Bird Collision Deterrence
Material Threat Factor
Reference Standard

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Purpose

As many as a billion birds die, every year, colliding with glass on buildings in North America (Loss et al., 21014) for two simple reasons. Birds have no concept of glass as a transparent or reflective barrier. They take reflections literally and may also try to fly through glass to habitat on the other side (Sheppard and Phillips, 2015). Birds have cultural and intrinsic value, but they also contribute hundreds of billions of dollars annually in ecological services, moving seeds to regenerate habitat, consuming insects that eat crops, destroy forests and transmit diseases like West Nile Virus (Sekercioglu et al., 2016). Birds are also the basis of a birdwatching industry estimated to U.S. Fish and Wildlife Service, 2020), so this is a tremendous waste of a valuable natural resource. As recognition of this problem grew, earlier in this century, bird-rescue groups began to recommend 'increasing visual noise on the façade' or not using 'large' panels of glass.

These early guidelines for bird-friendly design strategies were undermined because recommendations were non-specific, and it was difficult to determine what constituted compliance. It is also difficult to objectively define what makes glass 'bird-friendly'. Although used frequently, the term itself provides no specific guidance. Architects interested in designing a building that does not kill birds could select products for their insulation value or breaking strength, but there was no similar system for specifying bird-friendly materials.

In 2010, American Bird Conservancy and a team of experts developed the concept of "threat factor" (TF) as a way to assign scores that measure birds' ability to see and avoid patterned glass and other materials. These scores allow architects to design buildings using rated glass and also permit evaluation of products that can be applied to existing glass ("retrofits") to reduce collisions. They also made it possible to create a credit for reducing bird collisions in the LEED rating system (.

Ideally, Threat Factors could be derived from monitoring collisions on a diversity of existing windows, replacing that glass with a product thought to be bird-friendly, and then continuing to monitor for differences. Unfortunately, this type of data is very rare and this type of test would also be very costly. It would also take years to acquire enough monitoring data to reliably detect a trend and, importantly, it would kill birds.

ABC realized the need to create a way to objectively evaluate the effectiveness of a given material for deterring collisions. The first method used was a 'tunnel test', originally developed in Austria in response to high rates of bird deaths on highway noise barriers. [refer to separate doc or separate section on tunnel function?]. As more information has accumulated, we have developed additional ways to assign TF scores. We will continue to enlarge the Reference Standard as new techniques and information allow.

Developed and Maintained via Consensus Process

The Reference Standard is part of a process of peer reviewed, scientific enquiry. "Tunnel testing" is a non-injurious, standardized binomial choice technique that uses wild birds to determine the relative effectiveness of patterns at deterring bird collisions. It was first developed for evaluating glass at the Hohenau Bird Banding Station in

Austria (Rössler and Zuna-Kratky. 2004; Rössler, 2005'; Rössler et al., 2007; Rössler and Laube, 2008; Rössler, 2013; Rössler et al., 2015; Sheppard, 2019), although Ley was using something similar at the Max Planck Institute as early as 2006 (Ley, 2006; Fiedler and Ley, 2013). Tunnel testing produces 'tunnel scores' (TS= the percentage of a test group that flies towards the control glass), and tunnel scores are the basis for Threat Factors. For many materials, TF=100 -TS.

Other types of tunnel binomial choice protocols have been used in related research on responses to light color (Goller et al., 2018), and investigating avian response to obstacle flight (Bhagavatula et al, 2011, Lin et al., 2014, Ros et al., 2017; Schiffner et al., 2014; Schiffner, Ingo and Mandyam V. Srinivasan, 2015; Vo et al., 2016).

Currently, in the U.S., American Bird Conservancy's tunnel testing takes place at the Carnegie Museum of Natural History's Powdermill Nature Reserve. Both the Austrian tunnel protocol and the U.S. tunnel have been peer reviewed in scientific journals (Rössler et al., 2015; Sheppard, 2019). The Austrian process is also the Austrian Standard for Evaluating Freestanding Glass (ONR 191040). The ABC tunnel was evaluated with reference to the Austrian tunnel and found to produce statistically equivalent results(Sheppard, 2019).

In addition to ABC staff, the tunnel protocol is overseen by Carnegie Staff and the Bird-safe Building Alliance. A second tunnel will be constructed in 2020 at Foreman's Branch Biological Station, affiliated with Williams College, in Virginia. The tunnel protocols have been evaluated by the Institutional Animal Care and Use Committees of the Wildlife Conservation Society and Fordham University, and maintains appropriate State and Federal permits. A detailed description of the tunnel test can be found in Appendix Q.

Peer reviewed literature has supported the results of tunnel testing. Research that provides information on avian visual ecology, flight behavior and route choice flight (Bhagavatula et al, 2011, Lin et al., 2014, Ros et al., 2017; Schiffner et al., 2014; Schiffner, Ingo and Mandyam V. Srinivasan, 2015; Vo et al., 2016) explains, for example, that pattern spacing guidelines found to deter collisions correlate with dimensions of bird bodies in flight. Reports from monitoring programs providing data on collisions rates before and after application of retrofit deterrents (Cusa et al., 2015; FLAP Canada, 2018) indicate that TF scores do represent relative effectiveness at deterring collisions.

In order to keep tunnel testing from creating a bottleneck and to make a range of options available quickly, ABC partners with the Bird-Safe Building Alliance (BSBA) a group consisting of architects experienced in bird-friendly design, conservation biologists, and other collision experts. A minimum of six people can use a range of additional information sources to assign a TF. In a simplistic example, this allows us to assign a score of TF=0 to a brick wall without having to conduct a tunnel test (see xxx).

Conservative TFs can be assigned to products that: a) were tested using other, peer-reviewed protocols (Hohenau tunnel, Muhlenberg College) that BSBA has determined to

be equivalent or translatable to tunnel testing scores, b) were studied by scientists or experienced building collision monitors with a documented reduction in collisions of at least 50%. TFs can be assigned to materials that are similar to tested materials. TFs can be assigned to materials that meet a descriptive standard.

Scope of Standard

It should be stated here that this standard does not apply to most glass, because most glass is the cause of bird collision mortality. This standard applies to

1. glass that incorporates a pattern, created by coatings, frit or other obstructions. This category is not limited to glass designed and marketed to deter collisions.
2. It also applies to glass that is opaque and does not create a strong reflection, like some continuous surface etched glass ie spandrel glass.

Both these categories include glass assemblies like Insulated Glass Units (IGUs), monolithic and laminated glass. The standard distinguishes relative effectiveness among members of these categories of materials.

Referenced Documents
(see also appendix X, annotated bibliography)

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

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.

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

Bhagavatula, Partha S.C harles Claudianos, Michael R. Ibbotson, and Mandyam V. Srinivasan, 2011. Optical Flow Cues Guide Flight in Birds. Current Biology 21, 1794–1799. DOI 10.1016/j.cub.2011.09.009

.

Bracey, Matthew A. Etterson, Gerald J. Niemi, and Richard F. Green (*2016*) Variation in bird-window collision mortality and scavenging rates within an urban landscape. The Wilson Journal of Ornithology: June 2016, Vol. 128, No. 2, pp. 355- 367.

Cabrera-Cruz, Sergio A., Jaclyn A. Smolinsky and Jeffrey J. Buler, 2018. Light pollution is greatest within migration passage areas for nocturnally-migrating birds around the world. Scientific Reports 8:3261 DOI:10.1038/s41598-018-21577-6

Cabrera-Cruz, Sergio A., Jaclyn A. Smolinsky, Kyle P. McCarthy and Jeffrey J. Buler, (2019). Urban areas affect flight altitudes of nocturnally migrating birds. Journal of Animal Ecology. doi: 10.1111/1365-2656.13075

Cusa, Marine, Donald A. Jackson and Michael Mesure, 2015. Window collisions by migratory bird species: urban geographical patterns and habitat associations. Urban Ecosystems doi:10.1007/s11252-015-0459-3)

Fiedler, Wolfgang and Hans-Willy Ley, 2013. Ergebnisse von Flugtunnel-tests im Rahmen der Entwicklung von Glasscheiben mit UV-Signatur zur Vermeidung von Vogelschlag. Ber Vogelschutz 49/50:115-134.

FLAP Canada, 2018. An analysis of collision mitigation effectiveness pre- and post-installation of bird collision deterrents at four Toronto buildings. Unpublished report.

Goller, Benjamin, Bradley F. Blackwell, Travis L. DeVault, Patrice E. Baumhardt and Esteban Fernández-Juricic (2018). Assessing bird avoidance of high-contrast lights using a choice test approach: implications for reducing human-induced avian mortality. PeerJ DOI 10.7717/peerj.5404

Hager, Steven B. et al., 2017. Continent-wide analysis of how urbanization affects bird-window collision mortality in North America. Biological Conservation 212: 209-215
http://dx.doi.org/10.1016/j.biocon.2017.06.014

Håstad, Olle and Anders Ödeen, 2014. A vision physiological estimation of ultraviolet window marking visibility to birds. PeerJ 2:e621; DOI10.7717/peerj.621

Klem, D., Jr. 1989. Bird-window collisions. Wilson Bulletin 101(4):606-620.
Klem, D., Jr. 1990a. Collisions between birds and windows: Mortality and prevention. Journal of Field Ornithology 61(1):120-128.

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

Klem, Daniel Jr. and Peter G. Saenger, 2013. Evaluating the Effectiveness of Select Visual Signals to Prevent Bird-window Collisions. The Wilson Journal of Ornithology 125(2):406–41. Download at: http://www.muhlenberg.edu/main/academics/biology/faculty/klem/aco/Bi rd-window.html

Ley, H.W. 2006. Experimentelle Überprüfung der Wahrnehmbarkeit patentierter Vogelschutzgläser durch eine Stichprobe mitteleuropäischer Gartenvögel. Max

Planck Institut für Ornithologie [available for download from http://www.wua-wien.at/publikationen]

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

Lin H-T, Ros IG, BiewenerAA. 2014 Through the eyes of a bird:modelling visually guided obstacle flight.J. R. Soc. Interface 11: 20140239. http://dx.doi.org/10.1098/rsif.2014.0239

Loss, Scott R., Tom Will, Sara S. Loss and Peter P. Marra, 2014. Bird–building collisions in the United States: Estimates of annual mortality and species vulnerability. Condor 116:8-23. DOI: 10.1650/CONDOR-13- 090.1

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

Martin, Graham R. 2012. Through birds' eyes: insights into avian sensory ecology. Journal of Ornithology, August 2012, Volume 153, Issue 1 Supplement, pp 23-48.

Mitrus, Cezary and Adam Zbyryt, 2017. Reducing avian mortality from noise barrier collisions along an urban roadway. Urban Ecosystems https://doi.org/10.1007/s11252-017-0717-7

Ödeen, Anders and Olle Håstad, 2013. The phylogenetic distribution of ultra violet vision in birds. BMC Evolutionary Biology 2013, 13:36 http://www.biomedcentral.com/1471-2148/13/36

Ros IG, Bhagavatula PS, LinH-T, Biewener AA. 2017 Rules to fly by: pigeons navigating horizontal obstacles limit steering by selecting gaps most aligned to their flight direction. Interface Focus 7:20160093. http://dx.doi.org/10.1098/rsfs.2016.0093

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 http://www.wua-wien.at/publikationeno].

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.

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 http://www.wua-wien.at/publikationen].

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).

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 http://www.wua-wien.at/publikationen].

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 http://www.wua-wien.at/publikationen.

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 http://www.wua-wien.at/publikationen]. English summary at http://wua-wien.at/images/stories/publikationen/avoiding-bird- collisions-glass-surfaces-2008.pdf

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.

Rössler, Martin, Erwin Nemeth & Alexander Bruckner, 2015. Glass pane markings to prevent bird-window collisions: less can be more. Biologia 70/4: 535—541. DOI: 10.1515/biolog-2015-0057

Rössler, Martin, 2013. VERMINDERUNG VON VOGELANPRALL AN GLASFLÄCHEN PRÜFBERICHTABC BIRD TAPE, TESA ® 4593. Prüfung im Flugtunnel II
der Biologischen Station Hohenau-Ringelsdorf nach ONR 191040 und unter Einbeziehung von Spiegelungen bei dunklem Hintergrund (WIN-Versuch). In German. Download at
http://wuawien.at/images/stories/publikationen/vogelanprall-bird-tape- tesa.pdf
English summary courtesy of City of Vienna, Office of Environmental Protection Two kinds of transparent adhesive tapes have been tested –ABC Bird Tape and Tesa® 4593.

Schiffner, Ingo, Hong D Vo, Partha S Bhagavatula and Mandyam V Srinivasan,

2014. Mind the Gap. Frontiers in Zoology 11:64
http://www.frontiersinzoology.com/content/11/1/64

Schiffner, Ingo and Mandyam V. Srinivasan, 2015. Direct Evidence for Vision- based Control of Flight Speed in Budgerigars Sci Rep. 2015; 5: 10992.Published online 2015 Jun 5. doi: 10.1038/srep10992.

Seewagen, Chad, 2011. A review of experimental methods used to test the effectiveness of bird-deterring glass. Unpublished report, American Bird Conservancy.

Sekercioglu, H, Daniel G. Wenny and C. J. Wheland, eds.. 2016. Why Birds Matter: Avian Ecological Function and Ecosystem Services . University of Chicago Press. Chicago. 387 pp.

Sheppard, Christine, 2019. Evaluating the relative effectiveness of patterns on glass as deterrents of bird collisions with glass. Global Ecology and Conservation 20 (2019) e00795. https://doi.org/10.1016/j.gecco.2019.e00795

Sheppard, Christine and Glenn Phillips, 2015. *Bird-Friendly Building Design,* 2nd Ed. (The Plains, VA: American Bird Conservancy, 2015). Free download at: http://abcbirds.org/wp-content/uploads/2015/05/Bird-friendly- Building-Guide_2015.pdf.

Tan, Dereck, 2018. Birdstrike deterrent through community-based application of oil-paint markers on glass. Biodiversity Research Center, Beaty Biodiversity Museum University of British Columbia.

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. Ef fectiveness of raptor silhouettes at preventing small bird collisions with glass. Master's thesis, University of Vienna, Vienna, Austria.]

U.S. Fish and Wildlife Service, accessed September 26, 2020. https://www.fws.gov/birds/bird-enthusiasts/bird-watching/valuing-birds.php

Vo, Hong D., Ingo Schiffner & Mandyam V. Srinivasan, 2016. Anticipatory Manoeuvres in Bird Flight. Nature: Scientific Reports 6:27591 DOI: 10.1038/srep27591

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.**

Terminology

Threat Factor

Tunnel Score
Contrast sensitivity
Pattern

Visible Light Reflection

> The percentage of visible light that is reflected by the glass surface, measured in the 380-780nm wavelength range perpendicular to the surface. The VLR can be given as the reflection from the external surface 1 or internal surface 2. The higher the percentage the more reflection. Also known as LR, VR and Rvis.

VLR

EVR

UV

Threat Factor

Tunnel Score

Fly-Through

Reflection

Glazing Assembly – consists of products

Birds

Binomial Choice-Protocol

Migratory Bird

Mist Net

Pattern

Data Sheet

Key Performance Criteria & Variables

9. Determination of Threat Factors
   a. TF per Bird-friendly Materials Evaluation Program at Carnegie Museum's Avian Research Center Test Protocol
   b. TF per Prescriptive Criteria

c. TF per other evaluation protocols

10. TF Data Sheet Template