

The History of Wildlife Strikes and Management at Airports

The first human-powered flight took place in December 1903, when Orville and Wilbur Wright successfully flew their experimental aircraft at Kitty Hawk, North Carolina, USA. Birds, which had been practicing powered flight for about 150 million years, suddenly had a new “competitor” for airspace, and the bird-aircraft collision problem (hereafter referred to as bird strikes) began shortly thereafter (Cleary and Dolbeer 2005). On 7 September 1905, the first reported bird strike, as recorded by Orville Wright in his diary, occurred when his aircraft hit a bird over a cornfield near Dayton, Ohio, USA. Flocks of red-winged blackbirds (*Agelaius phoeniceus*) and other birds are often attracted to cornfields in autumn to feed (Dolbeer 1990), making it likely that a red-winged blackbird caused the first known bird strike. In addition to birds, mammals and other wildlife can be a problem for safe aircraft operations. The first reported mammal strike occurred on 25 July 1909, at the start of Louis Bleriot’s historic first flight across the English Channel from Les Baraques, France. While warming up the engine of the Bleriot XI aircraft, an excited farm dog ran into the spinning propeller (http://www.pbs.org/wgbh/nova/transcripts/3207_bleriot.html).

On 3 April 1912, Calbraith Rodgers, the first person to fly across the continental USA, was killed in the first fatal crash resulting from a wildlife strike when his aircraft struck a gull (*Laridae*) along the coast of Southern California (Cleary and Dolbeer 2005). Despite this tragic event, strikes with birds and other wildlife were of little concern for the first 50 years of aviation.

In fact, only three civil aircraft were destroyed and two human fatalities were documented worldwide between 1912 and 1959 (Fig. 1.1). But in October 1960, a turboprop-powered Lockheed Electra crashed in Boston Harbor, Boston, Massachusetts, USA, shortly after takeoff, following the ingestion of over 200 European starlings (*Sturnus vulgaris*) into the air intakes of three of the aircraft’s four engines. Sixty-two people died, a fatality count which to date remains the highest for a bird-induced plane crash. During 1960–2010, bird and other wildlife strikes destroyed 160 civil aircraft, 49 from 2001 through 2010. For military aviation, more destroyed aircraft and deaths related to wildlife strikes occurred in the 1940s due to the introduction of jet-powered aircraft and increased numbers of low-level flights.

Why So Many Wildlife Strikes?

There are multiple reasons for the dramatic increase in wildlife strikes since the 1960s. First, the advent of turbine-powered passenger aircraft in the 1960s revolutionized air travel, but it also magnified the problem of wildlife strikes. Early piston-powered commercial aircraft were noisy and relatively slow. Birds could usually avoid these aircraft, and those strikes that did occur typically resulted in little or no damage to the plane. However, modern jet aircraft are faster than their predecessors, relatively quiet, and their engine fan blades are often more vulnerable to strike damage than propellers. When turbine-powered aircraft collide with birds or other wildlife, structural damage affecting the

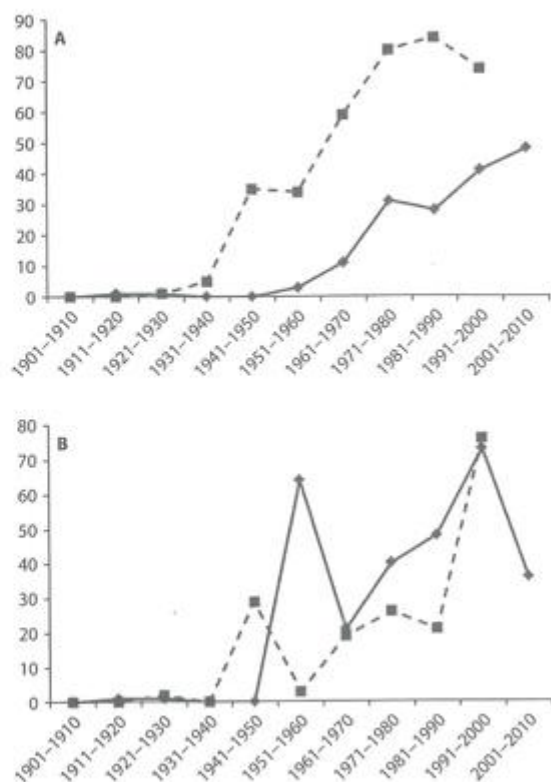


Fig. 1.1. (A) Number of aircraft destroyed and (B) human fatalities by bird and other wildlife strikes by decade. Solid lines show data for civil aircraft, and dashed lines show data for military aircraft. The years 2001–2010 are not included for military aircraft because the data for that decade are incomplete. Data from Richardson and West (2000), Thorpe (2003, 2005, 2010), and Dolbeer et al. (2012)

integrity and function of the engine or flight surface is more likely (Dolbeer et al. 2012).

Second, multiple-engine damage from the ingestion of flocks of birds became a growing concern as commercial air carriers replaced older three- or four-engine aircraft fleets with more efficient and quieter two-engine turbine-powered aircraft (Frings 1984, Hovey et al. 1992). About 90% of the 2,100 U.S. passenger aircraft had three or four engines in 1965. In 2005, the passenger fleet in the USA had grown to about 8,200 aircraft, and only about 10% had three or four engines (U.S. Department of Transportation 2009). With steady advances in technology over the past several decades, today's two-engine aircraft are more powerful and reliable than yesterday's three- and four-engine aircraft. However, in the event of a multiple-ingestion event (as

exemplified by the US Airways Flight 1549 incident on 15 January 2009; National Transportation Safety Board 2010), aircraft with two engines have vulnerabilities not shared by their three or four engine-equipped counterparts (Solman 1973). In addition, birds appear less able to detect and avoid modern jet aircraft with quieter turbofan engines compared to older aircraft with noisier engines (Solman 1976; Burger 1983; Kelly et al. 1999, 2001; Kelly and Allan 2006; see also International Civil Aviation Organization 1993). Modern turbofan engines typically have inlets with larger diameters than earlier jet-powered aircraft, which also increases the probability of bird ingestion (Banilower and Goodall 1995).

Third, worldwide air travel has become commonplace. Data from the Federal Aviation Administration (FAA) indicate that commercial air traffic in the USA increased from about 14 million movements (takeoffs or landings) in 1975 to 25 million movements in 2010 (FAA 2010). Worldwide, commercial jet aircraft movements increased from about 26 million in 1991 to 40 million in 2010 (Boeing Commercial Airplanes 2010). Aircraft have also assumed a vital role in tactical and logistical military operations. These factors have resulted in dramatically increased air traffic (Kelly and Allan 2006).

Fourth, the increased use of the skies by traveling humans has coincided with an unprecedented period of successful wildlife management and environmental protection in North America and elsewhere in the world. Aggressive natural resource and environmental protection programs by public and private wildlife management and conservation groups beginning in the late 1960s have contributed to impressive population increases of many large-bodied species such as white-tailed deer (*Odocoileus virginianus*), American alligators (*Alligator mississippiensis*), Canada geese (*Branta canadensis*), double-crested cormorants (*Phalacrocorax auritus*), sandhill cranes (*Grus canadensis*), American white pelicans (*Pelecanus erythrorhynchos*), gulls (*Larus* spp.), raptors (falcons, hawks, and eagles; order Falconiformes), vultures (*Cathartes aura* and *Coragyps atratus*), and wild turkeys (*Meleagris gallopavo*; Buurma 1996, Dolbeer and Eschenfelder 2003). At the same time, many of these species (e.g., white-tailed deer, Canada geese, and wild turkeys) have expanded into suburban and urban areas, including airports, and are thriving in response to pro-

tection and changes to habitats in these areas (Smith et al. 1999). Most of these species have body masses >1.8 kg (4 lb) and thus are more likely than smaller species to cause damage to aircraft when struck, and exceed certification standards for most airframe components and engines (Dolbeer et al. 2000, 2012; Dolbeer and Eschenfelder 2003; DeVault et al. 2011). Thus the increased probability of damaging wildlife strikes since the 1960s is primarily related to the increase in air traffic by two-engine, large-inlet, turbine-powered aircraft concurrent with major increases in populations of many large-bodied wildlife species.

Mitigating Risk through Wildlife Management Programs

The previously mentioned Lockheed Electra crash in Boston Harbor in 1960 marked the dawn of wildlife management programs to mitigate bird strikes in airport environments. Initially, leadership in this emerging field came from Canada and Europe, as exemplified by the creation of Bird Strike Committee Canada and Bird Strike Committee Europe (now the International Bird Strike Committee, or IBSC) in the 1960s. At that time, researchers sought to collect bird-strike statistics in Europe and North America. In the early 1970s, research was published on vegetation management at British airports to discourage starlings and other bird species (Brough 1971), and a biologist with the Canadian Wildlife Service wrote the first book outlining the nature and management of the bird-strike problem (Blokpoel 1974).

The bird-induced crashes of a Learjet 24 at DeKalb-Peachtree Airport, Atlanta, Georgia, USA, in 1973 and a DC-10 at John F. Kennedy International Airport, New York, New York, USA, in 1974 (Thorpe 2005) were both attributed, at least in part, to nearby landfills that attracted blackbirds (*Icteridae*) and gulls. These crashes led to recommended land-use restrictions near airports by the FAA and International Civil Aviation Organization. In addition, civil aviation authorities developed regulations (e.g., FAA 2004) to require that airports experiencing bird strikes assess and manage these hazards through habitat management and control techniques. The FAA in 1991 and the International Civil Aviation Organization in 2008 expanded their regulations and standards to include hazardous terrestrial wildlife such

as deer (Dolbeer et al. 2005, International Civil Aviation Organization 2009).

In 1991, a major program to manage the local nesting gull population was launched at John F. Kennedy International Airport (Dolbeer et al. 1993), which marked the initiation of aggressive management actions at airports to mitigate risks of bird and other wildlife strikes in the USA. During the 1990s, the FAA and International Civil Aviation Organization developed major databases on such strikes (Dolbeer et al. 2012). These databases indicated that most damaging strikes caused by birds in the 1990s (about 65% of strikes with civil aircraft in the USA) were in the airport environment (<152 m [500 feet] above ground level; Dolbeer 2006), which reinforced efforts to develop effective wildlife hazard management programs at airports (e.g., Cleary and Dolbeer 2005). Transport Canada published a sequel to Blokpoel's (1974) book in 2004 (MacKinnon 2004). From 2005 through 2006, the FAA developed standards for biologists working at airports (FAA 2012) and the IBSC developed a set of best practices for bird control units at airports (Allan 2005).

As a result of these efforts by federal agencies, private-sector biologists, and airport operational personnel, there has been a steady increase in the implementation and improvement of wildlife hazard management plans for airports worldwide over the past 20 years. For example, biologists from the U.S. Department of Agriculture Wildlife Services program provided assistance at 832 airports to mitigate wildlife risks during 2010, compared to only 42 and 193 airports assisted in 1990 and 1998, respectively (Begier and Dolbeer 2011; Fig. 1.2, see p. 4). An analysis of strike data for civil aviation in the USA from 1990 through 2009 indicated that these airport-based programs reduced the rate of damaging strikes at airports (Dolbeer 2011), but likely had little or no impact on the rate of damaging strikes outside the immediate airport environment (>152 m above ground level).

The Future

Although measurable progress has been made in recent years to keep hazardous birds off airports (Dolbeer 2011), increased efforts are needed to make areas within and surrounding airports less attractive to these same birds (e.g., de Hoon and Buurma 2000, Washburn

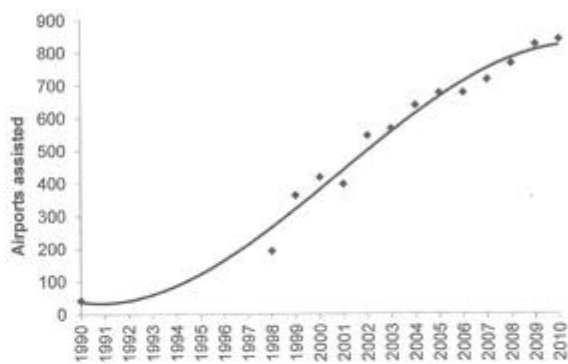


Fig. 1.2. Number of U.S. civil and military airports assisted (including through technical and direct management) by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, to reduce wildlife hazards (1990–2010). Data from Begier and Dolbeer (2011)

2010). In addition, airport managers worldwide face new challenges regarding the management of wildlife hazards. As the demand for air travel has increased, forthcoming changes to airport capacity are being met with calls for planning to maintain biodiversity in the airport environment (Blackwell et al. 2009a). Further, concerns over fossil fuel consumption have fostered research in renewable energy, with airport properties serving as potential sites for solar, biofuel, and (under limited circumstances) wind energy production (Blackwell et al. 2009a, DeVault et al. 2012). How changes in airport capacity and land use will ultimately affect wildlife populations and the associated risks to aviation (e.g., DeVault et al. 2011, Martin et al. 2011) remains unclear.

Programs to manage wildlife and associated habitats at and near airports will not, by themselves, resolve this conflict. To mitigate the risks caused by birds within and outside airport fences, increased efforts are needed in the field testing and refinement of bird-detecting radar systems (Nohara et al. 2005, Klope et al. 2009; Chapter 13). The ultimate goal is to integrate bird-detecting radar into air traffic control (ATC) procedures in a manner analogous to what has been accomplished with wind-shear detection and avoidance. These efforts will require increased risk management training for flight crews, air carrier operations personnel, and ATC personnel (Eschenfelder and DeFusco 2010). In addition, more research is needed on avian sensory perception and reaction to moving objects. Such research may lead to the development of aircraft lighting systems (which

could include various pulse rates and wavelengths in the electromagnetic spectrum) to enhance detection, speed perception, and avoidance of departing and arriving aircraft by birds (Blackwell et al. 2009b, 2012).

The mitigation of risks posed to aviation by birds and other wildlife is a complex endeavor in today's world, requiring expertise from a variety of biological, engineering, and safety disciplines. The following chapters discuss various components of the conflict between nature and aviation, as well as the research and management efforts underway to make our skies safer for birds and people. Progress is being made on several fronts, but much remains to be done.

LITERATURE CITED

- Allan, J. R. 2005. Minimum best practice standards for aerodrome bird control. Proceedings of the International Bird Strike Committee 27:1–8.
- Banilower, H., and C. Goodall. 1995. Bird ingestion into large turbofan engines. DOT/FAA/CT-93/14. Federal Aviation Administration Technical Center, Atlantic City, New Jersey, USA.
- Begier, M. J., and R. A. Dolbeer. 2011. Protecting the flying public and minimizing economic losses within the aviation industry: technical, operational, and research assistance provided by USDA-APHIS-Wildlife Services to reduce wildlife hazards to aviation, fiscal year 2010. U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, Washington D.C., USA.
- Blackwell, B. F., T. L. DeVault, E. Fernández-Juricic, and R. A. Dolbeer. 2009a. Wildlife collisions with aircraft: a missing component of land-use planning on and near airports? *Landscape and Urban Planning* 93:1–9.
- Blackwell, B. F., T. L. DeVault, T. W. Seamans, S. L. Lima, P. Baumhardt, and E. Fernández-Juricic. 2012. Exploiting avian vision with aircraft lighting to reduce bird strikes. *Journal of Applied Ecology* 49:758–766.
- Blackwell, B. F., E. Fernández-Juricic, T. W. Seamans, and T. Dolans. 2009b. Avian visual configuration and behavioural response to object approach. *Animal Behaviour* 77:673–684.
- Blokpoel, H. 1974. Bird hazards to aircraft. Canadian Wildlife Service, Ministry of Supply and Services, Ottawa, Ontario, Canada.
- Boeing Commercial Airplanes. 2010. Statistical summary of commercial jet aircraft accidents, 1959–2010. <http://www.boeing.com/news/techissues/pdf/statsum.pdf>.
- Brough, T. 1971. Experimental use of long-grass in the U.K. Proceedings of the Bird Strike Committee Europe 6.
- Burger, J. 1983. Jet aircraft noise and bird strikes: why more birds are being hit. *Environmental Pollution* 30:143–152.

- Buurma, L. S. 1996. Superabundance of birds: trends, wetlands and aviation. *Proceedings of the Bird Strike Committee Europe* 23:43–50.
- Cleary, E. C., and R. A. Dolbeer. 2005. *Wildlife hazard management at airports: a manual for airport operators*. Second edition. Federal Aviation Administration, Office of Airport Safety and Standards, Washington, D.C., USA.
- de Hoon, A., and L. Buurma. 2000. Influence of land use on bird mobility: a case study of Eindhoven Airport, 1998–1999. *Proceedings of the International Bird Strike Committee* 25.
- DeVault, T. L., J. L. Belant, B. F. Blackwell, J. A. Martin, J. A. Schmidt, and L. Wes Burger Jr. 2012. Airports offer unrealized potential for alternative energy production. *Environmental Management* 49:517–522.
- DeVault, T. L., J. L. Belant, B. F. Blackwell, and T. W. Seamans. 2011. Interspecific variation in wildlife hazards to aircraft: implications for airport wildlife management. *Wildlife Society Bulletin* 35:394–402.
- Dolbeer, R. A. 1990. Ornithology and integrated pest management: the red-winged blackbird (*Agelaius phoeniceus*) and corn. *Ibis* 132:309–322.
- Dolbeer, R. A. 2006. Height distribution of birds as recorded by collisions with civil aircraft. *Journal of Wildlife Management* 70:1345–1350.
- Dolbeer, R. A. 2011. Increasing trend of damaging bird strikes with aircraft outside the airport boundary: implications for mitigation measures. *Human–Wildlife Interactions* 5:235–248.
- Dolbeer, R. A., J. L. Belant, and J. Sillings. 1993. Shooting gulls reduces strikes with aircraft at John F. Kennedy International Airport. *Wildlife Society Bulletin* 21:442–450.
- Dolbeer, R. A., and P. Eschenfelder. 2003. Amplified bird-strike risks related to population increases of large birds in North America. *Proceedings of the International Bird Strike Committee* 26:49–67.
- Dolbeer, R. A., S. E. Wright, and E. C. Cleary. 2000. Ranking the hazard level of wildlife species to aviation. *Wildlife Society Bulletin* 28:372–378.
- Dolbeer, R. A., S. E. Wright, and P. Eschenfelder. 2005. Animal ambush at the airport: the need to broaden ICAO standards for bird strikes to include terrestrial wildlife. *Proceedings of the International Bird Strike Committee* 27:102–113.
- Dolbeer, R. A., S. E. Wright, J. Weller, and M. J. Begier. 2012. *Wildlife strikes to civil aircraft in the United States, 1990–2011*. Serial Report No. 17 DOT/FAA/AS/00-6(AAS-310). U.S. Department of Transportation, Federal Aviation Administration, Washington D.C., USA.
- Eschenfelder, P., and R. DeFusco. 2010. Bird strike mitigation beyond the airport, pilots must be prepared for bird strike avoidance and damage control. *AeroSafety World*. August:44–47.
- FAA. Federal Aviation Administration. 2004. Title 14 U.S. Code of Federal Regulations. Part 139: certification of airports. U.S. Department of Transportation, Washington, D.C., USA.
- FAA. Federal Aviation Administration. 2010. Terminal Area Forecast (TAF) system. <http://aspm.faa.gov/main/taf.asp>.
- FAA. Federal Aviation Administration. 2012. Qualifications for wildlife biologist conducting wildlife hazard assessments and training curriculums for airport personnel involved in controlling wildlife hazards on airports. Advisory Circular 150/5200-36. U.S. Department of Transportation, Washington, D.C., USA.
- Frings, G. 1984. A study of bird ingestions into large high bypass ratio turbine aircraft engines. DOT/FAA/CT-84/13. U.S. Department of Transportation, Federal Aviation Administration, Atlantic City, New Jersey, USA.
- Hovey, P. W., D. A. Skinn, and J. J. Wilson. 1992. Engine bird ingestion experience of the Boeing 737 aircraft—expanded database (October 1986–September 1989). DOT/FAA/CT-91/32. U.S. Department of Transportation, Federal Aviation Administration, Atlantic City, New Jersey, USA.
- International Civil Aviation Organization. 1993. *Convention on international civil aviation (international standards and recommended practices)*. Annex 16: environmental protection. Third edition. Montreal, Quebec, Canada.
- International Civil Aviation Organization. 2009. *Convention on international civil aviation (international standards and recommended practices)*. Annex 14: aerodromes. Volume I. Aerodrome design and operations. Fifth edition. Montreal, Quebec, Canada.
- Kelly, T. C., and J. Allan. 2006. Ecological effects of aviation. Pages 5–24 in J. Davenport and J. L. Davenport, editors. *The ecology of transportation: managing mobility for the environment*. Springer, Dordrecht, Netherlands.
- Kelly, T. C., R. Bolger, and M. J. A. O’Callaghan. 1999. The behavioral response of birds to commercial aircraft. *Proceedings of the Bird Strike Committee—USA/Canada* 99:77–82.
- Kelly, T. C., M. J. A. O’Callaghan, and R. Bolger. 2001. The avoidance behaviour shown by the rook (*Corvus frugilegus*) to commercial aircraft. Pages 291–299 in H. J. Pelz, D. P. Cowan, and C. J. Feare, editors. *Advances in vertebrate pest management*. Filander Verlag, Fürth, Germany.
- Klope, M. W., R. C. Beason, T. J. Nohara, and M. J. Begier. 2009. Role of near-miss bird strikes in assessing hazards. *Human–Wildlife Interactions* 3:208–215.
- MacKinnon, B. 2004. *Sharing the skies: an aviation industry guide to the management of wildlife hazards*, TP 13549. Transport Canada, Aviation Publishing Division, Ottawa, Ontario, Canada.
- Martin, J. A., J. L. Belant, T. L. DeVault, L. W. Burger Jr., B. F. Blackwell, S. K. Riffell, and G. Wang. 2011. Wildlife risk to aviation; a multi-scale issue requires a multi-scale solution. *Human–Wildlife Interactions* 5:198–203.
- National Transportation Safety Board. 2010. Loss of thrust in both engines after encountering a flock of birds and subsequent ditching on the Hudson River, US Airways Flight

- 1549, Airbus A320-214, N106US. Aircraft Accident Report NTSB/AAR-10/03. Washington, D.C., USA.
- Nohara, T. J., P. Weber, A. Premji, C. Krasnor, S. A. Gauthreaux, M. Brand, and G. Key. 2005. Affordable avian radar surveillance systems for natural resource management and BASH applications. Proceedings of the International Radar Conference. IEEE, 14–18 August 2005, Vancouver, British Columbia, Canada.
- Richardson, W. J., and T. West. 2000. Serious birdstrike accidents to military aircraft: updated list and summary. Proceedings of the International Bird Strike Committee 25:67–98.
- Smith, A., S. R. Craven, and P. D. Curtis. 1999. Managing Canada geese in urban environments. Jack Berryman Institute Publication 16. Cornell Cooperative Extension, Ithaca, New York, USA.
- Solman, V. E. F. 1973. Birds and aircraft. *Biological Conservation* 5:79–86.
- Solman, V. E. F. 1976. Aircraft and birds. Proceedings of the Bird Control Seminar 7:83–88.
- Thorpe, J. 2003. Fatalities and destroyed aircraft due to bird strikes, 1912–2002. Proceedings of the International Bird Strike Committee 26:85–113.
- Thorpe, J. 2005. Fatalities and destroyed aircraft due to bird strikes, 2002–2004 (with an appendix of animal strikes). Proceedings of the International Bird Strike Committee 27:17–24.
- Thorpe, J. 2010. Update on fatalities and destroyed civil aircraft due to bird strikes with appendix for 2008 to 2009. Proceedings of the International Bird Strike Committee 29:1–9.
- U.S. Department of Transportation. 2009. National transportation statistics. Table 1-13: active U.S. air carrier and general aviation fleet by type of aircraft research and innovative technology administration. http://www.bts.gov/publications/national_transportation_statistics/html/table_01_13.htm.
- Washburn, B. E. 2010. Evaluation of the North Shore Marine Transfer Station and its compatibility with respect to bird strikes and safe air operations at LaGuardia Airport. Report for the Associate Administrator of Airports, Office of Airport Safety and Standards, Airport Safety and Operations. Federal Aviation Administration. Washington, D.C., USA.