Biological Conservation 212 (2017) 209–215

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Continent-wide analysis of how urbanization affects bird-window collision mortality in North America

Stephen B. Hager[a,*], Bradley J. Cosentino[b], Miguel A. Aguilar-Gómez[c], Michelle L. Anderson[d], Marja Bakermans[e], Than J. Boves[f], David Brandes[g], Michael W. Butler[h], Eric M. Butler[i], Nicolette L. Cagle[j], Rafael Calderón-Parra[k], Angelo P. Capparella[l], Anqi Chen[m], Kendra Cipollini[n], April A.T. Conkey[o], Thomas A. Contreras[p], Rebecca I. Cooper[f], Clay E. Corbin[q], Robert L. Curry[r], Jerald J. Dosch[s], Martina G. Drew[q], Karen Dyson[m], Carolyn Foster[m], Clinton D. Francis[t], Erin Fraser[u], Ross Furbush[v], Natasha D.G. Hagemeyer[w], Kristine N. Hopfensperger[x], Daniel Klem Jr.[y], Elizabeth Lago[z], Ally Lahey[aa], Kevin Lamp[ab], Greg Lewis[ac], Scott R. Loss[ad], Craig S. Machtans[ae], Jessa Madosky[af], Terri J. Maness[ag], Kelly J. McKay[ah], Sean B. Menke[ai], Katherine E. Muma[aj], Natalia Ocampo-Peñuela[j], Timothy J. O'Connell[ad], Rubén Ortega-Álvarez[k], Amber L. Pitt[q], Aura L. Puga-Caballero[ak], John E. Quinn[ac], Claire W. Varian-Ramos[al], Corey S. Riding[ad], Amber M. Roth[am], Peter G. Saenger[y], Ryan T. Schmitz[an], Jaclyn Schnurr[ao], Matthew Simmons[ap], Alexis D. Smith[aq], Devin R. Sokoloski[ar], Jesse Vigliotti[as], Eric L. Walters[w], Lindsey A. Walters[x], J.T. Weir[at], Kathy Winnett-Murray[au], John C. Withey[z], Iriana Zuria[av]

[a] Department of Biology, Augustana College, Rock Island, IL 61201, USA
[b] Department of Biology, Hobart and William Smith Colleges, Geneva, NY 14456, USA
[c] Facultad de Ciencias, Universidad Nacional Autónoma de México (UNAM), Avenida Universidad 3000, Circuito Exterior S/N, Delegación Coyoacán, C.P. 04510 Ciudad Universitaria, Distrito Federal, Mexico
[d] Department of Biology, The University of Montana Western, Dillon, MT 59725, USA
[e] Department of Biology and Biotechnology, Worcester Polytechnic Institute, Worcester, MA 01609, USA
[f] Department of Biological Sciences, Arkansas State University, AR 72467, USA
[g] Department of Civil & Environmental Engineering, Lafayette College, Easton, PA 18042, USA
[h] Department of Biology, Lafayette College, Easton, PA 18042-1778, USA
[i] Natural Sciences and Mathematics, Shaw University, Raleigh, NC 27601, USA
[j] Nicholas School of the Environment, Duke University, Durham, NC 27708, USA
[k] Iniciativa para la Conservación de las Aves de América del Norte-México (NABCI-México), Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), Liga Periférico-Insurgentes Sur, No. 4903, Col. Parques del Pedregal, Delegación Tlalpan 14010, Distrito Federal, Mexico
[l] School of Biological Sciences, Illinois State University, Normal, IL 61790-4120, USA
[m] University of Washington, Gould Hall, Box 355740, Seattle, WA 98195, USA
[n] Center for the Sciences and Agriculture, Wilmington College, Wilmington, OH 45177, USA
[o] Department of Animal, Rangeland, & Wildlife Sciences, Texas A & M University-Kingsville, Kingsville, TX 78363, USA
[p] Biology Department, Washington and Jefferson College, 60 S. Lincoln St., Washington, PA 15301, USA
[q] Department of Biological Sciences, Bloomsburg University, Bloomsburg, PA 17815-1301, USA
[r] Department of Biology, Villanova University, Villanova, PA 19085-1669, USA
[s] Biology Department, Macalester College, St. Paul, MN 55105, USA
[t] Department of Biological Sciences, California Polytechnic State University, San Luis Obispo, CA 93407, USA
[u] Environmental Science (Biology), Memorial University of Newfoundland, Grenfell Campus, Corner Brook, NL A2H 5G4, Canada
[v] Principia College, Elsah, IL, USA
[w] Department of Biological Sciences, Old Dominion University, Norfolk, VA 23529, USA
[x] Department of Biological Sciences, Northern Kentucky University, Highland Heights, KY 41099, USA
[y] Acopian Center for Ornithology, Muhlenberg College, Allentown, PA 18104, USA
[z] Department of Biological Sciences, Florida International University, Miami, FL 33199, USA
[aa] 305 Kabler Road, Virginia Beach, VA 23456, USA
[ab] 1252 Deer Hill Road, Long Lake, MN 55356, USA
[ac] Furman University, 3300 Poinsett Highway, Greenville, SC 29613, USA
[ad] Oklahoma State University, 008C Ag Hall, Stillwater, OK 74078, USA
[ae] Environment and Climate Change Canada, Canadian Wildlife Service, 91780 Alaska Highway, Whitehorse, YT Y1A 5X7, Canada
[af] Biology Department, University of Tampa, 401 W Kennedy Blvd Tampa, FL 33606, USA
[ag] School of Biological Sciences, Louisiana Tech University, Ruston, LA 71272, USA
[ah] BioEco Research and Monitoring Center, Hampton, IL 61256, USA
[ai] Lake Forest College, Lake Forest, IL 60045, USA
[aj] Biology Department, Ithaca College, Ithaca, NY 14850, USA

http://dx.doi.org/10.1016/j.biocon.2017.06.014
Received 11 April 2017; Received in revised form 9 June 2017; Accepted 16 June 2017
Available online 10 July 2017
0006-3207/

[ak] Museo de Zoología "Alfonso L. Herrera", Facultad de Ciencias, Universidad Nacional Autónoma de México (UNAM), Avenida Universidad 3000, Circuito Exterior S/N, Delegación Coyoacán, C.P. 04510 Ciudad Universitaria, Distrito Federal, Mexico
[al] Biology Department, Colorado State University - Pueblo, Pueblo, CO 81001, USA
[am] School of Forest Resources and Environmental Science, School of Forest Resources and Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME 04469, USA
[an] University of Wisconsin-Platteville, Platteville, WI 53818, USA
[ao] Wells College, Aurora, NY 13026, USA
[ap] University of Minnesota Crookston, MN 56716, USA
[aq] University of Illinois at Chicago, Chicago, IL 60607, USA
[ar] 710 S. Atlantic St., Dillon, MT 59725, USA
[as] Environment Canada, Canadian Wildlife Service, 91780 Alaska Highway, Whitehorse, YT Y1A 5X7, Canada
[at] University of Toronto Scarborough, Scarborough, Ontario MIC 1A4, Canada
[au] Department of Biology, Hope College, Holland, MI 49423, USA
[av] Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Hidalgo, Km 4.5 carr. Pachuca-Tulancingo s/n, col. Carboneras, Mineral de la Reforma, Hidalgo C.P. 42184, Mexico

ARTICLE INFO

Keywords:
Bird-window collisions
Anthropogenic mortality
Lights out program
Bird migration
Habitat selection
Behavioral divergence

ABSTRACT

Characteristics of buildings and land cover surrounding buildings influence the number of bird-window collisions, yet little is known about whether bird-window collisions are associated with urbanization at large spatial scales. We initiated a continent-wide study in North America to assess how bird-window collision mortality is influenced by building characteristics, landscaping around buildings, and regional urbanization. In autumn 2014, researchers at 40 sites (N = 281 buildings) used standardized protocols to document collision mortality of birds, evaluate building characteristics, and measure local land cover and regional urbanization. Overall, 324 bird carcasses were observed (range = 0–34 per site) representing 71 species. Consistent with previous studies, we found that building size had a strong positive effect on bird-window collision mortality, but the strength of the effect on mortality depended on regional urbanization. The positive relationship between collision mortality and building size was greatest at large buildings in regions of low urbanization, locally extensive lawns, and low-density structures. Collision mortality was consistently low for small buildings, regardless of large-scale urbanization. The mechanisms shaping broad-scale variation in collision mortality during seasonal migration may be related to habitat selection at a hierarchy of scales and behavioral divergence between urban and rural bird populations. These results suggest that collision prevention measures should be prioritized at large buildings in regions of low urbanization throughout North America.

1. Introduction

Annual avian mortality resulting from collisions with buildings is estimated at nearly 1 billion birds in North America (Klem, 1990; Machtans et al., 2013; Loss et al., 2014). Numerous bird species are affected by bird-building collisions, including species of conservation concern (Machtans et al., 2013; Loss et al., 2014). Nocturnally migrating birds are known to strike the windows of buildings in large cities after becoming attracted to and disoriented by artificial lighting or when low cloud cover forces individuals to fly at altitudes below the top of many sky scrapers (Longcore and Rich, 2004). During the daytime hours, birds may strike windows after mistaking the reflected environment in sheet glass for habitat and open flight space (Klem, 1989; Martin, 2011).

Window collision risk is primarily related to structural features of buildings and land cover features immediately surrounding buildings. For example, mortality is highest at large buildings with many windows and lowest at small structures with proportionately fewer windows (O'Connell, 2001; Hager et al., 2008, 2013; Klem et al., 2009; Machtans et al., 2013; Loss et al., 2014; Kahle et al., 2016; Ocampo-Peñuela et al., 2016). Moreover, bird-window collisions are more frequent at buildings surrounded by low levels of impervious surfaces (e.g., paved roadways, sidewalks, and parking lots) and structures (e.g., buildings) (Hager et al., 2013; Cusa et al., 2015). Differences in building size and the patchy nature of development in cities and towns create strong spatial variation in the number of birds that collide with glass (Bayne et al., 2012; Hager et al., 2013; Machtans et al., 2013; Loss et al., 2014).

Although building characteristics and local land cover are important drivers of bird-window collisions, we do not understand how urbanization at large spatial scales affects collision mortality. Regional urbanization may influence mortality by mediating bird community structure and abundance (e.g., Blair, 1996, Pennington et al., 2008), particularly if there is covariation between species distributions and susceptibility of species to collisions. Urbanization may also affect bird-window collisions by shaping intraspecific variation in behavioral traits associated with collision risk, such as flight behavior. For example, behavioral divergence is commonly found between urban and non-urban bird populations due to phenotypic plasticity or adaptation (Sol et al., 2013). The degree of broad-scale urbanization may work with local-scale factors to affect collision risk in an additive fashion. Alternatively, associations between urbanization and either community structure or behavioral traits may lead to variation in the effects of building features and landscaping on collision risk between urban and rural areas.

Our objective was to examine how local factors (i.e., building structural features and land cover) and large-scale urbanization together affect continent-wide variation in bird-window collision mortality. We monitored buildings that varied in size and land cover types for collision mortality at 40 locations across North America during the autumn migratory season, and then examined the relative effects of building size, local land cover, and regional urbanization on collisions. We included models with interaction terms to determine if the effects of building size and local land cover on collision mortality depended on broad-scale urbanization. Knowledge of local and regional-scale drivers of bird-window collisions would assist in prioritizing mitigation measures aimed at reducing collision mortality at the riskiest structures and landscapes in North America.

* Corresponding author.
E-mail addresses: stevehager@augustana.edu (S.B. Hager), cosentino@hws.edu (B.J. Cosentino).