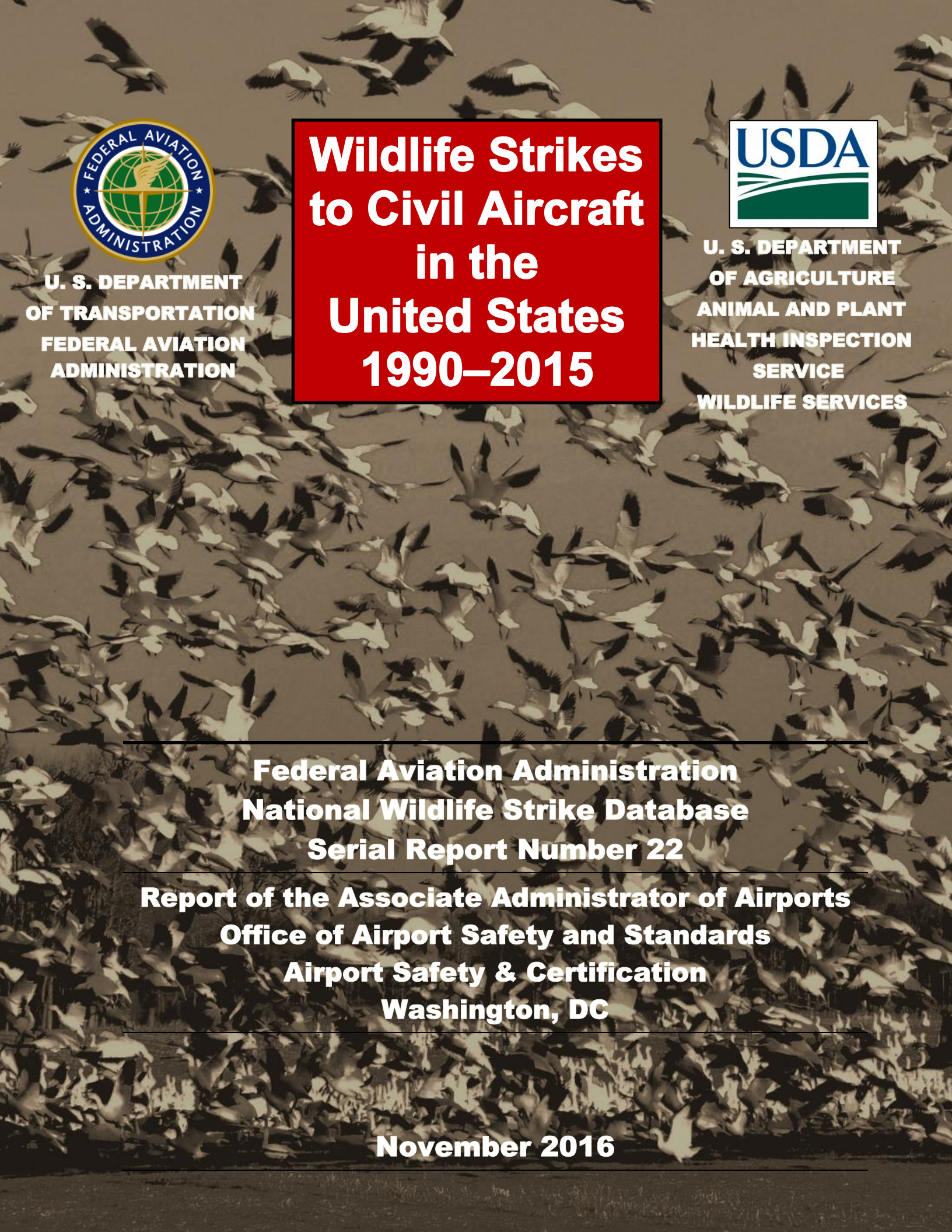

Wildlife Strikes to Civil Aircraft in the United States 1990–2015

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

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ANIMAL AND PLANT HEALTH INSPECTION SERVICE
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COVER PHOTOGRAPH

The North American snow goose population, which migrates to the contiguous United States in winter from arctic regions of Canada and Alaska, has doubled since 1990 to about 5 million birds in 2015. This large flock of migratory snow geese was foraging in fields and marshes near Dover Air Force Base, Maryland in January 2015. Unlike Canada geese, snow geese typically do not attempt to feed in grassy areas at airports but rather in agricultural fields and marshes outside airport fences. From 1990-2015, 130 strikes involving snow geese and civil aircraft were reported in the USA, including 7 in 2015. About 85% of these strikes occurred during climb and descent phases of flight at greater than 500 feet AGL, and 75% of the strikes occurred at night. Research is being conducted to develop procedures and technologies, such as avian radar and aircraft lighting, to reduce these off-airport strikes with birds such as snow geese. Cover photo, John Weller, FAA.

Bombay Hook is well known for its wintering flocks of greater snow geese. The geese arrive in October and depart for the Arctic in February and March. Seasonal counts exceeding 200,000 have been recorded in recent years. Photo by Jim Flowers (jflowers@artsnimages.com).

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ACKNOWLEDGMENTS

We give a special recognition to Sandra Wright who retired in December 2015 after managing the National Wildlife Strike Database from its inception in 1995. With her knowledge of birds and aviation combined with adept computer and editing skills and a keen attention to detail, she was able to organize all wildlife strikes reported to the FAA and accurately enter them into the database. She built the database from 1,847 reports in 1990 to 13,795 reports entered in 2015 (169,856 reports total for 1990-2015). The number of strikes entered into the database is indeed impressive, but the most important accomplishment during Sandy's 20-year tenure was her ability to manage the quality and consistency of the data so that analyses such as presented in this report could be accomplished.

Sandra Wright received a "Recognition of Excellence" award from the FAA at the Bird Strike Committee-USA meeting in Chicago, August 2016.

We acknowledge and thank all of the people who took the time and effort to report the 169,856 wildlife strikes summarized in this report – pilots, mechanics, control tower personnel, airport operations personnel, airline flight safety officers, airport wildlife biologists, and many others. We acknowledge the suggestions and critiques made by various people over the years that have enhanced the usefulness and accuracy of the report. In particular, we thank Roger Nicholson, Boeing Aircraft Company, for timely advice during the development of this and previous reports. We also recognize Phyllis Miller, Scientific Data Technician for the National Wildlife Strike Database, for editing and entering strike records in preparation for the analyses presented in this report. We thank Sandra Wright and Phyllis Miller for assistance in editing this report.

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EXECUTIVE SUMMARY - PART 1: WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES, 1990–2015

2015 marked the sixth anniversary of the emergency forced landing of US Airways Flight 1549 in the Hudson River on 15 January 2009 after Canada geese were ingested in both engines on the Airbus 320. The incident resulted in increased media attention to wildlife strikes and demonstrated to the public that wildlife strikes are a serious but manageable aviation safety issue. The civil and military aviation communities continue to understand that the threat from aircraft collisions with wildlife is real and increasing. Globally, wildlife strikes have killed more than 262 people and destroyed over 247 aircraft since 1988. Factors that contribute to this increasing threat are increasing populations of large birds and increased air traffic by quieter, turbofan-powered aircraft.

This report presents a summary analysis of data from the National Wildlife Strike Database for the 26-year period 1990 through 2015. A sample of 28 significant wildlife strikes to civil aircraft in the USA during 2015 is also included as Appendix I.

The number of strikes annually reported to the FAA has increased 7.4-fold from 1,847 in 1990 to a record 13,795 in 2015. The 2015 total was an increase of 103 strikes (<1 percent) compared to the 13,692 strikes reported in 2014. For 1990–2015, 169,856 strikes were reported (166,276 in USA and 3,580 strikes by U.S.-registered aircraft in foreign countries). In 2015, birds were involved in 95.8 percent of the reported strikes, terrestrial mammals in 1.6 percent, bats in 2.3 percent and reptiles in 0.3 percent. Although the number of reported strikes in USA has dramatically increased, the number of reported damaging strikes has actually declined since 2000. Whereas the number of reported strikes increased 130 percent from 6,000 in 2000 to 13,795 in 2015, the number of damaging strikes declined 19 percent from 762 to 616. The decline in damaging strikes has been most pronounced for commercial aircraft in the airport environment (at ≤1,500 feet above ground level [AGL]). Damaging strikes have not declined for general aviation (GA) aircraft.

In 2015, 79 percent and 2 percent of the 13,795 strike reports were filed using the electronic and paper versions, respectively, of FAA Form 5200-7, Bird/Other Wildlife Strike Report. Since the online version of this form became available in April 2001, use of the electronic reporting system has climbed dramatically.

The number of USA airports with strikes reported increased from 334 in 1990 to a record 674 in 2015. The 674 airports with strikes reported in 2015 were comprised of 404 airports certificated for passenger service under 14 CFR Part 139 and 270 GA aviation airports. From 1990 - 2015, strikes have been reported from 1,939 USA airports.

Fifty-two percent of bird strikes occurred between July and October; 29 percent of deer strikes occurred in October - November. Terrestrial mammals are more likely to be struck at night (63 percent) whereas birds are struck more often during the day (63 percent). Birds, terrestrial mammals, and bats are all much more likely to be struck

during the arrival phase of flight (61, 64, and 84 percent of strikes, respectively) compared to departure (35, 33 and 14 percent, respectively).

For commercial and GA aircraft, 71 and 73 percent of bird strikes, respectively, occurred at or below 500 feet above ground level (AGL). Above 500 feet AGL, the number of strikes declined by 34 percent for each 1,000-foot gain in height for commercial aircraft, and by 44 percent for GA aircraft. Strikes occurring above 500 feet were more likely to cause damage than strikes at or below 500 feet. The record height for a reported bird strike was 31,300 feet.

From 1990 to 2015, 529 species of birds, 43 species of terrestrial mammals, 22 species of bats, and 18 species of reptiles were identified as struck by aircraft. Waterfowl, gulls, and raptors are the species groups of birds with the most damaging strikes; Artiodactyls (mainly deer) and carnivores (mainly coyotes) are the terrestrial mammals with the most damaging strikes. Although the percentage of wildlife strikes with reported damage has averaged 9 percent for the 26-year period, this number has declined from 20 percent in 1990 to 5 percent in 2015.

A negative effect-on-flight was reported in 6 percent and 20 percent of the bird and terrestrial mammal strike reports, respectively. Precautionary/emergency landing after striking wildlife was the most commonly reported negative effect (5,539 incidents), including 53 incidents in which the pilot jettisoned fuel (an average of 14,373 gallons) to lighten aircraft weight and 95 incidents in which an overweight landing was made. Aborted take-off was the second most commonly reported negative effect (2,232 incidents). These negative incidents included 520 aborted take-offs at $\geq$100 knots within the 26-year time span. Similar to the trend shown for the percentage of strikes causing damage, the percentage of strikes with a reported negative effect-on-flight has declined from a high of 12 percent in 1996 to 4 percent in 2015. For commercial aircraft, the number of high-speed ($\geq$100 knots) aborted take-offs has declined from a high of 25 in 2000 to 6 in 2015.

For the 30 species of birds most frequently identified as struck by civil aircraft, 1990–2015, there was a strong correlation (R^2 = 0.81) between mean body mass and the likelihood of a strike causing damage to aircraft. For every 100 gram increase in body mass, there was a 1.26% increase in the likelihood of damage. Thus, body mass is a good predictor of relative hazard level among bird species.

Sixty-eight strikes have resulted in a destroyed aircraft from 1990-2015; 41 (60 percent) of these occurred at GA airports. The annual cost of wildlife strikes to the USA civil aviation industry in 2015 was projected to be a minimum of 69,497 hours of aircraft downtime and $229 million in direct and other monetary losses. Actual losses are likely much higher.

This analysis of 26 years of strike data documents the progress being made in reducing damaging strikes for commercial aircraft which primarily use Part 139-certificated airports. Management actions to mitigate the risk have been implemented at many

airports since the 1990s; these efforts are likely responsible for the general decline in reported strikes with damage and a negative effect-on-flight from 2000-2015 in spite of continued increases in populations of many large bird species. However, much work remains to be done to reduce wildlife strikes. Management actions at airports should be prioritized based on the hazard level of species observed in the aircraft operating area.

To address strikes outside the airport environment, the general public and aviation community must first widen its view of wildlife management to minimize hazardous wildlife attractants within 5 miles of airports. Second, the aviation community needs to broaden the view of wildlife strike risks from a ground-based wildlife management problem to an airspace management problem that also encompasses Air Traffic Control, flight crews, and aircraft manufacturers. Long-term goals include the integration of avian radar and bird migration forecasting into airspace management and the development of aircraft lighting systems to enhance detection and avoidance by birds. Finally, there continues to be a need for increased and more detailed strike reporting, especially for General Aviation aircraft. When reports are filed, it is important that relevant information be provided whenever possible regarding species identification, number of wildlife struck, time and height of strike, phase of flight, and damage to aircraft components.

EXECUTIVE SUMMARY– PART 2: FAA ACTIVITIES FOR MITIGATING WILDLIFE STRIKES

In 2015, the FAA and USDA continued to move forward with educating the aviation community, creating new guidance, and focusing on data collection and research in order to mitigate wildlife strikes. All Part 139 airports have either completed a Wildlife Hazard Assessment (Assessment) or are in the process of finalizing an Assessment. Strike reporting continued to increase, especially with general aviation (GA) aircraft, which increased strike reporting by 13 percent between 2014 and 2015. Similarly, reported damaging strikes also increased 13 percent during this time period. Overall, GA strike reporting increased 40 percent in the five years between 2011 and 2015 while the damaging strikes reported increased 37 percent in the same time period. The FAA implemented three performance metrics to monitor strike reporting trends and GA wildlife mitigation. The performance metrics include percentage of damaging strikes, strike reporting rates, and tracking of GA airports that conduct Assessments and Wildlife Hazard Site Visits (Site Visit). We have expanded outreach to increase GA strike reporting, continued a robust research program, and incorporated new technology to allow simplified and paperless strike reporting.

The FAA insured Airport Improvement Program (AIP) funding was available for airports to conduct Assessments and develop Wildlife Hazard Management Plans (Plan). These funds are also available to assist airports with the construction of adequate wildlife exclusion fencing. These efforts have led to improved wildlife programs and increased strike reporting in both commercial and general aviation. The FAA continues work with industry to encourage all certificated airports to develop a continuing

monitoring program once a Plan has been finished to proactively monitor wildlife hazards, analyze trends, and to understand and anticipate fluctuations in risk. The FAA also encourages federally obligated GA airports to conduct Assessments or Wildlife Hazard Site Visits to provide fundamental wildlife and habitat information for an effective, airport-specific, wildlife hazard mitigation program.

Our research efforts continue. The USDA APHIS WS National Wildlife Research Center (NWRC), through an interagency agreement with FAA, continues its efforts to improve wildlife management techniques and practices on and near airports. These efforts include:

- Alternative habitat management strategies to reduce attraction to airports of hazardous wildlife species,
- Techniques for restricting access of hazardous wildlife species to attractive features like storm water ponds,
- Technologies for harassing and deterring hazardous species,
- Using satellite telemetry and other animal tracking techniques to investigate spatial ecology of raptors and other birds hazardous to aircraft,
- Aircraft-mounted lighting systems to enhance bird detection and avoidance of aircraft.

The FAA funded and assisted with the development of two recent Airport Cooperative Research Program (ACRP) reports to aid airports with the mitigation of wildlife hazards. In 2015, ACRP Report 122 *Innovative Airport Responses to Threatened / Endangered Species* and Report 125 *Balancing Airport Stormwater and Bird Hazard Management* were published to assist airports with the difficulties of balancing human safety, species protection and airport construction requirements. In addition, ACRP Synthesis 39 report *Airport Wildlife Population Management* (2013) and Synthesis 52 report *Habitat Management to deter Wildlife at Airports* (2014) also are available from the Transportation Research Board (TRB) of the National Academies at http://www.trb.org/Publications/Publications.aspx.

Technological advances have helped ease and streamline the strike reporting process. The form used to report wildlife strikes, FAA Form 5200-7, Bird/Other Wildlife Strike Report, has been available online since April 2001. In addition, the FAA developed mobile application software that allows strike reporting from your smart phone. An extension to the mobile application software also placed a Quick Response (QR) Code for smart phones on the bottom of the 2011 – 2014 “Report Wildlife Strikes” posters, which allows anyone to report a wildlife strike via the web or their personal data devices. As a result, electronic filings have dramatically increased. Last year, at least 85 percent of the 13,795 strike reports were filed electronically. This number is closer to 93 percent because an additional 8 percent of all reports were filed using multiple techniques; most of which included an electronic method.

2014 was the inaugural year for the Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award. The award honors the incomparable dedication of Dr. Richard Dolbeer and Sandy Wright; each being exceptional in the management of the National

Wildlife Strike Database (NWSD) since the FAA first contracted the U.S. Department of Agriculture (USDA) in 1995 to oversee the collection, quality control, analysis and summation of strike reports.

The Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award recognizes those airports that have exhibited a noteworthy strike reporting program. The idea was to recognize the top five reporting programs in both the Certificated and GA airport categories.

The determination of a winner for each of the two categories was very difficult; each of the finalist airports deserving recognition. The Top 5 Certificated airports were: Dallas-Fort Worth (DFW), Los Angeles (LAX), La Guardia (LGA), John F Kennedy (JFK) and Salt Lake City (SLC). Honorable mention goes to Kansas City International Airport (MCI). The Top 5 GA airports were Morristown Municipal Airport (MMU), Centennial (APA), Van Nuys (VNY), Cecil Airport (VQQ) and Waukesha County (UES). Honorable mention went to Fort Lauderdale Executive Airport (FXE) and Jacksonville Executive (CRG).

For their commitment to the identification and documentation of wildlife / aircraft strike information, the FAA proudly recognizes the superior strike reporting programs at **La Guardia International Airport** and **Van Nuys Airport** as the winners of the 2015 Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award. The bar remains high; and these airports, as well as each of the finalists, well deserve the recognition. Congratulations.

Finally, 2015 marked the 50th anniversary of the first official strike reporting document by the FAA. On November 27, 1965, the FAA published Advisory Circular (AC) 150/ 5200-2 Bird Strike/ Incident Report Form. The purpose of the AC was to inform both military and civilian aviation organizations that FAA Form 3830 ”Bird Strike/ Incident Report Form” was available for use and that bird remains could be sent to the U.S. National Museum in Washington, DC for identification.

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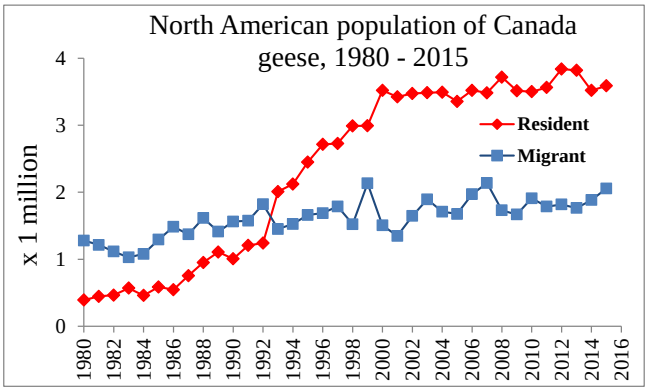
PART 1: WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES, 1990–2015

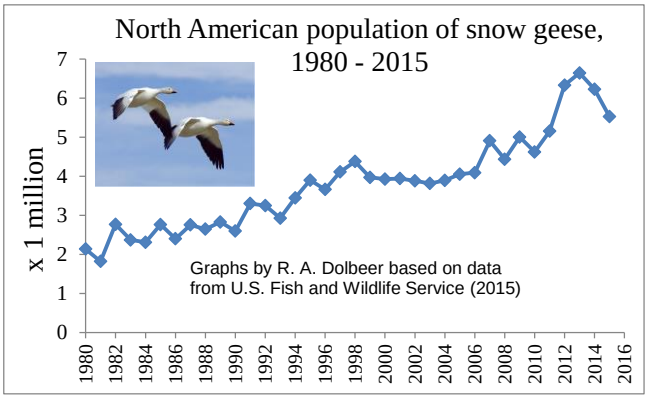
An Airbus 330 ingested a red-tailed hawk into the # 1 engine during landing roll at a west coast airport, March 2015. The bird bounced off the fuselage before entering the engine. Four fan blades (background) and 7 exit guide vanes were replaced. The heat exchanger was clogged with bird remains. Aircraft was out of service 6 days and repair costs were $1.5 million. Photo, airport operations.

INTRODUCTION

Bird strikes are a serious aviation safety issue as demonstrated in recent years by the emergency forced landing of an Airbus 320 with 159 passengers and crew in the Hudson River in January 2009 after Canada geese were ingested in both engines (National Transportation Safety Board 2010, Marra et al. 2009) and the 19-fatality crash of a Dornier 228-200 in Nepal in September 2012 after a black kite was struck on take-off (Thorpe 2012, Addendum 3). Globally, bird and other wildlife strikes killed more than 262 people and destroyed over 247 aircraft from 1988 – September 2016 (Richardson and West 2000; Thorpe 2003; 2005; 2012, Dolbeer, unpublished data). Three factors that contribute to this increasing threat are:

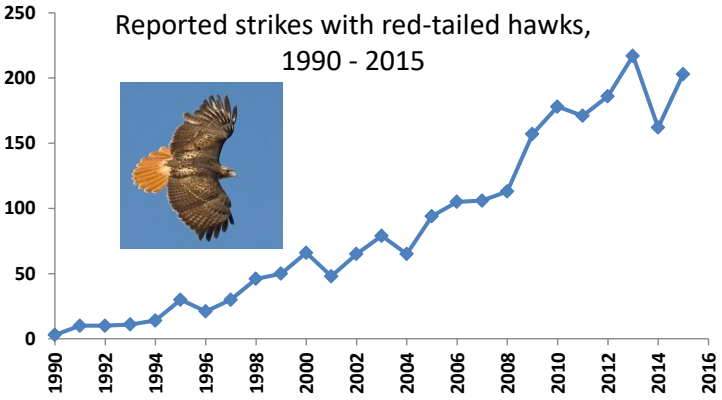
1. Many populations of large bird and mammal species commonly involved in strikes increased markedly in the last few decades and adapted to living in urban environments, including airports. For example, the resident (non-migratory) Canada goose population in the USA and Canada increased from about 1.0 million to 3.6 million from 1990 to 2014 (Dolbeer et al. 2014, U.S. Fish and Wildlife Service. 2015). During the same time period, the North American snow goose population increased from about 2.6 million to 5.5 million birds (U.S. Fish and Wildlife Service. 2015). Canada and snow goose populations appear to be stabilizing after these years of increase. Dolbeer and Begier (2013) examined the estimated population trends and numbers for the 21 species of birds in North America with mean body masses ≥4 lbs and at least 10 strikes with civil aircraft from 1990-2012. Of these 21 species, 17 had shown population increases from 1990-2012 with a net gain of 17 million birds. Previous research had documented that 13 of the 14 bird species in North America with mean body masses ≥8 lbs showed significant population increases from 1970 to the early 1990s (Dolbeer and Eschenfelder 2003). The white-tailed deer population increased from a low of about 350,000 in 1900 to about 15 million in 1984 and to over 28 million by 2010 (McCabe and McCabe 1997, VerCauteren et al. 2011).





The North American population of Canada geese has stabilized in recent years after a period of rapid expansion of the resident (non-migratory) population from 1984 – 2000. The snow goose population also shows signs of stabilization after 3 decades of growth. In 2015, there were 59 and 7 strikes reported for Canada and snow geese, respectively, compared to peak numbers of 89 (in 1998) and 12 (in 2009).

2. Concurrent with population increases of many large bird species, commercial air traffic in the USA increased from about 23.3 million movements in 1990 to a peak of 29.5 million movements in 2000. Since 2000, commercial air traffic has declined to 24.6 million movements in 2015 (Table 2). Passenger enplanements in the USA increased from about 495 million in 1990 to 705 million in 2000 and 780 million in 2015 (Federal Aviation Administration 2016*a*). Commercial air traffic in the USA is predicted to grow at a rate of about 1.1 percent per year from 24.6 million movements in 2015 to 30.3 million by 2030. Passenger enplanements are predicted



The red-tailed hawk population in North America increased by 50% from 1990-2015 (Sauer et al, 2016). The number of reported strikes peaked at 217 in 2013 and was 203 in 2015. Hawk photo courtesy of: www.simply-san-juan.com.

to grow at a rate of about 2.1 percent per year from 780 million in 2016 to 1.06 billion in 2030.

3. Commercial air carriers have replaced their older three or four-engine aircraft fleets with more efficient and quieter, two-engine aircraft. In 1965, about 87 percent of the 1,037 turbine-powered passenger aircraft in the USA had three or four engines. By 1990, the fleet had grown to 5,743 turbine-powered aircraft of which 32 percent had 3 or 4 engines. In 2008, only 8 percent of the 7,371 turbine-powered aircraft had three or four engines (U.S. Department of Transportation 2016). With the 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 (e.g., the US Airways Flight 1549 incident on 15 January 2009), aircraft with two engines may have vulnerabilities not shared by their three or four engine-equipped counterparts. In addition, previous research has indicated that birds are less able to detect and avoid modern jet aircraft with quieter turbofan engines (Chapter 3, International Civil Aviation Organization 1993) than older aircraft with noisier (Chapter 2) engines (Burger 1983, Kelly et al. 1999).

As a result of these factors, experts within the Federal Aviation Administration (FAA), U.S. Department of Agriculture (USDA), U.S. Navy, and U.S. Air Force expect the risk of wildlife-aircraft collisions to be a continuing challenge over the next decade.

The FAA has initiated several programs to address this important safety issue. Among the various programs is the collection and analysis of data from wildlife strikes. The FAA began collecting wildlife strike data in 1965. However, except for cursory examinations of the strike reports to determine general trends, the data were never submitted to rigorous analysis until the 1990s. In 1995, the FAA, through an interagency agreement with the USDA, Wildlife Services, (USDA/WS), initiated a project to obtain more objective estimates of the magnitude and nature of the national wildlife strike problem for civil aviation. This project involves having specialists from the USDA/WS: (1) edit all strike reports (FAA Form 5200-7, *Bird/Other Wildlife Strike Report*) received by the FAA since 1990 to ensure consistent, error-free data; (2) enter all edited strike reports in the FAA National Wildlife Strike Database; (3) supplement FAA-reported strikes with additional, non-duplicated strike reports from other sources; (4) provide the FAA with an updated computer file each month containing all edited

strike reports; and (5) assist the FAA with the production of annual and special reports summarizing the results of analyses of the data from the National Wildlife Strike Database. Such analyses are critical to determining the economic cost of wildlife strikes, the magnitude of safety issues, and most important, the nature of the problems (e.g., wildlife species involved, types of damage, height and phase of flight during which strikes occur, and seasonal patterns). The information obtained from these analyses provides the foundation for FAA national policies and guidance and for refinements in the development and implementation of integrated research and management efforts to reduce wildlife strikes. Data on the number of strikes causing damage to aircraft or other adverse effects (e.g., aborted take-off) also provide a benchmark for individual airports to evaluate and improve their Wildlife Hazard Management Plans in the context of a Safety Management System (Dolbeer and Begier 2012).

The pilot of an Embraer 170 detected severe vibrations in #2 engine at 200 feet AGL on initial climb from an Ohio airport at night, March 2015. A turn-around and emergency landing was made. Inspection revealed blood and numerous bent fan blades. DNA analysis of blood residue by Smithsonian revealed engine had ingested a mallard. From 1990-2015, 41% of mallard strikes have occurred at night. Photo by aircraft owner.

The first annual report on wildlife strikes to civil aircraft in the USA was completed in November 1995 (Dolbeer et al. 1995). This is the 22nd report in the series and covers the 26-year period, 1990–2015. Current and historic annual reports are accessible as PDF files at: http://www.faa.gov/airports/airport_safety/wildlife/

To supplement the statistical summary of data presented in tables and graphs, a sample of 28 significant wildlife strikes to civil aircraft in the USA during 2015 is presented in Appendix A. These recent strike examples demonstrate the widespread and diverse nature of the problem. A more extensive list of significant strike events, 1990–2015, is available at http://www.faa.gov/airports/airport_safety/wildlife/.

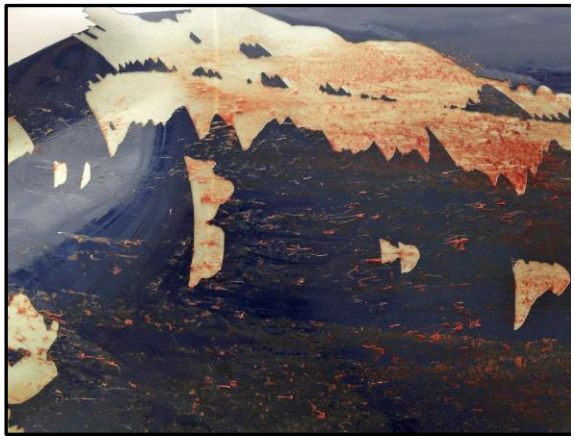
RESULTS

NUMBER OF REPORTED STRIKES AND STRIKES WITH DAMAGE

The number of strikes annually reported to the FAA has increased 7.4-fold from 1,847 in 1990 to a record 13,795 in 2015. The 2015 total was an increase of 103 strikes (<1 percent) compared to the 13,692 strikes reported in 2014 (Table 1, Figure 1). For the 26-year period (1990–2015), 169,856 strikes were reported of which 166,276 (98 percent) occurred in the USA[1]. In 2015, birds were involved in 95.8 percent of the reported strikes in the USA, terrestrial mammals in 1.6 percent, bats in 2.3 percent and reptiles in 0.3 percent (Table 2).

Although the number of reported strikes has steadily increased, it is important to note that the overall number of reported damaging strikes has actually declined since 2000 (Table 1, Figure 2). Whereas the number of reported strikes increased 130 percent from 6,000 in 2000 to 13,795 in 2015, the number of damaging strikes declined 19 percent from 762 to 616. From 2014 to 2015, the number of damaging strikes increased 6 percent from 582 to 616.

This overall decline in damaging strikes since 2000 has occurred in the commercial aviation sector. While the number and rate (per 100,000 movements) of all strikes with commercial aircraft has increased 79 and 115 percent, respectively, from 2000 to 2015, the number and rate of damaging strikes has declined 32 and 19 percent, respectively (Table 3, Figure 3).



A Boeing 737 struck a flock of birds at 800 feet AGL on departure from a Utah airport, March 2015, causing substantial damage to radome. Aircraft continued to destination where repairs were made. Bird remains (bottom photo) sent to Smithsonian were Identified as gull but exact species was not determined. Photo by aircraft owner.

Overall since 2000, the decline in damaging strikes for commercial aircraft has occurred primarily in the airport environment (strikes occurring on departure or arrival at ≤1,500

[1] The database contains strikes involving U.S.- or foreign-registered aircraft in the USA and U.S.-registered aircraft in foreign countries.

feet above ground level [AGL]). Damaging strikes at >1,500 feet AGL have not shown a pattern of decline (Figure 4). These declines in damaging strikes for commercial aviation since 2000 have occurred in spite of an increase in populations of hazardous wildlife species (Dolbeer and Eschenfelder 2003, Dolbeer and Begier 2013) and, as noted above a major increase in reported strikes. These data demonstrate progress in wildlife hazard management programs at airports certificated for passenger traffic under 14 CFR-Part 139 regulations (Dolbeer 2011). The data also demonstrate the lack of progress in mitigating the risk of strikes outside the airport environment at certificated airports.

As with commercial aircraft, there has been a steady increase in the strike rate for general aviation (GA) aircraft, from 0.77 in 2000 to 2.05 in 2015 (Table 4). However, in contrast to commercial aviation, the rate of damaging strikes with GA aircraft has not declined since 2000 but has fluctuated between 0.23 (in 2001 and 2005) and 0.41 (in 2013, Table 4, Figure 3). For GA aircraft, there has not been a decline in damaging strikes in the airport environment (at ≤1,500 feet AGL), and there has been an increase in damaging strikes at >1,500 feet AGL (Figure 4).

METHODS OF REPORTING STRIKES

In 2015, 79 percent and 2 percent of the 13,795 strike reports were filed using the electronic and paper versions, respectively, of FAA Form 5200-7, *Bird/Other Wildlife Strike Report*. Eight percent of reports came from multiple sources (i.e., more than one type of report was filed for same strike). Strike reports submitted to the FAA via the Air Traffic Organization (ATO) Mandatory Occurrence Reporting (MOR) system comprised 6 percent of reports. Under FAA Order JO 7210.632, (effective 30 Jan 2012), ATO personnel are required to report all bird strikes of which they become aware. The remaining 5 percent of strike reports filed in 2015 were obtained from various sources (Table 5).

A CRJ 100/200 on departure from a Minnesota airport hit a soaring bald eagle at 5000 feet AGL on 31 March 2015 causing major damage to leading edge of wing. The pilot returned the aircraft to airport and made an overweight landing. Cost of repairs was $100,000. Bald eagles have a mean body mass of 9 lbs for males and 12 lbs for females. In 2015, 24 bald eagle strikes with civil aircraft were reported in USA.

SOURCE OF REPORTS

In 2015, airport operations personnel filed 61 percent of the strike reports (including "Carcass Found" reports), followed by pilots (21 percent), airlines operations personnel (5 percent), Air Traffic Control personnel (16 percent), and other (2 percent, Table 6). In 2015, about 85 percent of the reported strikes involved commercial aircraft; the remainder involved business, private, and government aircraft (Table 7).

A B-737 aircraft struck a migrating bird on approach at night to a west coast airport in October 2015, damaging the vertical stabilizer. Costs exceeded $100,000; aircraft was out of service 72 hours. Feather remains (seen in photo) sent to Smithsonian were identified as from greater yellowlegs. This was the first reported strike involving this species and a civil aircraft in USA, 1990-2015. Photo by aircraft owner.

The number of USA airports with strikes reported has increased steadily from 334 in 1990 to 674 in 2015 (Table 8, Figure 5). The 674 airports with strikes reported in 2015 were comprised of 404 airports certificated for passenger service under 14 CFR Part 139 and 270 general aviation airports. From 1990 - 2015, 147,178 strikes have been reported from 1,939 USA airports. In addition, 3,580 strikes involving USA-registered civil aircraft were reported at 296 foreign airports in 108 countries, 1990 – 2015 (249 strikes at 97 foreign airports in 59 countries in 2015).

TIMING OF OCCURRENCE AND PHASE OF FLIGHT OF STRIKES

From 1990 – 2015, most bird strikes (52 percent) occurred between July and October (Figure 6) which is when birds are migrating and populations are at their annual peak in North America following the nesting season. Sixty-three percent of bird strikes occurred during the day and 30% at night (Table 9). Almost twice as many strikes (61 percent of total) occurred during the arrival (descent, approach, or landing roll) phase of flight compared to 35 percent during departure (take-off run and climb, Table 10).

Similar to the pattern shown with birds, most terrestrial mammal strikes occurred between July and November; with 29 percent of deer strikes concentrated in October-November (Figure 6). Most terrestrial mammal strikes (63 percent) occurred at night (Table 9). As with birds, about twice as many strikes (64 percent of total) occurred during the arrival (final approach or landing roll) phase of flight compared to 33 percent during take-off run and initial climb (Table 10).

For bats, 81 percent of strikes occurred at night (Table 9). The difference in numbers of strikes during arrival compared to departure phase of flight was even greater for bats

compared to birds and terrestrial mammals. Eighty-four percent of reported bat strikes occurred during arrival compared to only 14 percent during departure (Table 10).

HEIGHT ABOVE GROUND LEVEL (AGL) OF STRIKES

Bird strikes with commercial aircraft- From 1990 – 2015, about 41 percent of bird strikes with commercial aircraft occurred when the aircraft was at 0 feet AGL, 71 percent occurred at 500 feet or less AGL, and 92 percent occurred at or below 3,500 feet AGL (Table 11). Less than 1 percent of bird strikes occurred above 9,500 feet AGL. Above 500 feet AGL, the number of reported strikes declined consistently by 34 percent for each 1,000-foot gain in height (Figure 7). The record height for a reported bird strike involving a commercial aircraft in USA was 31,300 feet AGL.

Strikes occurring above 500 feet AGL had a greater probability of causing damage to the aircraft compared to strikes at 500 feet or less. Although only 29 percent of the reported strikes were above 500 feet AGL, these strikes represented 44 percent of the damaging strikes (Table 11, Figure 8).

A Citation Mustang at 3,000 feet AGL and 4 miles out on approach to an Ohio airport struck a soaring turkey vulture in September 2015. The leading edge of wing was penetrated, causing leakage from a fuel tank. There were 54 turkey vulture strikes reported in 2015. Photo by airport operations personnel.

Bird strikes with general aviation (GA) aircraft- From 1990 – 2015, about 37 percent of the bird strikes with GA aircraft occurred when the aircraft was at 0 feet AGL, 73 percent occurred at 500 feet or less AGL, and 97 percent occurred at or below 3,500 feet AGL (Table 12). Less than 1 percent of bird strikes occurred above 6,500 feet AGL. Above 500 feet AGL, the number of reported strikes declined consistently by 44 percent for each 1,000-foot gain in height (Figure 7). The record height for a reported bird strike involving a GA aircraft in USA was 24,000 feet AGL.

Strikes occurring above 500 feet AGL had an even greater probability of causing damage to GA aircraft compared to strikes at 500 feet or less than was shown above for commercial aircraft. Although only 27 percent of the reported strikes were above 500

feet AGL, these strikes represented 49 percent of the damaging strikes (Table 12, Figure 8).

Terrestrial mammal strikes- As expected, terrestrial mammal strikes predominately occurred at 0 feet AGL; however, 9 percent of the reported strikes occurred when the aircraft was in the air immediately after lift-off or before touch down (e.g., when an aircraft struck a deer with the landing gear, Table 10).

AIRCRAFT COMPONENTS DAMAGED

The aircraft components most commonly reported as struck by birds from 1990 – 2015 were the nose/radome, windshield, wing/rotor, engine, and fuselage (Table 13). Aircraft engines were the component most frequently reported as being damaged by bird strikes (28 percent of all damaged components). There were 16,694 strike events in which a total of 17,494 engines were reported as struck (15,921 events with one engine struck, 752 with two engines struck, 15 with three engines struck, and 6 with four engines struck). In 4,370 damaging bird-strike events involving engines, a total of 4,516 engines was damaged (4,227 events with one engine damaged, 141 with two engines damaged, 1 with three engines damaged, and 1 with four engines damaged).

Aircraft components most commonly reported as struck by terrestrial mammals were the landing gear, “other”, propeller, and wing/rotor. Aircraft components most commonly reported as damaged were the landing gear, wing/rotor, propeller, and “other” (Table 13).

REPORTED DAMAGE

For the 164,444 strike reports involving birds from 1990–2015, 13,558 (8 percent) indicated damage to the aircraft (Table 14). When classified by level of damage, 7,230 (4 percent) indicated the aircraft suffered minor damage; 3,460 (2 percent) indicated the aircraft suffered substantial damage; 2,831 (2 percent) reported an uncertain level of damage; and 37 reports (less than 1 percent) indicated the aircraft was destroyed as a result of the bird strike (Table 14).

For the 3,572 terrestrial mammal strikes reported, 1,074 (30 percent) indicated damage to the aircraft. When classified by level of damage; 548 (15 percent) indicated the aircraft suffered minor damage; 414 (12 percent) indicated the aircraft suffered substantial damage; 81 (2 percent) reported an uncertain level of damage; and 31 (1 percent) indicated the aircraft was destroyed as a result of the strike (Table 14). Not surprisingly, a much higher percentage of terrestrial mammal strikes (30 percent) resulted in aircraft damage than did bird strikes (8 percent). Deer (1,113 strikes, of which 938 caused damage; Table 18) were involved in 31 percent of the strikes and 87 percent of the damaging strikes involving terrestrial mammals.

Although the percentage of wildlife strikes (all species) with reported damage has averaged 9 percent for the 26-year period (Table 14), this number has declined from 20

percent in 1990 to 5 percent in 2015 (Figure 9).

Reported Negative Effect-on-Flight

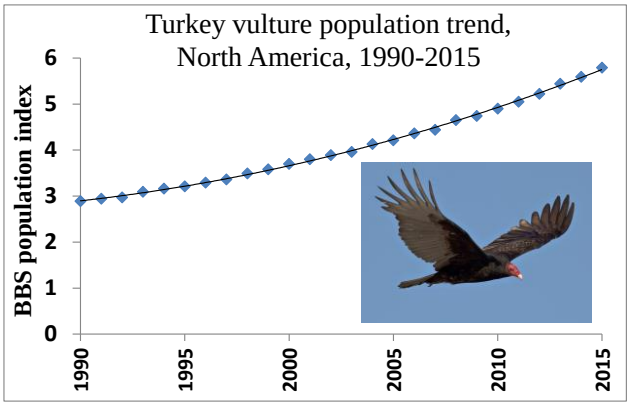
A negative effect-on-flight was reported in 6 percent and 20 percent of the bird and terrestrial mammal strike reports, respectively, (Table 15). Precautionary/ emergency landing after striking wildlife was the most commonly reported negative effect (5,539 incidents, 3 percent of strike reports). These precautionary landings included 211 incidents in which the pilot jettisoned fuel (53) or burned fuel in a circling pattern (63) to lighten aircraft weight or in which an overweight landing was made (95, Table 16, Figure 10). In the 53 reported incidents in which fuel was jettisoned, an average of 97,738 pounds (14,373 gallons) of fuel was dumped per incident (range 515 – 39,706 gallons).

Aborted take-off after striking wildlife was the second most commonly reported negative effect (2,232 incidents, 1 percent of strike reports, Table 15). These negative incidents included 520 aborted take-offs in which the pilot initiated the abort at an aircraft speed of 100 knots (115 miles per hour) or greater (Table 17). For commercial aircraft, the number of high-speed aborted take-offs has declined from a high of 25 in 2000 to a low of 6 in 2015 (Figure 11). For general aviation aircraft, there has not been a decline in high-speed aborted take-offs in recent years.

Similar to the trend shown for the percent of strikes causing damage, the percentage of wildlife strikes (all species) with a reported negative effect on flight has declined from a high of 12 percent in 1996 to 4 percent in 2014 and 2015 (Figure 9).

Wildlife Species Involved in Strikes

Table 18 shows the number of reported strikes, strikes causing damage, strikes having a negative effect-on-flight, strikes involving >1 animal, the reported aircraft down time, and the reported costs by identified wildlife species, 1990 - 2015. This information can be useful in comparing the relative hazard level of bird and other wildlife species encountered during Wildlife Hazard Assessments at airports and in the development of priorities for Wildlife Hazard Management Plans (see also Dolbeer and Wright 2009 and DeVault et al, 2011).



The turkey vulture population doubled in North America, 1990-2015 based on Breeding Bird Survey (BBS) data (Sauer et al. 2016). Given this growth and a mean population estimate of 5.1 million in 1998-2007 (Blancher et al. 2013), the overall population in 2015 is likely over 8 million birds. In 2015, 89 vulture strikes were reported (54 turkey, 18 black, 17 unidentified to species). Graph by R. A. Dolbeer.

Birds- Of the 164,444 reported bird strikes, 67,061 (41 percent) identified the bird to exact species and an additional 19,482 strikes (12 percent) identified the bird at least to species group (e.g., gull, hawk, duck). Species identification has improved from less than 20 percent in the early 1990s to 56-60 percent in 2012-2015 (Figure 12). In all, 529 species of birds have been identified as struck by aircraft, and 252 of these species were reported as causing damage, 1990–2015. In 2015, 338 bird species were identified as struck by civil aircraft (Figure 12).

Doves/pigeons (14 percent), raptors (13 percent), gulls (12 percent), shorebirds (9 percent), and waterfowl (6 percent) were the most frequently struck bird groups (Table 19). Doves/pigeons, raptors, and gulls each were involved in over 2 times more strikes than waterfowl (10,586-12,196 and 4,951, respectively). Waterfowl, however, were involved in 4.0 times more damaging strikes than doves/pigeons and 1.4 times more damaging strikes than gulls or raptors. Waterfowl comprised 29 percent of all damaging strikes in which the bird type was identified, 1990–2015. Doves/pigeons and gulls were responsible for the greatest number of bird strikes (2,373 and 2,188, respectively) that involved multiple birds.

Table 20 lists the 30 species of birds identified most frequently as struck by civil aircraft for 1990–2015 and for 2015 only. Mourning doves, American kestrels, killdeer, barn swallows, European starlings, and horned larks were the 6 most frequently identified species struck by civil aircraft overall from 1990–2015 and in 2015 only. Canada geese, the 10th most frequently identified species struck overall from 1990–2015, declined to the 22nd most frequently struck species in 2015 in spite of the fact that the overall population in North America has increased over 2 fold, 1990–2015 (U.S. Fish and Wildlife Service 2015). This decline is likely related to the integrated management programs implemented in the past decade at many airports to dissuade feeding and nesting by Canada geese (Dolbeer et al. 2014).

This Hawker 800 hit several Canada geese at 600 feet during initial climb from a Minnesota airport in January 2015. One goose was ingested into the #1 engine, damaging fan blades. Another bird damaged the wing and another struck the empennage. The pilot shut down the engine and returned to airport, landing safely. Forty-two percent of strikes with Canada geese involve multiple birds. Photo by aircraft owner.

For the 30 species of birds most frequently identified as struck by civil aircraft, 1990–2015, there was a strong correlation (R^2 = 0.81) between mean body mass and the likelihood of a strike causing damage to aircraft (Figure 13). For every 100 gram increase in body mass, there was a 1.26% increase in the likelihood of damage. Thus, body mass is a good predictor of relative hazard level among bird species, as noted previously by Dolbeer et al. (2000) and DeVault et al (2011).

Terrestrial mammals, bats, and reptiles- The most frequently struck terrestrial mammals were Carnivores and Artiodactyls (37 and 33 percent, respectively, Tables 18, 19). Coyotes were the

most frequently struck Carnivore and deer were the most frequently struck Artiodactyl. Artiodactyls were responsible for 91 percent of the mammal strikes that resulted in damage and 73 percent of the mammal strikes that involved multiple animals. In all, 43, 22 and 18 identified species of terrestrial mammals, bats, and reptiles, respectively, were reported struck; 22, 2 and 2 identified species of these respective wildlife taxa caused damage to aircraft (Table 18).

HUMAN FATALITIES AND INJURIES DUE TO WILDLIFE STRIKES

For the 26-year period, reports were received of 12 wildlife strikes that resulted in 26 human fatalities (Table 20). Six of these strikes resulting in 8 fatalities involved unidentified species of birds. Red-tailed hawks (8 fatalities), American white pelicans (5), Canada geese (2), and white-tailed deer, brown-pelicans, and turkey vultures (1 each) were responsible for the other 18 fatalities. Reports were received of 229 strikes that resulted in 400 human injuries (Table 21). Waterfowl (ducks and geese; 53 strikes, 159 humans injured), vultures (34 strikes, 42 injuries), and deer (20 strikes, 29 injuries) caused 107 (58 percent) of the 183 strikes resulting in injuries in which the species or species group was identified. Canada geese caused 117 (35 percent) of the 339 injuries in which the species or species group was identified.

AIRCRAFT DESTROYED DUE TO WILDLIFE STRIKES

A flock of 30 green-winged teal flew across the path of a Diamond 20 aircraft piloted by a student at 250 feet AGL and 65 knots during touch-and-go practice at an airport in Utah, March 2015. The propeller struck 1 bird, the remains of which were found on runway during a follow-up inspection. The flight instructor made a precautionary landing. There was no damage. Photo, airport operator.

For the 26-year period, reports were received of 68 aircraft destroyed or damaged beyond repair due to wildlife strikes (range of 0 to 6 per year, Tables 14, 22, Figure 14). The majority (43; 63 percent) were small (≤2,250 kg maximum take-off mass) general aviation (GA) aircraft. Terrestrial mammals (primarily white-tailed deer) were responsible for 31 (46 percent) of the incidents. Canada geese (5 incidents) and vultures (4 incidents) were responsible for 41 percent of the 22 incidents involving birds in which the species or species group was identified.

Forty-one (60 percent) of the 68 wildlife strikes resulting in a destroyed aircraft occurred at GA airports, 15 occurred “en route”, 7 occurred at USA airports certificated for passenger service under 14 CFR Part 139, and 3 occurred in miscellaneous situations (taking off from river, herding cattle, and aerial application of pesticides). Two occurred at a foreign airport (Table 22). GA airports, often located in rural areas with inadequate fencing to exclude large mammals, face unique challenges in mitigating wildlife risks to aviation (DeVault et al.

2008; Dolbeer et al. 2008).

ECONOMIC LOSSES DUE TO WILDLIFE STRIKES

Of the 24,478 reports from 1990 – 2015 that indicated the strike had an adverse effect on the aircraft and/or flight, 8,911 provided an estimate of the aircraft downtime (949,768 hours, mean = 106.6 hours/incident, Tables 18, 23, 24). Regarding monetary losses, 3,945 reports provided an estimate of direct aircraft repair costs ($649.3 million, mean = $164,595/incident), and 2,962 reports gave an estimate of other monetary losses ($81.7 million, mean = $27,599/incident)[2]. Other monetary losses include such expenses as lost revenue, the cost of putting passengers in hotels, re-scheduling aircraft, and flight cancellations.

Analysis of 14 groups of strike reports from 3 Part 139 airports certificated for passenger service and 3 airlines for the years 1991-2004 indicated that 11 to 21 percent of all strikes were reported to the FAA (Cleary et al. 2005, Wright and Dolbeer 2005). An independent analysis of strike data for a certificated airport in Hawaii in the 1990s indicated a similar reporting rate (Linnell et al. 1999). Strike reporting for general aviation (GA) aircraft at GA airports was estimated at less than 5 percent in the 1990s and early 2000s (Dolbeer et al. 2008, Dolbeer 2009). More recent analyses estimated that strike reporting for all civil aircraft combined (commercial and general aviation) at Part 139 airports had improved to 39 percent in 2004-2008 and to 47 percent in 2009-2013 (Dolbeer 2009, 2015). Strike reporting for commercial aircraft only at Part 139 airports was an estimated 79 percent in 2004-2008 and 91 percent in 2009-2013; reporting of strikes with damage was estimated at 78 percent and 93 percent for these respective time periods. In addition to the underreporting of strikes, only 36 percent of the 24,478 reports from 1990–2015 indicating an adverse effect provided estimates of aircraft downtime, 16 percent provided estimates of repair (direct) costs, and 12 percent provided estimates of other (indirect) costs (these respective percentages were 49, 14, and 20 for 2015 only, Tables 23, 24). Furthermore, some reports providing cost estimates were filed before aircraft

An EC-130 medical transport helicopter en route at 1000 feet AGL in Kentucky hit a black vulture, October 2015. The bird, diving to avoid the aircraft, penetrated the overhead window and struck a crew member. The crew member, wearing a helmet with visor, was only slightly injured. The pilot landed safely in a soybean field. Photo aircraft owner.

[2] Costs from years prior to 2015 are inflation-adjusted to 2015 U.S. dollars.

damage and downtime had been fully assessed. As a result, the information on the number of strikes and associated costs compiled (summarized by species of wildlife struck in Table 18) is believed to significantly underestimate the economic magnitude of the problem.

Assuming (1) all 24,478 reported wildlife strikes that had an adverse effect on the aircraft and/or flight engendered similar amounts of downtime and/or monetary losses and (2) that these reports are all of the damaging strikes that occurred, then at a minimum, wildlife strikes annually cost the USA civil aviation industry, on average, 112,536 hours of aircraft downtime and $191 million in monetary losses ($156 million in direct costs and $35 million in other costs), 1990–2015 (Table 24). For 2015 only, the minimum estimates would be 69,497 hours of downtime and $229 million in direct and indirect costs. For reasons outlined above, we project that actual costs are likely 2 or more times higher than these minimum estimates.

CONCLUSIONS

The analysis of 26 years of strike data reveals the magnitude and nature of wildlife strikes with civil aircraft in the USA, and documents that progress is being made in reducing damaging strikes. Although wildlife strikes continue to pose an economic and safety risk for civil aviation in the USA, management actions to mitigate these risks have been implemented at many airports, especially beginning in 2000 when the FAA's manual Wildlife Hazard Management at Airports was initially available to airports nationwide (Cleary and Dolbeer 1999, second edition 2005). These efforts (examples of which are documented in Wenning et al. 2004, DeFusco et al. 2005, Dolbeer 2006a, Human Wildlife Conflicts Journal 2009, Human-Wildlife Interactions Journal 2011, Dolbeer 2011, DeVault et al. 2013, Dolbeer et al. 2014) are likely responsible for the general decline in reported strikes with damage and negative effects-on-flight from 2000-2015 for commercial aircraft (Table 1, Figures 2, 3, 4, 9, 11) in spite of continued increases in populations of many large bird species. As another measure of the increase in wildlife management activities, USDA Wildlife Services biologists provided assistance at 850 civil and military airports nationwide in 2015 to mitigate wildlife risks to aviation compared to only 42 airports in 1991 and 193 in 1998 (Begier et al. 2016). However, much work remains to be done to reduce wildlife strikes.

A trail camera documented this red fox entering an eastern USA airport underneath the perimeter fence, January 2015. By monitoring wildlife tracks and activity along fences, airport biologists can locate and correct ingress points. During 2015, 338, 20, 10, and 8 species of birds, terrestrial mammals, bats, and reptiles, respectively, were reported as struck by civil aircraft in USA. This included 11 red foxes. Photo D. Colbert, USDA.

To address the problem in the airport environment, airport managers first need to assess the wildlife hazards on their airports with the help of qualified airport biologists (FAA Advisory Circular 150/5200-36A, Qualifications for Wildlife Biologist Conducting Wildlife Hazard Assessments and Training Curriculums for Airport Personnel Involved in Controlling Wildlife Hazards on Airports). They then must take appropriate actions, under the guidance of these biologists, to minimize risks posed by wildlife. Management actions should be prioritized based on the hazard level of species (Table 18, Figure 13) observed in the aircraft operating area. The manual *Wildlife Hazard Management at Airports* (Cleary and Dolbeer 2005), available online in English, Spanish, and French at http://wildlife.faa.gov, provides guidance for conducting wildlife hazard assessments and in developing and implementing wildlife hazard management plans

Management efforts to reduce the risks of bird strikes have primarily focused on airports since various historical analyses of bird strike data for civil aviation have indicated the majority of strikes occur in this environment (during take-off and landing at ≤1,500 feet above ground level). However, the successful mitigation efforts at Part 139-certificated airports that have reduced damaging strikes for commercial aviation in recent years, which must be sustained, have done little to reduce strikes outside the airport environment such as occurred with US Airways Flight 1549 in 2009 (Dolbeer 2011).

To mitigate the risk for strikes beyond the airport fence, the general public and aviation community must first widen its view of wildlife management to consider habitats and land uses within 5 miles of airports. Wetlands, dredge-spoil containment areas, municipal solid waste landfills, and wildlife refuges can attract hazardous wildlife. Such land uses, as discussed in FAA Advisory Circular 150/5200-33B, Hazardous Wildlife Attractants on or Near Airports, are often incompatible with aviation safety and should either be prohibited near airports or designed and operated in a manner that minimize the attraction of hazardous wildlife (e.g., Washburn et al. 2010).

Second, the aviation community needs to broaden the view of wildlife strike risks from a ground-based wildlife management problem solely dealt with by airports to an airspace management problem that also encompasses Air Traffic Control, flight crews, and aircraft manufacturers. Long-term goals include the integration of avian radar and bird migration forecasting into airspace management (Nohara et al. 2011, Gerringer et al. 2016). The development of aircraft lighting systems to enhance detection and avoidance by birds (Blackwell et al. 2012, DeVault et al. 2015, Dolbeer and Barnes 2017) is also needed as part of an integrated program.

Finally, there continues to be a need for increased and more detailed strike reporting, especially for General Aviation aircraft. When reports are filed, relevant information should be provided whenever possible regarding species identification, number of wildlife struck, time and height of strike, phase of flight, and damage to aircraft components (Dolbeer 2015, see Appendix B: Reporting a Strike and Identifying Species of Wildlife Struck). A problem that is not understood and well defined cannot be properly managed.

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TABLES

Table 1. Number of reported wildlife strikes to civil aircraft in USA and to U.S.-registered civil aircraft in foreign countries, 1990–2015.

	USA[1]		Foreign		Total	
Year	Strikes	Damage strikes	Strikes	Damage strikes	Strikes	Damage strikes
1990	1,813	363	34	6	1,847	369
1991	2,351	394	37	5	2,388	399
1992	2,528	360	38	5	2,566	365
1993	2,541	395	34	4	2,575	399
1994	2,600	453	35	7	2,635	460
1995	2,716	485	52	11	2,768	496
1996	2,885	492	51	10	2,936	502
1997	3,386	569	69	9	3,455	578
1998	3,731	574	68	10	3,799	584
1999	5,014	685	99	18	5,113	703
2000	5,871	741	129	21	6,000	762
2001	5,695	630	125	15	5,820	645
2002	6,082	660	143	11	6,225	671
2003	5,864	612	138	20	6,002	632
2004	6,402	610	159	16	6,561	626
2005	7,046	585	181	20	7,227	605
2006	7,078	579	162	18	7,240	597
2007	7,603	554	142	16	7,745	570
2008	7,444	511	188	14	7,632	525
2009	9,255	584	253	20	9,508	604
2010	9,673	578	231	18	9,904	596
2011	9,849	519	266	23	10,115	542
2012	10,638	590	267	21	10,905	611
2013	11,203	593	200	13	11,403	606
2014	13,462	567	230	15	13,692	582
2015	13,546	604	249	12	13,795	616
Total	**166,276**	**l4,287**	**3,580**	**358**	**169,856**	**14,645**

[1] See Table 2 for breakdown of strikes occurring in USA by type of wildlife.

Table 2. Number of reported wildlife strikes to civil aircraft in USA by wildlife group, 1990–2015.

Year	Birds	Bats	Terrestrial mammals[1]	Reptiles[1]	Total strikes	Strikes with damage
1990	1,758	3	52	0	1,813	363
1991	2,291	3	57	0	2,351	394
1992	2,453	2	72	1	2,528	360
1993	2,469	6	66	0	2,541	395
1994	2,515	2	82	1	2,600	453
1995	2,620	4	84	8	2,716	485
1996	2,792	1	89	3	2,885	492
1997	3,277	1	94	14	3,386	569
1998	3,610	3	111	7	3,731	574
1999	4,912	6	95	1	5,014	685
2000	5,730	15	123	3	5,871	741
2001	5,541	8	138	8	5,695	630
2002	5,930	19	118	15	6,082	660
2003	5,715	20	124	5	5,864	612
2004	6,243	27	126	6	6,402	610
2005	6,881	27	131	7	7,046	585
2006	6,883	46	139	10	7,078	579
2007	7,373	52	171	7	7,603	554
2008	7,213	44	182	5	7,444	511
2009	8,950	67	228	10	9,255	584
2010	9,305	112	245	11	9,673	578
2011	9,499	138	197	15	9,849	519
2012	10,255	161	203	19	10,638	590
2013	10,744	224	203	32	11,203	593
2014	12,952	254	221	35	13,462	567
2015	12,983	317	210	36	13,546	604
Total	**160,894**	**1,562**	**3,561**	**259**	**166,276**	**14,287**

[1] For terrestrial mammals and reptiles, species with body masses <1 kilogram (2.2 pounds) are excluded from database (Dolbeer et al. 2005).

Table 3. Number and rate of reported wildlife strikes and strikes with damage for commercial air carrier aircraft, USA, 1990–2015 (see Figure 3).

	No. of reported strikes[1]			Strikes/100,000 movements	
Year	All strikes	Strikes with damage	Aircraft movements (x 1 million)[2]	All strikes	Strikes with damage
1990	1,347	219	23.24	5.80	0.94
1991	1,779	249	24.75	7.19	1.01
1992	1,796	207	25.14	7.14	0.82
1993	1,781	232	25.54	6.97	0.91
1994	1,893	279	26.55	7.13	1.05
1995	1,983	311	27.01	7.34	1.15
1996	2,057	310	27.55	7.47	1.13
1997	2,431	368	27.73	8.77	1.33
1998	2,482	361	27.97	8.87	1.29
1999	3,779	461	28.73	13.15	1.60
2000	4,378	492	29.51	14.83	1.67
2001	4,049	430	29.13	13.90	1.48
2002	4,276	452	27.60	15.49	1.64
2003	4,152	398	27.88	14.89	1.43
2004	4,551	390	28.85	15.77	1.35
2005	4,982	398	29.22	17.05	1.36
2006	4,759	385	28.28	16.83	1.36
2007	4,861	338	28.44	17.09	1.19
2008	4,444	323	27.94	15.90	1.16
2009	5,882	371	25.45	23.11	1.46
2010	5,793	360	25.10	23.08	1.43
2011	5,723	321	25.11	22.79	1.28
2012	6,143	368	24.89	24.68	1.48
2013	6,270	307	24.59	25.50	1.25
2014	7,969	326	24.42	32.64	1.34
2015	7,849	333	24.61	31.89	1.35
Total	**107,409**	**8,989**	**695.25**	**15.45**	**1.29**

[1] Strikes involving an unknown operator (40,433 of which 39,386 were “Carcass Found” reports--see Tables 6 and 7) were excluded from this analysis as were all strikes by USA-registered aircraft in foreign countries.

[2] Departures and arrivals by fiscal year (1 Oct-30 Sep) for air carrier, commuter, and air taxi service aircraft (Federal Aviation Administration 2016*a*).

Table 4. Number and rate of reported wildlife strikes and strikes with damage for general aviation aircraft, USA, 1990–2015 (see Figure 3).

	No. of reported strikes[1]			Strikes/100,000 movements	
Year	All strikes	Strikes with damage	Aircraft movements (x 1 million)[2]	All strikes	Strikes with damage
1990	332	132	77.50	0.43	0.17
1991	405	130	83.50	0.49	0.16
1992	432	142	82.30	0.52	0.17
1993	447	159	80.37	0.56	0.20
1994	475	172	79.16	0.60	0.22
1995	480	170	77.18	0.62	0.22
1996	505	179	78.95	0.64	0.23
1997	505	189	79.93	0.63	0.24
1998	566	204	84.23	0.67	0.24
1999	620	212	85.33	0.73	0.25
2000	673	246	87.07	0.77	0.28
2001	695	194	85.89	0.81	0.23
2002	781	208	85.76	0.91	0.24
2003	683	208	83.43	0.82	0.25
2004	695	217	82.67	0.84	0.26
2005	667	186	81.13	0.82	0.23
2006	687	194	80.15	0.86	0.24
2007	670	213	80.19	0.84	0.27
2008	627	186	78.02	0.80	0.24
2009	860	213	73.60	1.17	0.29
2010	844	215	71.23	1.18	0.30
2011	918	198	69.90	1.31	0.28
2012	1,027	222	69.58	1.48	0.32
2013	1,104	285	68.81	1.60	0.41
2014	1,337	239	68.18	1.96	0.35
2015	1,399	271	68.25	2.05	0.40
Total	**18,434**	**5,184**	**2,042.30**	**0.90**	**0.25**

[1] Strikes involving an unknown operator (40,433 of which 39,386 were “Carcass Found” reports--see Tables 6 and 7) were excluded from this analysis as were all strikes by USA-registered aircraft in foreign countries.

[2] Itinerant and local departures and arrivals by fiscal year (1 Oct-30 Sep) for general aviation aircraft (Federal Aviation Administration 2016*a*).

Table 5. Methods of reporting and source of information for reported wildlife strikes to civil aircraft, USA[1], 1990–2015, and 2015 only.

	1990–2015		2015 only	
Source	Total	% of total	Total	% of total
FAA Form 5200-7E (Electronic)[2]	83,873	49	10,956	79
FAA Form 5200-7 (Paper)[2]	42,855	25	267	2
Air Transport report	15,351	9	315	2
Multiple[3]	13,577	8	1,066	8
Airport report	6,209	4	62	<1
Other[4]	1,806	1	26	<1
Daily Report (FAA)	1,533	1	271	2
Mandatory Occurrence Report	1,859	1	829	6
Preliminary Aircraft Incident Report	880	1	0	0
Engine manufacturer	811	<1	0	0
Aircraft Incident Report	712	<1	1	<1
Aviation Safety Reporting System	199	<1	0	0
National Transportation Safety Board	83	<1	1	<1
Aircraft Incident Preliminary Notice	67	<1	0	0
Transport Canada	37	<1	1	<1
U.S. Air Force (BASH)	4	<1	0	0
Total	**169,856**	**100**	**13,795**	**100**

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] Bird/Other Wildlife Strike Report. Electronic filing of reports (http://wildlife.faa.gov) began in April 2001. In 2001, 0.4 percent of reports were filed electronically compared to 79 percent in 2015. The paper version of FAA Form 5200-7 (mailed to FAA headquarters) declined from 56 percent of all reports in 2001 to 21 percent in 2006 and 2 percent in 2015.

[3] More than one type of report was filed for the same strike.

[4] Various sources such as news media and Commercial Incident Reports.

Table 6. Person filing report of wildlife strike to civil aircraft, USA[1], 1990–2015, and 2015 only.

	1990–2015		2015 only	
Person filing report	Total	% of total	Total	% of total
Airport Operations	66,729	45	7,879	59
Carcass Found[2]	39,387	59	4,261	54
Other Reports[3]	27,342	41	3,618	46
Pilot	33,607	23	2,679	20
Airline Operations	29,029	20	684	5
Tower	15,912	11	2,000	15
Other	3,342	2	215	2
Total known	**148,619**	**100**	**13,457**	**100**
Unknown	**21,237**		**338**	
Total	**169,856**		**13,795**	

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] Airport personnel found fresh wildlife remains within 250 feet of a runway centerline or elsewhere on or near airport that appeared to have been struck by aircraft, but no strike was observed or reported by pilot, tower, or airline.

[3] Airport personnel observed strike or reported a strike that had been communicated to them by pilot, tower, or airline.

Table 7. Number of reported wildlife strikes to civil aircraft by type of operator, USA[1], 1990–2015, and 2015 only.

	1990–2015		2015 only	
Type of operator	Total	% of total	Total	% of total
Commercial[2]	**110,831**	**86**	**8,084**	**85**
General aviation	**18,591**	**14**	**1,412**	**15**
Business	14,718	11	1193	13
Private	2,558	2	91	1
Government/ Police[3]	1,315	1	128	1
Total known	**129,422**	**100**	**9,496**	**100**
Unknown[4]	**40,434**		**4,299**	
Total	**169,856**		**13,795**	

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] Air carrier, commuter, and air taxi service with 3-letter Operator Code.

[3] U.S. Customs and Border Protection (USCBP) and U.S. Coast Guard (USCG) aircraft were respectively involved in 33 percent (434) and 27 percent (358) of the 1,315 Government/police strikes, 1990–2015. For 2015 only, 17 percent (23) and 23 percent (29) of the 128 Government/police strikes involved USCBP and USCG aircraft, respectively.

[4] Ninety-seven percent (39,386) of the 40,433 strikes involving an unknown operator were "Carcass Found" reports, 1990–2015. For 2015 only, over 99 percent (4,261) of the 4,299 strikes involving an unknown operator were "Carcass Found" reports (see Table 6).

Table 8. Number of Part 139-certificated airports[1] and general aviation (GA) airports with reported wildlife strikes and number of strikes reported for these airports, civil aircraft, 1990–2015 (see also Figure 5)[2].

	Part 139 airports		GA airports		All USA airports	
Year	Airports	Strikes	Airports	Strikes	Airports	Strikes
1990	235	1,507	99	167	334	1,674
1991	260	1,992	97	200	357	2,192
1992	256	2,175	108	229	364	2,404
1993	259	2,227	100	218	359	2,445
1994	267	2,223	110	247	377	2,470
1995	263	2,331	120	210	383	2,541
1996	262	2,507	108	193	370	2,700
1997	286	2,911	124	202	410	3,113
1998	293	3,218	145	269	438	3,487
1999	304	3,807	146	258	450	4,065
2000	315	4,477	151	277	466	4,754
2001	319	4,438	149	292	468	4,730
2002	309	4,787	154	308	463	5,095
2003	307	4,665	154	331	461	4,996
2004	311	5,231	175	320	486	5,551
2005	323	5,511	175	331	498	5,842
2006	325	5,942	143	271	468	6,213
2007	331	6,583	162	325	493	6,908
2008	333	6,641	162	309	495	6,950
2009	367	8,027	236	461	603	8,488
2010	377	8,314	216	470	593	8,784
2011	370	8,464	228	498	598	8,962
2012	388	8,922	254	580	642	9,502
2013	382	9,137	272	621	654	9,758
2014	397	11,042	279	701	676	11,743
2015	404	11,115	270	696	674	11,811
Total	**527**	**138,194**	**1,412**	**8,984**	**1,939**	**147,178**

[1] There were 532 airports in USA certificated for passenger service under CFR Part 139 regulations in October 2016 (FAA 2016*b*).

[2] In addition, 3,580 strikes involving USA-registered aircraft were reported from 296 foreign airports in 108 countries. Furthermore, 3,064 strikes (3,052 bird and 12 bat strikes) were reported in which aircraft was en route (Table 10). An additional 14,935 strikes were reported in which either evidence of strike was discovered on aircraft after landing but phase of flight where strike occurred could not be determined or an airport was not named on reporting form.

Table 9. Reported time of occurrence of wildlife strikes with civil aircraft, USA[1], 1990–2015[2].

	Birds		Terrestrial mammals		Bats	
Time of day	26-year total	% of total known	26-year total	% of total known	26-year total	% of total known
Dawn	3,414	3	61	3	4	1
Day	64,182	63	491	25	56	13
Dusk	4,365	4	156	8	21	5
Night	30,654	30	1,230	63	353	81
Total known	**102,615**	**100**	**1,938**	**100**	**434**	**100**
Unknown[3]	**61,829**		**1,634**		**1,147**	
Total	**164,444**		**3,572**		**1,581**	

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] In addition, 259 strikes with reptiles were reported from 1990–2015: time not reported (219), day (31), night (6), dusk (2), and dawn (1).

[3] Of the 64,829 strike reports with “Unknown” time of day (all species), 39,387 (61 percent) were “Carcass Found” reports (Table 6).

Table 10. Reported phase of flight at time of occurrence of wildlife strikes with civil aircraft, USA[1], 1990–2015[2].

	Birds		Terrestrial mammals[3]		Bats	
Phase of flight	26-year total	% of total known	26-year total	% of total known	26-year total	% of total known
Parked	77	<1	2	<1		0
Taxi	344	<1	42	2		0
Take-off Run	19,800	18	647	31	19	4
Climb	18,828	17	45	2	35	8
Departure[4]	520	<1	1	<1	7	2
En Route	3,052	3		0	12	3
Arrival[4]	155	<1	1	<1		0
Descent	3,192	3		0	9	2
Approach	45,461	41	148	7	319	72
Landing Roll	18,862	17	1,208	57	44	10
Local[4]	298	<1	9	<1		0
Total known	**110,589**	**100**	**2,103**	**100**	**445**	**100**
Unknown[5]	**53,855**		**1,469**		**1,136**	
Total	**164,444**		**3,572**		**1,581**	

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] In addition, 259 strikes with reptiles were reported: phase of flight not reported (210), take-off run (17), landing roll (17), taxi (8), and approach (5; pilot had a missed approach because reptile was on the runway).

[3] Terrestrial mammal (e.g., deer, coyote) was hit after aircraft lifted off runway or just before touchdown, or pilot had a missed approach because mammal was on runway.

[4] Phase of flight was determined to be Arrival, Departure, or Local (i.e., pilot conducting "touch-and-go" operations) but exact phase of flight could not be determined.

[5] Of the 56,670 strike reports with "Unknown" phase of flight (all species), 39,387 (70 percent) were "Carcass Found" reports (Table 6).

Table 11. Number of reported bird strikes to commercial aircraft[1] by height above ground level (AGL), USA[2], 1990–2015. See Figure 7 for graphic analysis of strike data from 501 to 18,500 feet AGL[3].

Height of strike (feet AGL)	All reported strikes			Strikes with damage		
	26-year total	% of total known	% cumulative total[4]	26-year total	% of total known	% cumulative total[4]
0	33,100	41	41	1,831	29	29
1-500	24,611	30	71	1,769	28	56
501-1500	8,810	11	82	947	15	71
1501-2500	4,607	6	88	571	9	80
2501-3500	3,361	4	92	375	6	86
3501-4500	1,990	2	94	220	3	89
4501-5500	1,470	2	96	175	3	92
5501-6500	961	1	97	122	2	94
6501-7500	663	1	98	84	1	95
7501-8500	490	1	99	73	1	96
8501-9500	264	<1	99	34	1	97
9501-10500	344	<1	99	57	1	98
10501-11500	185	<1	100	43	1	99
>11500[5]	296	<1	100	90	1	100
Total known	**81,152**	**100**		**6,391**	**100**	
Unknown height	**28,050**			**2,710**		
Total	**109,202**			**9,101**		

[1] Air carrier, commuter, and air taxi service with 3-letter Operator Code (see Table 7); 841 strikes in which height of strike was reported but type of operator was unknown were excluded from analysis.

[2] Includes strikes to U.S.-registered aircraft in foreign countries.

[3] A more detailed analysis of bird strikes by height AGL is provided by Dolbeer (2006*b*).

[4] The cumulative percentage of strikes that occur at or below the upper range of the corresponding 1,000-foot interval.

[5] Twenty-four strikes involving commercial aircraft (10 with damage to aircraft) were reported at ≥20,000 feet AGL; the highest was 31,300 feet.

Table 12. Number of reported bird strikes to general aviation aircraft[1] by height above ground level (AGL), USA[2], 1990–2015. See Figure 7 for graphic analysis of strike data from 501 to 12,500 feet AGL[3].

Height of strike (feet AGL)	All reported strikes			Strikes with damage		
	26-year total	% of total known	% cum-ulative total[4]	26-year total	% of total known	% cum-ulative total[4]
0	5,537	37	37	644	17	17
1-500	5,471	36	73	1,299	34	51
501-1500	2,217	15	88	981	26	76
1501-2500	910	6	94	443	12	88
2501-3500	417	3	97	205	5	93
3501-4500	212	1	98	99	3	96
4501-5500	101	1	99	46	1	97
5501-6500	62	<1	99	31	1	98
6501-7500	52	<1	99	20	1	98
7501-8500	29	<1	100	17	<1	99
8501-9500	18	<1	100	10	<1	99
9501-10500	19	<1	100	13	<1	100
10501-11500	4	<1	100	2	<1	100
>11500[5]	26	<1	100	17	<1	100
Total known	**15,075**	**100**		**3,827**	**100**	
Unknown height	**2,323**			**532**		
Total	**17,398**			**4,359**		

[1] Private, Business, and Government/Police aircraft (see Table 6); 841 strikes in which height of strike was reported but type of operator was unknown were excluded from analysis.

[2] Includes strikes to U.S.-registered aircraft in foreign countries.

[3] A more detailed analysis of bird strikes by height AGL is provided by Dolbeer (2006*b*).

[4] The cumulative percentage of strikes that occur at or below the upper range of the corresponding 1,000-foot interval.

[5] Five strikes involving general aviation aircraft (4 with damage to aircraft) were reported at ≥20,000 feet AGL; the highest was 24,000 feet.

Table 13. Civil aircraft components reported as being struck and damaged by wildlife, USA[1], 1990–2015.

	Birds (26-year total)				Terrestrial mammals (26-year total)			
Aircraft component	Number struck	% of total	Number damaged	% of total	Number struck	% of total	Number damaged	% of total
Windshield	23,503	16	1,011	6	8	0	17	1
Nose	20,594	14	1,037	6	105	4	100	5
Wing/rotor	19,845	14	3,862	24	302	11	315	16
Radome	17,832	12	1,550	10	15	1	15	1
Engine(s)[2]	17,494	12	4,516	28	181	7	177	9
Fuselage	17,210	12	676	4	143	5	151	8
Other	15,820	11	1,302	8	339	12	280	14
Landing gear	6,409	4	530	3	1,216	44	472	24
Propeller	3,131	2	275	2	326	12	301	15
Tail	1,861	1	659	4	62	2	83	4
Light	970	1	692	4	44	2	51	3
Total[3]	**144,669**	**100**	**16,110**	**100**	**2,741**	**100**	**1,962**	**100**

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] For birds, 17,494 engines were reported as struck in 16,694 strike events involving engines (15,921 events with one engine struck, 752 with two engines struck, 15 with three engines struck, and 6 with four engines struck). A total of 4,516 engines was damaged in 4,370 bird-strike events with engine damage (4,227 events with one engine damaged, 141 with two engines damaged, 1 with three engines damaged, and 1 with four engines damaged). For terrestrial mammals, 181 engines were reported as struck in 171 strike events (161 events with one engine struck and 10 with two engines struck). A total of 177 engines was damaged in 158 terrestrial mammal strike events with engine damage (139 events with one engine damaged and 19 with two engines damaged). Some engines were damaged without being struck when the landing gear collapsed.

[3] In addition, bat strikes had 769 and 13 components reported as struck and damaged, respectively: radome/nose (274, 1), windshield (136, 2), engine (51, 3), propeller (5, 1), wing/rotor (137, 5), fuselage (73, 0), tail (10, 0), other (48, 0), landing gear (31, 0), light (4, 1). For reptile strikes, there were 44 and 6 components reported struck and damaged, respectively: windshield (1, 1), wing/rotor (2, 1), fuselage (1, 1), landing gear (38, 1), tail (1, 1), other (2, 1).

Table 14. Number of civil aircraft with reported damage resulting from wildlife strikes, USA[1], 1990–2015. See Tables 1 - 4 and Figures 2 – 4, 9, and 14 for trends in damaging strikes, 1990–2015.

	Reported strikes					
	Birds		Terrestrial mammals		Total (all species)[2]	
Damage category[3]	26-year total	% of total[4]	26-year total	% of total[4]	26-year total	% of total[4]
None	**104,314**	**63**	**929**	**26**	**105,933**	**62**
Unknown	**46,572**	**28**	**1,569**	**44**	**49,278**	**29**
Damage	**13,558**	**8**	**1,074**	**30**	**14,645**	**9**
Minor	7,230	4	548	15	7,786	5
Uncertain	2,831	2	81	2	2,913	2
Substantial	3,460	2	414	12	3,878	2
Destroyed	37	<1	31	1	68	<1
Total	**164,444**	**100**	**3,572**	**100**	**169,856**	**100**

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] Included in totals are 1,581 and 259 strikes involving bats and reptiles, respectively. For bats, 650 reports indicated no damage, 920 failed to indicate if damage occurred, and 11 indicated damage (7 minor, 1 uncertain level, 3 substantial [caused by megabats at foreign airports]). For reptiles, 40 reports indicated no damage, 217 failed to indicate if damage occurred, and 2 indicated damage (1 minor, 1 substantial).

[3] The damage codes and descriptions are from the International Civil Aviation Organization (1989): Minor = the aircraft can be rendered airworthy by simple repairs or replacements and an extensive inspection is not necessary; Uncertain = the aircraft was damaged, but details as to the extent of the damage are lacking; Substantial = the aircraft incurs damage or structural failure that adversely affects the structure strength, performance, or flight characteristics of the aircraft and that would normally require major repair or replacement of the affected component (specifically excluded are bent fairings or cowlings; small dents or puncture holes in the skin; damage to wing tips, antenna, tires, or brakes; and engine blade damage not requiring blade replacement); Destroyed = the damage sustained makes it inadvisable to restore the aircraft to an airworthy condition.

[4] The percentage of strikes causing damage is calculated using the total strikes reported as the divisor, including the 49,278 reports that did not indicate if damage occurred or not (Unknown). “Carcass found” reports (see Table 6) comprised 39,387 (80 percent) of these 49,278 reports. If the Unknown reports are excluded from the calculations, then 12, 54, and 12 percent of the strikes caused damage for birds, terrestrial mammals, and all species, respectively.

Table 15. Reported effect-on-flight of wildlife strikes to civil aircraft, USA[1], 1990–2015.

	Reported strikes					
	Birds		Terrestrial mammals		Total[2]	
Effect-on-flight[3]	26-year total	% of total[3]	26-year total	% of total[4]	26-year total	% of total[4]
None	**87,668**	**53**	**863**	**24**	**89,098**	**52**
Unknown	**66,891**	**41**	**1,996**	**56**	**70,139**	**41**
Negative effect	**9,885**	**6**	**713**	**20**	**10,619**	**6**
Precautionary landing	5,425	3	105	3	5,539	3
Aborted take-off	1,999	1	232	6	2,232	1
Engine shutdown[5]	411	<1	32	1	443	<1
Other	2,050	1	344	10	2,405	1
Total	**164,444**	**100**	**3,572**	**100**	**169,856**	**100**

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] Included in totals are 1,581 and 259 strikes involving bats and reptiles, respectively. For bats, 532 reports indicated no effect-on-flight, 1,038 failed to indicate if an effect-on-flight occurred, and 11 indicated a negative effect (8 precautionary landings, 3 “Other”). For reptiles, 35 reports indicated no effect-on-flight, 214 failed to indicate if an effect-on-flight occurred, and 10 indicated a negative effect (1 precautionary landing, 1 aborted take-off, 8 “Other”).

[3] Effect-on-flight: None = flight continued as scheduled, although delays and other cost caused by inspections or repairs may have been incurred after landing; Aborted take-off = pilot aborted take-off on departure runway after initiating take-off run (aircraft may have become airborne but pilot landed on departing runway without doing a “go around”); Precautionary landing (includes “declared emergency” landings) = pilot completed take-off but returned to land at departure airport or landed at an “other-than-destination” airport after strike; Engine shut down = pilot shut down engine or engine stopped running because of strike; Other = miscellaneous effects, such as reduced speed because of shattered windshield, flight delays, or crash landing; Unknown = report did not give sufficient information to determine an effect-on-flight (Dolbeer et al. 2000).

[4] The percentage of strikes causing negative effect-on-flight is calculated using the total strikes reported as the divisor, including the 70,139 reports that did not indicate if a negative effect occurred or not (Unknown). “Carcass found” reports (see Table 6) comprised 39,387 (56 percent) of these 70,139 reports. If the Unknown reports are excluded from the calculations, then 10, 45, and 11 percent of the strikes caused a negative effect-on-flight for birds, terrestrial mammals, and all species, respectively.

[5] In 6 reports, effect-on-flight was classified as “Engine shutdown” but pilot also aborted take-off.

Table 16. Number of reported incidents where pilot made a precautionary or emergency landing after striking birds during departure in which fuel was jettisoned or burned (circling pattern) to lighten aircraft weight or in which an overweight (greater than maximum landing weight) landing was made (no fuel jettison or burn), USA civil aircraft, 1990–2015[1]. See Figure 10 for trend in incidents, 1990–2015.

Action taken after bird strike on departure	Number of incidents	Comments and number of incidents by aircraft model
Fuel jettison	53	A mean of 97,738 lbs (14,373 gallons) of fuel jettisoned per incident (range 3,500 – 270,000 lbs; 515 - 39,706 gallons). Aircraft: B-747 (19); B-767 (7); B-727 (6); DC-10/MD-11 (8); B-777 (3); Learjet 31/35 (3); L-1011, Lockheed P38, CL601, DA-2000, and unknown (1 each)
Fuel burn	63	Aircraft: EMB-120/145/170/190 (9); B-737 (8); A-319 to A330 (8); CL-RJ 100/700/900 (7); Learjet 24/60 (5); MD-80/88 (3); B-747, DHC8-Dash 8, and PA-28 (2 each); and 17 other aircraft types with 1 each.
Overweight landing	95	Aircraft: B-737 (25); A-320/330 (18); B-757 (15); MD-80/82 (10); B-767 (9); CRJ-100 to 700 (5); EMB-145/170 and MD-83 (3 each); A-300, MD-11, and C-500/600 (2 each); CL-RJ 900; DA-50 Falcon and Dornier 328 (1 each).
Total	**211**	**A mean of 8.1 (range 0 – 16) incidents (fuel jettison, fuel burn, or overweight landing) per year, 1990 – 2015.**

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

Table 17. Indicated airspeed (nautical miles/hour [knots])[1] at time pilot aborted take-off after striking or observing a bird or other wildlife species on runway, civil aircraft, USA[2], 1990–2015. See Figure 11 for trend in high-speed aborted take-offs at ≥100 knots caused by birds or other wildlife, 1990–2015.

	Commercial aircraft[3]		General aviation aircraft[4]		All aircraft[5, 6]	
Aircraft speed (knots)	26-year total	% of total known	26-year total	% of total known	26-year total	% of total known
1-49	26	3	82	16	110	8
50-99	388	48	307	60	699	53
≥100	393	49	125	24	520	39
Total known	**807**	**100**	**514**	**100**	**1,329**	**100**
Unknown	**567**		**321**		**903**	
Total	**1,374**		**835**		**2,232**	

[1] A speed of 100 knots equals 185 kilometers/hour (115 miles/hour).

[2] Includes strikes to U.S.-registered aircraft in foreign countries.

[3] Air carrier, commuter, and air taxi service with 3-letter identifying code (see Table 7).

[4.] Business, Private, or Government aircraft (see Table 7).

[5] Included in totals are 23 aborted take-offs in which type of operator was unknown. For these 23 events, the speed was unreported (15), 1-49 knots (2), 50-99 knots (4), and ≥100 knots (2).

[6] Includes 6 incidents in which effect-on-flight was classified as “Engine shutdown” (Table 15) but pilot also aborted take-off.

Table 18. Total reported strikes, strikes causing damage, strikes having a negative effect-on-flight (EOF), strikes involving >1 animal, aircraft downtime, and costs by identified wildlife species for civil aircraft, USA[1], 1990–2015 (page 1 of 22).

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Birds						
Loons	**42**	**26**	**18**		**6,181**	**3,276,708**
Loons	2	1	1			
Common loon	31	20	12		5,669	3,130,582
Red-throated loon	8	4	5		320	144,773
Pacific loon	1	1			192	1,353
Grebes	**118**	**25**	**13**	**13**	**2,043**	**3,229,790**
Grebes	11	2	1	2	200	20,454
Eared grebe	13	2		1	154	221,107
Western grebe	39	13	8	8	1,570	2,825,136
Pied-billed grebe	38	4	1		45	23,376
Horned grebe	12	3	2	1	74	139,717
Red-necked grebe	3	1	1	1		
Clark's grebe	1					
Great crested grebe	1					
Albatrosses/shearwaters	**82**	**9**	**6**	**5**	**197**	**82,317**
Laysan albatross	37	8	5	1	197	82,317
Black-footed albatross	5	1				
Bonin petrel	12			4		
Northern fulmar	1					
Shearwaters	1					
Wedge-tailed shearwater	13		1			
Townsend's shearwater	11					
Fork-tailed storm-petrel	1					
Bd-rumped storm-petrel	1					
Tropicbirds	**28**	**14**	**11**		**231**	**136,942**
Tropicbirds	11	8	5		151	62,922
White-tailed tropicbird	14	5	5		80	66,131
Red-tailed tropicbird	3	1	1			7,889
Pelicans	**89**	**45**	**36**	**16**	**4,955**	**11,066,932**
Pelicans	5	3			108	21,000
Australian pelican	1	1	1			
Brown pelican	65	28	23	8	497	474,901
American white pelican	18	13	12	8	4,350	10,571,031
Red-footed booby	**1**					

Table 18. Continued (Page 2 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Cormorants	**138**	**49**	**36**	**23**	**2,305**	**5,064,679**
Cormorants	3	1			12	15,000
Great cormorant	2	1		2		
Double-cr. cormorant	130	46	35	21	2,269	5,049,679
Pelagic cormorant	2					
Brandt's cormorant	1	1	1		24	
Anhinga	**32**	**15**	**11**	**4**	**239**	**787,744**
Frigatebirds	**19**	**7**	**5**		**41**	**30,499**
Great frigatebird	11	3	3		21	24,339
Magnificent frigatebird	8	4	2		20	6,160
Herons, egrets, bitterns	**1,522**	**189**	**191**	**206**	**8,986**	**14,989,220**
Herons, egrets, bitterns	3					
Herons	51	12	10	2	99	4,363
Gray heron	1	1	1			
Great blue heron	366	74	60	8	3,826	6,609,231
Blk-crowned night-heron	79	9	4	5	111	379,130
Little blue heron	8					300
Green heron	19			1		
Yw-crowned night-heron	35	8	5	2	150	618,693
Tricolored heron	2					
American bittern	10	3	2		646	55,694
Yellow bittern	116		2	7		
Least bittern	1					
Egrets	332	32	51	89	3,624	4,624,118
Cattle egret	378	33	45	80	254	155,789
Great egret	88	13	8	11	177	2,494,160
Intermediate egret	1					
Snowy egret	32	4	3	1	99	47,742
Storks	**18**	**6**	**3**	**4**	**24**	**22,818**
White stork	1	1				
Wood stork	17	5	3	4	24	22,818
Ibises, spoonbills	**49**	**13**	**13**	**9**	**165**	**1,070,650**
Ibises	5		1	1		
Glossy ibis	3	1	1	1		2,108
White ibis	22	3	5	2	134	60,244
White-faced ibis	16	9	5	5	19	996,610
Roseate spoonbill	3		1		12	11,688

Table 18. Continued (Page 3 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Waterfowl	**4,951**	**2,011**	**1,043**	**1,710**	**162,974**	**243,843,168**
Ducks, geese, swans	141	69	32	56	823	1,424,290
Ducks	819	282	130	264	9,970	8,784,092
American wigeon	71	27	11	21	5,061	1,995,631
Northern pintail	149	70	39	66	2,258	7,959,754
Green-winged teal	67	16	9	19	906	1,122,017
Blue-winged teal	49	17	7	11	364	1,162,514
Eurasian wigeon	1			1		
Mallard	867	194	114	198	13,532	20,136,427
Common eider	3	2	1	1		
Ring-necked duck	28	10	6	9	1,287	92,859
Greater scaup	13	3	3	5		
Wood duck	54	17	6	9	519	163,444
Muscovy duck	4	1	2		120	608,279
Common goldeneye	6	2	1			2,470
Red-breasted merganser	7	1		1	2	
Hooded merganser	10	3		1	54	260,631
Common merganser	4	2	2	1	120	3,812
Northern shoveler	73	27	9	24	2,292	2,748,552
Gadwall	74	29	14	23	803	9,818,635
Canvasback	23	11	5	9	603	2,653,028
American black duck	59	6	3	17	2,604	1,048,065
Mottled duck	26	4	4	5	25	
Lesser scaup	53	20	11	16	1,479	266,213
Ruddy duck	65	13	4	8	164	101,142
Redhead	8	3		3	65	201,658
Bufflehead	19	2	4	1	376	12,601
Long-tailed duck	6	4	3	1	20	47,509
Philippine duck	1	1	1	1	96	11,987,748
Blk-bellied whistling-duck	6	3	1	1	48	
Cinnamon teal	5	1		1	20	6,831
White-winged scoter	3	2	2	1	1,400	517,133
Hawaiian duck	14			4		
Harlequin duck	1					
Barrow's goldeneye	1					
Surf scoter	1					
Geese	373	217	95	136	27,953	3,366,797
Snow goose	130	101	54	77	13,680	32,518,339

Table 18. Continued (Page 4 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Canada goose	1,584	781	440	662	74,566	127,119,594
Brant	37	11	5	9	120	100,444
Grtr white-fronted goose	52	33	11	31	928	5,772,569
Emperor goose	2	1				10,325
Cackling goose	11	6	1	3	149	175,684
Hawaiian goose	2	1	1	1	9	
Swans	2	1				
Mute swan	9	2	1	2		
Tundra swan	16	13	9	10	486	482,685
Trumpeter swan	2	2	2	1	72	1,171,396
Hawks, eagles, vultures	**5,938**	**1,428**	**936**	**190**	**134,967**	**111,946,408**
Unknown birds of prey	40	17	7	1	2,559	24,088
New World Vultures	325	192	96	28	27,890	13,836,483
Black vulture	145	90	55	11	13,622	6,211,387
Turkey vulture	639	325	207	36	40,037	12,824,279
Osprey	326	69	43	5	3,220	873,762
White-tailed kite	40	4	2		46	6,173,797
Black kite	3	2	1			
Mississippi kite	6					
Swallow-tailed kite	4		1		1	37
Eagles	8	3	2	1		
Bald eagle	226	88	68	14	8,827	26,352,206
White-bellied sea-eagle	1	1	1			
Golden eagle	20	4	5	1	3,724	969,202
Hawks	1,323	255	181	34	12,896	5,551,495
Northern goshawk	3					
Red-tailed hawk	2,243	323	236	49	17,758	27,637,113
Rough-legged hawk	91	8	3		21	64,649
Red-shouldered hawk	52	4	5		210	3,960
Swainson's hawk	133	16	11	2	1,141	601,366
Sharp-shinned hawk	27	2			1,048	409,624
Cooper's hawk	94	4	4	1	5	
Ferruginous hawk	32	5	1		88	3,869,795
Broad-winged hawk	26	10	3	3	1,607	155,067
Harris's hawk	2					
Hawaiian hawk	1		1		2	
White-tailed hawk	3					
Eurasian buzzard	3	1			24	

Table 18. Continued (Page 5 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Northern harrier	119	3	2	3	1	289,575
Old world vultures	2	1		1		
Lappet-faced vulture	1	1	1		240	6,098,523
Falcons and Caracaras	**5,061**	**62**	**109**	**213**	**1,847**	**3,350,228**
Falcons and Caracaras	50	3	4	2	82	56,591
Falcons, kestrels	1			1	13	
Peregrine falcon	311	23	16	13	232	688,603
Gyrfalcon	2					
Merlin	99	2	3	5	25	528,795
Prairie falcon	24	1	2	2		6,112
American kestrel	4,550	28	81	190	1,454	2,070,127
Eurasian kestrel	4	1	1			
Crested caracara	19	4	2		41	
Yellow-headed caracara	1					
Gallinaceous birds	**279**	**68**	**53**	**58**	**3,442**	**6,559,369**
Grouse	6	2		4		
Greater sage-grouse	34	12	6	13	556	507,388
Sharp-tailed grouse	7	1	1		24	804
Ruffed grouse	1					
Spruce grouse	1					
Ptarmigans	3	1	1	2	18	72,317
Willow ptarmigan	6	3	1	4	207	137,633
Rock ptarmigan	1	1				
Quails, pheasants	1	1				17,108
Quails	9		3	2		
Northern bobwhite	13	2	3	2	73	1,157
Scaled quail	5					
Ring-necked pheasant	85	17	13	6	883	110,628
Red-legged partridge	1					
Gray partridge	20	4	4	8	42	5,286,996
Chukar	4		1	1		
Gray francolin	3					
Black francolin	5					
Helmeted guineafowl	2	1		2		
Wild turkey	72	23	20	14	1,639	425,338
Cranes	**132**	**54**	**34**	**38**	**2,415**	**405,732**
Sandhill crane	131	53	34	38	2,367	345,239

Table 18. Continued (Page 6 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Whooping crane	1	1			48	60,493
Rails, gallinules	**329**	**65**	**35**	**16**	**4,521**	**7,937,965**
Rails	8	1	1	1		
Sora	46	4	1	4	107	106,708
Common gallinule	7	1	1		24	1,289
American coot	238	58	30	11	4,309	7,799,361
Eurasian coot	1					
Purple gallinule	5	1	1		72	30,607
Virginia rail	14		1		9	
Clapper rail	9					
Yellow rail	1					
Shorebirds	**7,384**	**153**	**181**	**1,058**	**3,687**	**6,807,614**
Shorebirds	27			9		
American oystercatcher	23			2		
Plovers, lapwings	1			1		
Plovers	62	3	4	10	24	
European golden-plover	5			1		
American golden-plover	151	5	5	43	86	114,141
Black-bellied plover	133	8	5	23	28	211,580
Snowy plover	3			2	1	
Killdeer	4,509	51	74	437	949	4,099,230
Pacific golden-plover	950	11	14	132	212	364,703
Semipalmated plover	82			25		
Piping plover	1	1		1	2	222
Wilson's plover	3					
Northern lapwing	1	1	1	1	25	
Southern lapwing	1	1	1			10,691
Sandpipers, curlews	276	15	27	84	181	208,033
Upland sandpiper	233	7	7	21	17	2,607
Spotted sandpiper	26	2	1	4		
Willet	6			2		
Common snipe	11			1		
American woodcock	87	3	3	5	20	11,882
Dunlin	77	6	6	27	652	295,452
Baird's sandpiper	31	1		4	18	88,633
Western sandpiper	126	4	7	77	175	180,123
Pectoral sandpiper	35	3	3	11	22	158,451
Sanderling	26	1	3	9	6	

Table 18. Continued (Page 7 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Buff-breasted sandpiper	38	1		8		
Ruddy turnstone	21			2		
Bar-tailed godwit	1					
Least sandpiper	136	1	5	37	8	
Semipalmated sandpiper	73		1	31	1	487
Lesser yellowlegs	18	3		4	2	
Short-billed dowitcher	11	3		3	6	10,541
Hudsonian godwit	5	1	1	2	96	34,889
Solitary sandpiper	6	1		2		
Greater yellowlegs	11	5	1	2	120	59,190
Long-billed dowitcher	9			3	1	
Red knot	4		1			
White-rumped sandpiper	9			1		
Black turnstone	1					
Marbled godwit	3	1	1	1	48	173,258
Wilson's snipe	82	5	3	7	27	18,153
Rock sandpiper	1			1		
South American snipe	1					
Stilt sandpiper	1					
Eurasian curlew	1					
Whimbrel	18	2	1	4	360	54,114
Long-billed curlew	7	1	1	1	504	698,163
Red-necked phalarope	10	2	1	4	60	
Wilson's phalarope	14	3	3	7	36	13,071
Red phalarope	1					
American avocet	6	1	1	3		
Black-necked stilt	9			3		
Double-striped thick-knee	1					
Jaegers	**6**					
Parasitic jaeger	2					
Long-tailed jaeger	4					
Gulls	**10,586**	**1,446**	**1,204**	**2,188**	**60,005**	**58,887,723**
Gulls	6,591	1,097	889	1,611	41,073	29,558,039
Herring gull	1,210	116	109	132	2,362	4,843,913
Mew gull	65	6	4	10	28	104,003
Ring-billed gull	1,534	122	110	264	8,762	4,574,981
Glaucous-winged gull	126	24	15	15	301	1,810,776
Great black-backed gull	112	12	8	11	199	1,935,667

Table 18. Continued (Page 8 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Franklin's gull	122	6	9	41	44	210,889
Laughing gull	439	19	24	53	737	730,533
Bonaparte's gull	45	2	3	11		94,012
Lesser black-backed gull	6	2	1	1		
Western gull	129	15	8	11	231	2,065,335
California gull	174	19	18	21	5,061	712,588
Heermann's gull	1			1		
Black-headed gull	7	1	1		250	8,918
Thayer's gull	3					
Yellow-legged gull	3	3	3	3	456	11,913,382
Glaucous gull	19	2	2	3	501	324,687
Terns, kittiwakes	**197**	**8**	**7**	**36**	**92**	**192,618**
Terns	49	2		16		
White-winged tern	2			1		
Little tern	2			1		
Caspian tern	24	1		1		97,398
Common tern	19	1		3		79,117
Sandwich tern	2					
Gull-billed tern	4					
Black tern	2				2	
Fairy tern	3					
White tern	8	1	2	2	34	
Arctic tern	5	1		2		
Roseate tern	1					
Forster's tern	12		1	2	4	
Least tern	24			3		
Black noddy	6			2		
Brown noddy	8		1	1		
Royal tern	5		1	1	3	
Sooty tern	4	1	1		48	16,000
Black-legged kittiwake	3					
Red-legged kittiwake	1					
Black skimmer	11	1		1		
Pigeon guillemot	1					
Puffins	1		1		1	103
Pigeons, doves	**12,196**	**497**	**643**	**2,373**	**28,479**	**22,354,509**
Pigeons, doves	29	4	5	12	1,637	678
Pigeons	14	1	2	5	6	

Table 18. Continued (Page 9 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Common wood-pigeon	6			1		
Band-tailed pigeon	19	6	1	3	184	193,902
Rock pigeon	2,899	247	265	900	14,522	12,036,517
Picazuro pigeon	1					
Doves	1,050	46	89	240	645	648,936
Eurasian collared dove	23		1	4	24	1,000
Mourning dove	7,566	182	262	1,165	11,161	9,113,292
Spotted dove	196	4	10	10	137	356,965
Zebra dove	295	3	8	26	32	1,111
Inca dove	15			1		
Island turtle-dove	7					
White-winged dove	64	3		6	102	2,108
Common ground-dove	7					
Zenaida dove	4	1			29	
Ruddy ground-dove	1					
Parrots	**26**			**3**	**5**	**7,305**
Parrots	3			1		
Budgerigar	15					
Monk parakeet	4			1		
Olive-throated parakeet	1			1		
Nanday parakeet	3				5	7,305
Cuckoos	**59**	**9**	**2**	**6**	**710**	**228,370**
Cuckoos	9	3		2	684	175,936
Yellow-billed cuckoo	41	6	2	4	25	52,434
Common cuckoo	1					
Black-billed cuckoo	5				1	
Philippine drongo-cuckoo	1					
Greater roadrunner	2					
Owls	**2,585**	**141**	**90**	**30**	**3,017**	**9,788,136**
Owls	305	32	20	6	986	502,372
Barn owl	1,133	40	28	16	370	3,066,199
Snowy owl	199	18	12	1	858	1,856,103
Little owl	1					
Short-eared owl	461	10	14	3	132	1,548,246
Long-eared owl	16	3	1		24	52,707
Northern saw-whet owl	7	1			96	
Burrowing owl	199	2	1	2	8	827
Barred owl	25	1	1			167

Table 18. Continued (Page 10 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Northern pygmy-owl	1					
Great gray owl	2					
Eastern screech-owl	5	2			24	13,498
Western screech-owl	2					
Great horned owl	228	32	13	2	519	2,748,017
Northern hawk-owl	1					
Nightjars	**592**	**3**	**3**	**29**	**69**	
Nightjars	10					
Whip-poor-will	8			2		
Common poorwill	11			1		
Lesser nighthawk	12					
Chuck-will's-widow	12		1		1	
Common nighthawk	527	3	2	26	68	
Common pauraque	10					
Nacunda nighthawk	1					
Antillean nighthawk	1					
Swifts	**637**	**10**	**12**	**53**	**1,275**	**34,571**
Swifts	15	1	1	3	1	
Black swift	3					
Chimney swift	524	7	9	48	1,247	34,571
Common swift	8	1		1		
Vaux's swift	46				24	
White-throated swift	41	1	2	1	3	
Hummingbirds	**43**			**1**		
Hummingbirds	1					
Ruby-thrd hummingbird	21					
Rufous hummingbird	8			1		
Anna's hummingbird	9					
Blk-chinned hummingbird	2					
Allen's hummingbird	1					
Calliope hummingbird	1					
Belted kingfisher	**11**					
Woodpeckers	**199**	**16**	**7**	**7**	**447**	**153,038**
Woodpeckers	12	1	1		1	
Northern flicker	105	8	1	2	274	119,176
Yellow-bellied sapsucker	66	6	2	5	171	14,846
Hairy woodpecker	3					
Red-naped sapsucker	4	1	2			19,016

Table 18. Continued (Page 11 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Downy woodpecker	4		1		1	
Red-bellied woodpecker	2					
Red-breasted sapsucker	2					
Red-headed woodpecker	1					
Unidentified passiformes	**727**	**24**	**20**	**49**	**170**	**147,949**
Flycatchers	**657**	**6**	**8**	**45**	**16**	**18,579**
Tyrant flycatchers	36			6	1	805
Eastern wood-pewee	11			4		
Gray kingbird	1					
Great crested flycatcher	10					
Eastern kingbird	42	1	1	1		13,446
Scissor-tailed flycatcher	198	1	4	11		652
Acadian flycatcher	4					
Say's phoebe	6					
Western kingbird	255	3	2	16	3	1,540
Ash-throated flycatcher	4					
Great kiskadee	1					
Western wood-pewee	4					
Sulphur-bellied flycatcher	1					
Eastern phoebe	19			2		
Yellow-bellied flycatcher	10			2		616
Least flycatcher	10					
Hammond's flycatcher	6					
Pacific-slope flycatcher	17			1	10	1,500
Gray flycatcher	3			1	1	20
White-crested elaenia	1					
Willow flycatcher	4			1		
Alder flycatcher	11	1				
Cordilleran flycatcher	2				1	
Dusky flycatcher	1		1			
Larks	**3,774**	**18**	**40**	**602**	**261**	**919,368**
Eurasian skylark	82			4	1	
Horned lark	3,692	18	40	598	260	919,368
Swallows	**7,789**	**39**	**124**	**1,640**	**789**	**471,637**
Swallows	1,012	7	41	305	61	478
Purple martin	172	10	4	41	305	109,642
Bank swallow	385	2	6	143	13	8,122
Barn swallow	4,105	15	53	754	331	86,159

Table 18. Continued (Page 12 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Cliff swallow	1,373	3	12	218	62	264,601
Tree swallow	641		7	167	15	2,635
Violet-green swallow	24	1		1		
N. rough-winged swallow	64	1	1	6	2	
Cave swallow	13			5		
Black drongo	**12**			**2**		
Starlings, mynas	**4,029**	**131**	**190**	**1,373**	**3,113**	**7,127,433**
European starling	3,930	129	184	1,348	3,070	7,127,433
Common myna	99	2	6	25	43	
Crows, ravens	**694**	**66**	**57**	**86**	**9,677**	**2,700,620**
Crows, ravens	2	1		1		
Crows	195	20	12	34	18	126,078
American crow	442	33	38	46	6,464	1,833,405
Carrion crow	2					
Hooded crow	1	1	1			
Northwestern crow	7			1		
Rook	1					
Ravens	1	1			6	19,480
Common raven	43	10	6	4	3,189	721,657
Jays, magpies	**49**	**3**	**2**	**6**	**2**	**940**
Blue jay	26			1	1	
Gray jay	1					
Magpies	2					
Yellow-billed magpie	8			2		
Black-billed magpie	12	3	2	3	1	940
Chickadees, nuthatches	**31**	**1**		**9**		
Chickadees	1					
Black-capped chickadee	23	1		6		
Mountain chickadee	1			1		
Gray-headed chickadee	1			1		
Carolina chickadee	2			1		
Bushtit	2					
White-breasted nuthatch	1					
Red-vented bulbul	**4**			**1**		
Wrens	**134**	**3**	**4**	**12**	**34**	**30,430**
Wrens	52	1	2	9		
Marsh wren	20	1	2	1	32	29,917
House wren	36	1		1	1	513

Table 18. Continued (Page 13 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Carolina wren	6			1		
Rock wren	2					
Cactus wren	4					
Winter wren	9				1	
Bewick's wren	2					
Sedge wren	3					
Mimics	**257**	**3**	**3**	**14**	**134**	**2,009,396**
Brown thrasher	19	1		1	103	2,000,226
Sage thrasher	2					
Curve-billed thrasher	1					
Long-billed thrasher	1			1		
Mockingbirds	2			1		
Northern mockingbird	101	2	2	2		
Tropical mockingbird	1					
Gray catbird	130		1	9	31	9,170
Thrushes	**1,501**	**102**	**53**	**112**	**3,829**	**4,091,118**
Thrushes	44	3	1	2	7	33,191
Western bluebird	6	1			21	1,120
Swainson's thrush	161	12	5	14	61	2,553,118
Redwing	1					
American robin	971	70	38	67	2,973	1,454,753
Song thrush	1			1		
Hermit thrush	161	5	3	8	732	12,571
Eastern bluebird	10			1		
Gray-cheeked thrush	21		2	3		
Varied thrush	47	10	1	7	32	36,010
Wood thrush	32	1	1	5		355
Mountain bluebird	29			4		
Veery	17		2		3	
Wrentits, gnatcatchers	**18**		**1**	**2**	**2**	
Wrentit	1					
Blue-gray gnatcatcher	17		1	2	2	
Kinglets	**110**		**2**	**8**	**7**	**300**
Golden-crowned kinglet	27			2		
Ruby-crowned kinglet	83		2	6	7	300
Pipits	**146**	**1**	**2**	**28**	**28**	
Meadow pipit	1					
American pipit	139	1	2	28	28	

Table 18. Continued (Page 14 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Sprague's pipit	6					
Waxwings	**189**	**7**	**5**	**43**	**324**	**355,761**
Bohemian waxwing	3			2		
Cedar waxwing	186	7	5	41	324	355,761
Shrikes	**24**		**1**	**1**		
Northern shrike	1					
Loggerhead shrike	23		1	1		
Vireos	**163**	**3**	**3**	**12**	**40**	**11,393**
Vireos	4					
White-eyed vireo	7			1	2	10
Blue-headed vireo	10			2	5	
Yellow-throated vireo	3					
Warbling vireo	25	1		1	3	8,712
Red-eyed vireo	106	2	3	8	30	2,671
Cassin's vireo	3					
Philadelphia vireo	5					
Japanese white-eye	**2**					
Warblers	**1,026**	**8**	**14**	**66**	**266**	**21,918**
Wood warblers	83	1		8		1,939
Canada warbler	19		2		2	105
Yellow-breasted chat	13			1		
Pine warbler	18			2		
Black-and-white warbler	26			1		
Northern parula	15			1	24	2,165
Ovenbird	64	1	1	3	9	1,928
Wilson's warbler	53			1	4	5,918
Common yellowthroat	80	1	1	4	2	257
Yellow-rumped warbler	185		3	12	14	539
Blackpoll warbler	55			4	4	1,381
Mourning warbler	6					
American redstart	37	1	1	3	12	
Orange-crowned warbler	24					
Yellow warbler	48	2	1	4	169	
Cape May warbler	3					
Hooded warbler	2	1				
Prairie warbler	6					
Northern waterthrush	33			2	11	
Nashville warbler	27		1	2		

Table 18. Continued (Page 15 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Townsend's warbler	18		1	1		102
Palm warbler	44		2	4	3	7,379
Magnolia warbler	30		1	2	6	205
Bk-throated blue warbler	22					
Prothonotary warbler	2					
MacGillivray's warbler	6					
Yellow-throated warbler	21			3		
Bk-throated gray warbler	2				2	
B-throated green warbler	14			1		
Hermit warbler	1					
Tennessee warbler	24			3	2	
Chestnut-sided warbler	11			1		
Blackburnian warbler	9					
Bay-breasted warbler	6			1		
Connecticut warbler	1					
Kentucky warbler	14			2	2	
Worm-eating warbler	3	1				
Blue-winged warbler	1					
Meadowlarks	**3,284**	**28**	**53**	**302**	**425**	**1,007,311**
Meadowlarks	522	4	11	48	17	732
Eastern meadowlark	1,687	9	26	138	188	634,539
Western meadowlark	1,075	15	16	116	220	372,040
Blackbirds, grackles	**2,308**	**111**	**132**	**548**	**1,628**	**1,804,241**
Blackbirds	1,276	80	89	365	607	1,464,254
Red-winged blackbird	326	5	15	42	36	21,702
Yellow-headed blackbird	15	2	1	2	7	24,350
Brewer's blackbird	61	1	1	9	1	
Brown-headed cowbird	218	2	5	55	24	6,200
Bobolink	30		1	3	2	
Rusty blackbird	5					
Tricolored blackbird	1					
Grackles	147	11	5	31	728	213,036
Common grackle	161	7	11	34	175	74,407
Boat-tailed grackle	26	2	3	2	48	
Great-tailed grackle	42	1	1	5		292
Orioles	**35**	**1**	**3**	**2**	**2**	**216**
Orioles	4					
Baltimore oriole	22	1	2	2	2	216

Table 18. Continued (Page 16 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Orchard oriole	3					
Bullock's oriole	7		1			
Hooded oriole	3					
Tanagers	**40**	**3**	**1**	**4**	**87**	**1,169**
Scarlet tanager	21	2		2	81	
Western tanager	14	1	1	1	6	1,169
Summer tanager	5			1		
Finches	**1,063**	**13**	**43**	**286**	**246**	**34,389**
Finches	93	1	5	22	7	
Lapland longspur	59	1	4	23	25	
Chtnut-collared longspur	2					
Dark-eyed junco	149	2	2	7	75	11,470
Rose-breasted grosbeak	14		1	2	4	819
Common Chaffinch	2					
Island canary	1					
Pine siskin	21	2		9	3	
Common redpoll	2					974
Purple finch	5					
Red crossbill	3			1		
Evening grosbeak	1					
American goldfinch	64		2	2	3	
House finch	120	1	2	10	15	50
Smith's longspur	7			1		
Dickcissel	19	1		3		1,127
White-winged crossbill	1					
Red avadavat	7			3		
McCown's longspur	1					
Lesser goldfinch	4					
Black-headed grosbeak	6					
Cassin's finch	1					
Pine grosbeak	1					
Gr-crowned Rosy-Finch	1					
Blue grosbeak	5					
Hoary redpoll	2			1		
Red-crested cardinal	6			1	1	
Northern cardinal	13					
Snow bunting	293	4	24	178	107	19,949
Indigo bunting	27		2	2	4	

Table 18. Continued (Page 17 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Lazuli bunting	4					
Lark bunting	123	1		19	2	
McKay's bunting	1		1	1		
Painted bunting	4					
Black-faced bunting	1			1		
Sparrows	**4,578**	**68**	**129**	**845**	**1,183**	**926,633**
Sparrows	3,168	48	114	742	683	78,987
Harris's sparrow	6			1		
Swamp sparrow	60			3	5	1,000
Savannah sparrow	486	5	6	28	32	20,811
Fox sparrow	48	3	1	3	25	59,630
White-throated sparrow	208	3	3	21	43	20,216
Golden-crowned sparrow	6			1		
Field sparrow	47			4	1	
Lark sparrow	23	1		2		15,000
White-crowned sparrow	75	4	2	4	371	679,000
Grasshopper sparrow	76	2	1	3	9	33,884
Java sparrow	3			1		
Vesper sparrow	49	1		5		
Chipping sparrow	71	1		6		105
Lincoln's sparrow	52		2	2	4	16,427
Song sparrow	136			16	8	1,094
Sage sparrow	7				1	
American tree sparrow	26			2		257
Nelson's s-tailed sparrow	5				1	222
Black-throated sparrow	1					
Brewer's sparrow	13			1		
Le Conte's sparrow	4					
Cassin's sparrow	3					
Clay-colored sparrow	4					
Baird's sparrow	1					
Towhees	**37**	**1**		**1**	**9**	**15,003**
Eastern towhee	25	1		1	9	15,003
Green-tailed towhee	5					
California towhee	1					
Spotted towhee	6					
Waxbills, mannikins	**277**		**2**	**77**	**21**	**9,958**
Waxbills, mannikins	3					

Table 18. Continued (Page 18 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Common waxbill	7			1		
Munias	122			13		
Scaly-breasted munia	87		1	37	19	6,744
Chestnut munia	53		1	22	2	3,214
White-throated munia	5			4		
House sparrow	**236**	**3**	**3**	**24**	**30**	**2,226**
Total known birds	**86,543**	**7,012**	**5,597**	**14,489**	**455,640**	**533,963,041**
Total unknown birds	**77,901**	**6,546**	**4,288**	**7,747**	**176,721**	**132,130,177**
Unknown bird-?size	**6,979**	**473**	**431**	**387**	**11,165**	**4,387,545**
Unknown bird - large	**2,795**	**1,070**	**527**	**291**	**48,730**	**52,248,896**
Unknown bird - medium	**34,760**	**4,048**	**2,118**	**2,724**	**93,736**	**56,808,021**
Unknown bird - small	**33,367**	**955**	**1,212**	**4,345**	**23,090**	**18,685,715**
Total birds[4]	**164,444**	**13,558**	**9,885**	**22,236**	**632,361**	**666,093,218**
Flying mammals (bats)						
Megabats (fruit bats)	**14**	**2**	**2**	**4**	**99**	**4,562,642**
Megabats (unk spp)	13	2	2	4	99	4,562,642
Flying fox	1					
Microbats (echo locating)	**1,557**	**8**	**9**	**112**	**130**	**21,741**
Microbats (unk spp)	734	5	5	66	51	1,719
Vesper bats	62			1	1	1,282
Red bat	125	2		8	50	13,308
Hoary bat	63			2	7	2,853
East small-footed myotis	1					
Little brown bat	111			4		
Big brown bat	71		2	6		
Silver-haired bat	48			2	3	900
Seminole bat	4					
Eastern pipistrelle	15					
Northern yellow bat	3					
Evening bat	9					
Indiana bat	2					
Yuma myotis	1					
Long-eared myotis	1					
Western yellow bat	1					
Common pipistrelle	1					
Long-legged myotis	1					
Free-tailed bats	59			7	12	551

Table 18. Continued (Page 19 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Brazilian free-tailed bat	235	1	2	15	6	1,128
Pocketed free-tailed bat	2					
Big free-tailed bat	1					
Western mastiff bat	2					
Florida bonneted bat	1					
Gray sac-winged bat	1					
Jamaican fruit bat	3			1		
Total known bats	**1,571**	**10**	**11**	**116**	**229**	**4,584,383**
Total unkn-Mega or Micro	**10**	**1**		**1**		**9,823**
Total bats[5]	**1,581**	**11**	**11**	**117**	**229**	**4,594,206**
Terrestrial mammals						
Marsupials (Vir. opossum)	**208**	**1**		**1**		
Xenarthyras (armadillo)	**32**	**1**	**4**		**11**	**1,302**
Lagomorphs	**556**	**8**	**10**	**8**	**21**	**130,571**
Lagomorphs	1	1				
Hares	7		1		1	
Black-tailed jackrabbit	287	4	2	1	12	34,260
White-tailed jackrabbit	47		1	2	1	
Antelope jackrabbit	1					
Rabbits	100		2	5	1	
Eastern cottontail	85	3	4		6	96,311
Desert cottontail	28					
Rodents	**265**	**2**	**8**	**5**	**6**	**488**
North American beaver	2					
Prairie dogs	1					
Black-tailed prairie dog	49		1	2		
White-tailed prairie dog	5					
Gunnison's prairie dog	15		1	3		
Woodchuck	148	2	6		6	488
Yellow-bellied marmot	1					
Fox squirrel	1					
Muskrat	27					
N. American porcupine	15					
Coypu (nutria)	1					
Carnivores	**1,327**	**75**	**147**	**19**	**17,309**	**4,301,186**
Canids	4	1	1			
Coyote	503	44	94	6	14,209	3,779,688

Table 18. Continued (Page 20 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Domestic dog	45	15	24	1	559	400,700
Foxes	66	4	7	1	10	1,085
Red fox	156	4	13		364	59,326
Common gray fox	10	2	2		5	526
Kit fox	4					
Raccoon	111	4	4	4	2,160	59,861
White-nosed coati	1					
Ringtail	1					
Skunks	57		1	2	2	
Striped skunk	321			5		
River otter	2	1				
Badger	5					
Mink	6					
Domestic cat	31					
Small Indian mongoose	3					
American black bear	1		1			
Artiodactyls	**1,155**	**976**	**533**	**90**	**298,821**	**55,917,721**
Deer	18	16	9		696	275,936
White-tailed deer	1,016	851	464	79	248,023	45,749,554
Mule deer	79	71	36	3	21,409	1,474,032
Wapiti (elk)	11	11	5	1	11,660	7,627,167
Moose	5	4	4			
Caribou	2	2	1			
Cattle	11	11	8	4	9,215	508,376
Pronghorn	9	8	5	2	5,130	245,538
Swine (pigs)	2	1			2,688	37,118
Collared peccary	2	1	1	1		
Perissodactyls	**4**	**4**	**3**		**1,008**	**37,332**
Horse	3	3	3		1,008	37,332
Burro	1	1				
Total known t. mammals	**3,547**	**1,067**	**705**	**123**	**317,176**	**60,388,600**
Unkn terrestrial mammals	**25**	**7**	**8**	**1**		
Total t. mammals[6]	**3,572**	**1,074**	**713**	**124**	**317,176**	**60,388,600**
Reptiles						
Turtles	**213**	**1**	**4**	**2**		
Turtles	67		2			
Florida soft shell turtle	10	1	1			

Table 18. Continued (Page 21 of 22)

Wildlife group or species	26-year totals (1990–2015)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With neg. EOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Pond slider	3					
Eastern mud turtle	1					
Chicken turtle	1					
Striped mud turtle	1					
Eastern box turtle	11					
Common snapping turtle	28		1			
Diamondback terrapin	43			2		
Painted turtle	24					
Florida red-bellied cooter	2					
Gopher tortoise	18					
Alligator snapping turtle	1					
Coastal plain cooter	3					
American alligator	**19**	**1**	**2**		**3**	
Green iguana	**11**		**4**			
Snakes	**16**					
Snakes	6					
Bull snake	5					
Northern water snake	2					
E. d-back rattlesnake	1					
Water moccasin	1					
Eastern pine snake	1					
Total reptiles[7]	**259**	**2**	**10**	**2**	**3**	
Total known (all species)	**91,920**	**8,091**	**6,323**	**14,730**	**773,048**	**598,936,024**
Total (unknown species)	**77,936**	**6,554**	**4,296**	**7,749**	**176,721**	**132,140,000**
Grand total	**169,856**	**14,645**	**10,619**	**22,479**	**949,769**	**731,076,024[8]**

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] These reported economic losses by species and species groups should be considered as relative indices of losses and not as actual estimated losses. For commercial aviation, an estimated 20 percent of strikes were reported in the 1990s. More recent analyses estimated that strike reporting for all civil aircraft combined (commercial and general aviation) at Part 139 airports had improved to 39 percent in 2004-2008 and to 47 percent in 2009-2013 (Dolbeer 2009, 2015). Strike reporting for commercial aircraft only at Part 139 airports was an estimated 79 percent in 2004-2008 and 91 percent in 2009-2013; reporting of strikes with damage was estimated at 78% and 93 percent for these respective time periods. In addition, only about 53 percent of reported strikes identified the wildlife species or species group responsible, 1990–2015. Furthermore, of the 14,645 reports indicating damage to the aircraft, only 27 percent (3,945) also provided an estimate of repair costs, and only 35 percent (8,911) of the 25,264 strikes indicating an adverse effect estimated the

Table 18. Continued (Page 22 of 22)

downtime (see Tables 23, 24). Finally, even when cost estimates were provided, some reports were filed before aircraft damage had been fully assessed. See Tables 23 and 24 for a more detailed projection of actual economic losses.

[3] More than 1 animal was struck by the aircraft.

[4] Of the 164,444 reported bird strikes, 67,061 (41 percent) identified the bird to exact species (529 species total of which 252 caused damage) and an additional 19,482 strikes (12 percent) identified the bird at least to species group (e.g., gull, hawk, duck). Exact species identification has improved from less than 20 percent in the early 1990s to 56-60 percent in 2012-2015 (Figure 7).

[5] Of the 1,581 reported bat strikes, 702 (44 percent) identified the bat to exact species (22 species total of which 2 caused damage) and 869 (55 percent) identified the bat to species group (14 megabats [old world fruit bats], 855 microbats [echo-locating bats]). There were 10 bat strikes classified as unknown bat (either megabat or microbat).

[6] Of the 3,572 reported terrestrial mammal strikes, 3,293 (92 percent) identified the mammal to exact species (43 species total of which 22 caused damage) and 254 (7 percent) identified the mammal at least to species group.

[7] All of the 259 reported reptile strikes were identified to species group and 183 (71 percent) were identified to exact species (18 species total of which 2 caused damage).

[8] Reported costs of $731,076,024 include $649,328,522 in direct repair costs and $81,747,502 in other costs.

Table 19. Number of reported strikes, strikes with damage, and strikes involving multiple animals for the five most commonly struck bird groups and three most commonly struck terrestrial mammal groups, civil aircraft, USA[1], 1990–2015.

	Reported strikes		Strikes with damage		Strikes with >1 animal	
Species group[2]	26-year total	% of total known	26-year total	% of total known	26-year total	% of total known
Birds						
Doves/pigeons	12,196	14	497	7	2,373	16
Raptors[3]	10,999	13	1,490	21	403	3
Gulls	10,586	12	1,446	21	2,188	15
Shorebirds	7,384	9	153	2	1,058	7
Waterfowl	4,951	6	2,011	29	1,710	12
All other known	40,427	47	1,415	20	6,757	47
Total known birds	**86,543**	**100**	**7,012**	**100**	**14,489**	**100**
Unknown birds	**77,901**		**6,546**		**7,747**	
Total birds	**164,444**		**13,558**		**22,236**	
Terrestrial mammals						
Carnivores	1,327	37	75	7	19	15
Artiodactyls	1,155	33	976	91	90	73
Lagomorphs	556	16	8	1	8	7
All other known	509	14	8	1	6	5
Known t. mammals	**3,547**	**100**	**1,067**	**100**	**123**	**100**
Unknown t. mammals	**25**		**7**		**1**	
Total t. mammals	**3,572**		**1,074**		**124**	

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] See Table 18 for listing of species within each species group and Table 20 for the most frequently struck species.

[3] Hawks, eagles, vultures, falcons, and caracaras.

Table 20. The 30 species of birds identified most frequently as struck by civil aircraft in USA, 1990–2015 and 2015 only. See Figure 13 for relation between mean body mass of species and percent of strikes causing damage.

	Strikes (1990–2015)[1]			Strikes (2015 only)[1]		
Rank	Bird species	Number	% causing damage	Bird species	Number	% causing damage
1	Mourning dove	7,566	2.4	Mourning dove	693	1.7
2	American kestrel	4,550	0.6	Barn swallow	618	0.2
3	Killdeer	4,509	1.1	Killdeer	607	0.8
4	Barn swallow	4,105	0.4	Horned lark	503	0.2
5	European starling	3,930	3.3	American kestrel	496	0.4
6	Horned lark	3,692	0.5	European starling	268	1.5
7	Rock pigeon	2,899	8.5	Eastern meadowlark	257	0.0
8	Red-tailed hawk	2,243	14.4	Cliff swallow	247	0.0
9	Eastern meadowlark	1,687	0.5	Red-tailed hawk	206	12.6
10	Canada goose	1,584	49.3	Rock pigeon	172	1.7
11	Ring-billed gull	1,534	8.0	Western meadowlark	169	1.8
12	Cliff swallow	1,373	0.2	American robin	153	7.8
13	Herring gull	1,210	9.6	Ring-billed gull	115	7.0
14	Barn owl	1,133	3.5	Chimney swift	108	0.9
15	Western meadowlark	1,075	1.4	Barn owl	106	1.9
16	American robin	971	7.2	Tree swallow	87	0.0
17	Pacific golden-plover	950	1.2	Savannah sparrow	83	0.0
18	Mallard	867	22.4	Pacific golden-plover	76	3.9
19	Tree swallow	641	0.0	Herring gull	76	7.9
20	Turkey vulture	639	50.9	Common nighthawk	63	0.0
21	Common nighthawk	527	0.6	Mallard	61	13.1
22	Chimney swift	524	1.3	Canada goose	59	40.7
23	Savannah sparrow	486	1.0	Turkey vulture	54	53.7
24	Short-eared owl	461	2.2	Bank swallow	51	0.0
25	American crow	442	7.5	Red-winged blackbird	51	0.0
26	Laughing gull	439	4.3	White-throated sparrow	46	2.2
27	Bank swallow	385	0.5	Western kingbird	45	0.0
28	Cattle egret	378	8.7	Yellow-rumped warbler	42	0.0
29	Great blue heron	366	20.2	Cedar waxwing	40	0.0
30	Osprey	326	21.2	House sparrow	40	0.0

[1] Actual number struck was higher for each species because only 41% and 58% of the bird strike reports from 1990–2015 and in 2015, respectively, identified the bird to species. For example, there were 6,591 gull strikes reported from 1990-2015 in which the species of gull was not determined (Table 18).

Table 21. Number of strikes to civil aircraft causing human fatality or injury and number of injuries and fatalities by wildlife species, USA[1], 1990–2015.

Species of wildlife	No. of strikes	No. of humans		Species of wildlife	No. of strikes	No. of humans
Strikes causing fatalities				**Strikes causing injuries (continued)**		
Unknown bird	6	8		Snow goose	3	3
Red-tailed hawk	1	8		Osprey	3	3
Amer. white pelican	1	5		Herring gull	3	3
Canada goose	1	2		Rock pigeon	3	3
White-tailed deer	1	1		Domestic dog	1	2
Brown pelican	1	1		Mule deer	1	2
Turkey vulture	1	1		Red-throated loon	1	2
Total fatalities	**12**	**26**		Sharp-tailed grouse	1	2
Strikes causing injuries				Eastern cottontail	1	1
Canada goose	15	117		Horse	1	1
Unknown bird	46	61		Horned grebe	1	1
White-tailed deer	19	27		Tropicbirds	1	1
Ducks	17	20		Red-tailed tropicbird	1	1
Turkey vulture	15	18		Great frigatebird	1	1
Black vulture	9	14		Magnificent frigatebird	1	1
New World Vultures	10	10		Egrets	1	1
Ring-billed gull	3	9		Snowy egret	1	1
Red-tailed hawk	7	9		White ibis	1	1
Gulls	8	9		Long-tailed duck	1	1
Bald eagle	4	7		Cackling goose	1	1
Geese	7	7		Sandhill crane	1	1
Mallard	5	6		Franklin's gull	1	1
American kestrel	1	5		Doves	1	1
Hawks	3	5		Mourning dove	1	1
D cormorant	4	5		Owls	1	1
Eurasian kestrel	1	4		American robin	1	1
Spotted dove	1	4		Baltimore oriole	1	1
Golden eagle	2	4		Great-tailed grackle	1	1
Anhinga	3	4		Sparrows	1	1
Lesser scaup	4	4		**Total injuries**	**229**	**400**
American coot	4	4				
Cattle	2	3				
Western grebe	2	3				

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

Table 22. Number of civil aircraft lost (destroyed or damaged beyond repair) after striking wildlife by wildlife species and aircraft mass category, USA[1], 1990–2015. See Figure 14 for number of lost aircraft by year, 1990–2015.

Wildlife species or species group	Aircraft[2] mass category (Maximum take-off mass in kilograms) ≤2,250	2,251-5,700	5,701-27,000	>27,000	Total aircraft lost
White-tailed deer	15	6	2		23
Unknown bird	11	2	2		15
Canada goose	1	3		1	5
Cattle	2	1			3
Turkey vulture	3				3
Bald eagle	2				2
Hawks	2				2
Eastern cottontail	1				1
Coyote			1		1
Domestic dog	1				1
Mule deer	1				1
Wapiti (elk)			1		1
Brown pelican	1				1
A. white pelican		1			1
D.-crested cormorant	1				1
Ducks	1				1
New World Vultures	1				1
Red-tailed hawk		1			1
Eurasian kestrel				1	1
Herring gull		1			1
Ring-billed gull		1			1
Mourning dove			1		1
Total	**43**	**16**	**7**	**2**	**68**

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] Engine types on the 68 destroyed aircraft were piston (49), turbofan (8), turboprop (5), turbojet (3), and turboshaft (3). Aircraft operators were business (38), private (24), commercial transport (5), and government (1).

[3] Forty-one (60 percent) of the 68 wildlife strikes resulting in a destroyed aircraft occurred at general aviation airports, 15 occurred “en route”, 7 occurred at USA airports certificated for passenger service under 14 CFR Part 139, 3 occurred in miscellaneous situations (taking off from river, herding cattle, aerial application of pesticides) and 2 occurred at foreign airports.

Table 23. Number of reported wildlife strikes indicating damage, a negative effect-on-flight (EOF), aircraft downtime, repair costs, and other costs; and the mean losses per report in hours of downtime and inflation-adjusted U.S. dollars, for civil aircraft, USA[1], 1990–2015.

	Number of reports indicating:					Mean losses per report[2]		
Year	Dam-age	Neg. EOF	Aircraft down time	Repair costs	Other costs	Down-time (hours)	Repair costs ($)	Other costs ($)
1990	369	146	60	33	16	56.4	216,810	62,238
1991	399	183	61	49	25	79.8	74,627	40,228
1992	365	218	81	51	28	111.9	107,131	5,391
1993	399	240	67	57	19	277.9	91,290	9,636
1994	460	272	103	73	29	388.4	78,548	93,798
1995	496	307	95	62	33	96.3	517,455	225,899
1996	502	355	144	86	39	137.3	86,998	26,034
1997	578	379	182	126	47	230.7	78,157	40,911
1998	584	400	205	135	54	119.5	203,741	29,049
1999	703	445	282	179	79	148.8	111,634	21,147
2000	762	477	351	205	93	195.2	99,945	116,380
2001	645	434	293	157	65	142.6	289,486	39,707
2002	671	498	383	166	63	135.6	152,429	64,633
2003	632	438	355	172	81	111.8	162,014	42,903
2004	626	429	325	213	92	166.3	105,648	22,806
2005	605	452	328	227	125	87.7	270,237	77,850
2006	597	429	333	172	102	116.8	217,940	13,553
2007	570	453	364	178	135	165.2	175,566	33,799
2008	525	408	371	156	141	116.2	121,366	14,416
2009	604	518	563	195	193	80.8	373,760	14,640
2010	596	467	528	174	165	66.3	128,480	13,571
2011	542	498	526	179	208	70.8	233,142	15,020
2012	611	539	687	228	263	75.6	108,771	8,343
2013	606	521	801	244	302	75.8	62,255	12,252
2014	582	571	717	218	273	63.2	129,913	10,444
2015	616	542	706	210	292	47.9	139,574	18,378
Total	**14,645**	**10,619**	**8,911**	**3,945**	**2,962**			
Mean	**563**	**408**	**343**	**152**	**114**	**106.6**	**164,595**	**27,599**

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] See Table 18 for actual losses reported in total and by species of wildlife, 1990-2015.

Table 24. Minimum projected annual losses in aircraft downtime (hours) and in repair and other costs (inflation-adjusted U.S. dollars) from wildlife strikes with civil aircraft, USA[1], 1990–2015. Losses are projected from mean reported losses per incident (Table 23). (Page 1 of 2).

Year	No. of adverse incidents[4]	Minimum projected losses[2, 3]			
		Down-time (hours)	Repair costs (x $1 million)	Other costs (x $1 million)	Total costs (x $1 million)
1990	424	23,892	92	26	118
1991	483	38,521	36	19	55
1992	493	55,179	53	3	55
1993	509	141,456	46	5	51
1994	582	226,070	46	55	100
1995	655	63,052	339	148	487
1996	684	93,891	60	18	77
1997	783	180,606	61	32	93
1998	806	96,319	164	23	188
1999	979	145,649	109	21	130
2000	1,112	217,046	111	129	241
2001	977	139,314	283	39	322
2002	1,104	149,706	168	71	240
2003	998	111,602	162	43	205
2004	950	158,029	100	22	122
2005	975	85,550	263	76	339
2006	941	109,910	205	13	218
2007	979	161,772	172	33	205
2008	905	105,126	110	13	123
2009	1,185	95,777	443	17	460
2010	1,128	74,777	145	15	160
2011	1,145	81,036	267	17	284
2012	1,330	100,611	145	11	156
2013	1,444	109,457	90	18	108
2014	1,456	92,078	189	15	204
2015	1,451	69,497	203	27	229
Total	**24,478**	**2,925,926**	**4,062**	**909**	**4,971**
Mean	**941**	**112,536**	**156**	**34**	**191**

Table 24. Continued (Page 2 of 2).

[1] Includes strikes to U.S.-registered aircraft in foreign countries.

[2] Minimum values are based on the assumption that all 24,478 reported strikes (mean of 941/year) indicating an adverse effect (see footnote 3) incurred similar amounts of damage and/or downtime and that these reports are all of the adverse-effect strikes that occurred, 1990–2015.

[3] Analyses of strike data from 1991-2004 indicated that 11 to 21 percent of strikes were reported for air carrier aircraft at Part 139 airports certificated for passenger traffic (Linnell et al. 1999, Cleary et al. 2005, Wright and Dolbeer 2005). Strike reporting for general aviation (GA) aircraft at GA airports was estimated at less than 5 percent in the 1990s and early 2000s (Dolbeer et al. 2008, Dolbeer 2009). More recent analyses estimated that strike reporting for all civil aircraft combined (commercial and general aviation) at Part 139 airports had improved to 39 percent in 2004-2008 and to 47 percent in 2009-2013 (Dolbeer 2009, 2015). Strike reporting for commercial aircraft only at Part 139 airports was an estimated 79 percent in 2004-2008 and 91 percent in 2009-2013; reporting of strikes with damage was estimated at 78 percent and 93 percent for these respective time periods. For these reasons, we project that actual costs are likely 2 or more times higher than these minimum estimates.

[4] Number of reports indicating one or more of the following: damage, negative effect on flight (EOF), downtime, repair costs, other costs.

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Figures

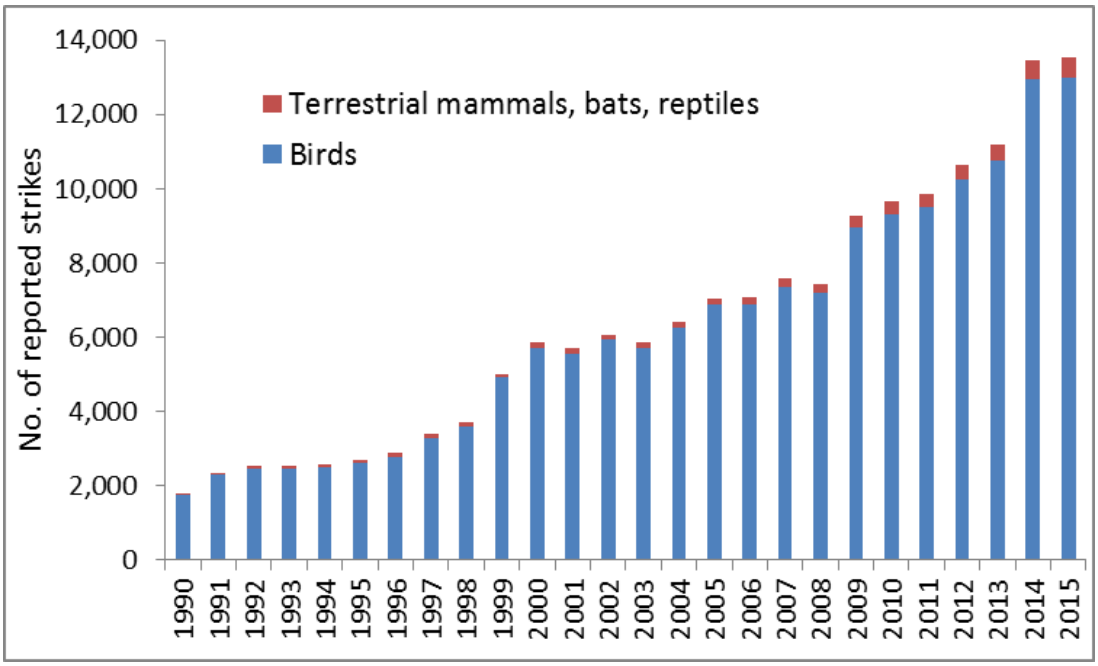


Figure 1. Number of reported wildlife strikes with civil aircraft, USA, 1990–2015. The 166,276 strikes involved birds (160,894), terrestrial mammals (3,561), bats (1,562), and reptiles (259). An additional 3,580 strikes were reported for U.S.-registered aircraft in foreign countries (see Tables 1 and 18).

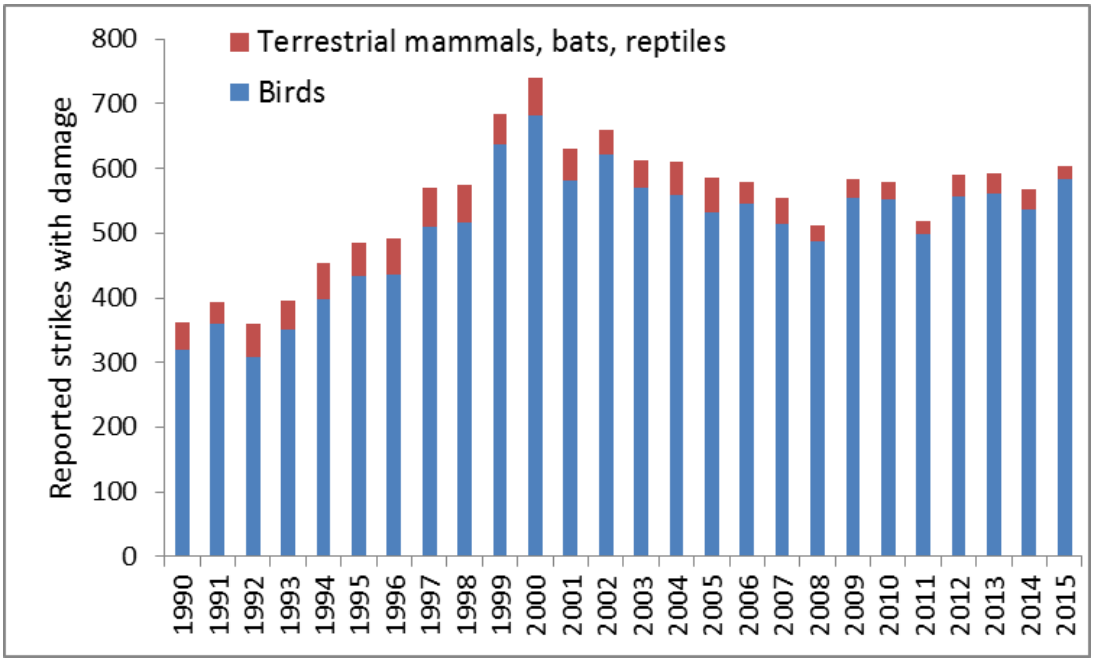
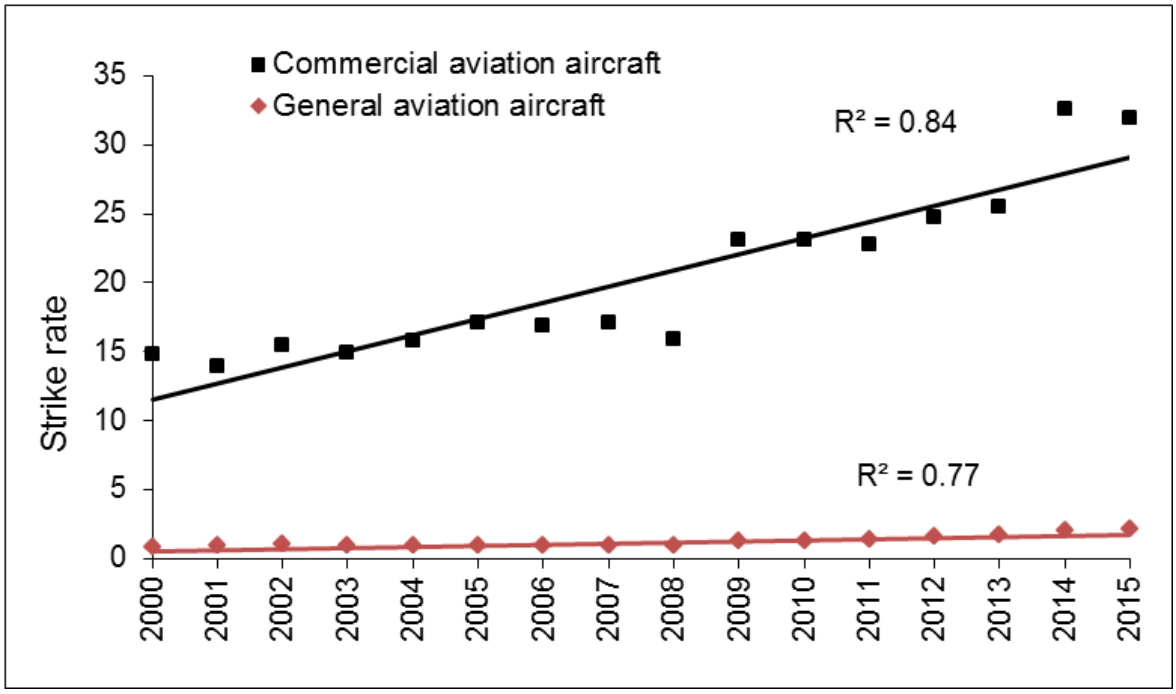


Figure 2. Number of reported wildlife strikes causing damage to civil aircraft, USA, 1990–2015. The 14,287 damaging strikes involved birds (13,204), terrestrial mammals (1,073), bats (8), and reptiles (2). An additional 358 damage strikes were reported for U.S.-registered aircraft in foreign countries (see Tables 1 and 18).



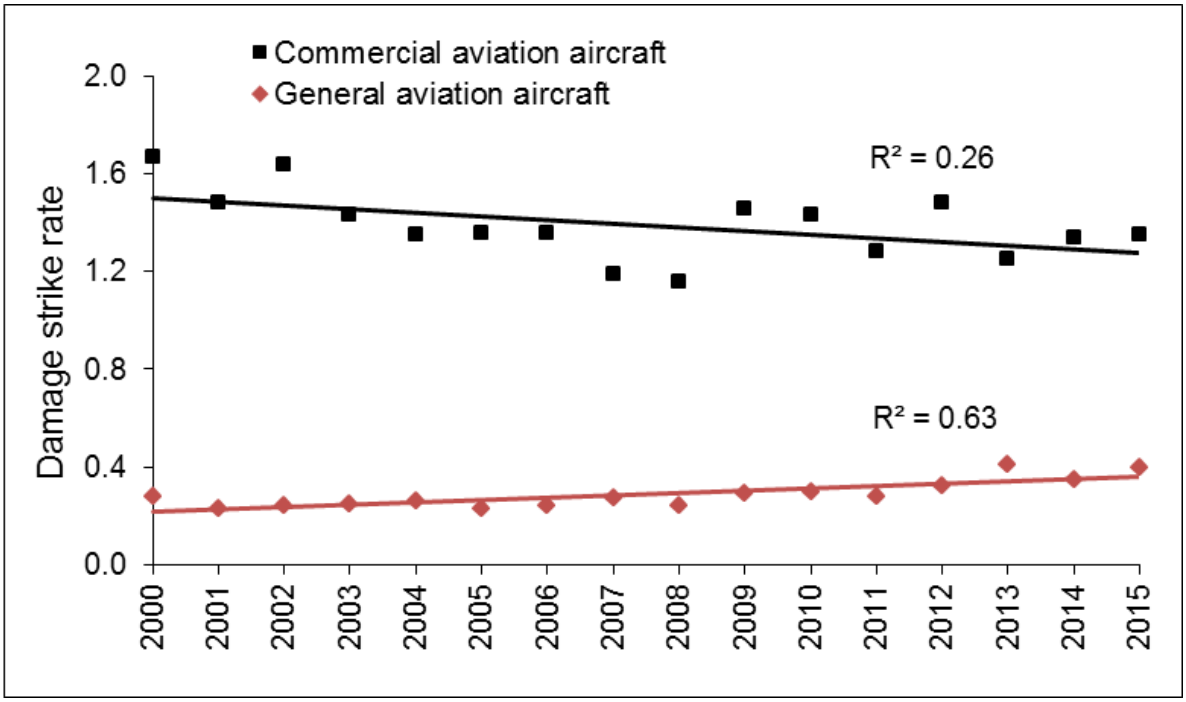


Figure 3. The strike rate and damaging strike rate (number of reported strikes and damaging strikes per 100,000 aircraft movements) for commercial (air carrier, commuter, and air taxi service) and general aviation aircraft, USA, 2000–2015. Strikes involving U.S.-registered aircraft in foreign countries are excluded. R^2 values greater than 0.25 and 0.39 indicate significant trends at the 0.05 and 0.01 levels of probability, respectively (Steel and Torrie 1960; see Tables 3 and 4 for complete data, 1990-2015).

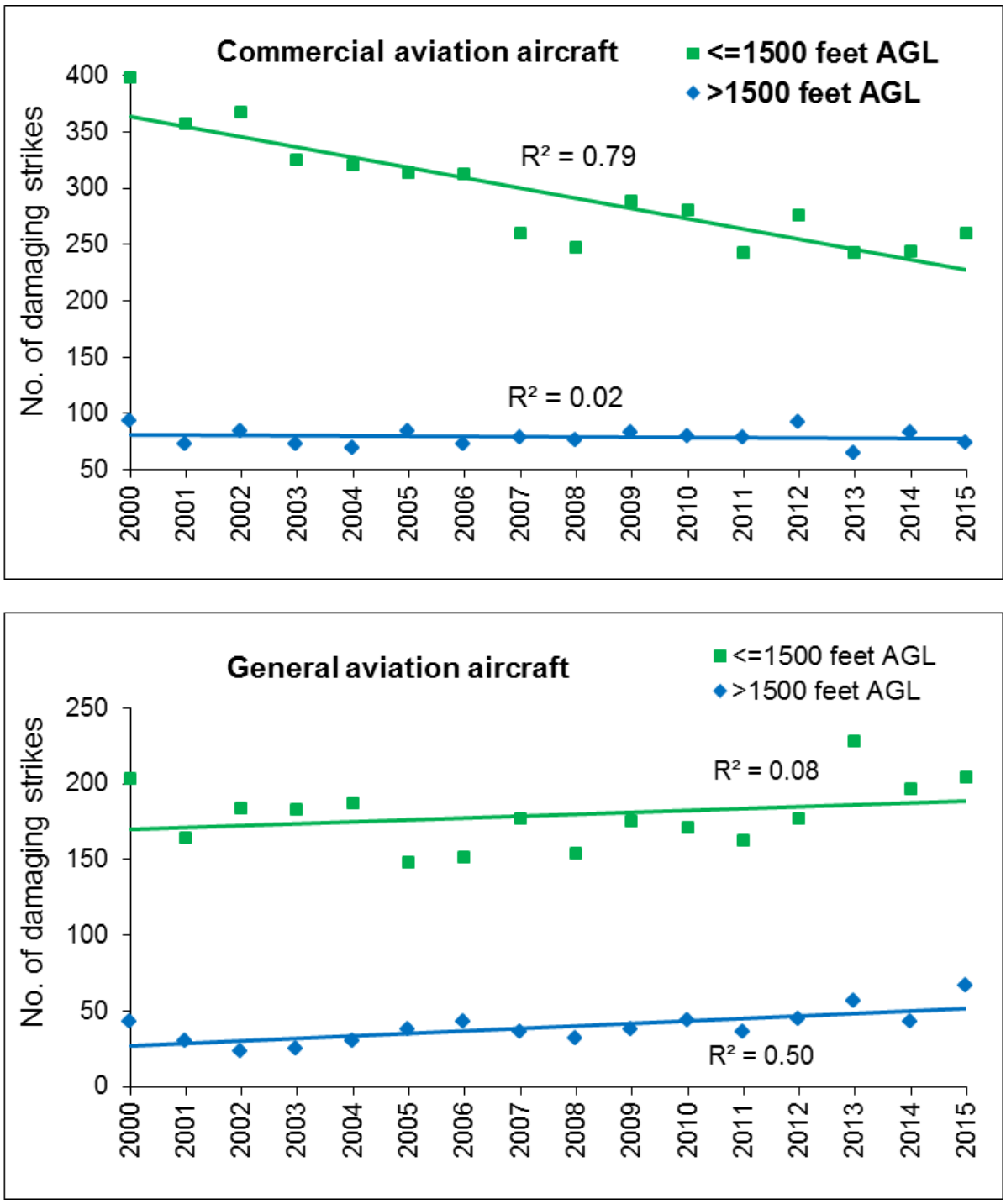


Figure 4. Number of damaging strikes with commercial (top graph) and general aviation (bottom graph) aircraft occurring at ≤ and >1500 feet above ground level (AGL) for all wildlife species, USA, 2000–2015. Strikes with unknown height AGL are included with strikes at ≤1500 feet AGL. Strikes involving U.S.-registered aircraft in foreign countries are excluded. R^2 values greater than 0.25 and 0.39 indicate significant trends at the 0.05 and 0.01 levels of probability, respectively (Steel and Torrie 1960).

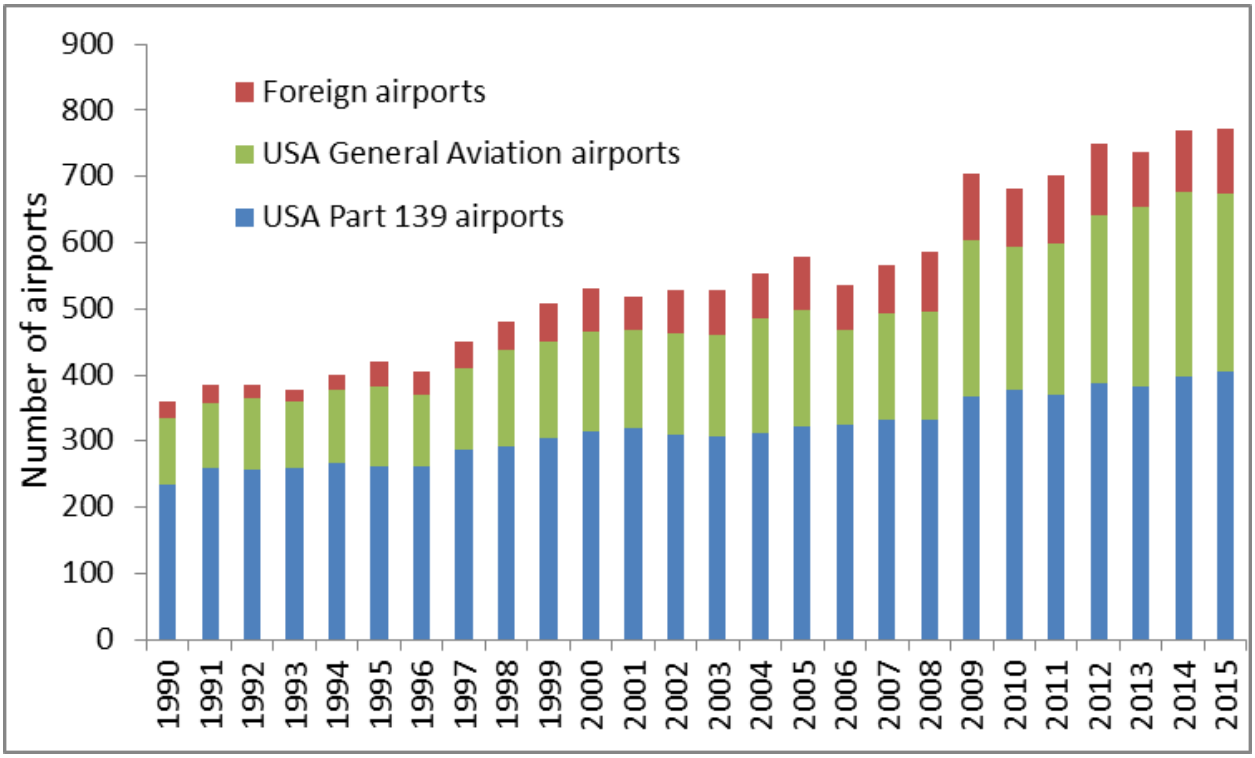
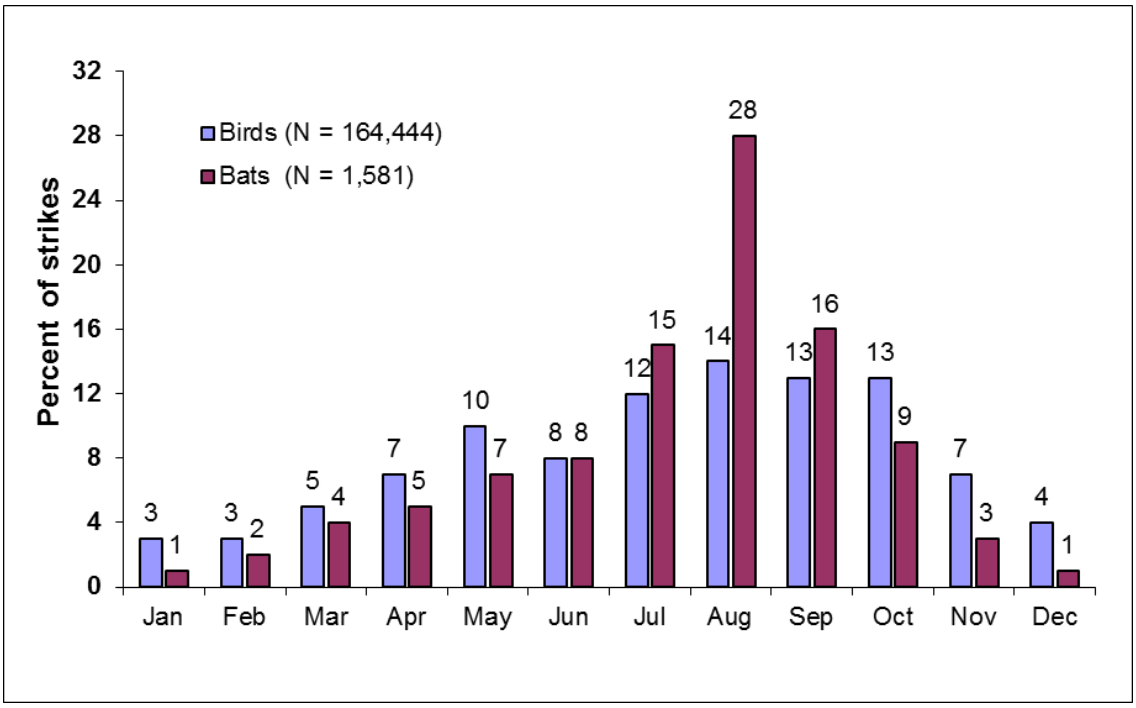


Figure 5. Number of Part 139-certificated airports and general aviation (GA) airports in USA with reported wildlife strikes and number of foreign airports at which strikes were reported for U.S.-registered civil aircraft, 1990–2015. Strikes were reported from 1,939 USA airports (527 Part 139-certificated, 1,412 GA) and 296 foreign airports in 108 countries, 1990-2015 (Table 8).



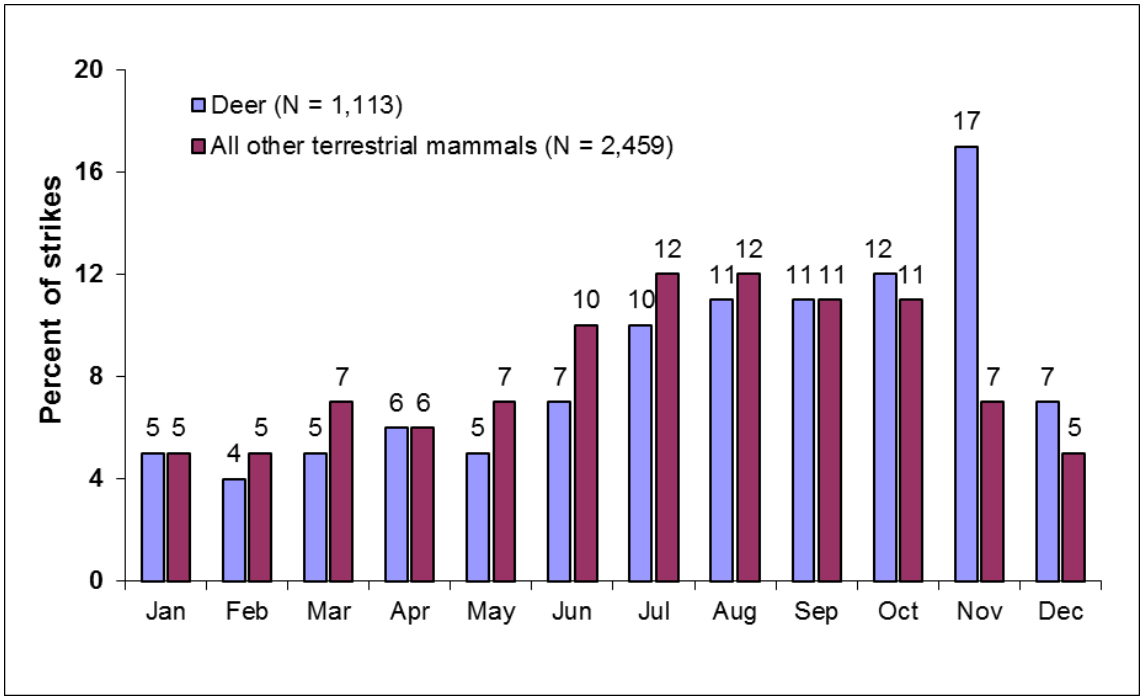
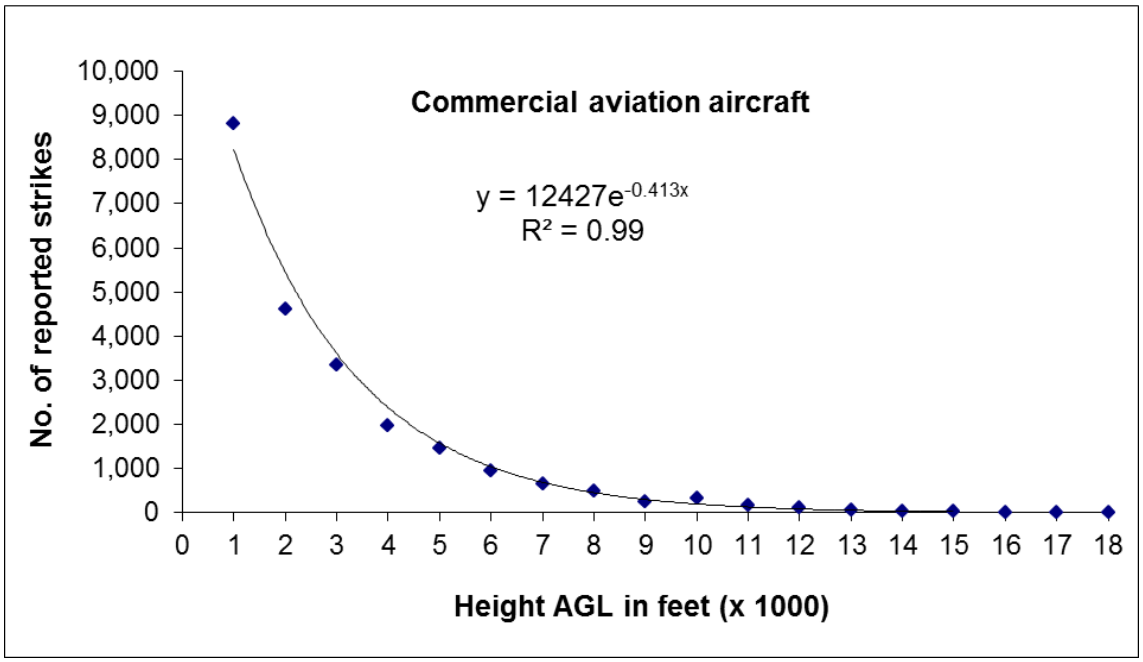


Figure 6. Percentage of reported bird and bat strikes (top graph) and deer and other terrestrial mammal strikes (bottom graph) with civil aircraft by month, USA, 1990–2015. In addition, 259 strikes with reptiles were reported of which 46 percent occurred in May - June. Deer strikes comprised 1,016 white-tailed deer, 79 mule deer, and 18 deer not identified to species (Table 18). Biondi et al. (2011) provide a more detailed analysis of deer strikes with civil aircraft in the USA.



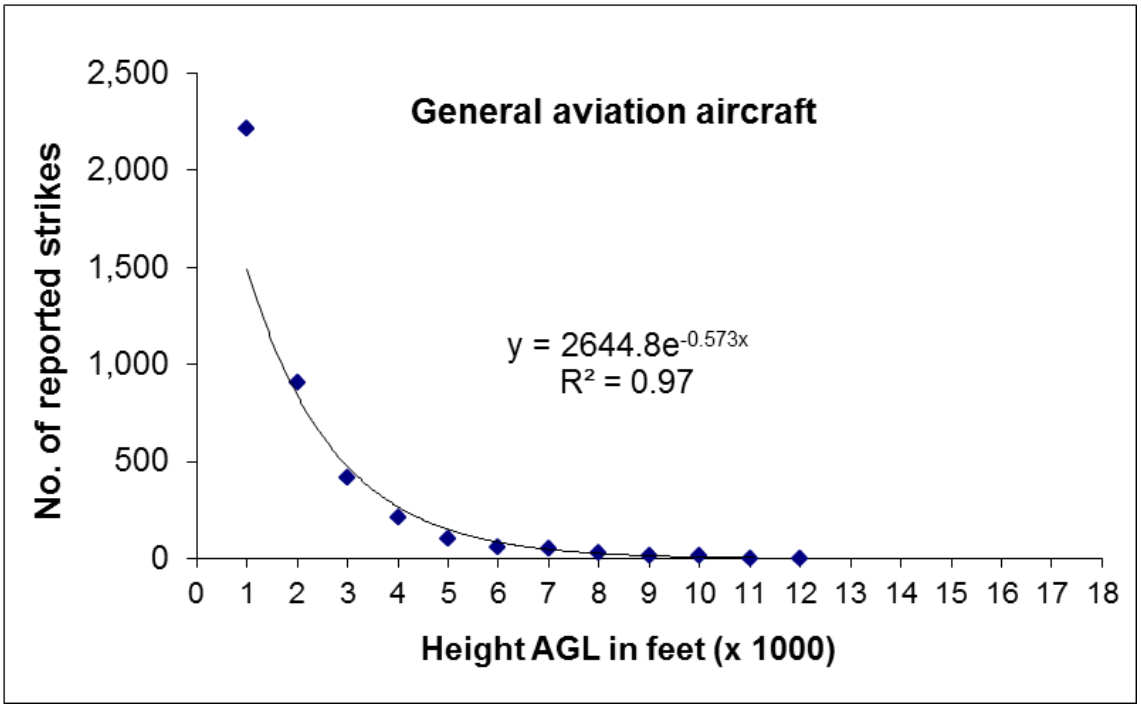
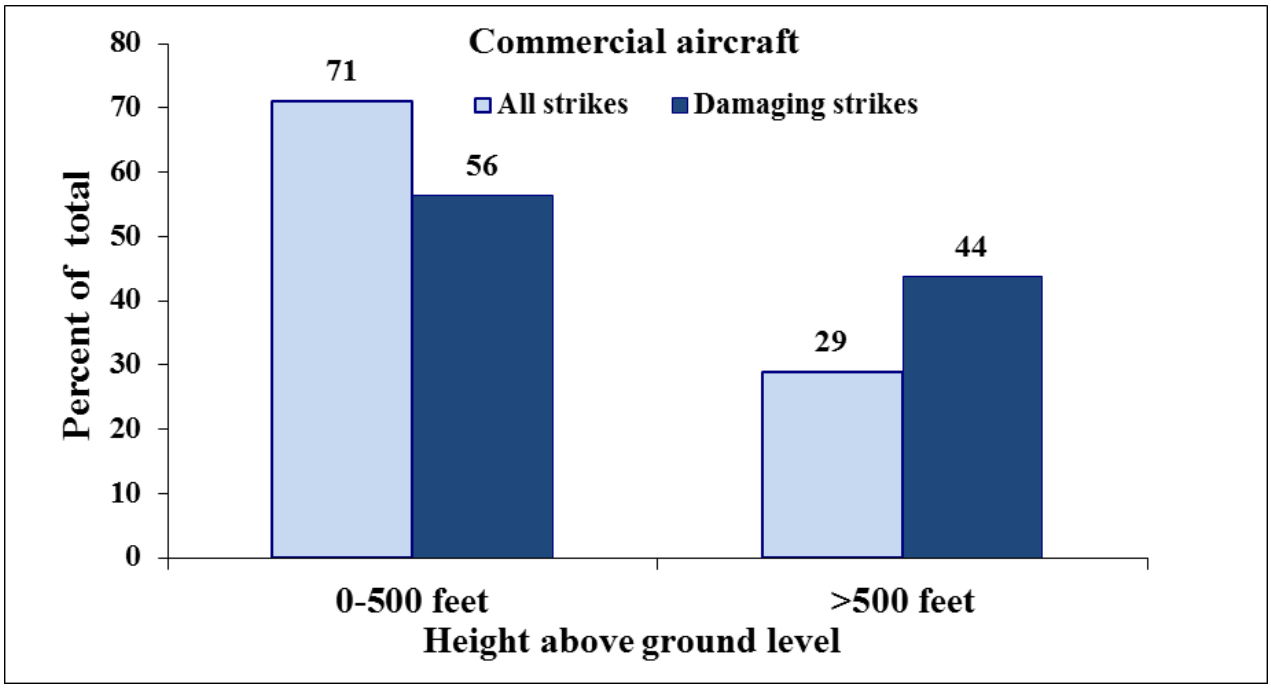


Figure 7. Number of reported bird strikes with commercial (top graph) and general aviation (GA) aircraft (bottom graph) in USA from 1990-2015 by 1,000-foot height intervals above ground level from 501—1,500 feet (interval 1) to 17,501—18,500 feet (interval 18) for commercial aircraft and to 11,501—12,500 feet (interval 12) for GA aircraft. These graphs exclude strikes occurring at ≤500 feet. Above 500 feet, the number of reported strikes declined consistently by 34 percent and 44 percent for each 1,000 foot gain in height for commercial and GA aircraft, respectively. The exponential equations explained 97 to 99 percent of the variation in number of strikes by 1,000-foot intervals from 501 to 18,500 feet for commercial aircraft and 501 to 12,500 feet for GA aircraft. See Tables 11 and 12 for sample sizes.



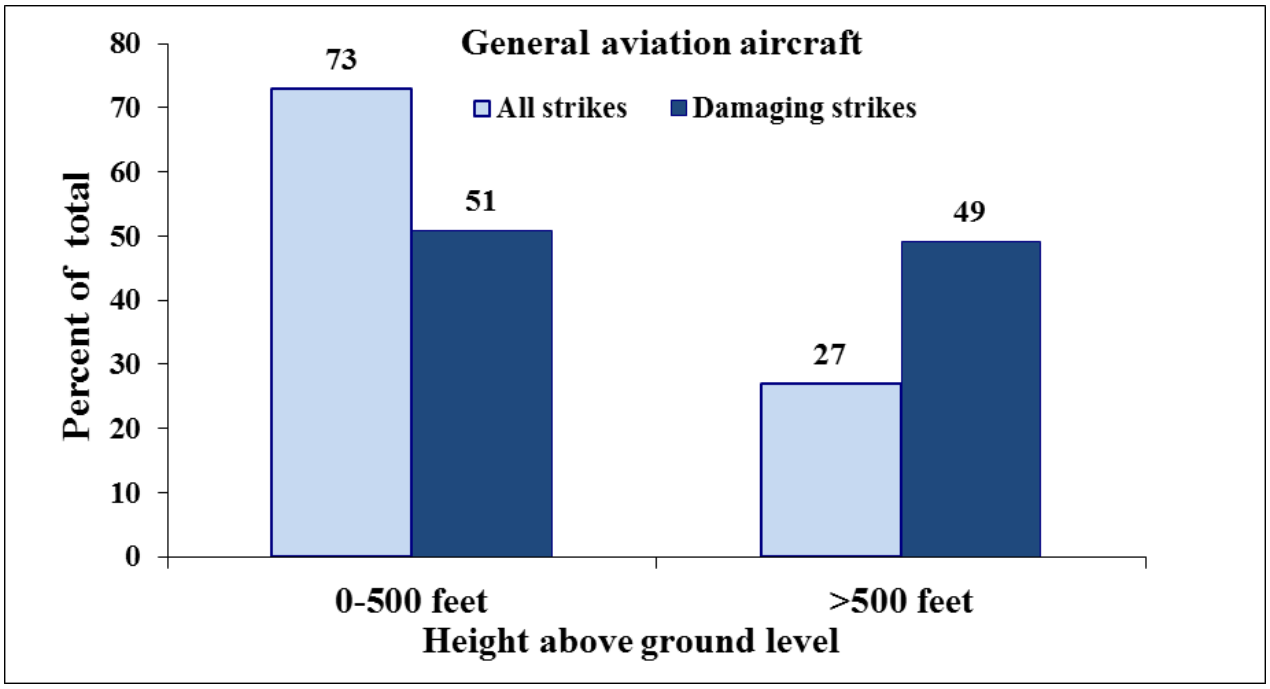
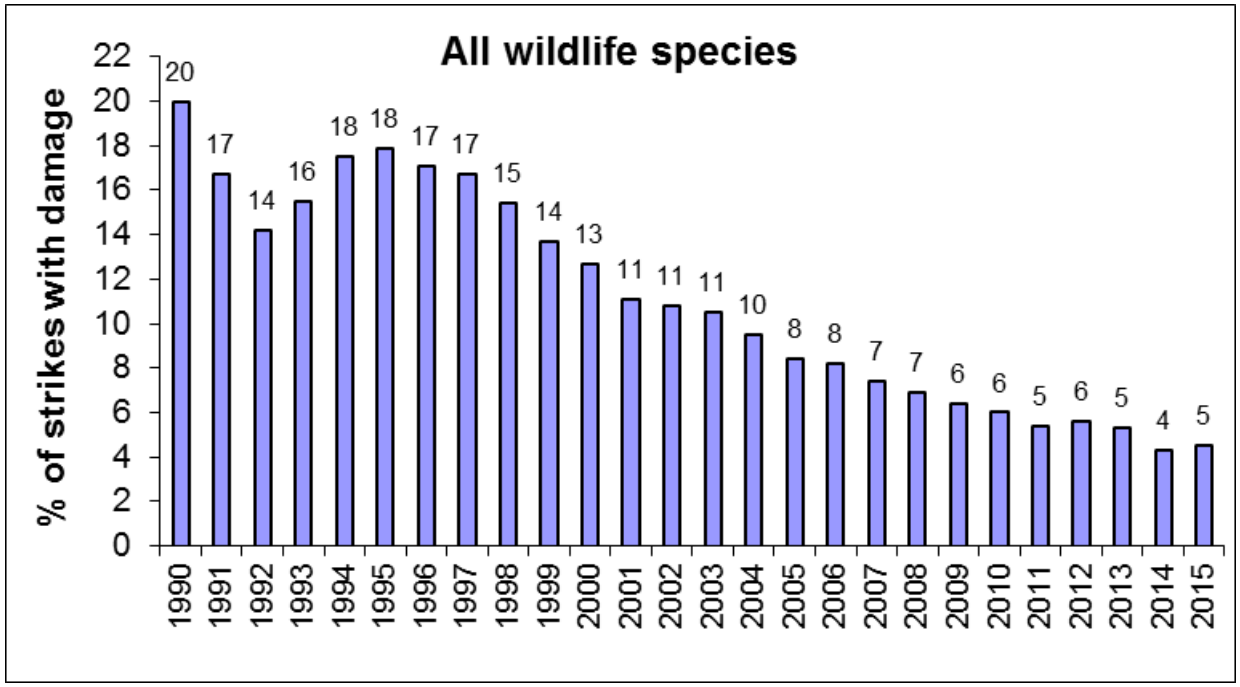


Figure 8. Percentage of total strikes and percentage of total damaging strikes occurring at 500 feet or less and above 500 feet for commercial (top graph) and general aviation (bottom graph) aircraft in USA, 1990–2015. See Tables 11 and 12 for sample sizes.



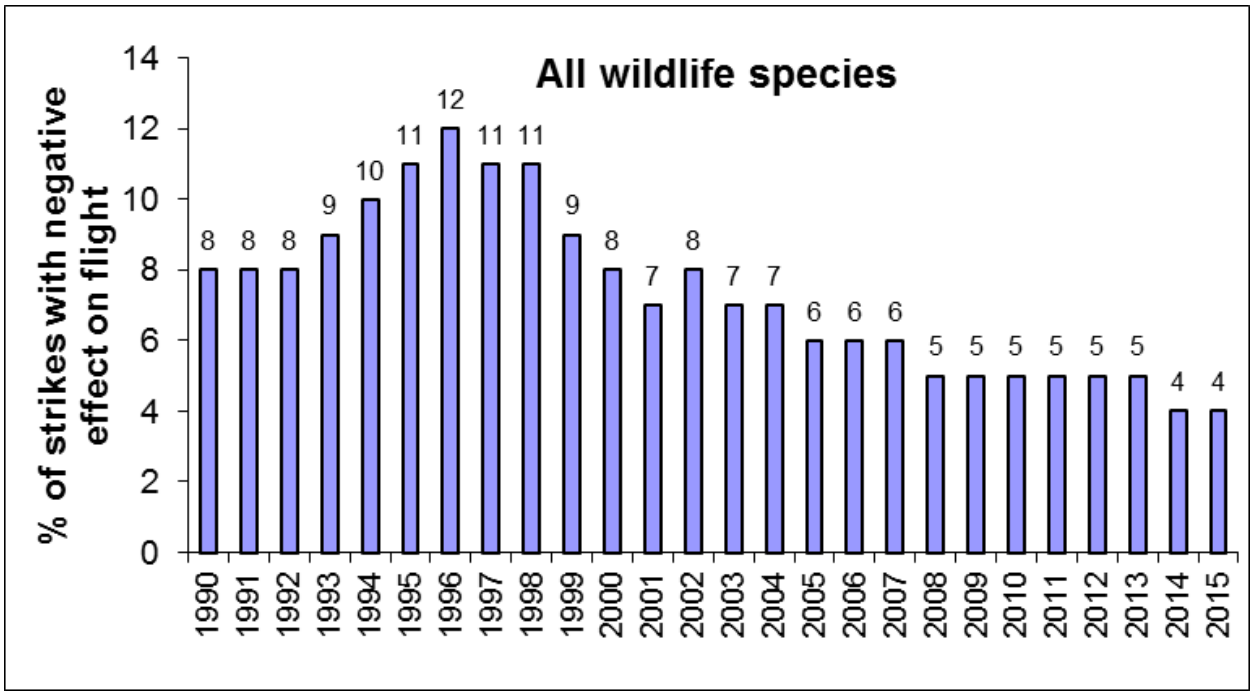


Figure 9. Percentage of reported strikes that indicated damage to the civil aircraft (top graph) or a negative effect-on-flight (bottom graph), USA, 1990–2015. See Tables 1, 14, and 15 for sample sizes and classifications of damage and negative effects-on-flight.

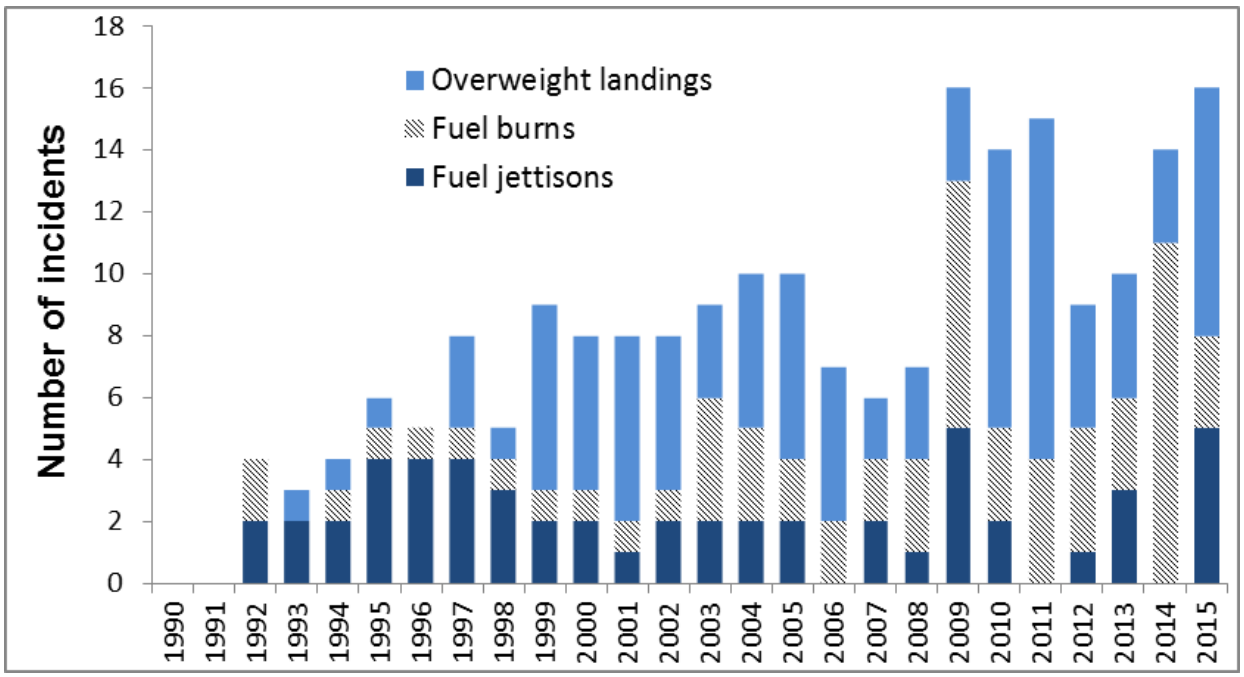


Figure 10. Number of reported incidents where pilot made an emergency or precautionary landing after striking birds during departure in which fuel was jettisoned or burned (circling pattern) to lighten aircraft weight or in which an overweight (greater than maximum landing weight) landing was made (no fuel jettison or burn), USA civil aircraft, 1990–2015. See Table 16 for details on aircraft involved and amount of fuel jettisoned.

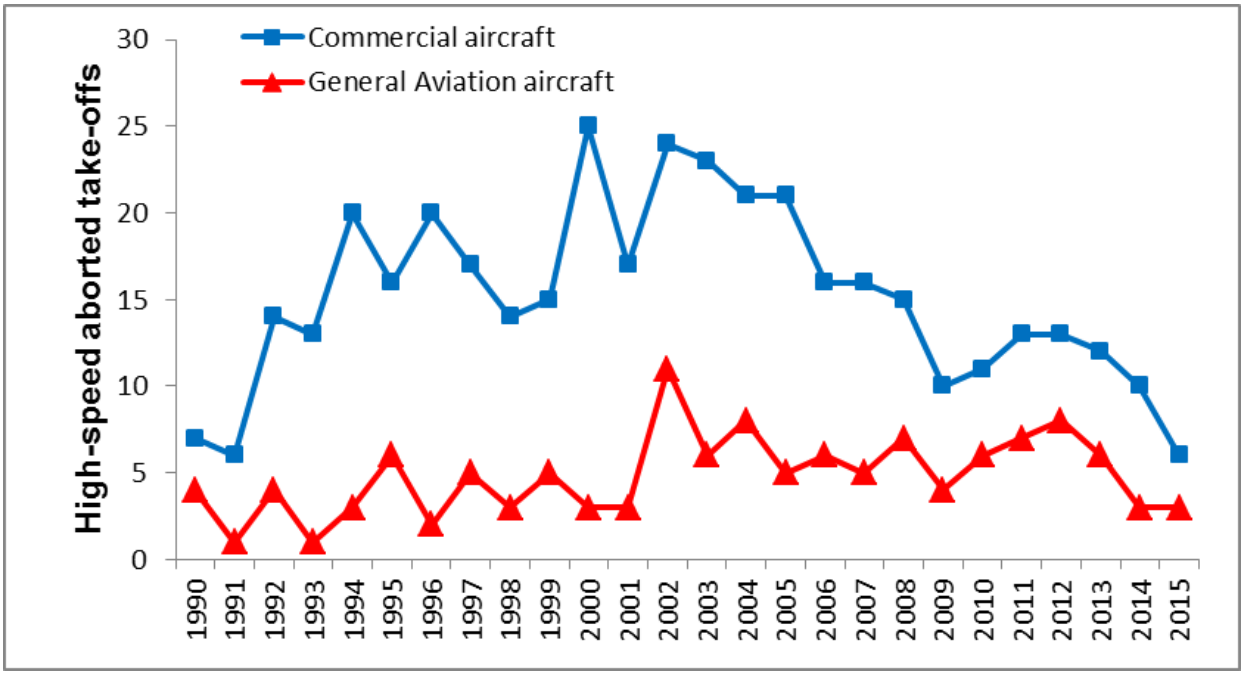


Figure 11. Number of reported incidents in which pilot made an aborted take-off at ≥100 knots after striking birds or other wildlife during take-off run, USA civil aircraft, 1990–2015. See Table 17 for classification of aborted take-offs by indicated airspeed.

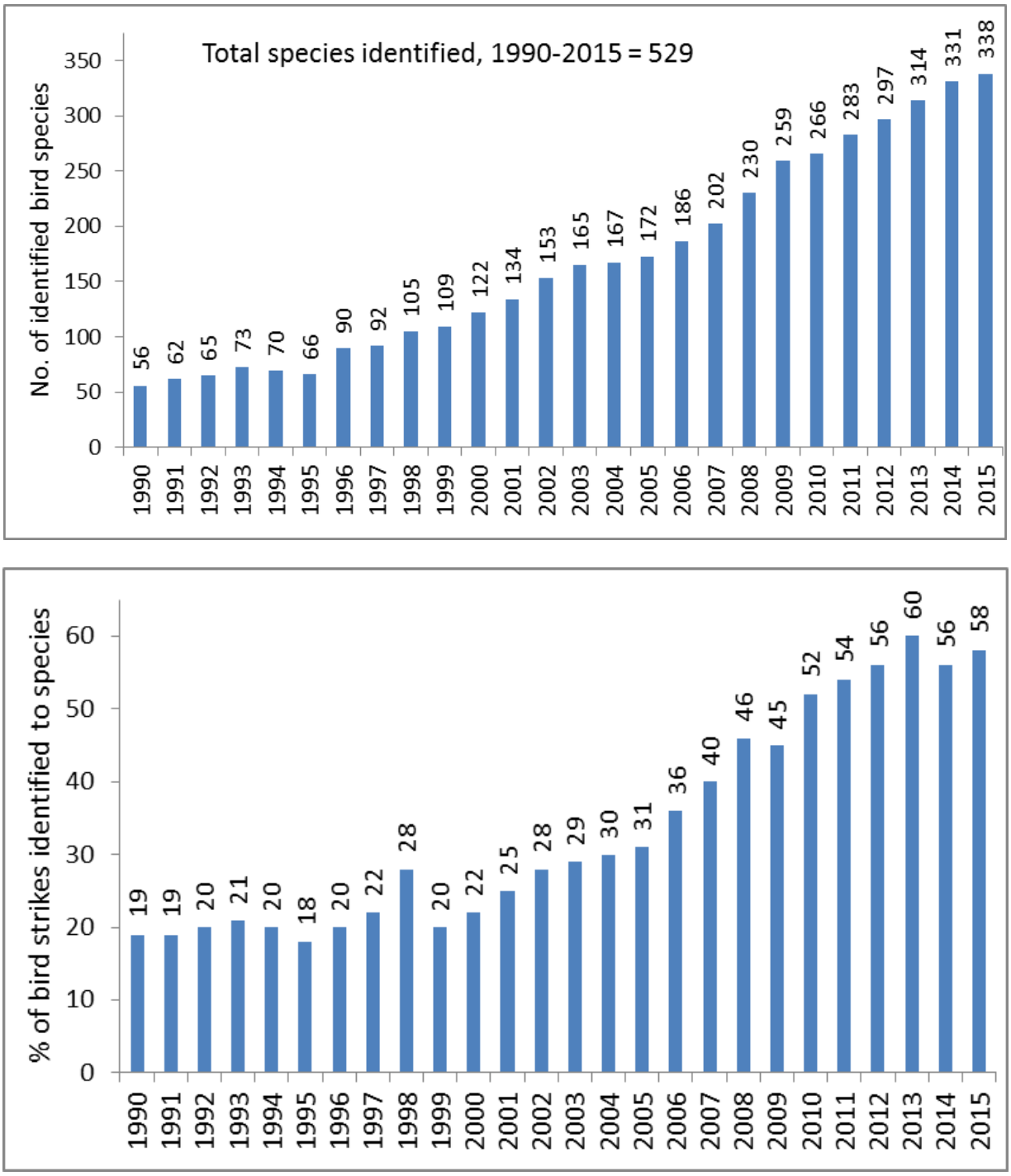


Figure 12. Number of identified bird species struck by civil aircraft each year (top graph) and the percentage of reported bird strikes in which the bird was identified to species (bottom graph), USA, 1990–2015. From 1990 through 2015, 529 different species of birds have been identified. See Tables 1 and 18 for sample sizes and list of species.

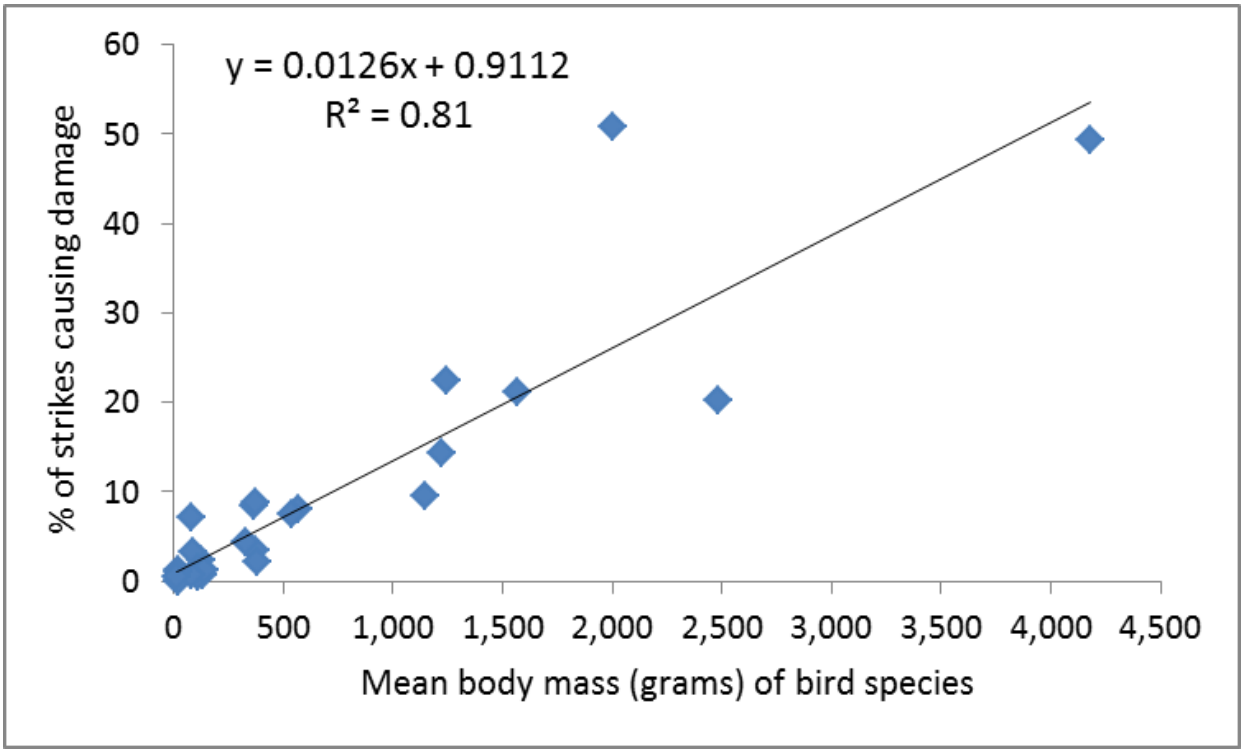


Figure 13. Relation between mean body mass (Dunning 2008) and likelihood of a strike causing damage to aircraft for the 30 species of birds most frequently identified as struck by civil aircraft in USA, 1990–2015 (Table 20). The linear regression equation explained 81% of the variation in the likelihood of damage among the 30 species. For every 100 gram increase in body mass, there was a 1.27% increase in the likelihood of damage.

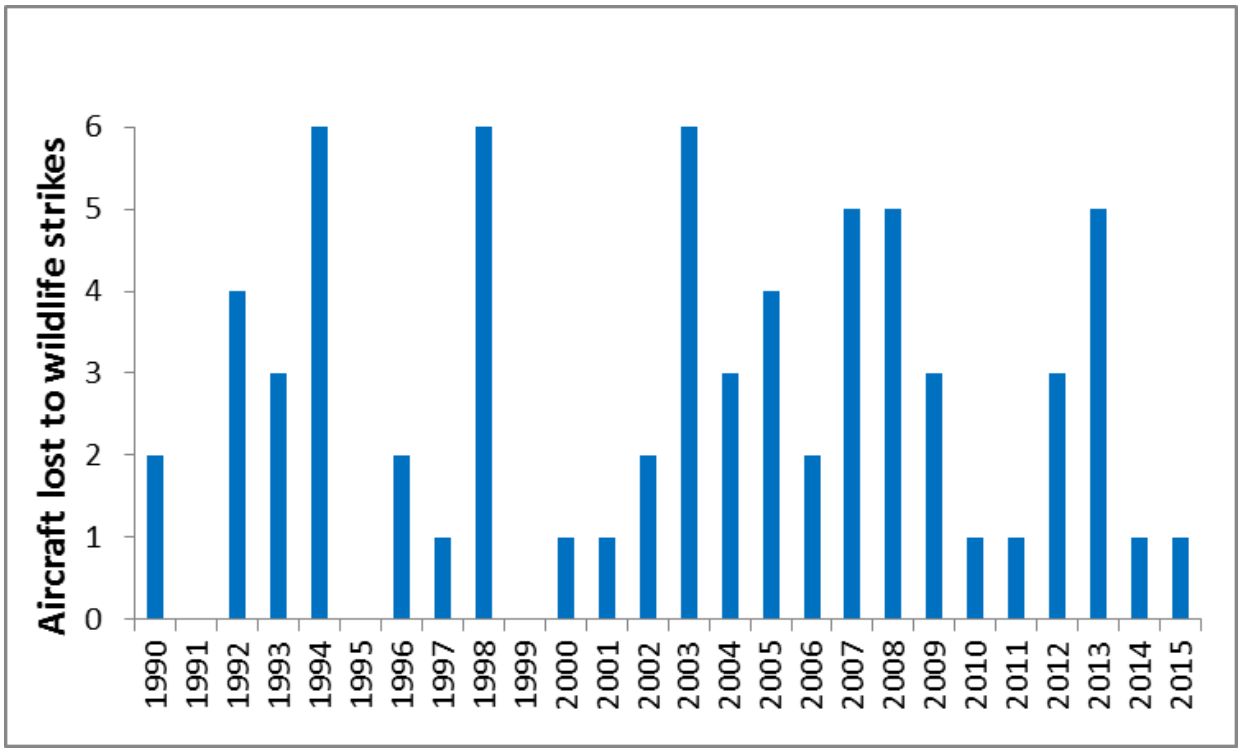


Figure 14. Number of aircraft destroyed or damaged beyond repair after striking wildlife, USA, 1990–2015. From 1990 - 2015, 68 aircraft have been lost (43 with maximum take-off mass ≤2,250 kg; 16, 2,251-5,700 kg; 7, 5,701-27,000 kg; 2, >27,000 kg). See Table 22 for wildlife species and types of aircraft and airports associated with these events.

PART 2: FAA ACTIVITIES FOR MITIGATING WILDLIFE STRIKES

In 2015, the FAA continued a multifaceted approach for mitigating wildlife strikes. This included continuing a robust research program, making improvements to the National Wildlife Strike Database (NWSD) and outreach, incorporating new technology to increase and simplify strike reporting, and providing Airport Improvement Program (AIP) funding to airports to conduct Wildlife Hazard Assessments (Assessments) and develop Wildlife Hazard Management Plans (Plans).

Strike Reporting

A new video provides guidance to pilots and airport operators on the role of wildlife strike reporting in preventing aviation accidents caused by birds and other animals. The video — titled the *2015 Wildlife Hazard Management and Strike Reporting Update* — is the second offering in the FAA's Office of Airports ongoing web-based series, http://www.faa.gov/airports/safety-video-series/. Videos in the series will be shared with representatives of the nation's estimated 535 certificated airports and thousands of non-certificated airports.

Wildlife strikes continue to capture media attention. While impacted pilots and airports are reporting strikes, they might not know the critical role their reports play in understanding wildlife issues and developing wildlife policies. The video highlights the benefits of the collection of wildlife strike data since the FAA began compiling reports submitted by airports, pilots, controllers, and other parties in its National Wildlife Strike database.

2015 Wildlife Hazard Management and Strike Reporting Update. This video shows viewers what happens when a strike is reported, from the initial report entry to how the data is analyzed and then used on a national, regional, and airport level.

The FAA has continued to update and improve the existing NWSD website (http://wildlife.faa.gov) to make it more user-friendly and to allow more advanced data mining. Search fields enable users to find data on specific airports, airlines, aircraft and engine types, as well as damage incurred, date of strike, species struck, and state without having to download the entire database. Similarly, the FAA has continued modifications to provide in-depth wildlife guidance at http://www.faa.gov/airports/airport_safety/wildlife. This guidance includes Advisory Circulars and CertAlerts, FAA NWSD analysis reports, the manual *Wildlife Hazard Management at Airports,* Airport Cooperative Research Program (ACRP) wildlife reports, hazardous wildlife mitigation and habitat attractants, Bird Hazard Mitigation

Systems (e.g., AHAS and BAM), Frequently Asked Questions and Answers on Wildlife Strikes, and more.

The FAA also developed software to make strike reporting easier. Now, anyone who needs to report a wildlife strike can do so via the new web site or their mobile devices at http://www.faa.gov/mobile. When airline and airport employees report a wildlife strike, the information is automatically sent to the FAA's wildlife strike database.

"Excellence in Strike Reporting" Award 2015

2014 was the inaugural year for the Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award. The award honors the incomparable dedication of Dr. Richard Dolbeer and Sandy Wright; each being exceptional in the management of the National Wildlife Strike Database (NWSD) since the FAA first contracted the USDA in 1995 to oversee the collection, quality control, analysis and summation of strike reports. From its genesis Sandy has reviewed each and every strike reported and entered it into the database while Dr. Dolbeer has provided in-depth analysis, conclusions and recommendations based on the results. Both have co-authored each and every annual strike report with the FAA. Although the award fittingly bears both their names, it would not be unfair to simply call it the "Doing it Wright" award for the tireless oversight and fact checking that Sandy has provided to create an unparalleled strike data collection.

Strike report forms were developed by the FAA after the catastrophic strike between Eastern Air Lines Lockheed Electra (Flight 375) and a flock of starlings (October 4, 1960); albeit the reports and analysis were sporadic and unreliable. Once the USDA and FAA started analyzing the strike reports in 1995, it was determined that the reliable data starting in 1990 represented a valid cut-off date.

The Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award medallion awarded to the winning Part 139 certificated airport and GA airport.

The Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award recognizes those airports that have exhibited a noteworthy strike reporting program. The number of US airports with strikes reported has increased from 334 in 1990 to a record 674 in 2015. The 674 airports with strikes reported in 2015 were comprised of 404 airports certificated for passenger service under 14 CFR Part 139 and 270 general aviation (GA) airports. From 1990 - 2015, strikes have been reported from 1,939 US airports.

Beyond the certificates presented to the winning airports the FAA created a fitting award medallion depicting the original Wright Flyer III and a flock of birds to commemorate the first documented strike on September 7, 1905. The medallion's inscription reminds us

all of the step-by-step process incorporating wildlife strike data with improved safety: Document-Analyze-Plan-Mitigate-Evaluate-Adapt.

The idea was to recognize the Top 5 reporting programs in both the Certificated and GA airport categories. The criteria for determining which airports will make the initial cuts are objective and include both quantity and quality of strike data (*keep in mind though that an airport will not win based solely on number of strikes reported). The criteria include but are not limited to:

1. Number of reports filed
2. Completeness of reports
3. Percentage of reports identified to species
4. Percentage of reports filed on-line
5. Timeliness of reports being submitted
6. Remains collected when available or necessary
7. Consistency filing reports

Further evaluation of the finalist strike reporting programs may include:

1. Modification of filed reports online when new information is discovered
2. Airport follows up with airline or engine manufacturer for missing information
3. Airport has someone on “Notification” list to receive notice when strikes are filed for their airport

The determination of a winner for each of the two categories was very difficult; each of the finalist airports deserving recognition. The Top 5 Certificated airports in 2015 were: Dallas-Fort Worth (DFW), Los Angeles (LAX), La Guardia (LGA), John F Kennedy (JFK) and Salt Lake City (SLC). Honorable mention goes to Kansas City International Airport (MCI). The Top 5 GA airports in 2015 were Morristown Municipal Airport (MMU), Centennial (APA), Van Nuys (VNY), Cecil Airport (VQQ) and Waukesha County (UES). Honorable mention went to Fort Lauderdale Executive Airport (FXE) and Jacksonville Executive (CRG).

For their commitment to the identification and documentation of wildlife / aircraft strike information, the FAA proudly recognizes the superior strike reporting programs at **La Guardia International Airport** and **Van Nuys Airport** as the winners of the 2015 Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award. The bar has been set high and these airports, as well as each of the finalists, well deserve the recognition. Congratulations.

FAA Guidance

The year 2015 marked the 50th anniversary of the first official strike reporting document by the FAA. On November 27, 1965, the FAA published Advisory Circular (AC) 150/ 5200-2 *Bird Strike/ Incident Report Form.* The purpose of the AC was to inform both military and civilian aviation organizations that FAA Form 3830 "*Bird Strike/ Incident Report Form"* was available for use and that bird remains could be sent to the U.S. National Museum (i.e., Smithsonian Institution National Museum of Natural History) in Washington, DC for identification.

In 2015, the FAA struck a commemorative 50th anniversary Challenge Coin to celebrate the first official strike reporting guidance in 1965.

Currently, Advisory Circular 150/5200-38 *Protocol for the Conduct and Review of Wildlife Hazard Site Visits, Wildlife Hazard Assessments, and Wildlife Hazard Management Plans* is scheduled for publication in 2017. This new AC defines the minimum acceptable standards for the conduct and preparation of Site Visits, Assessments and Plans. This AC provides guidelines that state when a Site Visit should be conducted, and when an Assessment must be conducted. The AC further defines and explains continual monitoring programs and provides checklists to help people evaluate Site Visits, Assessments and Plans.

CertAlert No. 13-01 *Federal and State Depredation Permit Assistance* issued in January 2013 provided assistance to airport operators with the acquisition of Federal or State depredation permits. The CertAlert supplied users with state fish, wildlife and natural resource agency web sites, contact information for USDA and United States Fish And Wildlife Service (USFWS) regional and state offices, USFWS Migratory Bird Permits Regulation 50 CFR § 21.41 and a copy of USFWS Migratory Bird Depredation Permit application form (Form 3-200-13). The FAA also published CertAlert No.14-01 *Seasonal Mitigation of Hazardous Species at Airports: Attention to Snowy Owls* to heighten awareness of transient hazardous wildlife such as snowy owls. Most recently, CertAlert 16-03 *Recommended Wildlife Exclusion Fencing* (August 2016) was published to provide current information for exclusion fencing and guidance to airports on the acquisition of wildlife exclusion fencing.

The FAA funded and assisted with the development of two recent Airport Cooperative Research Program (ACRP) reports to aid airports with the mitigation of wildlife hazards. In 2015, ACRP Report 122 *Innovative Airport Responses to Threatened / Endangered Species* and Report 125 *Balancing Airport Stormwater and Bird Hazard Management* were published to assist airports with the difficulties of balancing human safety, species protection and airport construction requirements. In addition, ACRP Synthesis 39 report *Airport Wildlife Population Management* (2013) and Synthesis 52 report *Habitat Management to deter Wildlife at Airports* (2014) also are available from the

Transportation Research Board (TRB) of the National Academies at http://www.trb.org/Publications/Publications.aspx.

Wildlife Hazard Mitigation Research

For the last 20 years, the FAA and the USDA have conducted a research program to make airports safer by reducing the risks of aircraft-wildlife collisions. The research efforts designed to improve wildlife management techniques and practices on and near airports include:

- Alternative habitat management strategies to reduce attraction to airports of hazardous wildlife species
- Techniques for restricting access of hazardous wildlife species to attractive features like storm water ponds
- Technologies for harassing and deterring hazardous species
- Movement patterns of red-tailed hawks following translocation from an airport
- Evaluation of translocation as a management tool for American kestrels at airports
- Aircraft-mounted lighting systems to enhance bird detection and avoidance of aircraft.
- Landscape-level analysis of land cover and birdstrike rate across airports

Translocation as a mitigation tool for raptors is being evaluated to determine its effectiveness and optimum protocols concerning distance, seasonality, age of bird and other considerations. Photo of red-tailed hawk feeding between runways at an eastern Part 139 airport courtesy John R Weller.

Avian or Bird Radar Technology

In 2001, the FAA began working with the U.S. Air Force to develop a radar system for detecting and tracking birds on or near airports. In 2006, the FAA refocused the radar research to evaluate the capability of commercially available, low-cost, portable radars to reliably detect and track birds on or near airports.

The Center of Excellence for Airport Technology (CEAT) at the University of Illinois has served as the FAA's research partner for the performance assessments of bird radar. Additional evaluations have continued through FAA's multi-year agreement with USDA who teamed up with the National Center of Atmospheric Research (NCAR) and Indiana State University to further evaluate the performance of bird radar systems. Though it is well established that radar can detect birds, there is little published information concerning the accuracy and detection capabilities related to range, altitude, target size, and effects of weather for avian radar systems.

In November, 2010, the FAA published a performance specification in the form of an Advisory Circular 150/5220-25 *Airport Avian Radar Systems*, which airports can use to competitively purchase bird radar systems. The guidelines provide the operational considerations of acquiring and using the technology to enhance wildlife hazard mitigation practices on civil airports. Under some circumstances, procurement of bird radar systems may be eligible for funding under the FAA's Airport Improvement Program (AIP). The FAA will continue to evaluate commercially available avian radars and emerging sensor technologies. A new research effort began at the end of 2011 and continued through 2014 that examined the feasibility and practicality of pilots and air traffic controllers using bird radar data.

Wildlife Hazard Assessments and Wildlife Hazard Management Plans

The FAA encouraged all certificated airports to conduct Assessments and develop Plans regardless if a triggering event under 14 CFR Part 139 has been experienced. To date, 100% of all required Part 139 airports have completed an Assessment or are a joint-use facility that maintains a Bird/ wildlife Aircraft Strike Hazard (BASH) Plan. Wildlife Hazard Assessments will allow an airport to:

- Identify trends in wildlife use of the airport (habitat preferences, seasonal composition and abundance of wildlife species, geography of strikes, seasonality of strikes, time and phase of flight of strikes, etc.)
- Prevent future strikes through operational changes, habitat (attractant) modifications, customized harassment, and/ or species removal
- Evaluate the overall risk level of wildlife strikes and the efficacy of the airport's wildlife hazard mitigation program (e.g., determine redundancy of species specific hazards, monitor reduction of onsite damaging strikes, monitor wildlife program communication and response efficiency, and improve overall program through annual review).

An Assessment provides fundamental wildlife and habitat information for an effective, airport-specific Plan. The Plan outlines a plan of action to minimize the risk to aviation safety, airport structures or equipment, or human health posed by populations of hazardous wildlife on and around an airport. To be effective, Plans must not only be fully implemented but routinely evaluated and modified to address an airport's changing environment, hazards and capabilities. The FAA supports completion of Assessments and Plans by providing financial assistance from the AIP.

Wildlife Hazard Assessments at GA Airports

On March 4, 2008, a catastrophic wildlife strike involving a Cessna 500 Citation and an unknown number of migratory white pelicans resulted in five fatalities approximately four miles from a GA airport. Following the investigation, the NTSB provided the FAA Recommendation A-09-73:

> *"Verify that all federally obligated general aviation airports that are located near woodlands, water, wetlands, or other wildlife attractants are complying with the requirements to perform wildlife hazard assessments as specified in Federal Aviation Administration Advisory Circular 150/5200-33B, Hazardous Wildlife Attractants On or Near Airports*"

The FAA established a program and schedule that outlined the implementation of Assessments or Site Visits based on the number of operations and based jet aircraft at the GA airport. To date, 124 airports (91%) of the 136 GA airports identified with the greatest need for wildlife data collection have conducted either Assessments or Site Visits. To assist the GA airports in conducting Assessments, we will continue to make AIP grant funds available to them.

Mitigating Strikes at GA Airports

The FAA funded and assisted with the development of two ACRP reports specifically to aid GA airports with the mitigation of wildlife hazards. ACRP Report 32 *Guidebook for Addressing Aircraft/ Wildlife Hazards at General Aviation Airports* and ACRP report *Synthesis 23 Bird Harassment, Repellent, and Deterrent Techniques for Use on and Near Airports* were distributed to all federally obligated NPIAS/GA airports. These reports, and five others published since 2010 provide practical guidance and specific techniques on how to address wildlife hazards and strikes at airports and are still available at http://www.trb.org/Publications/Publications.aspx.

Bird Strike Committee USA

The FAA participates in the Bird Strike Committee-USA as part of its continued public outreach and education effort to increase awareness within the aviation community about wildlife hazards. A Memorandum of Understanding between the FAA and the BSC USA was signed May 2012 to formalize this cooperative relationship. The BSC USA Steering Committee is comprised of 25 diverse, subject-matter experts representing Pilots, Airlines, Airframe and Engine Manufacturers, Wildlife Biologists, Airport Managers, Department of Defense personnel, ATC Personnel, Certification Inspectors, Research, Private Sector and Government Personnel. The BSC USA website http://www.birdstrike.org/ provides many useful resources, links and a quarterly newsletter to the industry and public.

Commercial Aviation Safety Team (CAST)

In 2010, the FAA Airports Safety and Standards (AAS), USDA and the Air Transport Association (now Airlines for America) requested that the Commercial Aviation Safety Team (CAST) formally charter a Joint Safety Analysis Team or similar effort to review the wildlife strike/ aviation problem. CAST determined that the Joint Implementation Measurement and Data Analysis Team (JIMDAT) group would track wildlife strikes and provide periodic monitoring reports to CAST concerning wildlife strikes.

During a February 2013 CAST meeting, CAST fully approved JIMDAT "Option 2" Birdstrike monitoring proposal. This included reporting fatality risk values at appropriate intervals and trending egregious events to provide confidence. Egregious event categories to monitor are: A/C Controllability, Fire, Multiple Systems Damaged, High Risk RTO, Loss of/Unreliable Cockpit Data, Cockpit Intrusion (Risk of Pilot Incapacitation), and Encountered Many Large Birds. Event categories were chosen by a SME panel as safety significant event precursors.

Performance Metrics

Starting in 2013 the FAA adopted the following performance metrics that will measure program efficacy under a voluntary strike reporting environment where the absolute number of bird strikes is not known. These three performance metrics allow the FAA to monitor multiple factors that affect strike reporting and overall strike reporting trends and the effectiveness of GA wildlife mitigation programs. To date, strike reporting trends continue to show an increase in overall reporting contrasted with an actual decline in damaging strikes from 762 in 2000 to 616 in 2015. Analyses of strike reporting trends will be continued (see Metric 2).

Metric 1: Monitor the ratio between the numbers of strikes with damage compared to total reported strikes. This ratio is independent of the total number of strikes reported and is a good measure of the effectiveness of overall mitigation procedures. We will use 2010 as the baseline data and calculate the performance measure for following years. The table below depicts the results of calculating the data for the 6- year period 2010 - 2015.

Year	Total strikes reported	Damaging strikes reported	Percentage damaging strikes vs. total strikes
2010	9,906	596	6.0%
2011	10,116	542	5.4%
2012	10,908	611	5.6%
2013	11,401	606	5.3%
2014	13,668	581	4.3%
2015	13,795	616	4.5%

Metric 2: Monitor estimated reporting rate of wildlife strikes. In 2015, the original five year study (Dolbeer 2009) that estimated the 39 percent reporting rate was updated to determine if our outreach efforts have increased the reporting rate (Dolbeer 2015). The estimated reporting rate has increased to 47 percent for all civil aircraft but is estimated to be 91 percent for strikes involving commercial aircraft at certificated airports.

Damaging strikes have continued to decline or remain stable. We will continue to update the study every 3 – 5 years.

Metric 3: The FAA will monitor the number of GA airport Assessments or Site Visits initiated. This is an important metric as we are just starting an initiative to complete Assessments or Site Visits at more than 2,700 GA airports. This initiative will run for more than 10 years, and it is important to track our progress.

As part of the FY 2015 business plan, FAA contacted all Group 1 GA Airports (100+ based jets and/or 75,000+ annual operations) and recommended they conduct a WHA or at least a Wildlife Hazard Site Visit (WHSV). Of the 136 total airports in this group 124 airports (91%) have conducted WHAs or WHSVs; two airports are not grant obligated and the remaining ten airports have not conducted a WHA or WHSV at this time.

APPENDIX A.

SELECTED SIGNIFICANT WILDLIFE STRIKES TO U.S. CIVIL AIRCRAFT, 2015

The U.S. Department of Agriculture, through an interagency agreement with the Federal Aviation Administration, compiles a database of all reported wildlife strikes to U.S. civil aircraft and to foreign carriers experiencing strikes in the USA. From 1990 through 2015, 169,856 strike reports from 1,939 USA airports and 296 foreign airports have been entered in the database (13,795 strikes from 674 USA and 97 foreign airports in 2015 alone, Tables 1, 8; Figure 5). The following 28 examples from the database in 2015 are presented to show the serious impact that strikes by birds or other wildlife can have on aircraft. These examples demonstrate the widespread and diverse nature of the problem. The examples are not intended to highlight or criticize individual airports because, as documented above, strikes have occurred on almost every airport in the USA. Some of the strike examples reported here occurred off airport property during approach or departure. For more information on wildlife strikes or to report a strike, visit *www.birdstrike.org* and *http://wildlife.faa.gov*.

Date:	3 January 2015
Aircraft:	B-737-300
Airport:	Denver International (CO)
Phase of Flight:	Approach (150 feet AGL)
Effect on Flight:	Engine shutdown
Damage:	Engine #1
Wildlife Species:	Canada goose
Comments from Report: Shut down engine on taxi as precaution. Number 1 engine struck and damaged with some fan blade damage. ID by Smithsonian, Division of Birds.	

Date:	7 January 2015
Aircraft:	B-757-200
Airport:	Portland International (OR)
Phase of Flight:	Climb (972 feet AGL)
Effect on Flight:	Precautionary landing
Damage:	Engine #1
Wildlife Species:	Northern pintail
Comments from Report: Emergency landing. Pilot reported a bad vibration immediately after takeoff. Runway inspection revealed five Northern pintail carcasses. At least one ingested into engine #1 damaging fan blades and cowling. Estimated cost of repairs ($5 million), other costs ($452,320). Aircraft was out of service for 11 days.	

Date:	23 March 2015
Aircraft:	B-737-800
Airport:	Dallas/Fort Worth International (TX)
Phase of Flight:	Climb (1,800 feet AGL)
Effect on Flight:	Precautionary landing
Damage:	Engine #1, wing, landing gear door
Wildlife Species:	Ring-necked duck
Comments from Report: Returned on Alert II conditions. ID by Smithsonian, Division of Birds. Time out of service was 4 days.	

Date:	31 March 2015
Aircraft:	CRJ-200
Airport:	Minneapolis-St Paul International (MN)
Phase of Flight:	Climb (5,000 feet AGL)
Effect on Flight:	Precautionary landing
Damage:	Wing
Wildlife Species:	Bald eagle
Comments from Report: Right wing leading edge dent 20-24 inches long, located mid-section of right wing. Returned for inspection. Repair costs ($50,000). ID by Smithsonian, Division of Birds.	

Date:	9 April 2015
Aircraft:	B-737-800
Airport:	Dallas/Fort Worth International (TX)
Phase of Flight:	Climb (50 feet AGL)
Effect on Flight:	Precautionary landing, emergency
Damage:	Engine #2
Wildlife Species:	Swainson’s hawk
Comments from Report: During climb, reported severe vibration in engine #2. Emergency declared and returned to airport. Damage found to several of the impeller blades of the engine. ID by Smithsonian, Division of Birds.	

Date:	25 April 2015
Aircraft:	A-319
Airport:	Jacksonville International (FL)
Phase of Flight:	Climb (350 feet AGL)
Effect on Flight:	Precautionary landing, emergency
Damage:	Engine #2, landing gear
Wildlife Species:	Canada goose
Comments from Report: Two Canada geese struck aircraft on the right side. One in the #2 engine and the other on right landing gear. Tower reported flames out of the #2 engine. Pilot declared an emergency for landing gear issue. Runway 8 closed for debris. Aircraft made an uneventful landing on runway 14. Aircraft time out of service reported as 20 days. Estimated costs of repairs ($1.5 million) and other costs ($30,000).	

Date:	30 April 2015
Aircraft:	CRJ -700
Airport:	LaGuardia (NY)
Phase of Flight:	Climb (200 feet AGL)
Effect on Flight:	Precautionary landing, flight cancelled
Damage:	Wing
Wildlife Species:	White-headed gull
Comments from Report: First officer advised they received a slat fault indication and declared an emergency landing. Damage caused to the inboard slats on the leading edge and aircraft will be out of service for repairs. Flight was cancelled and passengers were rebooked on another flight. ID by Smithsonian, Division of Birds.	

Date:	30 April 2015
Aircraft:	C-172R
Airport:	Rusk County (TX)
Phase of Flight:	Take-off
Effect on Flight:	Aborted take-off
Damage:	Horizontal stabilizer
Wildlife Species:	White-tailed deer
Comments from Report: Incident occurred during rotation during a touch and go procedure. Small button buck was struck by the horizontal stabilizer when the nose wheel was off the ground and the main gear was just leaving the ground. At approximately 40 AGL the pilot determined that there was adequate runway to safely land. Pilot reduced power and made a normal controlled landing. Extensive skin damage to the left half of the horizontal stabilizer including dents, ripples in skin, cracked and chipped paint.	

Date:	18 May 2015
Aircraft:	B-757-200
Airport:	Honolulu International (HI)
Phase of Flight:	Climb (7000 feet AGL)
Effect on Flight:	Precautionary landing, engine vibration
Damage:	Engine #1
Wildlife Species:	White Tern
Comments from Report: A small part of the engine was damaged and broken off. Aircraft time out of service reported as 1 day. ID by Smithsonian, Division of Birds.	

Date:	26 May 2015
Aircraft:	B-737-800
Airport:	Simón Bolívar International (Venezuela)
Phase of Flight:	Approach (300 feet AGL)
Effect on Flight:	Engine shutdown
Damage:	Engine #2
Wildlife Species:	New world vulture
Comments from Report: Damage required engine change. Aircraft time out of service reported as 6.5 days. Repair costs ($1 million) and other costs ($500,000). U.S. Carrier.	

Date:	3 June 2015
Aircraft:	A-320
Airport:	LaGuardia (NY)
Phase of Flight:	Approach (300 feet AGL)
Effect on Flight:	Go-around
Damage:	Landing gear
Wildlife Species:	Herring gull
Comments from Report: Bird struck left main gear shearing the landing gear sensor. Aircraft to remain overnight and ferry out to conduct gear swing testing. Aircraft time out of service was 5 hours. Repair costs ($825). ID by Smithsonian, Division of Birds.	

Date:	4 June 2015
Aircraft:	Grumman AA5
Airport:	Springhill (LA)
Phase of Flight:	Landing roll
Effect on Flight:	Aircraft controls effected
Damage:	Aircraft destroyed
Wildlife Species:	White-tailed deer
Comments from Report: On final approach pilot unable to see the runway clearly due to setting sun. Left wing struck a deer during the landing roll causing the aircraft to veer left off runway, collapsing gear. Damage to both wings, upper and lower cowling, spinner, all gear and wheel fairings, aft fuselage, flight controls, engine mount and oil cooler. Aircraft transferred to salvage.	

Date:	5 June 2015
Aircraft:	A-319
Airport:	Austin Straubel International (WI)
Phase of Flight:	Take-off
Effect on Flight:	Emergency
Damage:	Engine #2
Wildlife Species:	Gulls
Comments from Report: Significant damage to the #2 engine to include damaged first stage fan blades and damage to the interior of the cowl. Engine vibration. Removed and replaced the engine.	

Date:	22 June 2015
Aircraft:	Lear 35
Airport:	Grosse Ile Municipal (MI)
Phase of Flight:	Take-off
Effect on Flight:	Precautionary landing, aircraft controls effected
Damage:	Wing
Wildlife Species:	White-tailed deer
Comments from Report: On take-off roll while accelerating through 130 knots a “faint bump” was felt. Flt crew continued the take-off and experienced difficulty controlling the aircraft but were able to stabilize the aircraft in flight. Flt crew reported no annunciations or warnings on the flight deck. They were able to identify the damage to the leading edge of the right wing. Flt crew diverted to an alternate airport and landed without incident. Substantial damage to the right wing. Following the accident, the deer was found on the runway at the departure airport.	

Date:	23 June 2015
Aircraft:	A-320
Airport:	Orlando International (FL)
Phase of Flight:	Climb (3000 feet AGL)
Effect on Flight:	Precautionary landing, emergency
Damage:	Windshield
Wildlife Species:	Unknown large bird
Comments from Report: Both pilot and co-pilot saw a very large bird about 1 second before it impacted the First Officer’s forward windshield near upper frame. Upper part of window showed considerable cracking and some fine particles came into the cockpit. Decided to stay low and return because of pressurization and structural uncertainty. Two display units failed on impact. Declared an emergency and made an overweight landing uneventfully. Time out of service 26 hours. Costs reported as $6700.	

Date:	14 July 2015
Aircraft:	B-747-400
Airport:	Ted Stevens Anchorage International (AK)
Phase of Flight:	Climb (50 feet AGL)
Effect on Flight:	Engine shutdown
Damage:	Engine #4
Wildlife Species:	Bald eagle
Comments from Report: Two eagles observed together at 50 feet AGL at end of runway catching thermals. Last 200 feet of runway, 1 bird was ingested into #4 Engine. Time out of service 60 hours. Repair costs ($1 million)	

Date:	25 July 2015
Aircraft:	PA-24-250
Airport:	Philip (SD)
Phase of Flight:	Approach (2 feet AGL)
Effect on Flight:	Crash landing
Damage:	Windshield, wing, fuselage, tail, lights
Wildlife Species:	Deer
Comments from Report: Repair costs ($40,000).	

Date:	31 July 2015
Aircraft:	Challenger 300
Airport:	Columbus (GA)
Phase of Flight:	Take-off
Effect on Flight:	Precautionary landing
Damage:	Engine #2
Wildlife Species:	Mourning dove
Comments from Report: Slight airframe/engine vibration and noise during climb. Elected to return for a precautionary landing. Replaced 4 fan blades, fan inlet housing, frangible sleeve, #1 bearing, #1 carbon seal, spinner cover ring and 7 stator grommets. Time out of service 216 hours. Repair costs ($196,000) and other costs ($65,388). ID by Smithsonian, Division of Birds.	

Date:	10 August 2015
Aircraft:	C-152
Airport:	Ohio State University (OH)
Phase of Flight:	Take-off
Effect on Flight:	Aborted take-off
Damage:	Windshield
Wildlife Species:	Red-tailed hawk
Comments from Report: Bird circled in front of aircraft on take-off. Struck and shattered windscreen resulting in aborted take-off.	

Date:	20 August 2015
Aircraft:	CRJ-200
Airport:	Port Columbus Airport (OH)
Phase of Flight:	Take-off
Effect on Flight:	Precautionary landing, emergency
Damage:	Engine #2
Wildlife Species:	Red-tailed hawk
Comments from Report: Aircraft conducted an Alert 1 return to airport after ingesting a bird resulting in engine vibration. Runway inspection revealed a large debris field of remains consistent with ingestion. Aircraft has at least three damaged fan blades. Runway closed for approximately 25 minutes for cleanup. Time out of service approximately 24 hours. ID by Smithsonian, Division of Birds. Photos.	

Date:	8 September 2015
Aircraft:	B-747-400
Airport:	Amsterdam Schiphol (Amsterdam)
Phase of Flight:	Take-off
Effect on Flight:	Vibration, precautionary landing
Damage:	Engine #2
Wildlife Species:	Gull
Comments from Report: Engine #2 ingested a gull and damaged 5 fan blades. Engine vibration. Jettisoned 130,000 pounds of fuel. Aircraft time out of service approximately 20 hours. Repair costs ($30,000), other costs ($35,000).	

Date:	23 September 2015
Aircraft:	Eurocopter EC-135
Airport:	(CA)
Phase of Flight:	En Route
Effect on Flight:	Emergency landing
Damage:	Windshield
Wildlife Species:	Unknown
Comments from Report: Reported a bird strike with injury; requested emergency landing and ambulance. Passenger in rear of aircraft sustained a cut in the neck from flying glass from the broken windshield.	

Date:	8 October 2015
Aircraft:	A-330
Airport:	Seattle-Tacoma International (WA)
Phase of Flight:	Climb
Effect on Flight:	Precautionary landing, engine flame out
Damage:	Engine #2
Wildlife Species:	Red-tailed hawk
Comments from Report: Bird struck at V1 with nose wheel off the ground. Engine #2 flamed out and made a loud bang. Remains from the engine and the runway analyzed separately by the Smithsonian. ID by Smithsonian, Division of birds. Aircraft time out of service approximately 24 hours. Repair costs ($2 million), other costs ($200,000).	

Date:	26 October 2015
Aircraft:	Czech Sport, Piper Sport
Airport:	Collin County Regional Airport at McKinney (TX)
Phase of Flight:	Climb (400 feet AGL)
Effect on Flight:	Precautionary landing
Damage:	Windshield
Wildlife Species:	Turkey vulture
Comments from Report: Bird struck right side of canopy and shattered the glass over the airport threshold. Sole occupant was not injured.	

Date:	26 October 2015
Aircraft:	Eurocopter EC-130
Airport:	(KY)
Phase of Flight:	En Route
Effect on Flight:	Precautionary landing
Damage:	Fuselage, greenhouse window
Wildlife Species:	Black vulture
Comments from Report: Bird flew into path of aircraft, pilot started to turn left to deviate from the flight path of the bird. Once contact seemed imminent pilot banked the aircraft to the left in an effort to miss the bird. Bird contacted aircraft in the right greenhouse window and entered the aircraft. The window along with the upper plastic lining of the ceiling of the aircraft broke free and continued rearward along with the bird striking the paramedic in the face. Medic was wearing his issued helmet and had his tinted visor down at the time of the impact. Conducted precautionary landing and landed safely in an open field. Once safely on the ground the pilot and nurse evaluated medic for minor injuries. Local police, fire and EMS notified. Medic transported by ambulance to the ER. Reported as black vulture.	

Date:	10 November 2015
Aircraft:	Bell-427
Airport:	(FL)
Phase of Flight:	En Route
Effect on Flight:	Engine shutdown
Damage:	Windshield
Wildlife Species:	Turkey vulture
Comments from Report: Entire bird went through the windshield into the cockpit where it settled against the pilot's leg. Minor scratch to pilot. Flight aborted immediately and landed asap. Repair costs ($20,000).	

Date:	22 December 2015
Aircraft:	CRJ-200
Airport:	Charlotte-Douglas International (NC)
Phase of Flight:	Landing roll
Effect on Flight:	None
Damage:	Landing gear
Wildlife Species:	Coyote
Comments from Report: Crew reported seeing one coyote on runway and possibly striking the specimen during landing roll. Taxied to gate without incident. Carcass of one coyote found near the taxiway intersection. The runway was closed for less than one hour for cleanup of remains due to the strike. The hydraulic line was found damaged on the landing gear. Aircraft taken out of service and the next flight was delayed for an unknown amount of time due to inspections and damage.	

Date:	26 December 2015
Aircraft:	Boeing 737-300
Airport:	Sacramento International (CA)
Phase of Flight:	Climb
Effect on Flight:	Precautionary landing
Damage:	Tail
Wildlife Species:	Canada goose
Comments from Report: Reported as two ducks with primary impact points having been found. One struck the lower right hand side of the nose with no damage. The other bird impacted the left horizontal stabilizer approximately one foot from the outer end with extensive damage to the leading edge and caved in a section approximately eight to ten inches. Bird remains penetrated into the tail and remained throughout the flight. ID by Smithsonian, Division of Birds.	

APPENDIX B.

REPORTING A STRIKE AND IDENTIFYING SPECIES OF WILDLIFE STRUCK

Pilots, airport operations, aircraft maintenance personnel, and anyone else having knowledge of a strike should report the incident to the FAA using FAA Form 5200-7. Strikes can be reported electronically via the internet (http://wildlife.faa.gov) or Form 5200-7 can be accessed and printed for mailing in reports.

It is important to include as much information as possible on FAA Form 5200-7. All reports are carefully screened to identify duplicate reports prior to entry in the database. Multiple reports of the same incident are combined and often provide a more complete record of the strike event than would be possible if just one report were filed.

The National Museum of Natural History, Smithsonian Institution, has the 3rd largest bird collection in the world with over 640,000 specimens. The collection has representatives of about 80% of the 9,600 known species in the world's avifauna.

The identification of the exact species struck (e.g., ring-billed gull, Canada goose, mallard, mourning dove, or red-tailed hawk as opposed to gull, goose, duck, dove, or hawk) is particularly important. This species information is critical for biologists developing wildlife risk management programs at airports and for engineers working on airworthiness standards because a problem that cannot be measured or defined cannot be solved. Bird strike remains that cannot be identified by airport personnel can often be identified by a local biologist trained in ornithology or by sending feather and other remains in a sealed plastic bag (with FAA Form 5200-7) to:

Material sent via Express Mail Service:	**Material sent via U.S. Postal Service:**
Feather Identification Lab	Feather Identification Lab
Smithsonian Institution NMNH	Smithsonian Institution, NMNH
E600, MRC 116	E600, MRC 116
10th & Constitution Ave. NW	P.O. Box 37012
Washington, D.C. 20560-0116	Washington, D.C. 20013-7012
(label package “safety investigation material”)	(not recommended for priority cases)
Phone #s 202-633-0787 or 202-633-0791	

The number of bird strike cases processed by the Smithsonian Feather Identification Lab for the FAA (civil aviation) in 2015 was 3,118 with 3,512 separate identifications of species (some cases involved remains from multiple impact points). This compares to

3,209 cases in 2014, 2,474 cases in 2013, 2,072 cases in 2012, 1,580 cases in 2011 and 1,268 cases in 2010 (Dove et al. 2016). In addition, the Lab processed 3,991 cases involving 4,942 identifications for the U.S. Air Force and 730 cases involving 768 identifications for the U.S. Navy (not discussed in this report). DNA analysis (Dove et al. 2008) was used in 2,409 (69 percent) of all identifications for civil aviation to identify, supplement, or verify traditional identification methods.

Whenever possible, reporters should send whole feathers as diagnostic characteristics are often found in the downy barbules at the feather base. Wings, as well as breast and tail feathers, should be sent whenever possible. Beaks, feet, bones, and talons are also useful diagnostic materials. Even blood smears can provide material for DNA analysis (Dove et al. 2008). **Do not send entire bird carcasses through the mail!** However, photographs of the carcasses can be useful supplemental documentation.

Guidelines for Collecting Bird Strike Material

- Always include any feather material available.
- Include copy of report (FAA 5200-7).
- Always secure all remains in re-sealable plastic bag.

Feathers:

Whole Bird – Pluck a variety of feathers (breast, back, wing, tail)
Partial Bird – Collect a variety of feathers with color or pattern
Feathers only – Send all material available. Do not cut feathers from the bird (downy part at the base of the feathers is needed). Do not use any sticky substance (no tape or glue).

Tissue/blood ("Snarge"):

Dry material – Scrape or wipe off into a clean re-closeable bag **or** wipe area with pre-packaged alcohol wipe **or** spray with alcohol to loosen material then wipe with clean cloth/gauze. (Do not use water, bleach, or other cleansers; they destroy DNA.)
Fresh material – Wipe area with alcohol wipe and/or clean cloth/gauze **or** apply fresh tissue/blood to an FTA® DNA collecting card.

FTA® Micro Card and Sterile Applicators

If you send a lot of fresh blood/ tissue samples for DNA identification, you may want to consider getting Whatman FTA® DNA cards. The material is sampled with a sterile applicator and placed onto the surface of the card that "fixes" the DNA in the sample. For more information on ordering these items contact the Feather Lab.

Note: If you only occasionally send blood/ tissue samples, a paper towel with alcohol or alcohol wipe is still a good option for this type of material.

Additional information on sending bird remains to the Smithsonian is available at http://wildlife.faa.gov.