BIRD COLLISIONS WITH WINDOWS: AN ANNOTATED BIBLIOGRAPHY

First edition by
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INTRODUCTION

Searches of the Ornithological Worldwide Literature database, the Searchable Ornithological Research Archive, and Google Scholar were conducted to find peer-reviewed literature pertaining to bird collisions with glass. Numerous reports of collisions occur in state ornithology journals as well as bird club magazines and newsletters, newspapers, and other types of popular and grey literature. Such observations are not exhaustively covered in the bibliography as most do not provide novel information or insight on the issue (a list of some of those not annotated is provided in the appendix). Instead, the bibliography focuses more on empirical studies that contribute to an understanding of when, how, why, and where most collisions (primarily window collisions) occur, and that offer practical solutions.

The bibliography deviates from traditional format in that most annotations are longer. Longer, detailed annotations are provided because many of the articles may be relatively difficult for some to acquire and do not contain abstracts. Non-English-language literature is not comprehensively covered.

ANNOTATIONS

American Bird Conservancy, 2012. Collisions current information site: http://collisions.abcbirds.org.

This site provides updates to the material presented in Bird-friendly Building Design (Sheppard, 2011). It is also intended to assist developers, architects, and building owners working with LEED Pilot Credit #55 – Reducing Bird Collisions; regulators and builders researching the application of voluntary guidelines or mandatory standards for buildings; or anyone simply looking for detailed information on the collisions issue and designing structures that minimize bird deaths.

Arnold, Todd W. and Robert M. Zink, 2011. Collision Mortality Has No Discernible Effect on Population Trends of North American Birds. PLoS One 6(9) e24708.

Because mortality from collisions with anthropogenic objects are widely dispersed, calculating their impact is difficult. The authors collected 243,103 records of building collisions reported by FLAP (Evans-Ogden, 1996) and communication tower collisions summarized by Shire et al in 2000 (http://www.abcbirds.org/newsandreports/special_reports/towerkillweb.PDF). They found differential mortality by species, with higher levels for night flying and long distance migrants than for diurnal migrants or residents. They found no correlations between mortality rates and species population trends. The authors state that their conclusion should not reduce efforts to reduce mortality from collisions. (this paper has generated controversy and criticism – see Longcore et al 2012; Loss et al, 2012; Schaub et al, 2011).

Avery, M.L. 1979. Review of avian mortality due to collisions with man-made structures. U.S. Fish and Wildlife Service, 11 pp. Available for download at http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1001&context=icwdm birdcontrol.

A literature review that includes a brief section on bird collisions with glass. The findings of Klem (1979) are summarized.

Banks, R. C. 1976. Reflective plate glass - a hazard to migrating birds. BioScience 26(6):414.

Banks notes that large-scale mortality caused by collisions with man-made structures such as lighthouses and communications towers has received great notice for over a century, whereas smaller-scale and “less spectacular” deaths of individual birds from collisions with plate glass has received relatively little attention. He suspects the collective toll of the latter is significant and may in fact be greater than that caused by the more noted episodic mortality associated with towers and skyscrapers. This may be the first assertion of this in the scientific literature.

Banks notes that reflective plate glass is becoming a popular feature of office parks and similar structures constructed near vegetated areas. He expresses concern that the proliferation of such buildings will lead to increased migrant mortality.

Banks, R. C. 1979. Human related mortality of birds in the United States. Special Scientific Report 215, U.S. Fish and Wildlife Service, Washington D.C. 16pp.

The report contains a short section on window strike mortality. Banks uses an unexplained and arbitrary rate of one death per square mile per year to estimate a total annual mortality of 3.5 million birds in the U.S.

Bayne, Erin M., Corey A. Scobie and Michael Rawson, 2012. Factors influencing the annual risk of bird–window collisions at residential structures in Alberta, Canada. Wildlife Research - http://dx.doi.org/10.1071/WR11179

Estimates of mortality from building collisions, especially collisions with homes, are often challenged as being based on insufficient evidence. These authors hypothesize that the risk of bird–window collisions varies according to location (urban *v*. rural), home v. apartment, with or without feeders and age of neighbourhood.

The project was conducted by undergraduates as part of a biology class. On-line surveys from 1458 respondents gathered information on homes and yards, general demographic information about participants, and whether they had observed evidence of bird–window collisions at their home. 39% had seen a collision in the past year, totalling

2575, with a mean of 1.7 ± 4.6 (in the same range reported by Klem and Dunn); 0.7 ± 2.3 of these collisions (1044) were reported as deaths. Rural residences had more collisions than urban ones and residences with feeders had almost twice as many collisions as those without feeders. For urban dwellings, incidence of collisions increased with age of neighbourhood, associated with presence of mature trees. Frequency of collisions varied seasonally: 24% in fall, 35% summer, 25% spring 16% winter. Mortality patterns were similar: 26% fall, 31% summer, 26% spring 17% winter. 48 species were reported; 'American robins (*Turdus migratorius*) suffered a slightly higher mortality than was expected on the basis of the frequency of collisions, whereas black-capped chickadees (*Poceile atricapillus*) suffered a slightly lower mortality.'

Best, Joel, 2008. Birds -- Dead and Deadly: Why Numeracy Needs to Address Social Construction. Numeracy 1(1), article 6.
http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1001&context=numeracy

Best uses the way Klem's 1990 estimate of mortality from collisions and its derivation has morphed into certainty through 'social construction' in non-scientific contexts, especially by media or when used to justify taking action. It is important, when using statistics and other numbers, to understand where they came from originally. Another example is the threat of a possible epidemic avian flu in 2005.

Birds and Buildings Forum, 2007. Chicago Bird Safe Design Guide.

Downloadable:
http://www.birdsandbuildings.org/docs/ChicagoBirdSafeDesignGuide.pdf

Blem, C.R.and B.A.Willis, 1998. Seasonal variation of human – caused mortality of birds in the Richmond area. Raven 69(1):3-8.

The authors examined museum specimens salvaged from collisions with motor vehicles and windows to determine what species are most commonly killed and how collision frequency varies seasonally. The two causes of mortality are not addressed individually throughout the paper, preventing readers from interpreting results solely in the context of window collisions. One must assume the trends observed in the study are equally attributable to both types of mortality.

In total, permanent resident birds were significantly more common in the data set than winter residents, migrants, or summer residents. However, analyses of individual months found that in September and October, mortality was highest among migrants and in November, mortality was highest among winter residents. The most commonly killed species in each season are listed. The paper demonstrates that museum collections can be useful for studying avian window strike mortality (see also Codoner 1995 and Klem 1989).

Bocetti, C.I., 2011. Cruise ships as a source of avian mortality during fall migration. The Wilson Journal of Ornithology, 123(1):176-178. 2011.

Cruise ships are brilliantly lit through the night and may be an unrecognized source of collisions. The author reports 8 Yellow-throated Warblers killed in a single incident in 2003; cleaning staff acknowledged removal of additional collision victims. There were 2981 ship-nights in the Caribbean Sea alone in 2003, possibly killing over 700,000 birds. The author suggests both organized study of this source of mortality and working with ship-owning companies to develop improved lighting strategies.

Borden, W.C., O.M. Lockhart, A.W. Jones and M.S. Lyonn, 2010. Seasonal, taxonomic and local habitat components of bird-window collisions on an urban campus in Cleveland, OH. Ohio J Sci 110(3):44-52.

Many studies of collision mortality monitor tall buildings. The authors monitored collisions at a complex of mostly low-rise (<30m) buildings over 12 months and conclude that these also pose a significant hazard to birds. Mortality peaked during fall migration, with a smaller peak in spring, accounting for 90% of collisions. More glass on a building façade correlated with more collisions, as did reflections of trees in glass. Consistent with other monitoring reports, White-throated Sparrow was the most frequently killed species.

City of Toronto Green Development Standard, 2007. Bird-friendly development guidelines. City Planning, Toronto, Ontario, Canada. Downloadable at:http://www.toronto.ca/lightsout/pdf/development_guidelines.pdf

Toronto's guidelines for reducing risk from glass and lighting in construction, including illustrated examples.

Codoner, N. A. 1995. Mortality of Connecticut birds on roads and at buildings. Connecticut Warbler 15(3):89-98.

Codoner used museum collection and rehabilitation center data to determine if vehicle and window collision rates have changed between 1962 and 1993. The most commonly killed species and monthly mortality totals are reported.

Records of window strike mortality rose continuously during the time period examined. Codoner attributes the increase in window strike mortality to increased residential development in the region. She acknowledges the data may be biased by the increased popularity of wildlife rehabilitation in recent years.

Surprisingly the Sharp-shinned Hawk was found to be the most common species among window collision records, whereas common feeder birds, the Blue Jay and Northern Cardinal, were noticeably absent.

Window mortality was greatest during spring and autumn migrations. Mortality was also relatively high during the early summer months, unlike other studies (e.g., Klem 1989). Condoner speculates this may be due to increased foraging activity of adults to feed young during this time.

Collins, K. A. and D. J. Horn. 2008. published abstract. Bird-window collisions and factors influencing their frequency at Millikin University in Decatur, Illinois. . Bird-window collisions and factors influencing their frequency at Millikin University in Decatur, Illinois 101(supplement):50.

Bird collisions were monitored at 11 buildings on the Millikin campus, along with surface area and number of windows, presence of architectural features including alcoves and corridors, as well as landscape features. Most collisions were during migration periods and warblers most frequently killed. The authors estimate 8-11 birds killed/building/year. The total surface area of glass and total number of windows positively influenced the number of fatalities.

Drewitt, Allan I. and R.H.W. Langston, 2008. Collision Effects of Wind-power Generators and Other Obstacles on Birds. Ann. N.Y. Acad Sci 1134: 233-266.

A comprehensive review of the literature on collisions with stationary man-made objects, including wind turbines, communication towers, buildings, glass, power lines and fences. The authors note that there are few longitudinal studies of collisions and that the pattern of fatalities follows that of observer effort. They report on changes of emphasis over time in the literature with wind turbines the current focus. They discuss risk factors contributing to each type of collision.

Because so many factors are involved in each type of collisions, mortality estimates are necessarily imprecise: Deaths from wind turbines have been reported ranging from 0 to 60 per turbine per year, although off-shore wind farms appear to have less impact; mortality at towers is estimated at 4-50 million/year in the US; powerlines have produced <3-489deaths/km (this is likely to be a low estimate as only 1/5 of bodies are found.) This translates to 130-174 million/year in the US; glass mortality estimates of 1-10 birds/building/year, using 1986 building data gives 97-975 million/year. Fences erected to protect new forest growth from deer are less commonly studied, but have been shown to have serious impacts for some ground birds like grouse.

The impact of mortality on population sustainability is discussed but more work is needed to understand the implications, especially for rare or declining species. Measures to mitigate collision threats are enumerated. It is noted that large scale, consistent monitoring and standardized, comparable data formats are essential to providing information necessary to generate effective solutions. Experimentation is needed to devise methods of increasing the visibility of obstacles.

Dunn, E. H. 1993. Bird mortality from striking residential windows in winter. Journal of Field Ornithology 64(3):302-309.

Dunn analyzed surveys of people across North America who regularly feed wild birds around their homes during the winter and also record incidences of window collisions (Project Feeder Watch). Of the 5500 participants, 9.2% reported one or more instances of strike mortality. Window casualties were represented by 66 species, most of which are commonly associated with bird feeders. Dunn calculates a winter window strike mortality rate of 0.85 birds per home using the survey data. Accounting for the biases and assumptions behind this figure, she extrapolates to estimate total annual window mortality in North America at 0.65 to 7.70 window kills/home/year. Despite the extreme speculation behind the calculations, the estimate is similar to that of another study (Klem 1990a), adding validity to the result.

Dunn recommends screening windows and placing feeders where panic flights will lead birds away from windows as ways to reduce fatal collisions.

Erickson, W. P., G. D. Johnson, M.D. Strickland, D. P. Young Jr., K.J. Sernka and R.E. Good. 2001. Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States. A resource document of the National Wind Coordinating Committee, http://www.nationalwind.org/publications/wildlife/avian_collisions.pdf

The goal of this report is to put avian mortality from wind turbines into context with mortality from vehicles: 60-80 million, buildings and windows: 98-980 million, power lines: tens of thousands – 174 million, communication towers: 4-50 million, wind generation: 10,000-40,000. Differences in total mortality correlates directly with the magnitude of the structure ie 4 million miles of road, 15,000 wind turbines (in 2001). Windplant mortality data is expected to be more accurate than for other types of structure, as monitoring generally includes estimates for scavenging and considers observer detection biases.

Erickson, W. P., G. D. Johnson, D. P. Young Jr. 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. USDA Forest Service Gen. Tech. Rep. PSW-GTR-191, pp.1029-1041. Downloadable: http://www.fs.fed.us/psw/publications/documents/psw_gtr191/Asilomar/pdfs/1029-1042.pdf

A comprehensive review of multiple forms of human-caused bird mortality, including a section on collisions with buildings and windows. The findings of Klem (1990a) and Dunn (1993) are summarized.

Evans, A. M. 1976. Reflective glass. BioScience 26(10):596.

In response to Banks (1976), Evans adds that birds frequently fly towards the windows of his home but impending collisions are interrupted by porch screening outside of the windows. After being stopped abruptly, the birds appear to fly away unharmed. Evans concludes that birds cannot see wire or nylon window screening and such screening may therefore be an effective and practical method of preventing bird collisions at residential and small commercial buildings.

Evans-Ogden, L. P. 1996. Collision course: the hazards of lighted structures and windows to migrating birds. World Wildlife Fund Canada and the Fatal Light Awareness Program. 46 pp.

A lengthy overview of bird migration, size and distribution of North American cities, the attraction of nocturnal migrants to artificial light, and the overall hazards of tall illuminated buildings and reflective windows to birds in urban settings. Disorientation and night-time collisions with buildings caused by urban light pollution are the primary focus of the document, but a section on windows summarizes the previous research of D. Klem and acknowledges the additional significance of day-time collisions with glass.

Evans-Ogden, L.J., 2002. Summary Report on the Bird Friendly Building Program: Effect of Light Reduction on Collision of Migratory Birds. Special Report for the Fatal Light Awareness Program (FLAP) (available from FLAP). 29 pages.

An analysis of data on bird mortality, living birds recovered, weather and light emissions for 16 buildings, ranging from 8 to 72 stories, monitored during migration seasons in Toronto from 1997-spring 2001. Light emission was calculated from photographs taken on random nights, 8-10 times per season and seasonal average calculated. The percentage of windows illuminated on the building overall was multiplied by the number of building stories to create a measure of light impact. In spring 2001, light emission for each building was calculated on five nights and correlated with numbers of birds collected the following morning

While there was some correlation between building height and number of birds collected, the effect of light impact was much greater.

Also included is an analysis of surveys conducted with managers of the monitored buildings. There was a net decrease in light emissions from the buildings overall, corresponding to savings on energy costs in many, but not all cases.

While the total number of nights of volunteer activity varies between seasons and between years, the search effort on each individual night was assumed to be constant (i.e. fewer volunteers search for a longer time period, or many volunteers search for a shorter time period, with either scenario resulting in the maximum possible number of birds retrieved). This assumption allowed direct comparison of seasonal and annual values for average number of birds killed and found alive per night.

Fink, L. C. and T. W. French. 1971. Birds in downtown Atlanta- Fall, 1970. Oriole 36(2):13-20.

Injured and dead birds found near two skyscrapers are listed. In addition to striking the upper floors of the buildings during night flights, birds also collide with the clear glass facing of the ground floor of one of the buildings during daytime. The authors presume birds that fly into the glass are attempting to reach the potted shrubbery in the lobby.

Fatal Light Awareness Program (FLAP) website, updated in 2012. http://flap.org/

Includes bird-friendly guidelines for commercial and residential buildings, links to other guidelines, ordinances and resources, as well as links to current issues like collisions related lawsuits.

Gaston, K.J. and T.M. Blackburn, 1997. How many birds are there? Biodiversity and Conservation 6: 615-625.

Measurements of global biodiversity have generally focused at the species level. The authors use 4 different methods to estimate the total global number of birds, calculating numbers that range from 200 to 400 billion individuals.

Gelb, Y. and N. Delacretaz. 2006. Avian window strike mortality at an urban office building. Kingbird 56(3):190-198.

The authors studied spring and fall window collisions at a six-story New York City office building. A small recreational park frequently used as a stopover site by migrating songbirds is opposite the building. Significantly more dead birds were found below windows that reflected vegetation than windows on another side of the building that did not. Ninety two percent of salvaged birds were migratory species that only occur in the area during migration. A three day period in October during which search frequency was increased from once per day to five times per day found most collisions occurred during the morning hours. Various methods of reducing bird collisions with glass are recommended.

Graham, D. L. 1997. Spider webs and windows as potentially important sources of hummingbird mortality. Journal of Field Ornithology 68(1):98-101.

Graham observed daily collisions of birds with the windows of the La Selva Biological Station, Costa Rica. A detailed description of the windows is not given. Most collisions were non-lethal, but approximately 2-3 collisions per week resulted in death. Hummingbirds were the most commonly killed birds. Graham suspects the window mortality rate is great enough to significantly affect local hummingbird populations.

Grasso-Knight G. and M. Waddington. 2000. Bird collisions with windows on Swarthmore Campus. http://www.swarthmore.edu/NatSci/es/birdcollisions.html (accessed 20 August 2007).

Multiple campus buildings were surveyed for evidence of bird-window collisions during spring migration. The primary finding was bird mortality was unrelated to window size (see also Klem 1989). None of the study's results were robust, however, due to very small sample sizes.

Hager, S.B., H. Trudell, K.J. McKay, S.M. Crandall, L. Mayer. 2008. Bird density and mortality at windows. Wilson Journal of Ornithology 120(3):550-564.

This is the first study to test the hypothesis that window collision frequency and species richness of killed birds at a given site are positively correlated with the abundance and richness of birds in the surrounding area. Hager et al. monitored bird collisions year-round at buildings on two college campuses in Illinois and conducted point-counts in nearby wooded areas during the same time period.

The findings do not support the hypothesis that collision frequency is a function of local bird abundance. Rather, the authors conclude, window strike frequency is better explained by total window area, window height, surrounding habitat features, and behavioral differences among species (particularly between migrants and residents). Hence, birds in areas of relatively low abundance are not at decreased risk of collisions with windows and buildings in such areas should still take measures to reduce window strike potential.

The mortality rates of 55 and 24 birds/building/year observed during the study suggest the average mortality caused by commercial buildings in North America may be much greater than previously estimated (O'Connell 2001, Klem 1990).

Hager, Stephen B., 2009. Human-Related Threats to Urban Raptors. J. Raptor Res. 43(3):210–226

The author reviews 86 publications for information on raptor mortality in cities. Twenty-eight Falconiformes and 14 Strigiformes species are divided by degree of urban useage and dominant urban activities (feeding, breeding). Road use is treated similarly. To quote the abstract: *Within the Falconiformes (28 urban species), vehicle collisions and electrocutions were reported for most species (73% and 48%, respectively), and vehicular and window strikes were the leading sources of mortality for 39% and 12% of species, respectively. For the Strigiformes (14 urban species), vehicular (63%) and window (47%) collisions affected most species, and the primary sources of mortality were from vehicles (32%) and electrocution (5%). Window-strike mortality was reported for 45% of urban raptors and represented the leading source of mortality for Sharp-shinned Hawks (Accipiter striatus), Cooper's Hawks (A. cooperii), Merlins (Falco columbarius), and Peregrine Falcons (F. peregrinus). Mortality by electrocutions was also observed for 45% of the species.* Vehicle collisions were reported for 60% of species and for half of those was the primary source of mortality. The impact of collisions on population structure has been studied for very few species and more such work is needed. An appendix provides notes for each of the sources used in the review.

Hager, Stephen B., Bradley J. Cosentino and Kelly J. McKay, 2012. Scavenging effects persistence of avian carcasses resulting from window collisions in an urban landscape. J. Field Ornithol. 83(2) 203-211.

Estimates of bird mortality at windows may be underestimated because of carcass scavenging. Scavenger activity was monitored at 20 buildings on the campus of Augustana College in suburban Illinois for one week in each season of the year, using motion triggered cameras. Carcass survival was greatest in winter, was related negatively window area and to the amount of cover within 50 meters, and was related positively to pavement cover. The authors speculate that carcass survival time may be short in areas with habitat preferred by scavengers and where collisions create a predictable food source.

Harden, J. 2002. An overview of anthropogenic causes of avian mortality. Journal of Wildlife Rehabilitation 25(1):4-11.

Numerous causes of injury to, and death of, birds admitted to a New Mexico wildlife rehabilitation center are discussed. Window collisions accounted for 8% of all human-caused injury and mortality.

Haupt, H. and U. Schillemeit, 2011. Skybeamer und Gebäudeanstrahlungen bringen Zugvögel vom Kurs ab: Neue Untersuchungen und eine rechtliche Bewertung dieser Lichtanlagen. NuL 43 (6), 2011, 165-170 [Search/spot Lights and Building Lighting Divert Migratory Birds Off Course: New investigations and a legal evaluation of these lighting systems]

The study describes and quantitatively examines the effects of upward-directed light sources on night-migrating passerines. More than 90 % of all birds flying through a light beam showed abnormal reactions such as circling, turnaround flights, change of direction, speed reduction, or undirected flights. Even after crossing the light beam, distracted birds often continued their flight in the changed direction. The authors suggest that these observations should lead to a ban on search lights, undirected building illuminations and other light sources directed upwards, at least during main bird migration. Legal provisions for regulatory activities definitely exist. Against this background the paper outlines relevant legal regulations for nature conservation and emission control.

Johnson, R. E. and G. E. Hudson. 1976. Bird mortality at a glassed-in walkway in Washington State. Western Birds 7:99-107.

The authors recorded bird collisions with a four story glass walkway that connects two buildings on a rural college campus. The glass does not reflect images of nearby vegetation; rather, it is completely transparent and birds attempt to fly towards what is on the other side of the invisible barrier (trees and sky when approaching from the south and only sky when approaching from the north).

Mortality was greatest during migration seasons, especially fall. Two years into the study, 6-12 raptor decals were placed on the glass. The authors observed an overall decrease in fatal strikes of 64%. A table is provided that shows the effect of decals on individual species.

Jones, J. and Francis, C.M., 2003. The effects of light characteristics on avian mortality at light houses. J. Avian Biol. 34:328-333.

Lighthouses are among the first structures reported to cause collision mortalities. The lighthouse at Long Point, Lake Erie, Ontario, Canada from 1960-1989 killed a mean number of 200 birds in spring and nearly twice that in fall, with up to 2000 birds killed in a single night. When the lighthouse was automated in 1989, with a narrower and less powerful beam, the mean mortality dropped to 18.5 in spring and 9.6 in autumn, for 1990-2002.

Klem, D., Jr. 1979. Biology of collisions between birds and windows. Ph.D. dissertation, Southern Illinois University, Carbondale, IL.

Klem examined various aspects of window collisions, including the species known to collide with windows, age and sex distributions of collision victims, seasonal variation in collision frequency, effects of window size and type on collision frequency, and effectiveness of some methods of preventing window strikes. Most of this research was later published in scientific journals (Klem 1989; 1990a,b; Klem et al. 2004).

Klem, D., Jr. 1989. Bird-window collisions. Wilson Bulletin 101(4):606-620.

Klem analyzed window collision data obtained from ornithological collections, volunteer monitoring of two homes, and field experiments. He concludes the likelihood of birds striking windows is generally unaffected by species, age, and sex, window height, size, and orientation, type of glass (i.e., clear or reflective), season, time of day, and weather conditions. The study demonstrates that window collisions occur simply because birds do not recognize glass as a barrier and all birds are vulnerable. This is contrary to popular beliefs that window collision victims are usually unhealthy or otherwise impaired.

Klem, D., Jr. 1990a. Collisions between birds and windows: Mortality and prevention. Journal of Field Ornithology 61(1):120-128.

Houses and commercial buildings were monitored for window strikes during autumn and winter months. Based on the mortality observed at these sites, Klem reaches a conservative annual estimate of 1-10 birds killed per building per year. When multiplied by the number of buildings in the U.S., it is estimated that 97.6-975.6 million birds are killed by windows each year.

Experiments found single hawk silhouettes and other objects placed on windows did not significantly reduce mortality. Mortality was only reduced when several items were spaced <10 cm apart and covered most of the glass surface.

Klem, D., Jr. 1990b. Bird injuries, cause of death, and recuperation from collisions with windows. Journal of Field Ornithology 61(1):115-119.

Klem determines most collision victims die from intracranial hemorrhaging and subsequent brain damage; few suffer skeletal fractures.

Klem, D., Jr. 1991. Glass and bird kills: An overview and suggested planning and design methods of preventing a fatal hazard. Pp. 99-104 in L. W. Adams and D. L. Leedy (Eds.), Wildlife Conservation in Metropolitan Environments. Natl. Inst. Urban Wildl. Symp. Ser. 2, Columbia, MD.

Klem reviews existing knowledge and urges landscapers and architects to take measures to minimize window strike potential. Recommendations include feeder placement close to windows, covering of windows with netting or strips of translucent fabric, and window angling.

Klem, D. Jr., D. C. Keck, K. L. Marty, A. J. Miller Ball, E. E. Niciu, C. T. Platt. 2004. Effects of window angling, feeder placement, and scavengers on avian mortality at plate glass. Wilson Bulletin 116(1):69-73.

Experiments revealed that window strike mortality is inversely related to window angle and feeder distance, with the most angled windows and closest feeders causing the least mortality. Thus, angling windows slightly downwards and only placing feeders within 1 m of windows are recommended by the authors as practical solutions to reduce avian mortality at homes and commercial buildings.

The results of a carcass removal experiment suggest that scavengers can have a significant effect on detection probability (see also Young et al. 2003). Previously calculated strike rates that do not account for carcass removal are likely underestimates of true mortality. Future window strike studies should quantify scavenger removal in concert with bird mortality to ensure more precise mortality rate estimates.

Klem, D., Jr. 2006. Glass: A deadly conservation issue for birds. Bird Observer 34(2):73-81.

Klem provides an overview of his research on bird collisions with glass, followed by detailed explanations of potential solutions. Klem discusses past failures of the conservation community and building industry to recognize and respond to the issue. Klem notes a recent dramatic increase in awareness, particularly in the form of media attention.

Klem, D. Jr. 2009. Preventing Bird-Window Collisions. The Wilson Journal of Ornithology 121(2):314–321.

Klem conducted a series of aviary and field trials, testing commercial products a string of colored feathers (ineffective), Window Alert decals (effective when densely applied), CollidEscape (very effective), UV absorbing film (somewhat effective) , fritted glass (effective) and films made with high UV reflecting/high UV absorbing materials arranged in different configurations (some very effective). The UV films were prototypes, promising but not commercially available at this time). Continuous monitoring showed that 25% of collisions left no marks on glass.

Klem, D. Jr., C. J. Farmer, N. Delacretaz, Y. Gelb and P.G. Saenger, 2009. Architectural and Landscape Risk Factors Associated with Bird-Glass Collisions in an Urban Environment. Wilson Journal of Ornithology 121(1): 126-134.

Using mortality data from monitoring of 73 building facades in Manhattan, the authors test the hypothesis that architectural and/or landscape variables can account for risk of death from collisions. Mortality increased with glass area and height of vegetation.

Klem, D. Jr. 2010. Avian mortality at windows: the second largest human source of bird mortality on earth. Proc. Fourth Int. Partners in Flight Conference: Tundra to Tropics. pp 244-251. An overview of Klem's findings concerning bird collisions with plastic and glass.

Klem, D. Jr., 2010. Sheet Glass as a Principal Human-Associated Avian Mortality Factor Chapter 20 in Majumdar, S.K., Master, T.L., Brittingham, M., Ross, R.M., Mulvihill, R. and J. Huffman. *Avian Ecology and Conservation: A Pennsylvania Focus with National Implications.* Pennsylvania Academy of Science.

A review of factors and issues involved in collisions with glass. Quotes an AOU compilation of species reported by museums and individuals – the American Robin is the most frequent collision victim and the list is quite different from lists reported by urban monitoring programs. Klem also provides a table of Watchlist species that have been documented as collision casualties.

Ley, H.W. 2006. Experimentelle Überprüfung der Wahrnehmbarkeit patentierter Vogelschutzgläser durch eine Stichprobe mitteleuropäischer Gartenvögel. Max Planck Institut für Ornithologie [available for download from www.windowcollisions.info].

Ley, H.W. 2006. Experimental examination of the perceptibility of patented bird- protecting glass to a sample of Central European perching birds. Max Planck Institute for Ornithology, unpublished report [English translation available from ABC].

Using an indoor flight tunnel, Ley tested the effectiveness of 17 European- patented glass types specifically designed to reduce bird collisions. The glass reflects and/or absorbs ultraviolet light, intending to make the surface visible to birds while not appearing different than conventional glass to humans. Only one of the 17 types tested was significantly effective when compared to ordinary glass or a section of open air space. This type consisted of a combination of ultraviolet reflecting and absorbing vertical stripes. Descriptions of the 16 ineffective types are not provided. Ley cautions that the glass' effectiveness under more natural, outdoor conditions may differ from what was found during the indoor flight tunnel experiments. This work led to the first generation of Ornilux glass.

Longcore Travis, Catherine Rich, Pierre Mineau, Beau MacDonald, Daniel G. Bert, Lauren M. Sullivan, Erin Mutrie, Sidney A. Gauthreaux Jr, Michael L. Avery, Robert L. Crawford, Albert M. Manville II, Emilie R. Travis and David Drake, 2012. An estimate of avian mortality at communication towers in the United States and Canada.

http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0034025

Loss, Scott R., Tom Will and Peter P. Marra, 2012. Direct human-caused mortality of birds: improving quantification of magnitude and assessment of population impact. Frontiers in Ecology and the Environment, September, Vol. 10, No. 7 : 357-364

There are many types of human caused bird-mortality, including cats, collisions with buildings, turbines, towers, roads and power lines, pesticide poisoning, oiling and more. Quantifying mortality levels and impacts on populations has been difficult, however, with few rigorous studies available. The authors outline methodology and techniques of analysis that would produce more consistently useful results. This is important, as this information is the basis for policies and legislation.

Martin, G.R. 2011. Understanding bird collisions with man-made objects: a sensory ecology approach. Ibis 153:239-54.

To understand why birds collide with man-made objects it is important to knowing how birds see. This paper identifies aspects of bird vision and visual behavior that probably contribute to collisions – for example, in flight, at times, some birds may actually be blind in the direction of travel. Frontal vision may be tuned for direction of movement, not for detection of spatial detail. Birds in flight may predict that the environment ahead is open, because they have no template for recognizing wind turbines, buildings or power lines.

Martin, Graham R. 2011. Through birds' eyes: insights into avian sensory ecology. Journal of Ornithology, August 2012, Volume 153, Issue 1 Supplement, pp 23-48. This paper is well worth reading in its entirety.

Sensory ecology describes 'the information that underlies an animal's interactions with its environment' – the information that animals have available to them. The paper reviews Martin's own work in the field, for example how owls, kiwi, oilbirds and penguins differently solve problems related to nocturnal activity. He also uses a sensory ecology approach to examine why birds collide with man-made objects like power lines and wind turbines that to humans appear very obvious. Fundamental to avian sensory ecology is understanding important differences between the way birds and humans see their environment. Humans, with forward facing eyes, have significant three dimensional vision but a relatively restricted field of view compared to most birds, with eyes at the side of the head, restricted three dimensional vision and a field of view that in a few cases is actually 360 degrees. Other, equally major differences mean that human vision cannot be used to model avian vision.

Martin's conclusions concerning collisions include:

1. Some birds may be blind ahead of themselves in flight
2. Vision in the direction of travel is not high resolution vision and may be tuned for movement, not spatial detail
3. Birds use lateral vision for detection of food, predators etc and this may be why they look downwards during flight
4. Birds in flight may predict that the environment ahead is not cluttered

Merkel, Flemming Ravn and Kasper Lambert Johansen, 2011. Light induced bird-strikes on vessels in South West Greenland. Marine Pollution Bulletin 62: 2330-2336. Also available as a report at: www.natur.gl

41 bird mortality incidents reported by boats using searchlights to navigate in dark seas off SW Greenland. Up to 88 birds were killed with larger numbers happening in conditions of poor visibility because of snow. 95% of casualties were Common Eiders.

Newton, I., I. Wyllie, and L. Dale. 1999. Trends in the numbers and mortality patterns of Sparrowhawks (*Accipiter nisus*) and Kestrels (*Falco tinnunculus*) in Britain, as revealed by carcass analyses. Journal of Zoology 248:139-147.

The causes of death of 1,797 Sparrowhawks and 1,483 Kestrels found in Britain between 1963 and 1997 were determined. Window casualties accounted for 28.6% of Sparrowhawks and 0.5% of Kestrels. Differences in hunting methods of the two species make Sparrowhawks more vulnerable to window collisions. Numbers of Sparrowhawks killed by windows increased over the 35 years, likely a result of increased use of large plate glass in houses over the same period. The Kestrel showed little seasonal variation in window mortality, whereas Sparrowhawk window mortality increased greatly in August. Juveniles accounted for 93% of August Sparrowhawk collisions.

O'Connell, T. J. 2001. Avian window strike mortality at a suburban office park. Raven 72(2):141-149.

O'Connell monitored window strike mortality at four glass buildings in a Richmond, VA office park. Mortality was highest during migration seasons, and significantly more migrants were salvaged than resident or "feeder birds". This is inconsistent with the findings of some previous studies (Klem 1990a, Dunn 1993) and is likely because O'Connell surveyed buildings that do not attract birds with feeders.

The observed mortality rate was far greater than the estimates of Klem (1990a) and Dunn (1993), although inconsistencies in methodology among studies weaken comparisons. O'Connell recommends standardizing protocols for studies of window strike mortality to allow for better comparisons of results.

Because of the high mortality of migrants relative to resident species that are attracted to feeders, O'Connell concludes that bird mortality at office parks is more similar to that caused by skyscrapers or other tall structures than homes.

Rawlings, Cynthia M.and Horn, David Joseph 2010. Scavenging rates highest at windowed compared to windowless sites at Millikin University in Decatur, Illinois. Illinois State Academy of Science 103(3-4)

This study compared scavenging rates at windowed sites compared to windowless walls at Millikin University in Decatur, Illinois from Fall 2007 to Fall 2008. Twenty gram pieces of raw chicken were placed at 0 or 10 meters from windowed or windowless walls, with a total of 16 sites. Scavenging rates were fastest at sites 0 meters from windowed walls. Overall, scavenging rates were highest in spring and summer and did not reflect the frequency of collisions, highest during spring and fall migration. Among scavengers observed included domestic cats, squirrels and insects.

Rössler, M. and T. Zuna-Kratky. 2004. Vermeidung von Vogelanprall an Glasflächen. Experimentelle Versuche zur Wirksamkeit verschiedener Glas- Markierungen bei Wildvögeln. Bilogische Station Hohenau-Ringelsdorf [available for download from www.windowcollisions.info].

Rössler, M. and T. Zuna-Kratky. 2004. Avoidance of bird impacts on glass: Experimental investigation, with wild birds, of the effectiveness of different patterns applied to glass. Hohenau-Ringelsdorf Biological Station, unpublished report. (English translation available from ABC).

An outdoor flight tunnel was constructed to test the effectiveness of different marking patterns at reducing bird collisions with glass. The opening at the end of the tunnel through which birds would attempt to escape was partitioned so two pattern types could be tested simultaneously and directly compared. Tests were also conducted in which one pane was patterned and the other was plain. A mist net was suspended in front of the glass to prevent lethal collisions. Test patterns included vertical white strips of adhesive tape of varying widths and spacing, one horizontal stripe pattern, a non- geometric branch pattern, and a grid.

All patterns except the grid significantly reduced collisions when compared to plain glass. Among the effective patterns, the branch and vertical stripe patterns were significantly more effective than the horizontal pattern. During paired comparisons of patterns, 2cm wide vertical stripes with 10cm spacing was found to be most effective at reducing collisions. Results did not differ among groups of species associated with four different habitat types. The influence of bird body size on effectiveness was not investigated.

Rössler, M. 2005 Vermeidung von Vogelanprall an Glasflächen. Weitere Experimente mit 9 Markierungstypen im unbeleuchteten Versuchstunnel. Wiener Umweltanwaltschaft. Bilogische Station Hohenau-Ringelsdorf [available for download from www.windowcollisions.info].

Rössler, M. 2005. Avoidance of bird impact at glass areas: Further experiments with nine marking types in the unlighted tunnel. Hohenau-Ringelsdorf Biological Station, unpublished report. (English translation available from ABC).

Using the same methods as Rössler and Zuna-Kratky (2004), this study examined the effectiveness of eight additional patterns at reducing bird collisions. New patterns included: large circles, small circles, large squares, small squares, grid (wider stripes and larger cell sizes than Rössler and Zuna-Kratky [2004]), vertical stripes of irregular width, and thin, black, horizontal lines imbedded inside plexi-glass. All patterns were white except the last. All white patterns were created with adhesive tape except the small square pattern which was created by silk screening.

Each pattern significantly reduced collision frequency when compared to plain glass. Of these, the small square pattern was least effective. Rössler hypothesizes this may be due to the higher transparency of silk screening than adhesive tape. Small circles and irregular vertical stripes were 100% effective. The grid pattern containing vertical and horizontal stripes was no more effective than vertical stripes alone. The thin black horizontal stripes were effective despite having the lowest total coverage area of all patterns (6.7%). The patterns with the lowest coverage area (and therefore presumed by Rössler to be most aesthetically-acceptable to the public) and greatest effectiveness were thin black horizontal stripes, 2cm wide vertical white stripes with 10cm spacing, large circles, large squares, and the branch pattern previously studied (Rössler and Zuna-Kratky 2004).

Rössler, M., W. Laube, and P. Weihs. 2007. Vermeidung von Vogelanprall an lasflächen. Experimentelle Untersuchungen zur Wirksamkeit von lasmarkierungen unter natürlichen Lichtbedingungen im Flugtunnel II. Bilogische Station Hohenau-Ringelsdorf [available for download from www.windowcollisions.info].

Rössler, M., W. Laube, and P. Weihs. 2007. Investigations of the effectiveness of patterns on glass, on avoidance of bird strikes, under natural light conditions in Flight Tunnel II. Hohenau-Ringelsdorf Biological Station, unpublished report. English translation available for download from www.windowcollisions.info.

A new flight tunnel capable of rotating to maintain a constant orientation to the sun was constructed. It also allows light to fall in front as well as behind test panels . Using this tunnel, Rössler examined the effectiveness of new patterns and re-examined some patterns studied previously (2004, 2005). New patterns included: dots of 9mm radius, white vertical stripes 0.5cm wide with 10cm spacing, black vertical stripes 0.5cm wide with 10cm spacing, and black and white side-by-side vertical stripes of 2cm total width and 10cm spacing. Rössler also tested plain glass paired with an empty frame (i.e., free air space) to determine if plain glass is an appropriate control for use in experiments of pattern effectiveness.

The distribution of collisions with plain glass and open air did not differ, suggesting plain glass is a suitable control in pattern testing experiments. In general, low background light levels seemed to reduce the effectiveness of all pattern types, but sample sizes were insufficient for statistical analyses of individual patterns under different light conditions. Each pattern significantly reduced collision frequency when compared to plain glass. Black and white vertical stripes did not significantly differ from each other, indicating pattern color may not be important. As during previous experiments (Rössler and Zuna-Kratsky 2004, Rössler 2005), white horizontal stripes 2cm wide with 10cm spacing were least effective at reducing collisions. Similar to Rössler (2005), thin, black, horizontal stripes imbedded in the glass were most effective despite the low coverage area, the reasons for which remain unclear. The high effectiveness and low coverage area gives promise to the development of an effective, yet aesthetically-acceptable design.

Rössler, M. and W. Laube. 2008. Vermeidung von Vogelanprall an Glasflächen. Farben, Glasdekorfolie, getöntes Plexiglas: 12 weitere Experimente im Flugtunnel II. Bilogische Station Hohenau-Ringelsdorf [available for download from www.windowcollisions.info].

Rössler, M. and W. Laube. 2008. Avoidance of bird impacts on glass. Colors, decorative window-film, and noise-damping plexiglass: Twelve further experiments in flight tunnel II. Hohenau-Ringelsdorf Biological Station, unpublished report. (English translation available from ABC)

Using the same tunnel and protocol as Rössler et al. (2007), Rössler and Laube (2008) test bird collisions with tinted plexiglass, new pattern types, new colors, and a new adhesive material in addition to re-testing the “10v” pattern (20mm wide vertical white stripes with 10cm spacing) from prior studies. Glass with thin, black, horizontal stripes placed on the outside of glass was tested for comparison to the plexiglass with embedded, black, horizontal lines found to be highly effective by Rössler (2005) and Rössler et al. (2007). Tests conducted under low and high light conditions were compared, to determine how lighting influences pattern effectiveness.

A faux window frosting film was highly effective at reducing collisions, but this was likely due to the extreme coverage area of the patterns created with this material (25 and 50%). A version of the 10v pattern, with interrupted lines was highly effective when placed on both sides of the glass (over 90% effective) . The glass with outer black, horizontal lines and the plexiglass with embedded, black, horizontal lines did not differ significantly in effectiveness under higher intensity light conditions. Under lower intensity lighting, the plexiglass with embedded lines was more effective than the glass with similar stripes placed on the outer surface. All patterns, except the black horizontal lines, performed better under low light conditions than under bright conditions. The 10v pattern using orange lines instead of the traditional white lines, was highly effective under both lighting conditions and among the most effective of all patterns and colors tested.

Roth, T. C. II, S. L. Lima, W. E. Vetter. 2005. Survival and causes of mortality in wintering Sharp-shinned Hawks and Cooper’s Hawks. Wilson Bulletin 117(3):237-244.

Roth et al. radio-tracked a total of 67 Sharp-shinned and Cooper’s Hawks over five winters in rural and urban areas. Two birds were killed by window collisions. The authors observed several non-lethal window collisions where hawks contacted the glass feet-first, presumably in reaction to a perception of their own reflection as another bird.

Schaub, Michael, Marc Kèry , Pius Korner and Fränzi Korner-Nievergelt, 2011. A critique of ‘Collision Mortality Has No Discernible Effect on Population Trends of North American Birds’.
http://www.plosone.org/annotation/listThread.action;jsessionid=729FAA9E57422361740ADB1E3BE3851B?root=9659

The authors contest the assumption that lack of correlation between estimated collision risk and estimated population trend can be used to conclude that collision mortality produces no effect. They discuss several scenarios and note that local population level effects may be far more important than continent wide trends. Also, this sort of analysis is unlikely to be useful for rare species with small populations, where a single collision could be of significance, but would be unlikely to be recorded.

Schramm, I, Jacqueline Fiala, Therese Noe, Paul Sweet, Annette Prince and Caleb Gordon, 2007. Calls, captures and collisions: Triangulating three census methiods to better understand nightly passage of songbird migrants through the Chicago region during May. Meadowlark 16(4): 122-129.

Three different methods of characterizing the passage of migrating passerines through the Chicago area in May 2006-7 are compared: mist-net captures, nocturnal flight call recordings and window collisions rescues/collections. Combined data included 1432 identified and 2520 unidentified flight calls, 3040 mist-net captures and 1060 window collisions. The authors conclude that a combination of mist-netting and nocturnal flight call recording provides the most comprehensive picture on songbird migration, especially if combined with other information, including weather radar images and standardized daytime bird observations.

Sealy, S. G. 1985. Analysis of a sample of Tennessee Warblers window-killed during spring migration in Manitoba. North American Bird Bander 10(4):121-124.

Approximately 150 passerines struck a glass arboretum connecting two apartment buildings in Winnipeg in one afternoon. A detailed description of the structure is not provided. Seventy-one of the birds were Tennessee Warblers. All birds possessed some subcutaneous fat. There were significantly more males than females in the sample (51 males, 20 females). A nearby bird banding station operating at the same time, however, captured more females than males. Sealy does not conclude that males are more vulnerable to window strikes than females and offers no explanation of the contradictory results.

Sheppard, Christine, 2011. Bird-friendly Building Design. American Bird Conservancy, The Plains, VA 20198. 60 pages. http://collisions.abcbirds.org

Bird-friendly Building Design, published in 2011, explains in straightforward terms why birds hit glass, what features make certain buildings more prone to bird collisions, and the science behind the collision phenomenon. Most importantly, the book provides cost-neutral solutions for new building construction and reasonable ways that existing buildings can be retrofitted to make them bird-friendly.

Sloan, Allison, 2007. Migratory bird mortality at the World Trade Center and World Financial Center, 1997-2001: A deadly mix of lights and glass. Transactions of the Linnaean Society of NY 10:183-204. http://linnaeannewyork.org/Transactions%20X.pdf

Volunteers monitored bird mortality at the two World Trade Center towers and four other buildings in that complex, plus the nearby World Financial Center, starting in 1997. There were no mass kill events but carcasses were found consistently during

migration periods. The project was adopted by New York City Audubon in 2000, as Project Safe Flight. Monitoring took place daily; dead birds were collected, frozen, photographed and shipped to the Patuxent Wildlife Research Center. Injured birds were caught when possible and either released in a park or taken to a rehabilitator. 2352 birds of at least 83 species were found; 68% were dead. Monitoring took place near dawn; maintenance, security and office workers reported that birds continued to collide throughout the day. Some carcasses were observed to be taken by gulls or raptors, others were swept up by maintenance workers. It was not possible to monitor rooftops, ledges, setbacks etc, so actual mortality numbers were certainly higher. Weather and architectural factors involved in daily variations of collisions are discussed and an update covering 2001-2006 is included.

Snyder, L. L. 1946. "Tunnel fliers" and window fatalities. Condor 48(6):278.

Snyder surveyed accession records of the Royal Ontario Museum from the early 1940's to learn which species were most commonly salvaged from window strikes. He notes most of the commonly represented species are "tunnel fliers" that frequently fly through small spaces in dense understory habitats. This habit makes them more susceptible to window strikes (also asserted by Ross 1946, below).

Stedman, S. J. and Stedman, B. H. 1986. Preventing window strikes by birds. Migrant 57:18.

A brief recommendation to hang ¾ inch mesh nylon or plastic screening in front of windows to prevent lethal collisions.

Trybus, T. 2003. Wirksamkeit von Greifvogelsilhouetten zur Verhinderung von Kleinvogelanprall an Glasfronten. Die These des Masters, der Universität Wien [published in German with English abstract provided: Trybus, T. 2003. Effectiveness of raptor silhouettes at preventing small bird collisions with glass. Master's thesis, University of Vienna, Vienna, Austria.]

Raptor decals are shown to be ineffective at reducing bird collisions with large glass sound barriers in Vienna, Austria.

Veltri, C.J. and D. Klem Jr., 2005. Comparison of fatal bird injuries from collisions with towers and windows. J. Field Ornithol 76(2):127-133.

247 tower kills and 255 window kills were examined to determine type and extent of injuries and actual cause of death. Impact of bird age and weight was considered. Injuries caused by towers and windows were similar but subdermal injuries were more

severe in tower kills. Subadults experienced more severe subdermal injuries than adults in either category. 98-99% of collision victims had subdermal intracranial hemorrhage; few had evidence of skeletal fracture. Bleeding in and around the brain is the probable cause of most deaths. Early treatment to reduce brain edema is recommended for birds that survive a collision.

Wiese, Francis K., W. A. Montevecchi, G. K. Davoren, F. Huettmann, A. W. Diamond and J. Linke, 2001. Seabirds at Risk around Offshore Oil Platforms in the North-west Atlantic. Marine Pollution Bulletin 42(12):1285-1290. Download at: http://play.psych.mun.ca/~mont/pubs.html

This paper presents a literature review relating to seabird attraction to off-shore drilling platforms, recommends research to monitor and quantify attraction and mortality and develop mitigation. Seabirds aggregate at platforms, attracted by lights at night and associated food concentrations and mortality has been documented from collisions with the structure, oiling and flares. As drilling in the North Atlantic increases, this could become a serious source of mortality for seabirds, including migratory species.

Young, D. P. Jr., W. P. Erickson, M. D. Strickland, R. E. Good, K. J. Sernka. 2003. Comparison of avian responses to UV-light-reflective paint on wind turbines. Subcontract Report 500-32840, National Renewable Energy Laboratory, Golden, CO. 38pp.

Although this study focuses exclusively on bird collisions with wind turbines, the results of its carcass removal and searcher efficiency trials have important implications for observational studies of bird-glass collisions. Carcass removal trials found that the time carcasses remained in the study site prior to removal varied with bird body size and season. Searcher efficiency did not differ among seasons, but varied dramatically with bird size. Only 59% of small birds were detected compared to 87% and 92% detection of medium and large birds, respectively. Differences among species in scavenger and searcher detection probabilities may bias studies of avian window strike mortality that do not control for these variables.

Zink, R.M. and J. Eckles, 2010. Twin Cities Bird-Building Collisions: A Status Update on "Project Birdsafe". The Loon 82(1):34-37.

A summary of the Minnesota Project Birdsafe collisions monitoring program in Minneapolis and St. Paul, initiated in spring of 2007. The monitoring routes include a random sampling of buildings to help discriminate the effect of building design on collisions rate – most collisions occur at a few of the buildings monitored. The most common collision victims are listed, along with the least common. Collision peaks coincide with migration peaks.