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The National Wildlife Strike Database: A Scientific Foundation to Enhance Aviation Safety

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ABSTRACT: The U.S. Federal Aviation Administration's (FAA) National Wildlife Strike Database (NWSD) documents reports of civil aircraft collisions with wildlife in USA. The NWSD has been managed by the Wildlife Services Program of the U.S. Department of Agriculture through an interagency agreement since its inception. Although the NWSD includes about 170,000 reports of civil aircraft collisions with wildlife (97% birds) from 1990-2015 (14,000 in 2015), the overriding focus has been the quality control of data entered for over 90 variables ranging from species and numbers of wildlife struck, location and time of day, phase and height of flight, aircraft type, components struck and damaged, effect of strike on flight, and associated costs. This attention to detail allows the NWSD to be used in multiple ways to document the nature of the problem temporally and spatially for individual airports and nationwide. The NWSD is used by individual airports and FAA Airport Certification Inspectors to help objectively evaluate and improve Wildlife Hazard Management Plans by examining adverse-effect strike rates (number/100,000 aircraft movements) and the species causing those damaging strikes. The NWSD provides supportive evidence and guidance to state and federal agencies for issuing permits for wetland mitigation and removal of wildlife at airports. Nationally, the NWSD provides a science-based foundation for FAA regulations and Advisory Circulars related to wildlife management at airports and airworthiness standards for engines and aircraft components. In addition, the NWSD provides unique opportunities for basic research on topics such as bird migration (height and location of strikes) and bird behavior in relation to aircraft lighting. For example, recent research has shown that birds are more likely to strike the left side of aircraft where red navigation lights are located. The NWSD is a living document, continuously refined with new and revised strike events to enable improvements to aviation safety in an environmentally responsible, science-based manner.

KEY WORDS: aircraft, airport, aviation safety, bird strike, database, FAA, radar, Safety Management System, wildlife strike

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INTRODUCTION

Bird and other wildlife collisions with aircraft (wildlife strikes) are a serious aviation safety issue as demonstrated in recent years by the emergency forced landing of an Airbus 320 with 155 passengers and crew in the Hudson River in New York City in January 2009 after Canada geese (*Branta canadensis*) were ingested in both engines (National Transportation Safety Board 2010, Marra et al. 2009). Globally, bird and other wildlife strikes killed more than 282 people and destroyed over 262 aircraft from 1988 – 2017 (Richardson and West 2000; Thorpe 2012, Shaw and Dolbeer 2018).

Major factors contributing to this aviation safety threat in North America are 1) the increase since the 1980s in populations of many large (>1.8 kg) bird and mammal species, 2) the adaptation of these species to urban environments, including airports, and 3) the replacement of older 3- or 4-engine commercial aircraft fleets with more efficient and quieter, two-engine turbo-fan-powered aircraft (Burger 1983, Dolbeer et al. 2016).

The Federal Aviation Administration (FAA) began collecting wildlife strike data in 1965 from reports submitted voluntarily by civil airports, air carriers, and pilots. However, except for cursory examinations to determine general trends, the strike reports were never organized into a database and submitted to rigorous analysis until increasing attention was directed to the wildlife strike problem in the early 1990s (e.g., Dolbeer et al. 1993). The FAA recognized at this time that the growing conflict between wildlife and aviation safety needed to be objectively defined and understood to be managed properly. The wildlife strike issue was (and still is) especially complex in the USA. Wildlife strikes can jeopardize human lives and cause substantial economic losses at over 500 airports certificated for passenger traffic (Federal Aviation Administration 2018a) and at several thousand General Aviation airports. These strikes involve many familiar and popular resident and migratory wildlife species legally protected at the state, federal, and international level.

METHODS

In 1995, the FAA initiated a project through an interagency agreement with the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (WS), to obtain more objective estimates of the magnitude and nature of the wildlife strike problem nationwide for civil aviation. Specialists from WS 1) edited all strike reports (FAA Form 5200-7) received by the FAA from 1990 forward (by 1996, data entry was complete to the current year and has continued to the present); 2) supplemented strikes reported on Form 5200-7 with additional, non-duplicated strike reports from other sources; 3) entered all edited strike reports in a standardized format containing over 90 data fields into a National Wildlife Strike Database (NWSD); 4) routinely monitored the NWSD to correct errors and update strike events when new information became available; and 5) assisted the FAA with (a) streamlining the reporting of strikes electronically and promoting strike reporting throughout the aviation industry, (b) adding and improving linked databases on airports, wildlife species, aircraft, and aircraft engines, and (c) producing annual and special reports that summarized results of analyses of the data (e.g., Dolbeer 2015, Dolbeer et al. 2016).

In 1999, the FAA entered into an agreement with the Smithsonian Institution by which remains of birds or bats involved in strikes with civil aircraft in USA could be submitted to the Feather Lab in Washington D.C. for identification at no charge. The Feather Lab uses feather morphology and DNA analysis to identify remains to species (Dove et al. 2008, 2018; Marra et al. 2009) and works closely with WS to ensure species entries in the NWSD are accurate. The NWSD also contains a linked database that has the scientific name, mean and maximum body mass by gender (Dunning 2008), and legal status of each species reported as struck.

RESULTS

Basic Statistics on Reported Strikes

The NWSD contains about 170,000 strikes from 1990-2015 (Dolbeer et al. 2016). Birds (529 species identified) were involved in of 96.8% of the events followed by terrestrial mammals (43 species, 2.1%), bats (22 species, 0.9%) and reptiles (18 species, 0.2%). In 2015, about 60% of the strikes involving birds were identified to exact species with an additional 10% identified to genus or family taxonomic group (e.g., gull, duck, hawk, blackbird).

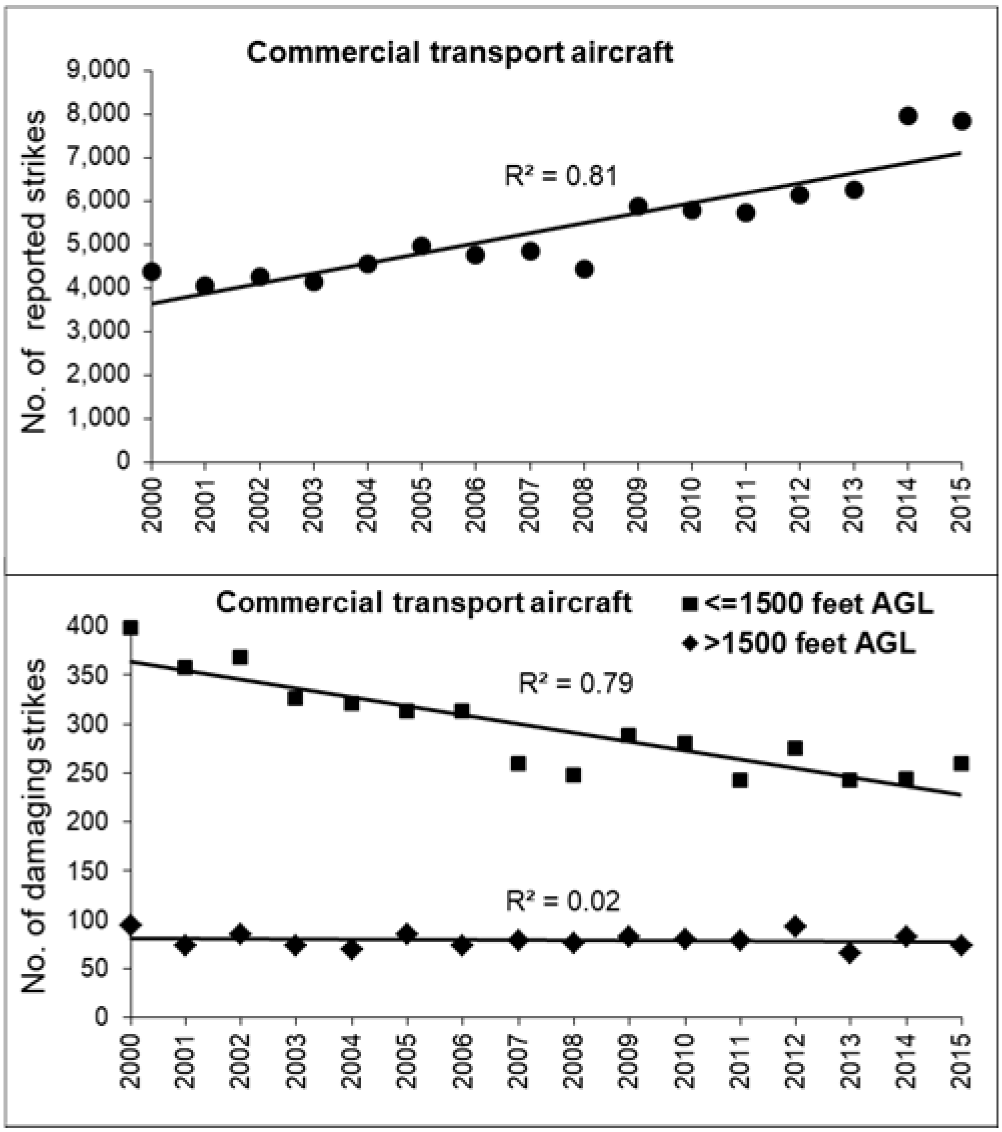

Figure 1. The number of reported wildlife strikes involving commercial transport aircraft increased (top graph) whereas the number of damaging strikes in the airport environment (<1500 feet AGL) declined (bottom graph) 1990-2015. Damaging strikes at >1500 feet AGL remained stable (bottom graph). Data are from National Wildlife Strike Database (Dolbeer et al. 2016).

Production of Annual Reports

The first annual report on wildlife strikes to civil aircraft in the USA based on the NWSD was released in November 1995 (Dolbeer et al. 1995). Since then, 21 consecutive annual reports have been published, the latest covering the years, 1990-2015 (Dolbeer et al. 2016). These reports, containing over 35 tables and graphs, provide detailed analyses of trends in strikes nationally since 1990 and are widely used by the aviation industry and news media (e.g., Broderick and Croft 2014, Marusak and Portillo 2017). Current and historic annual reports are accessible as PDF files at: http://www.faa.gov/airports/airport_safety/wildlife/.

Such analyses, presented in formal technical reports with supportive documentation, are critical to determining objective estimates and trends in the economic cost of wildlife strikes, the magnitude of safety issues, and most importantly, the nature of the problems (e.g., wildlife species involved, types of damage by types of aircraft, heights and phases of flight, and seasonal patterns). These analyses provide supportive evidence and guidance to local, state and federal agencies for issuing permits for wetland mitigation and removal of wildlife at airports. Nationally, the NWSD provides a science-based foundation for FAA regulations and Advisory Circulars related to wildlife management at airports and air-worthiness standards for engines and aircraft components (Cleary and Dolbeer 2005). Three bonuses of the annual reports are 1) they demonstrate to the aviation industry and public that the strike events submitted to FAA are being used to improve aviation safety in a timely manner, 2) the detailed analyses provide a means to detect and correct errors in the database, and 3) recognition is given to airports that have done an outstanding job of reporting strikes.

Examples of Use of NWSD for Managing the Strike Risk

Trend Analyses of Strikes and Damaging Strikes for Commercial Transport Aircraft

From 2000 to 2015, the number of reported strikes in the NWSD involving commercial transport aircraft doubled from about 4,000 to 8,000 (Figure 1), prompting some news media outlets to report that the wildlife strike problem was getting worse in spite of aggressive management programs being implemented at airports nationwide to mitigate the risk (e.g., Ruud 2015). However, what the data actually documented was that airports were doing a better job of reporting all strikes, most of which did no damage. The number of damaging strikes at ≤1,500 feet AGL (in the airport environment) to commercial transport aircraft actually declined ($P < 0.001$) from 398 in 2000 to 259 in 2015 (Figure 1), indicating management programs were having a positive effect in spite of overall increases in populations of many large, hazardous species (Dolbeer et al. 2014). However, the number of damaging strikes outside the airport environment (>1500 feet AGL where no management programs take place) has not shown a decline (Figure 1), indicating the need to integrate bird-detecting radar and enhanced aircraft lighting into current mitigation efforts (Dolbeer 2011, Nohara et al. 2011, Gerringer et al. 2016, Dolbeer and Barnes 2017).

Calculating Hazard Level and Risk for Species

Not all wildlife species pose the same hazard level to aircraft. One empirical way of estimating the hazard level of a species is to calculate the percentage of strikes in which damage to the aircraft occurs. For example, 49% of Canada goose strikes from 1990-2015 resulted in aircraft damage compared to 8% for ring-billed gulls (*Larus delawarensis*) and <1% for various swallows (Hirundinidae, Dolbeer et al. 2016). Thus, the NWSD can be used to objectively rank species observed at an airport as to their relative hazard so that the airport can prioritize management efforts based on the risk that each species poses (Dolbeer et al. 2000, DeVault et al. 2011). Risk can be measured as the hazard level of the species (% of strikes causing damage) times the number of individuals of the species observed in aircraft movement areas at the airport during routine surveys as part of an Airport's Wildlife Hazard Management Plan (WHMP).

Airport Wildlife Strike Summary and Risk Analysis Reports

These annual reports are generated from the NWSD for airports in the USA certificated for passenger traffic (FAA 2018a). They provide airport operators and FAA Airport Certification Inspectors with a 5-part overview of each airport's wildlife strike situation. In Part 1, the total number of strikes at ≤1500 and >1500 feet AGL and the number of those strikes causing an adverse effect (damage or negative effect on flight) are presented for the current year and past five years. In Parts 2 and 5, the adverse effect strike rate (per 100,000 aircraft movements) for strikes at ≤1500 and >1500 feet AGL, respectively, is compared to mean values for all airports in the FAA Region and in the USA that averaged over 50,000 aircraft movements per year. Part 3 provides a simple wildlife species risk analysis for adverse effect strikes occurring at≤1500 feet AGL to assist in setting species-specific risk management priorities. Part 4 provides a list of all adverse effect strikes occurring at >1500 feet AGL.

The data are separated into strikes at ≤1500 feet AGL and strikes during approach or departure at >1500 feet AGL because different management actions are required to reduce these strikes. Strikes occurring at ≤1500 feet AGL are generally within the 5-mile purview of an airport's WHMP (Federal Aviation Administration 2018b). Strikes occurring at >1500 feet AGL may be beyond the range of influence of the airport's traditional WHMP but are of interest to air carriers, Air Traffic Control, and community planners in developing strategies to mitigate the risk of these off-airport strikes on approach and departure (DeVault et al. 2016).

Figure 2. Safety poster produced in 2017 by Helicopter Association International based on published data from the National Wildlife Strike Database (Dolbeer 2006, Dolbeer et al. 2016).

For Parts 2 and 5, comparisons of each airport with regional and national means are made using adverse effect strike rates and not total strike rates. Total reported strikes for an airport is not a valid metric for measuring the effectiveness of the airport's WHMP because hazard levels of wildlife species struck vary among airports and some airports are more diligent than others in reporting all non-damaging strikes involving even the smallest of birds. For example, an airport reporting 10 strike events with swallows has a much less serious wildlife strike issue than an airport reporting 10 strike events with Canada geese. In contrast, adverse effect strikes are potential precursors to catastrophic events. Adverse effect strikes constitute a valid metric for measuring risk and provide a benchmark for individual airports to evaluate and improve their WHMPs in the context of a Safety Management System (Dolbeer and Wright 2009, Dolbeer and Begier 2012).

Bird Strikes by Height above Ground Level (AGL)

Analyses of bird strikes in the NWSD by height AGL has demonstrated that, above 500 feet AGL, the number of bird strikes declines by 32-44% for every 1,000-foot gain in height (Dolbeer 2006, Dolbeer et al. 2016). Among others, the International Helicopter Association is using this information (Figure 2) to provide guidance to pilots to mitigate the risk of strikes outside the airport environment where other mitigation measures are not available (as noted in Figure 1).

Influence of Aircraft Lighting on Strikes

Previous studies have indicated more birds collide with communication towers equipped with red warning lights than with towers equipped with lights of shorter wavelengths. A recent study (Dolbeer and Barnes 2017) used the NWSD to test the hypothesis that for turbine-powered jet aircraft with 2 underwing- or fuselage-mounted engines, more bird strikes occur to the left engine (close to where red navigation light is located) than to the right engine (near green navigation light). For both underwing- and fuselage-mounted engines, more ($P \leq 0.04$) strikes were reported for the left engine compared to the right. These findings suggest that modifying red navigation lights to include shorter wavelengths and the use of supplemental lights specifically designed for avian vision could enhance detection and reduce bird strikes (Blackwell et al. 2012).

Use of Database in Ornithological Research

In addition to the primary use in aviation safety, the NWSD provides a unique dataset to supplement ornithological research on topics such as bird migration (height, time, and location of strikes) and bird behavior. For example, the NWSD contains over 100,000 strike events with birds in which the height AGL was recorded including about 900 events at greater than or equal to 10,000 feet AGL (Dolbeer et al. 2016). Analyses of these events by time and location may provide insights on bird migration for certain species, especially in relation to cloud cover and other weather factors at the time. Pilots sometimes provide information in the Remarks field on bird reactions to approaching aircraft. As the amount, quality, and completeness of the data increase, the NWSD should serve as a valuable resource for basic and applied ornithological research not directly related to aviation safety. And perhaps some of this research may serendipitously provide insights to improve our ability to keep birds and aircraft separated.

DISCUSSION

Wildlife strikes with civil aircraft are particularly challenging to manage in the USA because they involve over 600 species of birds, terrestrial mammals, bats, and reptiles at several thousand civil airports that accommodate a wide range of aircraft in diverse ecological settings. Problems that are not well-defined and objectively measured cannot be managed properly. The NWSD, with 170,000 strike events from 1990-2015, provides a means to examine trends by types and severity of damage, wildlife species, wildlife body mass, airport types, aircraft models, aircraft components, phase of flight, and many other factors at the airport, regional, and national level. Thus, the NWSD provides that ability to define and measure the problem so that environmentally appropriate and defendable management actions can be taken to minimize the likelihood of strikes with the wildlife species that pose the highest risk.

A key factor in the success of the NWSD is the accuracy and consistency of data entered. Because strike reports are submitted by a variety of people and there are over 90 fields of data, we cannot overemphasis the importance of having a database manager knowledgeable in wildlife and aviation to oversee the final entry and release of data. It is also important to have the NWSD publicly available so that airports and airlines can examine their strikes and submit additional strikes or corrections when omissions and errors are noted. On-line access also provides transparency to the general public, news media, and environmental scientists. The NWSD is a dynamic, living database that is continuously updated with new strikes and revisions of previously entered data. Since 1995, the NWSD has enabled the aviation industry and wildlife profession to improve aviation safety in an environmentally responsible, science-based manner. As the NWSD grows and evolves, it will continue to play a critical role in mitigating the interaction of wildlife and aircraft in an increasingly crowded world.

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