest mortality. The results of the survey were incorporated into a Service Learning Project, in conjunction with Dr. H. Whiteman, Murray State University Department of Biological Sciences. The Service Learning Project aimed to educate MSU building supervisors with concerns associated with bird-window collisions, as well as suggest possible actions that could be taken to reduce the number of collisions at specific buildings on campus.

Methods

Thirty-one transects were established along the perimeter of thirteen buildings across the Murray State University campus. The locations of the transects sampled a variety of different architectural styles, windowpanes types, and linear orientations. Each building was classified as one of two categories: buildings with large, highly reflective or invisible windows were classified as "Highly Probable" to induce bird collisions and buildings with small or recessed, less reflective windows were classified as "Less Probable" to induce window collisions. Transect length was restricted according to ground vegetation under the windows since dense cover would inhibit accurate bird counts. Many buildings were therefore not sampled around their entire perimeter. A total of 14 transect lines (415 meters total) were established along "Highly Probable" buildings and 17 transect lines (775 meters total) were established along "Less Probable" buildings (Table 1). Transects were checked each afternoon over a 10-week period from 9 February to 19 April 2003. It was assumed that all fatalities found along the transect lines were caused by window-collision injuries. Dead birds discovered on campus that were not along a transect line were not included in the survey count. Each time a bird was found species, location, date, current temperature and weather data were recorded. At the end of the survey, temporal trends in window collisions were evaluated. The effect of building type on the number of bird collisions was analyzed using a Chi-squared statistical test in order to determine whether buildings with highly reflective or invisible glass were a greater hazard to birds. A report summarizing bird-window collisions on the Murray State University campus and suggesting various preventative steps to reduce associated

Table 1. Each transect was classified according to the type of building, those predicted to have windows that were "Highly Probable" to induce collisions, and those that were "Less Probable" to induce collisions.

HIGHLY PROBABLE		**LESS PROBABLE**	
	Transects		Transects
Lowry Center	130m	Blackburn Science Building	250m
Business Building	160m	Sparks Hall	81m
Dorm Breezeways	44m	Waterfield Library	85m
Curris Center	20m	Faculty Hall	180m
Collins Technology Center	60m	Applied Science Buildings	180m

mortality (Appendix A) was submitted to the building supervisors (Table 2) of the most problematic locations.

Results

A total of 21 birds were recorded during the collision mortality survey, representing nine different taxonomic families (Table 3). Fatalities included common resident birds such as the mourning dove, brown-headed cowbird, and robin as well as a number of non-local species such as the hermit thrush, Louisiana water thrush, Northern flicker, and sora rail. Only one fatality was recorded during the first three weeks of the survey. A sharp increase in collision mortality occurred in the middle of March, when four fatalities were recorded in week six. Weeks seven through nine each had three fatalities. The highest number of mortalities occurred during the third week of April, with seven birds being recorded in the last week of the survey (Fig. 1). The buildings classified as "Highly Probable" to induce bird-window collisions, due to their highly

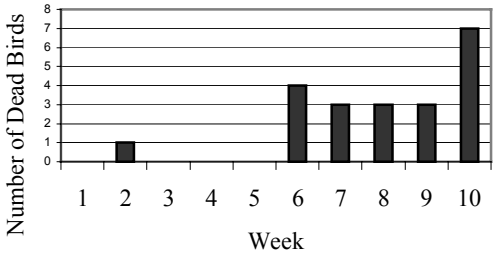

Fig. 1 Number of window collisions resulting in death over a ten-week period during spring of 2003.

Table 2. List of Murray State University building supervisors to which "Bird-Window Collisions on the Murray State University Campus: Spring 2003 Mortality Survey" report was sent to as part of Service Learning Project

Name	Title
Dr. G. Brockway	Provost and Vice President of Academic Affairs
Dr. D. Harrison	Dean, College of Business and Public Affairs
Dr. G. Muuka	Assistant Dean, College of Business and Public Affairs
Dr. N. Weber	Dean, College of Science, Engineering and Technology
David Wilson	Interim Director of Housing and Residence Life
Nolan Patton	Resident Director of Richmond College
Byran Hayse	Resident Director of Franklin College
Ken Ashlock	Resident Director of Clark College
Sara Bailey	Resident Director of Springer College

Table 3. List of species recorded during collision spring 2003 mortality survey at Murray State University

Common Name	Family	Number Dead
Robin	Turidae	4
Northern Cardinal	Cardinalidae	3
Mourning Dove	Columbidae	2
Northern Flicker	Picidae	2
Yellow-bellied Sapsucker	Picidae	2
Brown-headed Cowbird	Icteridae	1
Cedar Waxwing	Bombycillidae	1
Dark-eyed Junco	Emberizidae	1
Hermit Thrush	Turidae	1
Louisiana Water thrush	Parulidae	1
Rock Dove	Columbidae	1
Sora	Rallidae	1
Unidentified (due to lawnmower)		1

reflective or window collisions, due to their highly reflective or invisible glass panes, were found to have significantly more fatalities (x^2=19.76, p<.001) than buildings classified as "Less Probable" to induce window collisions (Fig. 2). Eighty-one percent of the window mortality on campus was observed in collisions with "Highly Probable" windows (Table 4). Specifically, the east-facing side of the Business Building and the five glass walkways contributed 72% of the total window collision mortality.

Discussion

Windows on the Murray State University campus result in fatal collisions for a wide range of bird species. Since the peak of spring migration runs from March through May, this survey showed the collisions trends of the first half of the migration period (Ogden 1996). The frequency of window collisions increases over the 10-week span of the survey, suggesting that higher mortality may occur during mid-migration when higher densities of birds are present in the area as they travel along the Mississippi and Atlantic flyways (Fig. 3). The Louisiana waterthrush and hermit thrush are among the 350 species of songbirds that migrate at night, and spend their days resting and feeding at various stopover locations along the route. The number of both local and migrant songbird fatalities documented in this survey is a highly conservative estimate of the total window-induced mortality occurring on campus. The actual number of bird-window collisions is likely to be much greater due to the fact that only one out of every two birds that collides with a window has an

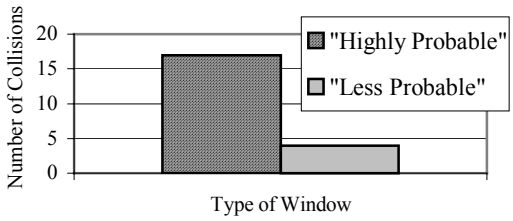

Fig. 2 The number of collisions occurring at windows predicted to be "Highly Probable" for inducing strikes versus those predicted to be "Less Probable" for inducing strikes. Significance was determined (p<.001) using a Chi-squared test, df=1, x^2=19.76.

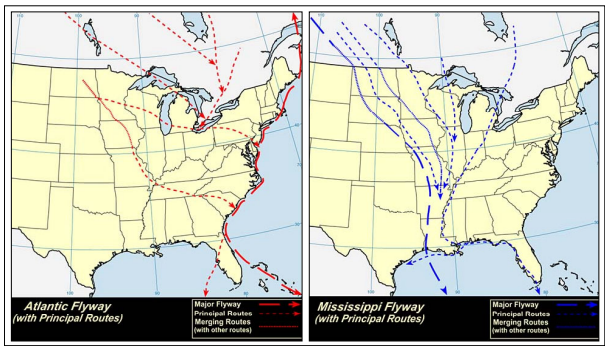

Fig. 3 Maps illustrate the Atlantic and Mississippi Flyways and principle routes that pass by western Kentucky during migration periods.

Table 4. Building-specific window collision mortality recorded on the Murray State University campus for spring 2003.

Building	Number of Collisions	% Total Mortality
Business Building	7	33.3
Dorm Breezeways	6	28.6
Lowry Center	3	14.3
Collins Technology Center	1	4.8
Curris Center	0	0
TOTAL "Highly Probable"	**17**	**81.0**
Blackburn Science Building	2	9.5
Applied Science Building	1	4.8
Waterfield Library	1	4.8
Faculty Hall	0	0
Sparks Hall	0	0
TOTAL "Less Probable"	**4**	**19.0**

immediate death (Klem 1989) and only a sample of the total buildings on the Murray State University campus was surveyed. Additional "Highly Probable" locations exist, including the northern wing of the Business Building, which likely have similar mortality consequences but were not sampled due to the hedges below the windows. Since each transect line was checked only once a day, the removal of bird carcasses by nocturnal scavengers (Klem 1990), grounds-keeping/lawnmowers, and other people is predicted to influence the total bird count observed and underestimate overall mortality.

Buildings characterized by highly reflective, and clear glass windows were found to be morehazardous to birds than other buildings characterized by smaller, tinted, recessed windows. The relationship between window type and collision mortality can be used to focus preventative efforts on the most problematic buildings. Within the group of hazardous buildings, the Business Building and the glass walkways of the residential colleges and the Lowry Center were major sources of mortality. Actions to reduce window mortality through the use of bird deterrents, and window treatments should therefore focus on these locations in particular. Preventative steps to reduce the number of window strikes should aim to break the illusion that glass is not a physical barrier. Klem (1990^{b}) concluded that objects or patterns, such as hawk silhouettes, placed on or near the windowpane cannot be spaced out more than 10cm apart across the entire area of the glass to be effective. Clear, invisible windowpanes, such as those found in the glass walkways can be made more visible to birds through the installation of interior treatments such as shades, curtains, decorative self-adhesive films, and large posters or tapestries. Windowpanes that reflect vegetation and sky must be treated on the exterior of the buildings in order to be visible from the outside. Exterior window films, such as the Fatal Light Awareness Program's (FLAP) *Collidescape*, create a one-way view that does not obstruct the view from inside but appears opaque on the exterior. Stained glass, and frosted and etched windows also make windows more visible to birds.

The high number of immediate fatalities recorded on campus is a concern due to the fact that collisions are concentrated at a select number of especially hazardous buildings and because the actual total number of campus-wide window strikes is predicted to be much greater. Bird mortality at Murray State University not only contributes to international pressures facing bird populations, but also results in sanitation and aesthetic issues caused by the presence of bird carcasses on campus sidewalks, lawns, and in front of building entrances. Awareness about the causes and implications of bird-window strikes will become increasingly important for resident and migratory birds as new construction introduces more glass-plated buildings and humans degrade areas of present habitat (Klem 1990^{b}).

Literature Cited

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APPENDIX A.

Bird-window collisions on the Murray State University campus

Background

The U.S. Fish and Wildlife Service estimates that window collisions result in more than 98 million bird deaths per year.

The cumulative impacts of window collision mortality on the 250 species of birds currently in decline in the U.S. is predicted to outweigh more publicized losses associated with pesticide poisoning, domestic cat predation, and oil spills.

While the "incidental, accidental, or unintentional take" of migratory birds is a criminal violation of the Migratory Bird Treaty Act, the USFWS supports prevention initiatives in circumstances where jurisdictional and private ownership issues are complex.

Window strikes are a result of the inability of birds to perceive clear glass as a barrier, and the illusion of open sky, trees and vegetation mirrored in reflective windows.

Collision Mortality Survey

The sight of a dead bird, lying under the glass walkway between Pogue Library and the Lowry Center, or kicked to the side of the Curris Center Entrance, is familiar to many students. The ground below the Business Building's reflective windows is known as a reliable place to find and study birds for ornithology and wildlife classes. Although many window strikes may be thought of as commonplace, and others go unnoticed, window collision mortality raises concerns regarding conservation implications, aesthetic impacts on the campus, and sanitation and disease issues.

A collision mortality survey was initiated to address three main objectives: 1) Estimate the severity of window collisions on the Murray State University Campus 2) Identify the buildings/ locations causing the greatest mortality 3) Suggest possible actions that could be taken to reduce window collisions

Methods

Thirty-one transects were established at 13 buildings across the campus. Buildings with highly reflective or clear windowpanes and glass breezeways were classified as "Highly Probable" to induce bird collisions. Buildings with less reflective, small, recessed windows were classified as "Less Probable" to induce bird collisions (Table 1). Each tract was checked daily over a 10-week period (February 9-April 19) during spring of 2003.

Results

A total of 21 birds were recorded over the 10 week period, representing 9 different taxonomic families (Table 2). The frequency of window collisions

Table 1. Each transect was classified according to the type of building, those predicted to have windows that were "Highly Probable" to induce collisions, and those that were "Less Probable" to induce collisions.

HIGHLY PROBABLE	LESS PROBABLE
Lowry Center	Blackburn Science Building
Business Building	Sparks Hall
Dorm Breezeways	Waterfield Library
Curris Center	Faculty Hall
Collins Technology Center	Applied Science Buildings

Table 2. List of species recorded during collision mortality survey at Murray State University

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Brown-headed Cowbird	Icteridae	1
Cedar Waxwing	Bombycillidae	1
Dark-eyed Junco	Emberizidae	1
Hermit Thrush	Turidae	1
Louisiana Water thrush	Parulidae	1
Rock Dove	Columbidae	1
Sora	Rallidae	1
Unidentified (due to lawnmower)		1

increased at week six, March 16-22, and remained high throughout the beginning of the migration period. The greatest number of bird collisions was week 10, April 13-19 (Fig 1).

The buildings classified as "Highly Probable" to induce bird-window collisions, due to their highly reflective or invisible, clear glass panes were found to have significantly more collisions resulting in mortality ($p<.005$) than buildings with less reflective, recessed windows (Fig 2). Eighty-one percent of the window mortality on campus was observed in collisions with "Highly Probable" windows, 72% of which was from the east-facing side of the Business Building and the five glass breezeways (Table 3.)

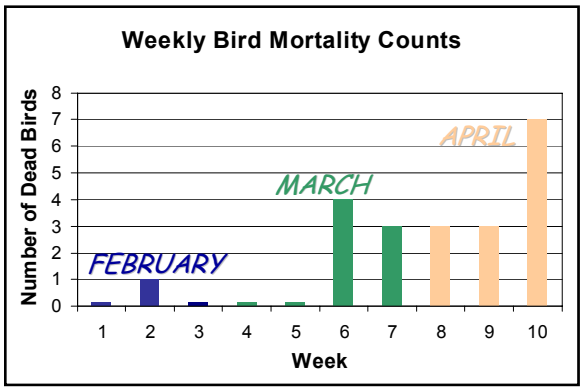

Fig. 1 Number of window collisions resulting in death over a ten-week period during spring of 2003.

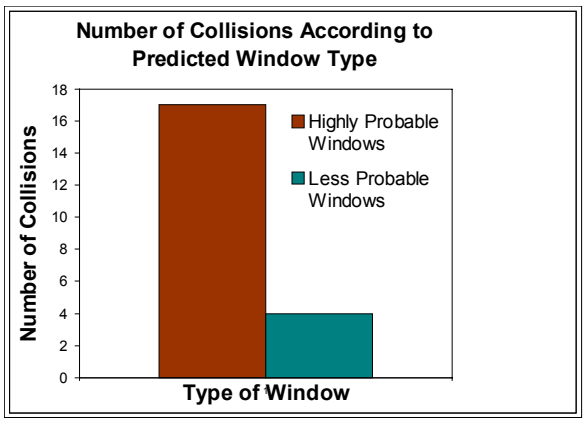

Fig. 2 The number of collisions occurring at windows predicted to be "Highly Probable" for inducing strikes versus those predicted to be "Less Probable" for inducing strikes. Significance was determined ($p<.005$) using a Chi-squared test.

Why are Bird-Window Collisions a Problem at MSU?

Many of the buildings on the Murray State Campus have reflective window glass that mirror open sky, and nearby trees. The presence of glass breezeways, such as the one between Pogue Library and the Lowry Center, and the four breezeways at the residential colleges allow a clear view through the walkway, giving the illusion of an unobstructed flight pathway. Clear glass windows, such as the tall panes of the Lowry Center and Curris Center, also portray an unobstructed path to indoor areas and windowsill plants and vegetation.

Table 3. Building-specific window collision mortality recorded on the Murray State University campus for spring 2003.

Building	Number of Collisions	% Total Mortality
Business Building	7	33.3
Dorm Breezeways	6	28.6
Lowry Center	3	14.3
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TOTAL "Highly Probable"	**17**	**81.0**
Blackburn Science Building	2	9.5
Applied Science Building	1	4.8
Waterfield Library	1	4.8
Faculty Hall	0	0
Sparks Hall	0	0
TOTAL "Less Probable"	**4**	**19.0**

The number of bird deaths recorded in this survey as a result of window collisions is a minimum representation of what may actually be occurring on campus. Actual numbers of bird-window collisions are likely to be much higher due to the fact that:

Only 1 out of every 2 birds that collides with a window has an immediate death (Klem 1989).

Only a sample of the total buildings on the MSU campus was included in the survey.

Many areas under problematic windows could not be surveyed due to dense vegetation and hedges.

Nocturnal scavengers commonly remove smaller bird carcasses (Klem 1990).

Human activities impact the number of dead birds found, i.e. removal of birds on sidewalks, collection of birds by biology students, destruction of bodies by lawnmowers/landscaping activities.

Window collisions affect both local birds and non-resident migrants. There are 350 songbirds that migrate during the night, and spend their days resting and feeding at various stopover locations along their route. Mortality caused by window collisions does not only impact local bird populations such as mourning doves, robins and cardinals, but all species of birds that pass through the area during spring and fall migration.

Dead birds outside the entrances of campus buildings, and in the lawn on the quad are unsightly and unsanitary. Many birds that fall victim to a window collision and fall on a sidewalk or near a door are kicked to the side, where they often remain until they decompose and are finally removed. Birds that fall into the grass or on the lawn are often never disposed of, but instead mulched into lots of smaller bird pieces by the lawnmowers. The presence of dead birds could potentially be a disease risk, in light of the new information being learned about the spread of West Nile Virus, and is unnecessary through the use of some simple preventative measures.

Preventing Bird-Window Collisions

While there are a number of methods that can be used to reduce the number of window strikes, they all rely on one basic principle: Breaking the illusion that glass is not a physical barrier.

Clear Glass Panes/ Glass Breezeways:
Problem: Invisibility

Making clear glass windows and walkways visible can be done on the interior side of the window. Drawing curtains and blinds, especially at night when indoor lights are on, are a simple solution that can prevent collisions. Breezeways can be modified so that a clear view from one side to the other is not visible, using curtains, posters, painted murals, or self-adhesive decorative films.

Reflective Glass Panes:
Problem: mirroring of habitat/sky

Preventative measures on reflective glass must be applied to the exterior of the window in order to break the illusion mirrored outside. Exterior adhesive films are available, including one-way films that appear opaque from the outside but give people inside a clear view out, while blocking UV rays and minimizing sun damage to indoor furniture.

Exterior netting can be used on the sides of problematic buildings to prevent collisions without hindering the view from inside. By leaving space between the net and the windows, birds can bounce off without injury.

A final alternative is the use of bird deterrents hung on the outside of the windows. Common deterrents include reflective tape or discs, predator cutouts, or owl eyes. This technique is not always effective unless multiple deterrents are hung no more than 10cm apart, but may help reduce collisions at windows that are especially problematic or during migration periods. Hawk silhouettes work better when they move, therefore hanging them on a rope or chain in front of the window is preferred over attaching them directly to the glass.

Planning Ahead in the Construction of Future Buildings:

Avoid reflective and mirrored glass, or install windows at a slight angle to reflect the ground

Use frosted, textured, and stained-glass window panes to increase visibility

Choose bird-friendly architectural styles that omit glass breezeways

Finding Solutions for the MSU Campus that are both effective and eye-pleasing

While the simple addition of traditional curtains and blinds can reduce bird collisions at windows with clear glass panes (provided they are drawn closed!), other windows may be more suited for more creative solutions. Murray State University has many talented and artistic students capable of designing banners, murals, faux-stained glass or frosted glass treatments that could be used to break the illusion of the dormitory breezeways. The glass walkway between Pogue Library and the Lowry Center could use similar techniques, as well as more professional designs through use of self-adhesive window films mimicking sandblasted, stained or etched glass. The most difficult places to prevent window strikes will be places such as the Business Building, that have reflective glass panes. In these places, opaque exterior window films such as *Collidescape* are needed (can be ordered through the Fatal Light Awareness Program, http://www.flap.org/new/prefr.htm.)

Summary

A survey of bird mortality due to window collisions on the Murray State University campus concluded that glass walkways and highly reflective windows result in a high number of bird deaths. The majority of bird-window collisions were found to be concentrated at the dormitory and Lowry Center breezeways and on the east side of the Business Building. Installing window applications that make glass panes more visible as physical barriers can reduce the number of collisions. Taking preventative measures to ensure fewer future bird deaths at Murray State University not only addresses international concerns about declining avian populations, but also makes our campus a cleaner and more bird-friendly place.

Resources

Deterrents:
http://www.dteenergy.com/community/environmental/pdfs/raptor.pdf

Adhesive Films:
http://www.decorativefilms.com/SolyxFilms.htm
http://www.betterenergyideas.com/index.html