Wildlife Strikes to Civil Aircraft in the United States 1990–2014

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Captured snowy owl ready for relocation. Photo courtesy PANYNJ.

AUTHORS

Richard A. Dolbeer, Science Advisor, Airport Wildlife Hazards Program, U.S. Department of Agriculture, APHIS, Wildlife Services, 6100 Columbus Ave., Sandusky, OH 44870

Sandra E. Wright, Wildlife Strike Database Manager, Airport Wildlife Hazards Program, U.S. Department of Agriculture, APHIS, Wildlife Services, 6100 Columbus Ave., Sandusky, OH 44870

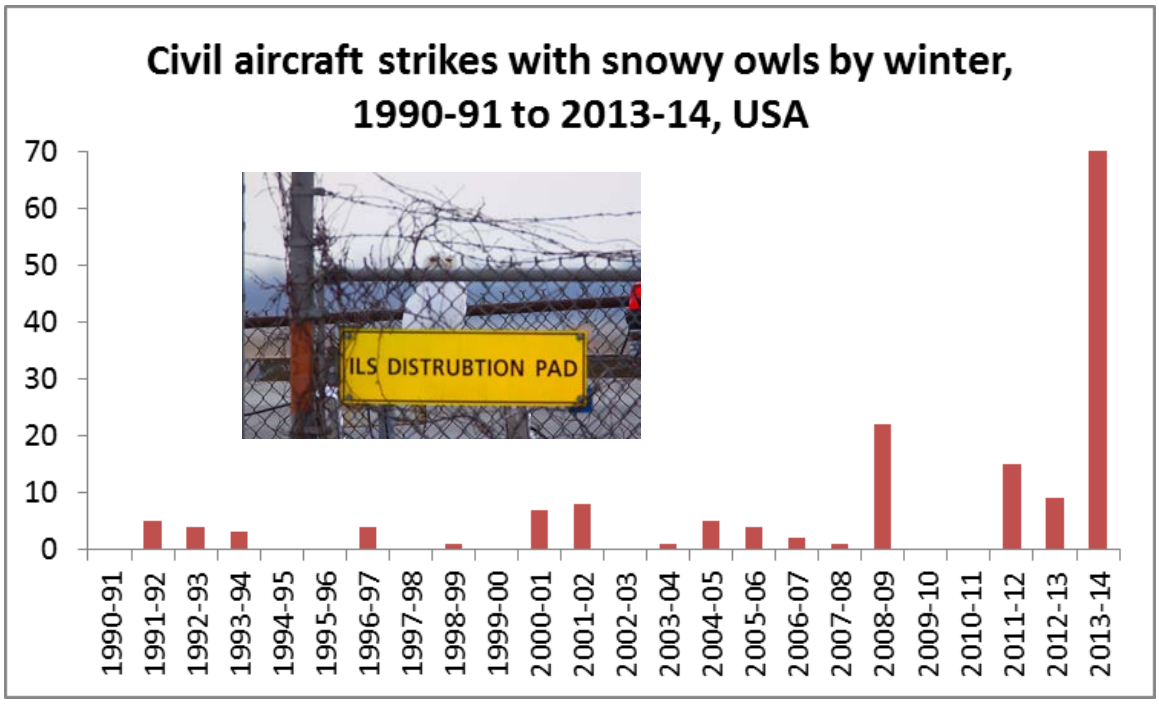
John R. Weller, National Wildlife Biologist, Office of Airport Safety and Standards, Federal Aviation Administration, 800 Independence Ave., SE, Washington, DC 20591

Amy L. Anderson, National Wildlife Biologist, Office of Airport Safety and Standards, Federal Aviation Administration, 800 Independence Ave., SE, Washington, DC 20591

Michael J. Begier, National Coordinator, Airport Wildlife Hazards Program, U.S. Department of Agriculture, APHIS, Wildlife Services, 1400 Independence Ave., SW, Washington, DC 20250

COVER PHOTOGRAPH

During the winter of 2013-2014 airport operators in the eastern and Midwestern USA had to deal with a "polar vortex" of cold weather, major snowfalls, and an unprecedented invasion of snowy owls from the Canadian arctic regions. Many airports had to implement trap and relocation programs to remove these large birds. Seventy snowy owl strikes were reported which was 3.2 times the previous record of 22 strikes recorded in the winter of 2008-2009. Snowy owls are the largest of the 19 owl species in North America with mean body masses of 5 lbs for females and 4 lbs for males. Cover photo, Christopher Castillo.



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We acknowledge and thank all of the people who took the time and effort to report the 156,114 wildlife strikes summarized in this report – pilots, mechanics, control tower personnel, airport operations personnel, airline flight safety officers, airport wildlife biologists, and many others. Sponsorship and funds for the ongoing maintenance and analysis of the FAA Wildlife Strike Database are provided by the FAA, Office of Airport Safety and Standards, Washington, DC, and the Airports Research and Development Branch, FAA William J. Hughes Technical Center, Atlantic City, NJ. 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 Edward Cleary, retired FAA biologist and Roger Nicholson, Boeing Aircraft Company, for timely advice during the development of this and previous reports.

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EXECUTIVE SUMMARY - PART 1: WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES, 1990–2014

2014 marked the fifth 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 over the past 5 years 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 258 people and destroyed over 245 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 25-year period 1990 through 2014. A sample of 25 significant wildlife strikes to civil aircraft in the USA during 2014 is also included as Appendix I.

The number of strikes annually reported to the FAA has increased 7.4-fold from 1,851 in 1990 to a record 13,668 in 2014. The 2014 total was an increase of 2,267 strikes (20 percent) compared to the 11,401 strikes reported in 2013. For 1990–2014, 156,114 strikes were reported. Birds were involved in 96.9 percent of the reported strikes, terrestrial mammals in 2.2 percent, bats in 0.8 percent and reptiles in 0.1 percent. Although the number of reported strikes has dramatically increased, the number of reported damaging strikes has actually declined since 2000. Whereas the number of reported strikes increased 127 percent from 6,009 in 2000 to 13,668 in 2014, the number of damaging strikes declined 24 percent from 764 to 581. While there was a 20 percent increase in reported strikes from 2013 to 2014, the number of damaging strikes declined 4 percent from 606 to 581. The decline in damaging strikes has been most pronounced for commercial aircraft in the airport environment (at $\leq$1,500 feet above ground level [AGL]). Damaging strikes have not declined for general aviation (GA) aircraft.

In 2014, 74 percent and 2 percent of the 13,668 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 331 in 1990 to a record 673 in 2014. The 673 airports with strikes reported in 2014 were comprised of 396 airports certificated for passenger service under 14 CFR Part 139 and 277 GA aviation airports. From 1990 - 2014, strikes have been reported from 1,871 USA airports.

Fifty-three 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 (64 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, 65, and 83 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 2014, 518 species of birds, 41 species of terrestrial mammals, 21 species of bats, and 17 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 25-year period, this number has declined from 20 percent in 1990 to 4 percent in 2014.

A negative effect-on-flight was reported in 6 percent and 21 percent of the bird and terrestrial mammal strike reports, respectively. Precautionary/emergency landing after striking wildlife was the most commonly reported negative effect (5,217 incidents), including 48 incidents in which the pilot jettisoned fuel (an average of 14,136 gallons) to lighten aircraft weight and 87 incidents in which an overweight landing was made. Aborted take-off was the second most commonly reported negative effect (2,146 incidents). These negative incidents included 882 aborted take-offs at $\geq$80 knots within the 25-year time span. Similar to the trend shown for the percentage of strikes causing damage, the percentage of strikes with a reported negative effect-on-flight has declined from a high of 12 percent in 1996 to 4 percent in 2014. For commercial aircraft, the number of high-speed ($\geq$80 knots) aborted take-offs has declined from a high of 39 in 2000 to 16 in 2014.

For the 30 species of birds most frequently identified as struck by civil aircraft, 1990–2014, there was a strong correlation (R^2 = 0.82) 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 1.27% increase in the likelihood of damage. Thus, body mass is a good predictor of relative hazard level among bird species.

Sixty-seven strikes have resulted in a destroyed aircraft from 1990-2014; 40 (60 percent) of these occurred at GA airports. The annual cost of wildlife strikes to the USA civil aviation industry in 2014 was projected to be a minimum of 172,151 hours of aircraft downtime and $208 million in direct and other monetary losses. Actual losses are likely much higher.

This analysis of 25 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 2000-2014 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 above 500 feet AGL, 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, on-going research and mitigation efforts to further develop and incorporate avian radar and bird migration forecasting and to study avian sensory perception to enhance aircraft detection and avoidance by birds should be maintained. Third, Federal guidance on wildlife hazards at airports should continue to be reviewed, and where necessary revised, to incorporate new information about wildlife hazards and wildlife strike reporting trends. Finally, there continues to be a need for increased reporting of wildlife strikes with details provided on species identification, number of wildlife struck, time, phase of flight, height, distance from airport, and damage costs.

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

In 2014, 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. The FAA reported in 2013 that 100 percent of Part 139 airports have completed a Wildlife Hazard Assessment (Assessment), are in the process of conducting an Assessment, or have taken a Federal grant to conduct an Assessment. Strike reporting continued to increase, especially with general aviation (GA) aircraft, which increased strike reporting by 8 percent between 2012 and 2013 and 21 percent between 2013 and 2014. Overall, GA strike reporting increased 58 percent in the five years between 2010 and 2014 while the damaging strikes reported increased only 12 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. While strike

reporting has increased, damaging strike numbers indicate that hazardous wildlife on and near airports have been successfully managed to decrease the risk of a strike.

The FAA continued to distribute the latest “Report Wildlife Strikes” awareness poster throughout 2013 - 2014. Overall, more than 36,000 posters have been distributed to 4,000+ Part 139 airports, GA airports, aviation flight schools and the aviation industry in the last four years. The distribution of strike awareness posters is one of several outreach activities to improve strike reporting and safety at airports.

The FAA continues work with industry to encourage all certificated airports to conduct Assessments, even if the certificated airport has not experienced one of the triggering events specified in Part 139.337. 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 new Airport Cooperative Research Program (ACRP) reports to aid airports with the mitigation of wildlife hazards. ACRP Synthesis 39 report *Airport Wildlife Population Management* (2013) and Synthesis 52 report *Habitat Management to deter Wildlife at Airports* (2014) are available from the Transportation Research Board (TRB) of the National Academies at http://www.trb.org/Publications/Publications.aspx. 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. These reports provide further guidance to all airports, including GA airfields with the mitigation of wildlife hazards.

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 every year after. Last year, 85 percent of the 13,668 strike reports were filed electronically.

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 five certificated airports were: Dallas-Fort Worth (DFW), Los Angeles (LAX), Portland (PDX), Seattle (SEA) and Denver (DEN). Honorable mentions go to Minneapolis-Saint Paul (MSP) and Orlando (MCO). The Top five GA airports were Morristown Municipal Airport (MMU), Centennial (APA), Van Nuys (VNY), Addison (ADS) and Dupage (DPA). Honorable mention went to Fort Lauderdale Executive Airport (FXE).

For their commitment to the identification and documentation of wildlife / aircraft strike information, the FAA proudly recognizes the superior strike reporting programs at Dallas-Fort Worth International Airport and Morristown Municipal Airport as the winners of the 2014 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.

Finally, 2015 marks the 50th anniversary of an 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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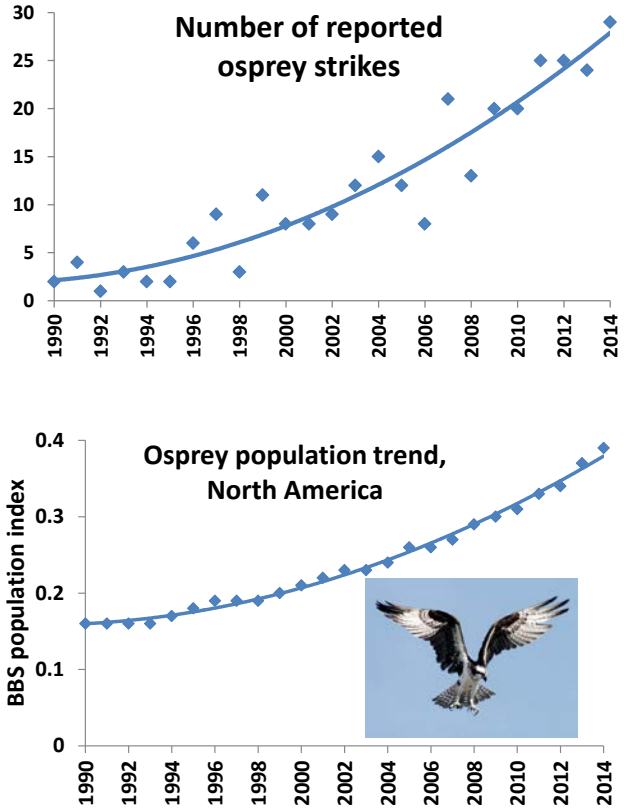
PART 1: WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES, 1990–2014

A Hawker 800 business jet struck a flock of double-crested cormorants at 700 feet AGL during departure from an eastern USA airport in April 2014. The multiple impacts of these 5-lb birds damaged the nose, fuselage, landing gear and #1 engine. The pilot declared an emergency and returned to land safely at the airport using 1 engine. The aircraft was out of service 168 hours and costs of repairs were at least $825,000. Photo provided by aircraft owner.

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 258 people and destroyed over 245 aircraft from 1988 – 2014 (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 have 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. 2014). During the same time period, the North American snow goose population increased from about 2.6 million to 6.2 million birds (U.S. Fish and Wildlife Service. 2014). Other large-bird species that have shown significant population increases from 1990 to 2014 include bald eagles (7.4 percent annual rate of increase), wild turkeys (10.4 percent), black vultures (5.6 percent), red-tailed hawks (2.0 percent), western grebes (4.1 percent), sandhill cranes (5.8 percent), great egrets (3.1 percent), and great blue herons (1.8 percent, Sauer et al. 2015). 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).



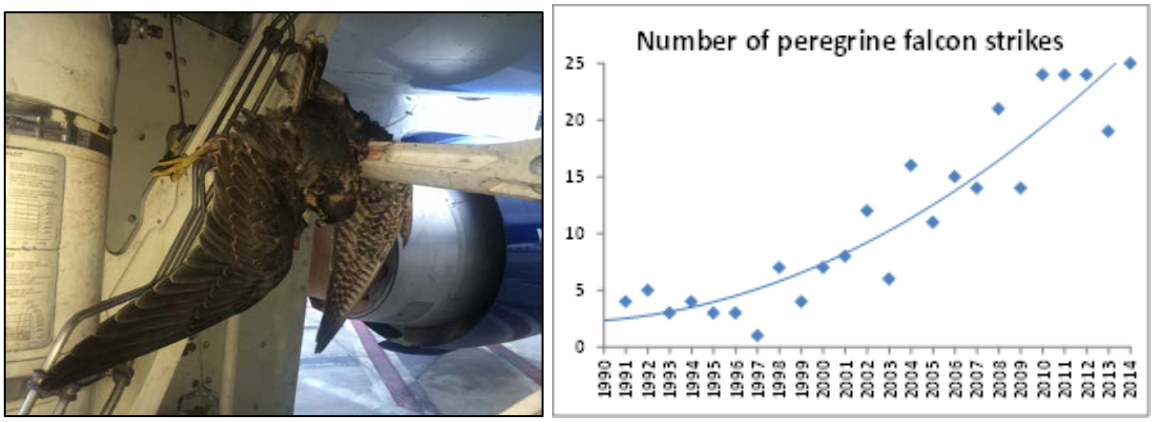
From 1990-2014, 293 osprey strikes were reported for civil aircraft in USA, including a record 29 in 2014. During these years, the osprey population increased at a mean annual rate of 3.8 percent (population graph by R. A. Dolbeer based on data from North American Breeding Bird Survey [Sauer et al. 2015]).

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 24.5 million movements in 2014 (Table 2). Passenger enplanements in the USA increased from about 495 million in 1990 to 705 million in 2000 and 748 million in 2014 (Federal Aviation Administration 2015*a*). Commercial air traffic in the USA is

predicted to grow at a rate of about 1.1 percent per year from 24.5 million movements in 2014 to 30.3 million by 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 2015). 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.



A peregrine falcon became wedged in the landing gear of an Embraer 190 during landing roll at a large east coast airport in August 2014. There was no damage to aircraft. From 1990-2014, 274 peregrine falcons were reported as struck by civil aircraft in USA, including a record 25 in 2014. Photo courtesy of airport operator.

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).

A DHC8 DASH aircraft struck several Canada geese during the initial take-off run from a Pennsylvania airport at dawn on 10 August 2014. The fuselage and a passenger window were damaged by a goose that was slung into side of aircraft after striking a propeller blade. The damaged propeller caused strong engine vibrations and pilot aborted take-off at 40 knots. 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 21th report in the series and covers the 25-year period, 1990–2014. 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 25 significant wildlife strikes to civil aircraft in the USA during 2014 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, 1990–2014, 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 1,851 in 1990 to a record 13,668 in 2014. The 2014 total was an increase of 2,267 strikes (20 percent) compared to the 11,401 strikes reported in 2013 (Table 1, Figure 1). For the 25-year period (1990–2014), 156,114 strikes were reported. Birds were involved in 96.9 percent of the reported strikes, terrestrial mammals in 2.2 percent, bats in 0.8 percent and reptiles in 0.1 percent (Table 1).

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 127 percent from 6,009 in 2000 to 13,668 in 2014, the number of damaging strikes declined 24 percent from 764 to 581. As noted above, while there was a 20 percent increase in reported strikes from 2013 to 2014, the number of damaging strikes declined 4 percent from 606 to 581.

This decline in damaging strikes has occurred in the commercial aviation sector. While the number and rate (per 100,000 movements) of all strikes with commercial aircraft has increased 68 and 119 percent, respectively, from 2000 to 2014, the number and rate of damaging strikes has declined 34 and 20 percent, respectively (Table 2, Figure 3).

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 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).

A Cessna 560 struck a turkey vulture at 1600 feet AGL on approach to a general aviation airport in Florida, July 2014. The leading edge of wing and deicing unit were damaged. Repair costs were $162,000 and aircraft was out of service for 2 months. Photo by aircraft owner.

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 1.94 in 2014. 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 3, Figure 3). For GA aircraft, there has not been a decline in damaging strikes in the airport environment (at ≤500 feet AGL) and there has been an increase in damaging strikes at >500 feet AGL (Figure 4).

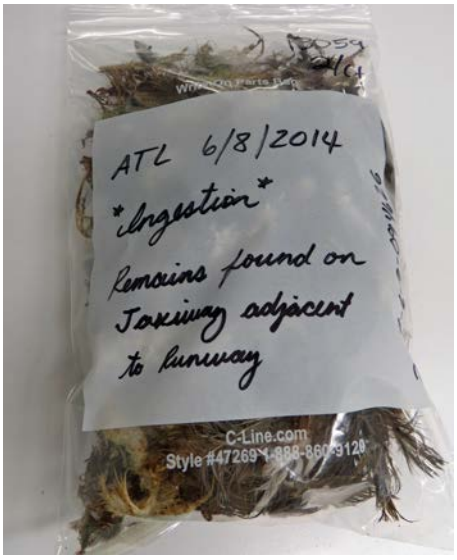
METHODS OF REPORTING STRIKES

In 2014, 74 percent and 2 percent of the 13,668 strike reports were filed using the electronic and paper versions, respectively, of FAA Form 5200-7, *Bird/Other Wildlife Strike Report*. Eleven 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 7 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 6 percent of strike reports filed in 2014 were obtained from various sources (Table 4).

SOURCE OF REPORTS

In 2014, airport operations personnel filed 54 percent of the strike reports (including "Carcass Found" reports), followed by pilots (20 percent), airlines operations personnel (8 percent), Air Traffic Control personnel (17 percent), and other (1 percent, Table 5). In 2014, about 86 percent of the reported strikes involved commercial aircraft; the remainder involved business, private, and government aircraft (Table 6).

The number of USA airports with strikes reported has increased steadily from 331 in 1990 to a record 673 in 2014 (Table 7, Figure 5). The 673 airports with strikes reported in 2014 were comprised of 396 airports certificated for passenger service under 14 CFR Part 139 and 277 general aviation airports. From 1990 - 2014, 135,038 strikes have been reported from 1,871 USA airports. In addition, 3,316 strikes involving USA-registered civil aircraft were reported at 286 foreign airports in 106 countries, 1990 – 2014 (230 strikes at 93 foreign airports in 54 countries in 2014).



A large bird was ingested into the #2 engine of a Boeing 737 at 500 feet AGL on departure from a southern USA airport, June 2014. The pilot put the damaged engine at idle speed and returned safely to airport. Bird remains from engine and runway sent to Smithsonian Feather Lab were identified as brown pelican. Engine had to be overhauled. Photo, Smithsonian.

A PA-28 aircraft struck a Canada goose at 50 feet AGL on final approach to a GA airport in the upper Midwest on 21 April 2014. The aircraft sustained substantial damage to the wing and was out of service 720 hours for repairs. Canada goose strikes with civil aircraft have declined from a peak of 87 reported in 1998 to 57 in 2014. Photo by aircraft owner.

TIMING OF OCCURRENCE AND PHASE OF FLIGHT OF STRIKES

From 1990 – 2014, most bird strikes (53 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 8). 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 9).

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 (64 percent) occurred at night (Table 8). As with birds, about twice as many strikes (65 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 9).

For bats, 82 percent of strikes occurred at night (Table 8). The difference in numbers of strikes during arrival compared to departure phase of flight was even great for bats compared to birds and terrestrial mammals. Eighty-three percent of reported bat strikes occurred during arrival compared to only 14 percent during departure (Table 9).

HEIGHT ABOVE GROUND LEVEL (AGL) OF STRIKES

Bird strikes with commercial aircraft- From 1990 – 2014, 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 10). 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 43 percent of the damaging strikes (Table 10, Figure 8).

Bird strikes with general aviation (GA) aircraft- From 1990 – 2014, 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 11). 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 11, 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 9).

AIRCRAFT COMPONENTS DAMAGED

A Boeing 767 departing a western airport in June 2014 struck several Canada geese at 400 feet AGL. The #2 Engine exhibited severe vibrations and the pilot made an emergency landing. Parts of 2 Canada geese and 2 fan blades were recovered from runway. Wing flaps were also damaged. Repair costs were $3.9 million. Photo by airport Operations personnel.

The aircraft components most commonly reported as struck by birds from 1990 – 2014 were the nose/radome, windshield, wing/rotor, engine, and fuselage (Table 12). Aircraft engines were the component most frequently reported as being damaged by bird strikes (29 percent of all damaged components). There were 15,870 strike events in which a total of 16,636 engines were reported as struck (15,130 events with one engine struck, 720 with two engines struck, 14 with three engines struck, and 6 with four engines struck). In 4,272 damaging bird-strike events involving engines, a total of 4,417 engines was damaged (4,130 events with one engine damaged, 140 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 12).

REPORTED DAMAGE

For the 151,267 strike reports involving birds from 1990–2014, 12,982 (9 percent) indicated damage to the aircraft (Table 13). When classified by level of damage, 6,964 (5 percent) indicated the aircraft suffered minor damage; 3,334 (2 percent) indicated the aircraft suffered substantial damage; 2,647 (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 13).

For the 3,360 terrestrial mammal strikes reported, 1,055 (31 percent) indicated damage to the aircraft. When classified by level of damage; 541 (16 percent) indicated the aircraft suffered minor damage; 408 (12 percent) indicated the aircraft suffered substantial damage; 76 (2 percent) reported an uncertain level of damage; and 30 (1 percent) indicated the aircraft was destroyed as a result of the strike (Table 13). Not surprisingly, a much higher percentage of terrestrial mammal strikes (31 percent) resulted in aircraft damage than did bird strikes (9 percent). Deer (1,094 strikes, of which 922 caused damage; Table 17) were involved in 33 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 25-year period (Table 13), this number has declined from 20 percent in 1990 to 4 percent in 2014 (Figure 9).

An Airbus 320 departing an east coast airport in March 2014 struck a sub-adult herring gull at 300 feet AGL. The bird became wedged in the radome and spattered blood over the left windshield. The pilot declared an emergency and diverted to a nearby major airport where a safe landing was made. The aircraft was out of service for 7 hours while the radome was replaced. Photo by Stan Nowak.

REPORTED NEGATIVE EFFECT-ON-FLIGHT

A negative effect-on-flight was reported in 6 percent and 21 percent of the bird and terrestrial mammal strike reports, respectively, (Table 14). Precautionary/ emergency landing after striking wildlife was the most commonly reported negative effect (5,217 incidents, 3 percent of strike reports). These precautionary landings included 195 incidents in which the pilot jettisoned fuel (48) or burned fuel in a circling pattern (60) to lighten aircraft weight or in which an overweight landing was made (87, Table 15, Figure 10). In the 48 reported incidents in which fuel was jettisoned, an average of 96,125 pounds (14,136 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 (2,146 incidents, 1 percent of strike reports, Table 14). These negative incidents included 882 aborted take-offs in which the pilot initiated the abort at an aircraft speed of 80 knots (92 miles per hour) or greater (Table 16). In 147 incidents, the aircraft speed at the time of abort was 120 knots (138 miles per hour) or greater. For commercial aircraft, the number of high-speed aborted take-offs has declined from a high of 39 in 2000 to a 16 in 2014 (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 (Figure 9).

WILDLIFE SPECIES INVOLVED IN STRIKES

Table 17 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 - 2014. 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).

Birds- Of the 151,267 reported bird strikes, 59,354 (39 percent) identified the bird to exact species and an additional 18,629 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 56-61 percent in 2013-2014 (Figure 12). In all, 518 species of birds have been identified as struck by aircraft, and 240 of these species were reported as causing damage, 1990–2014. In 2014, 330 bird species were identified as struck by civil aircraft.

A Boeing 757 struck a bird at 4600 feet AGL during climb out from a western airport in September 2014. Flight crew detected no abnormalities and continued to destination airport where large dent in radome was revealed. Bird remains were recovered and identified as Franklin's gull by Smithsonian Feather Lab. Aircraft was out of service 24 hours and repair costs were $30,000. Photo, USDA.

Doves/pigeons (14 percent), gulls (13 percent), raptors (13 percent), shorebirds (8 percent), and waterfowl (6 percent) were the most frequently struck bird groups (Table 18). Doves/pigeons, gulls, and raptors each were involved in over 2 times more strikes than waterfowl (9,967-11,254 and 4,675, 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, 1990–2014. Doves/pigeons and gulls were responsible for the greatest number of bird strikes (2,268 and 2,128, respectively) that involved multiple birds.

Table 19 lists the 30 species of birds identified most frequently as struck by civil aircraft for 1990–2014 and for 2014 only. Mourning doves, American kestrels, killdeer, European starlings, barn swallows, and horned larks were the 6 most frequently identified species struck by civil aircraft overall from 1990–2014 and in 2014 only. Canada geese, the 9th most frequently identified species struck overall from 1990–2014, declined to the 22nd most frequently struck species in 2014 in spite of the fact that the overall population in North America has increased 2.2 fold, 1990–2014 (U.S. Fish and Wildlife Service 2014). 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).

For the 30 species of birds most frequently identified as struck by civil aircraft, 1990–2014, there was a strong correlation (R^2 = 0.82) 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 1.27% 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 34 percent, respectively, Tables 17, 18). Coyotes were the most frequently struck Carnivore and deer were the most frequently struck Artiodactyl. Artiodactyls were responsible for 92 percent of the mammal strikes that resulted in damage and 75 percent of the mammal strikes that involved multiple animals. In all, 41, 21 and 17 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 17).

This Embraer 135 hit a common loon at 2900 feet on final approach into a Michigan airport in May 2014. The 12-lb bird penetrated the bulkhead and splattered blood on the flight crew. The aircraft landed safely. Aircraft was out of service over 6 months for repairs to radome, fuselage and instrument panels. Photo by aircraft owner.

HUMAN FATALITIES AND INJURIES DUE TO WILDLIFE STRIKES

For the 25-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 223 strikes that resulted in 388 human injuries (Table 20). Waterfowl (ducks and geese; 53 strikes, 159 humans injured), vultures (33 strikes, 41 injuries), and deer (20 strikes, 29 injuries) caused 106 (61 percent) of the 175 strikes resulting in injuries in which the species or species group was identified. Canada geese caused 117 (35 percent) of the 335 injuries in which the species or species group was identified.

AIRCRAFT DESTROYED DUE TO WILDLIFE STRIKES

For the 25-year period, reports were received of 67 aircraft destroyed or damaged beyond repair due to wildlife strikes (range of 0 to 6 per year, Tables 13, 21, Figure 14). The majority (42; 63 percent) were small (≤2,250 kg maximum take-off mass) general aviation (GA) aircraft. Terrestrial mammals (primarily white-tailed deer) were responsible for 30 (45 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 (60 percent) of the 67 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 21). 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).

An Airbus 319 ingested a red-tailed hawk in the #1 engine during the take-off run from a southern U.S. airport, August 2014. The pilot aborted take-off at 143 knots. Aircraft was out of service 120 hours; cost of engine replacement and other repairs was $6.5 million. Red-tails are the hawk species most frequently struck by civil aircraft in USA (Table 17). Photo, aircraft operator.

ECONOMIC LOSSES DUE TO WILDLIFE STRIKES

Of the 23,055 reports from 1990 – 2014 that indicated the strike had an adverse effect on the aircraft and/or flight, 8,219 provided an estimate of the aircraft downtime (981,200 hours, mean = 119.4 hours/incident, Tables 17, 22, 23). Regarding monetary losses, 3,731 reports provided an estimate of direct aircraft repair costs ($631.8 million, mean = $169,349/incident), and 2,671 reports gave an estimate of other monetary losses ($76.4 million, mean = $28,596/incident)[1]. Other monetary losses include such expenses as lost revenue, the cost of putting passengers

[1] Costs from years prior to 2014 are inflation-adjusted to 2014 U.S. dollars.

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% and 93 percent for these respective time periods. In addition to the underreporting of strikes, only 36 percent of the 23,055 reports from 1990–2014 indicating an adverse effect provided estimates of aircraft downtime, 16 percent provided estimates of direct costs, and 12 percent provided estimates of other (indirect) costs (these respective percentages were 49, 15, and 19 for 2014 only, Tables 22, 23). Furthermore, some reports providing cost estimates were filed before aircraft 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 17) is believed to significantly underestimate the economic magnitude of the problem.

During the winter of 2013-2014, snowy owls from the Canadian arctic invaded U.S. airports in record numbers. This owl was found perched on an aircraft during an early morning inspection at a Midwestern airport, January 2014. Photo USDA.

Assuming (1) all 23,055 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, 119,645 hours of aircraft downtime and $193 million in monetary losses ($157 million in direct costs and $36 million in other costs), 1990–2014 (Table 23). For 2014 only, the minimum estimates would be 172,151 hours of downtime and $208 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 25 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 2000-2014 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 838 civil and military airports nationwide in 2014 to mitigate wildlife risks to aviation compared to only 42 airports in 1991 and 193 in 1998 (Begier and Dolbeer 2015). However, much work remains to be done to reduce wildlife strikes.

Airports, with large expanses of open areas, can be attractive habitats for numerous wildlife species. In these photos from an east coast airport in 2014, a female northern harrier feeds on a brant (left) and rabbits use a narrow gap in a gate to gain access onto the airfield. During 2014, 330, 18, 13, and 8 species of birds, terrestrial mammals, bats, and reptiles, respectively, were reported as struck by civil aircraft in USA. Photos by airport operator.

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). They then must take appropriate actions, under the guidance of professional biologists trained in wildlife damage management at airports, to minimize the risks posed by wildlife. Management actions should be prioritized based on the hazard level of species (Table 17, Figure 13) observed in the aircraft operating area. The manual *Wildlife Hazard Management at Airports* (Cleary and Dolbeer 2005) provides guidance to airport personnel and biologists for conducting wildlife hazard assessments and in developing and implementing wildlife hazard management plans. Adobe Acrobat© PDF versions of the manual are available online in English, Spanish, and French at http://wildlife.faa.gov.

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 ≤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 such as occurred with US Airways Flight 1549 in 2009 (Dolbeer 2011).

A red-tailed hawk perches on a glideslope antennae at a west coast airport. As part of an airport's Wildlife Hazard Management Plan (WHMP), biologists and operations personnel should keep detailed records of wildlife observations, strikes, and management actions in a GIS format. These data can then be used in multiple ways to monitor and improve the WHMP. Photo USDA.

To mitigate the risk for strikes above 500 feet, 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 minimizes the attraction of hazardous wildlife. Second, on-going research and mitigation efforts to further develop and incorporate avian radar and bird migration forecasting and to study avian sensory perception to enhance aircraft detection and avoidance by birds should be maintained (e.g., Nohara et al. 2011, Blackwell et al. 2012, DeVault et al. 2015). Third, Federal guidance on wildlife hazards at airports should continue to be reviewed, and where necessary revised, to incorporate new information about wildlife hazards and wildlife strike reporting trends. Finally, there continues to be a need for increased and more detailed reporting of information about wildlife strikes, such as species identification and number of wildlife struck, time and height of strike, and damage costs (Dolbeer 2015, see Appendix B: Reporting a Strike and Identifying Species of Wildlife Struck).

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TABLES

Table 1. Number of reported wildlife strikes to civil aircraft by wildlife group, USA, 1990–2014 (see Figures 1 and 2).

Year	Birds	Bats	Terrestrial mammals[1]	Reptiles[1]	Total strikes	Strikes with damage
1990	1,795	4	52	0	1,851	372
1991	2,335	3	54	0	2,392	400
1992	2,497	2	73	1	2,573	367
1993	2,504	6	66	0	2,576	399
1994	2,554	2	82	1	2,639	462
1995	2,673	5	84	8	2,770	498
1996	2,844	1	90	3	2,938	502
1997	3,352	1	95	14	3,462	580
1998	3,687	3	111	7	3,808	586
1999	5,020	7	96	1	5,124	706
2000	5,867	16	123	3	6,009	764
2001	5,674	8	138	8	5,828	647
2002	6,073	19	118	15	6,225	671
2003	5,850	20	127	5	6,002	632
2004	6,399	27	129	6	6,561	626
2005	7,063	27	131	7	7,228	605
2006	7,041	49	140	10	7,240	597
2007	7,516	53	172	7	7,748	570
2008	7,399	46	183	5	7,633	526
2009	9,203	67	228	10	9,508	604
2010	9,537	113	245	11	9,906	596
2011	9,764	139	198	15	10,116	542
2012	10,521	165	203	19	10,908	611
2013	10,940	226	203	32	11,401	606
2014	13,159	255	219	35	13,668	581
Total	**151,267**	**1,264**	**3,360**	**223**	**156,114**	**14,050**

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

Table 2. Number and rate of reported wildlife strikes and strikes with damage for commercial air carrier aircraft, USA, 1990–2014 (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	1,348	222	23.26	5.80	0.95
1991	1,780	250	24.77	7.18	1.01
1992	1,796	207	25.17	7.14	0.82
1993	1,775	228	25.56	6.94	0.89
1994	1,892	278	26.58	7.12	1.05
1995	1,987	312	27.04	7.35	1.15
1996	2,054	308	27.57	7.45	1.12
1997	2,431	368	27.75	8.76	1.33
1998	2,485	360	28.00	8.88	1.29
1999	3,783	462	28.74	13.16	1.61
2000	4,383	494	29.53	14.84	1.67
2001	4,049	430	29.15	13.89	1.48
2002	4,268	452	27.61	15.46	1.64
2003	4,142	398	27.89	14.85	1.43
2004	4,547	390	28.87	15.75	1.35
2005	4,981	398	29.23	17.04	1.36
2006	4,757	385	28.29	16.81	1.36
2007	4,861	338	28.46	17.08	1.19
2008	4,443	324	27.96	15.89	1.16
2009	5,873	370	25.46	23.07	1.45
2010	5,793	362	25.12	23.06	1.44
2011	5,721	321	25.11	22.78	1.28
2012	6,152	368	24.89	24.72	1.48
2013	6,270	308	24.59	25.50	1.25
2014	7,959	326	24.47	32.52	1.33
Total	**99,530**	**8,659**	**671.07**	**14.83**	**1.29**

[1] Strikes involving an unknown operator (36,231 of which 35,109 were “Carcass Found” reports--see Tables 5 and 6) 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 2015*a*).

Table 3. Number and rate of reported wildlife strikes and strikes with damage for general aviation aircraft, USA, 1990–2014 (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	77.52	0.43	0.17
1991	406	130	83.51	0.49	0.16
1992	434	143	82.30	0.53	0.17
1993	447	159	80.37	0.56	0.20
1994	475	172	79.17	0.60	0.22
1995	482	172	77.18	0.62	0.22
1996	506	179	78.95	0.64	0.23
1997	508	190	79.93	0.64	0.24
1998	570	206	84.23	0.68	0.24
1999	622	214	85.33	0.73	0.25
2000	674	246	87.08	0.77	0.28
2001	697	196	85.90	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	80.22	0.84	0.27
2008	627	186	78.05	0.80	0.24
2009	860	213	73.63	1.17	0.29
2010	842	213	71.26	1.18	0.30
2011	918	198	69.93	1.31	0.28
2102	1,020	222	69.61	1.47	0.32
2013	1,102	284	68.84	1.60	0.41
2014	1,332	238	68.72	1.94	0.35
Total	**17,037**	**4,919**	**1,974.87**	**0.86**	**0.25**

[1] Strikes involving an unknown operator (36,231 of which 35,109 were “Carcass Found” reports--see Tables 5 and 6) 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 2015*a*).

Table 4. Methods of reporting and source of information for reported wildlife strikes to civil aircraft, USA, 1990–2014, and 2014 only.

	1990–2014		2014 only	
Source	Total	% of total	Total	% of total
FAA Form 5200-7E (Electronic)[1]	72,898	47	10,173	74
FAA Form 5200-7 (Paper)[1]	42,635	27	285	2
Air Transport report	15,058	10	464	3
Multiple[2]	12,490	8	1,501	11
Airport report	6,149	4	70	<1
Other[3]	1,787	1	23	<1
Daily Report (FAA)	1,264	<1	158	1
Mandatory Occurrence Report	1,032	<1	994	7
Preliminary Aircraft Incident Report	881	<1	0	0
Engine manufacturer	817	<1	0	0
Aircraft Incident Report	714	<1	0	0
Aviation Safety Reporting System	199	<1	0	0
National Transportation Safety Board	82	<1	0	0
Aircraft Incident Preliminary Notice	68	<1	0	0
Transport Canada	36	<1	0	0
U.S. Air Force (BASH)	4	<1	0	0
Total	**156,114**	**100**	**13,668**	**100**

[1] 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 74 percent in 2014. 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 2014.

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

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

Table 5. Person filing report of wildlife strike to civil aircraft, USA, 1990–2014, and 2014 only.

	1990–2014		2014 only	
Person filing report	Total	% of total	Total	% of total
Airport Operations	58,840	44	7,181	54
Carcass Found[1]	35,110	60	4,104	57
Other Reports[2]	23,730	40	3,077	43
Pilot	30,929	23	2,727	20
Airline Operations	28,359	21	1,014	8
Tower	13,918	10	2,286	17
Other	3,136	2	99	1
Total known	**135,182**	**100**	**13,307**	**100**
Unknown	**20,932**		**361**	
Total	**156,114**		**13,668**	

[1] 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.

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

Table 6. Number of reported wildlife strikes to civil aircraft by type of operator, USA, 1990–2014, and 2014 only.

	1990–2014		2014 only	
Type of operator	Total	% of total	Total	% of total
Commercial[1]	**102,703**	**86**	**8,173**	**86**
General aviation	**17,180**	**14**	**1,348**	**14**
Business	13,524	11	1,149	12
Private	2,469	2	88	1
Government/ Police[2]	1,187	1	111	1
Total known	**119,883**	**100**	**9,521**	**100**
Unknown[3]	**36,231**		**4,147**	
Total	**156,114**		**13,668**	

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

[2] U.S. Customs and Border Protection (USCBP) and U.S. Coast Guard (USCG) aircraft were respectively involved in 35 percent (412) and 28 percent (329) of the 1,187 Government/police strikes, 1990–2014. For 2014 only, 34 percent (38) and 36 percent (40) of the 111 Government/police strikes involved USCBP and USCG aircraft, respectively.

[3] Ninety-seven percent (35,110) of the 36,231 strikes involving an unknown operator were “Carcass Found” reports, 1990–2014. For 2014 only, 99 percent (4,104) of the 4,147 strikes involving an unknown operator were “Carcass Found” reports (see Table 5).

Table 7. 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, 1990–2014 (see also Figure 5)[2].

	Part 139 airports		GA airports		All USA airports	
Year	Airports	Strikes	Airports	Strikes	Airports	Strikes
1990	234	1,506	97	165	331	1,671
1991	260	1,989	94	198	354	2,187
1992	255	2,177	106	226	361	2,403
1993	257	2,222	99	217	356	2,439
1994	266	2,225	107	243	373	2,468
1995	261	2,327	119	210	380	2,537
1996	260	2,498	108	193	368	2,691
1997	285	2,913	123	203	408	3,116
1998	293	3,223	143	267	436	3,490
1999	303	3,811	145	258	448	4,069
2000	314	4,475	149	275	463	4,750
2001	318	4,438	149	292	467	4,730
2002	307	4,770	153	307	460	5,077
2003	305	4,650	153	330	458	4,980
2004	309	5,211	173	318	482	5,529
2005	322	5,499	174	330	496	5,829
2006	323	5,923	142	270	465	6,193
2007	329	6,567	162	325	491	6,892
2008	331	6,625	163	310	494	6,935
2009	364	8,006	231	449	595	8,455
2010	374	8,297	213	460	587	8,757
2011	367	8,447	224	492	591	8,939
2012	385	8,907	253	575	638	9,482
2013	380	9,124	272	614	652	9,738
2014	396	10,985	277	696	673	11,681
Total	**527**	**126,815**	**1,344**	**8,223**	**1,871**	**135,038**

[1] There were 541 airports in USA certificated for passenger service in 2013 under CFR Part 139 regulations in January 2015 (FAA 2015*b*).

[2] In addition, 3,316 strikes involving USA-registered aircraft were reported from 286 foreign airports in 106 countries. Furthermore, 2,825 strikes (2,814 bird and 11 bat strikes) were reported in which aircraft was en route when strike occurred (Table 9). 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 8. Reported time of occurrence of wildlife strikes with civil aircraft, USA, 1990–2014[1].

	Birds		Terrestrial mammals		Bats	
Time of day	25-year total	% of total known	25-year total	% of total known	25-year total	% of total known
Dawn	3,272	3	55	3	4	1
Day	59,900	63	467	25	44	12
Dusk	4,154	4	148	8	18	5
Night	28,407	30	1,186	64	297	82
Total known	**95,733**	**100**	**1,856**	**100**	**363**	**100**
Unknown[2]	**55,534**		**1,504**		**901**	
Total	**151,267**		**3,360**		**1,264**	

[1] In addition, 223 strikes with reptiles were reported from 1990–2014: time not reported (185), day (30), night (5), dusk (2), and dawn (1).

[2] Of the 55,534 strike reports with “Unknown” time of day (all species), 35,110 (63 percent) were “Carcass Found” reports (Table 5).

Table 9. Reported phase of flight at time of occurrence of wildlife strikes with civil aircraft, USA, 1990–2014[1].

	Birds		Terrestrial mammals		Bats	
Phase of flight	25-year total	% of total known	25-year total	% of total known	25-year total	% of total known
Parked	69	<1	2	<1	0	0
Taxi	324	<1	39	2	0	0
Take-off Run	18,654	18	626	31	18	5
Climb	17,724	17	44[2]	2	32	9
En Route	2,814	3	0	0	11	3
Descent	3,085	3	0	0	9	2
Approach	42,047	41	144[2]	7	257	71
Landing Roll	17,453	17	1,157	58	36	10
Total known	**102,170**	**100**	**2,012**	**100**	**363**	**100**
Unknown[3, 4]	**49,097**		**1,348**		**901**	
Total	**151,267**		**3,360**		**1,264**	

[1] In addition, 223 strikes with reptiles were reported: phase of flight not reported (176), take-off run (17), landing roll (17), taxi (8), and approach (5; pilot had a missed approach because reptile was on the runway).

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

[3] Of the 51,522 strike reports with "Unknown" phase of flight (all species), 35,110 (68 percent) were "Carcass Found" reports (Table 5).

[4] Unknown includes 42, 203 and 45 reported strikes, respectively, in which the phase of flight was determined to be Arrival, Departure, and Local (i.e., a pilot conducting "touch-and-go" operations) but exact phase of flight could not be determined.

Table 10. Number of reported bird strikes to commercial aircraft[1] by height above ground level (AGL), USA, 1990–2014. See Figure 7 for graphic analysis of strike data from 501 to 18,500 feet AGL[2].

	All reported strikes			Strikes with damage		
Height of strike (feet AGL)	25-year total	% of total known	% cum-ulative total	25-year total	% of total known	% cum-ulative total
0	30,868	41	41	1,782	29	29
1-500	23,108	31	71	1,710	28	57
501-1500	8,204	11	82	908	15	71
1501-2500	4,271	6	88	549	9	80
2501-3500	3,106	4	92	356	6	86
3501-4500	1,847	2	94	206	3	89
4501-5500	1,353	2	96	166	3	92
5501-6500	895	1	97	118	2	94
6501-7500	618	1	98	80	1	95
7501-8500	462	1	99	73	1	96
8501-9500	247	<1	99	33	1	97
9501-10500	320	<1	99	54	1	98
10501-11500	172	<1	100	42	1	99
>11500[3]	281	<1	100	88	1	100
Total known	**75,752**	**100**		**6,165**	**100**	
Unknown height	**25,522**			**2,593**		
Total	**101,274**			**8,758**		

[1] Air carrier, commuter, and air taxi service with 3-letter Operator Code (see Table 6); 906 strikes in which height of strike was reported but type of operator was unknown were excluded from analysis.

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

[3] Twenty-two strikes involving commercial aircraft (9 with damage to aircraft) were reported at ≥20,000 feet AGL; the highest was 31,300 feet.

Table 11. Number of reported bird strikes to general aviation aircraft[1] by height above ground level (AGL), USA, 1990–2014. See Figure 7 for graphic analysis of strike data from 501 to 12,500 feet AGL[2].

	All reported strikes			Strikes with damage		
Height of strike (feet AGL)	25-year total	% of total known	% cum-ulative total	25-year total	% of total known	% cum-ulative total
0	5,162	37	37	610	17	17
1-500	5,127	37	73	1,235	34	51
501-1500	2,052	15	88	931	26	77
1501-2500	840	6	94	415	11	88
2501-3500	374	3	97	188	5	94
3501-4500	190	1	98	92	3	96
4501-5500	95	1	99	46	1	97
5501-6500	57	<1	99	30	1	98
6501-7500	48	<1	99	18	<1	99
7501-8500	20	<1	100	10	<1	99
8501-9500	16	<1	100	9	<1	99
9501-10500	15	<1	100	9	<1	100
10,501-11500	4	<1	100	2	<1	100
>11500[3]	24	<1	100	16	<1	100
Total known	**14,024**	**100**		**3,611**	**100**	
Unknown height	**2,006**			**498**		
Total	**16,030**			**4,109**		

[1] Private, Business, and Government/Police aircraft (see Table 6); 906 strikes in which height of strike was reported but type of operator was unknown were excluded from analysis.

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

[3] Four strikes involving general aviation aircraft (3 with damage to aircraft) were reported at ≥20,000 feet AGL; the highest was 24,000 feet.

Table 12. Civil aircraft components reported as being struck and damaged by wildlife, USA, 1990–2014.

	Birds (25-year total)				Terrestrial mammals (25-year total)			
Aircraft component	Number struck	% of total	Number damaged	% of total	Number struck	% of total	Number damaged	% of total
Windshield	21,937	16	971	6	8	<1	16	1
Nose	19,133	14	984	6	105	4	100	5
Wing/rotor	18,332	14	3,683	24	295	11	307	16
Radome	16,638	12	1,497	10	14	1	15	1
Engine(s)[1]	16,636	12	4,417	29	178	7	175	9
Fuselage	16,107	12	643	4	141	5	148	8
Other	13,574	10	1,227	8	330	12	277	14
Landing gear	5,979	4	508	3	1,151	43	465	24
Propeller	2,953	2	265	2	321	12	298	15
Tail	1,740	1	621	4	61	2	81	4
Light	911	1	656	4	44	2	50	3
Total[2]	**133,940**	**100**	**15,472**	**100**	**2,648**	**100**	**1,932**	**100**

[1] For birds, 16,636 engines were reported as struck in 15,870 strike events involving engines (15,130 events with one engine struck, 720 with two engines struck, 14 with three engines struck, and 6 with four engines struck). A total of 4,417 engines was damaged in 4,272 bird-strike events with engine damage (4,130 events with one engine damaged, 140 with two engines damaged, 1 with three engines damaged, and 1 with four engines damaged). For terrestrial mammals, 178 engines were reported as struck in 168 strike events (158 events with one engine struck and 10 with two engines struck). A total of 175 engines was damaged in 156 terrestrial mammal strike events with engine damage (137 events with one engine damaged and 19 with two engines damaged). Some engines were damaged without being struck when the landing gear collapsed.

[2] In addition, bat strikes had 598 and 12 components reported as struck and damaged, respectively: radome/nose (209, 1), windshield (111, 2), engine (40, 3), propeller (4, 0), wing/rotor (106, 5), fuselage (53, 0), tail (9, 0), other (36, 0), landing gear (26, 0), light (4, 1). For reptile strikes, there were 42 and 6 components reported struck and damaged, respectively: windshield (1, 1), wing/rotor (1, 1), fuselage (1, 1), landing gear (36, 1); tail (1, 1), other (2, 1).

Table 13. Number of civil aircraft with reported damage resulting from wildlife strikes, USA, 1990–2014. See Tables 1, 2 and 3 and Figures 2, 3, 4 and 9 for trends in damaging strikes from 1990–2014.

	Reported strikes					
	Birds		Terrestrial mammals		Total (all species)[1]	
Damage category[2]	25-year total	% of total[3]	25-year total	% of total[3]	25-year total	% of total[3]
None	**96,287**	**64**	**869**	**26**	**97,698**	**63**
Unknown	**41,998**	**28**	**1,436**	**43**	**44,366**	**28**
Damage	**12,982**	**9**	**1,055**	**31**	**14,050**	**9**
Minor	6,964	5	541	16	7,513	5
Uncertain	2,647	2	76	2	2,724	2
Substantial	3,334	2	408	12	3,746	2
Destroyed	37	<1	30	1	67	<1
Total	**151,267**	**100**	**3,360**	**100**	**156,114**	**100**

[1] Included in totals are 1,264 and 223 strikes involving bats and reptiles, respectively. For bats, 504 reports indicated no damage, 749 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, 38 reports indicated no damage, 183 failed to indicate if damage occurred, and 2 indicated damage (1 minor, 1 substantial).

[2] 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.

[3] The percentage of strikes causing damage is calculated using the total strikes reported as the divisor, including the 44,366 reports that did not indicate if damage occurred or not (Unknown). “Carcass found” reports (see Table 5) comprised 35,110 (79 percent) of these 44,366 reports. If the Unknown reports are excluded from the calculations, then 12, 55, and 13 percent of the strikes caused damage for birds, terrestrial mammals, and all species, respectively.

Table 14. Reported effect-on-flight of wildlife strikes to civil aircraft, USA, 1990–2014.

	Reported strikes					
	Birds		Terrestrial mammals		Total[1]	
Effect-on-flight[2]	25-year total	% of total[3]	25-year total	% of total[3]	25-year total	% of total[3]
None	**80,556**	**53**	**803**	**24**	**81,818**	**52**
Unknown	**61,345**	**41**	**1,856**	**55**	**64,208**	**41**
Negative effect	**9,366**	**6**	**701**	**21**	**10,088**	**6**
Precautionary landing	5,104	3	104	3	5,217	3
Aborted take-off	1,917	1	228	7	2,146	1
Engine shutdown[4]	401	<1	32	1	433	<1
Other	1,944	1	337	10	2,292	1
Total	**151,267**	**100**	**3,360**	**100**	**156,114**	100

[1] Included in totals are 1,264 and 223 strikes involving bats and reptiles, respectively. For bats, 426 reports indicated no effect-on-flight, 827 failed to indicate if an effect-on-flight occurred, and 11 indicated a negative effect (8 precautionary landings, 3 “Other”). For reptiles, 33 reports indicated no effect-on-flight, 180 failed to indicate if an effect-on-flight occurred, and 10 indicated a negative effect (1 precautionary landing, 1 aborted take-off, 8 “Other”).

[2] 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).

[3] The percentage of strikes causing negative effect-on-flight is calculated using the total strikes reported as the divisor, including the 64,208 reports that did not indicate if a negative effect occurred or not (Unknown). “Carcass found” reports (see Table 5) comprised 35,110 (55 percent) of these 64,208 reports. If the Unknown reports are excluded from the calculations, then 10, 47, and 11 percent of the strikes caused a negative effect-on-flight for birds, terrestrial mammals, and all species, respectively.

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

Table 15. 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, 1990–2014. See Figure 10 for trend in incidents, 1990–2014.

Action taken after bird strike on departure	Number of incidents	Comments and number of incidents by aircraft model
Fuel jettison	48	A mean of 96,125 lbs (14,136 gallons) of fuel jettisoned per incident (range 3,500 – 270,000 lbs; 515 - 39,706 gallons). Aircraft: B-747 (18), B-767 (7), B-727 (6), DC-10/MD-11 (8), B-777 (3), Learjet 31/35 (2), L-1011 (1) DA-2000 (1), unknown (1).
Fuel burn	60	Aircraft: EMB-120/145/170/190 (9), B-737 (8), A-319 to A330 (8), CL-RJ 100/700/900 (7), MD-80/88 (3); B-747, DHC8-Dash 8, and PA-28 (2 each); and 19 other aircraft types with 1 each.
Overweight landing	87	Aircraft: B-737 (24), A-320/330 (17), B-757 (15), MD-80/82 (10), B-767 (8), EMB-145/170 (3), A-300, MD-11, and C-500/600 (2 each), and CL-RJ 900, CRJ-400, DA-50 Falcon, and Dornier 328 (1 each).
Total	**195**	**A mean of 7.8 (range 0 – 16) incidents (fuel jettison, fuel burn, or overweight landing) per year, 1990 – 2014.**

Table 16. Aircraft speed (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, 1990–2014. See Figure 11 for trend in aborted take-offs at >80 knots caused by birds or other wildlife, 1990–2014.

	Commercial aircraft[2]		General aviation aircraft[3]		All aircraft[4]	
Aircraft speed (knots)	25-year total	% of total known	25-year total	% of total known	25-year total	% of total known
1-39	15	2	27	6	44	3
40-79	132	17	229	47	364	28
80-119	528	67	204	42	735	57
≥120	118	15	28	6	147	11
Total known	**793**	**100**	**488**	**100**	**1,290**	**100**
Unknown	**542**		**296**		**856**	
Total	**1,335**		**784**		**2,146[5]**	

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

[2] Air carrier, commuter, and air taxi service with 3-letter identifying code (see Table 6).

[3.] Business, Private, or Government aircraft (see Table 6).

[4] Included in totals are 27 aborted take-offs in which type of operator was unknown. For these 27 events, the speed was unreported (18), 1-39 knots (2), 40-79 knots (3), 80-119 knots (3), and ≥120 knots (1).

[5] Includes 6 incidents in which effect-on-flight was classified as “Engine shutdown” (Table 14) but pilot also aborted take-off.

Table 17. 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, 1990–2014 (page 1 of 21).

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Birds						
Loons	**37**	**23**	**17**		**3,271**	**3,039,679**
Loons	2	1	1			
Common loon	30	19	12		5,669	3,101,362
Red-throated loon	6	3	4		218	18,155
Pacific loon	1	1			192	1,353
Grebes	**100**	**19**	**11**	**12**	**1,794**	**3,183,282**
Grebes	9	1		1		
Eared grebe	12	2		1	154	221,107
Western grebe	33	11	8	8	1,566	2,822,458
Pied-billed grebe	32	1	1			
Horned grebe	9	3	1	1	74	139,717
Red-necked grebe	3	1	1	1		
Clark's grebe	1					
Great crested grebe	1					
Albatroses, shearwaters	**79**	**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					
Wedge-tailed shearwater	11		1			
Townsend's shearwater	11					
Fork-tailed storm-petrel	1					
Bnd-rumped storm-petrel	1					
Tropicbirds	**22**	**12**	**10**		**207**	**111,618**
Tropicbirds	11	8	5		151	62,922
White-tailed tropicbird	8	3	4		56	40,807
Red-tailed tropicbird	3	1	1			7,889
Pelicans	**87**	**44**	**36**	**15**	**4,883**	**10,864,830**
Pelicans	5	3			108	21,000
Australian pelican	1	1	1			
Brown pelican	65	28	23	8	497	474,901
American white pelican	16	12	12	7	4,278	10,368,929
Red-footed booby	**1**					
Cormorants	**126**	**46**	**33**	**23**	**2,160**	**4,966,307**
Cormorants	3	1			12	15,000

Table 17. Continued (Page 2 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Great cormorant	2	1		2		
Dble-crested cormorant	118	43	32	21	2,124	4,951,307
Pelagic cormorant	2					
Brandt's cormorant	1	1	1		24	
Anhinga	**31**	**15**	**11**	**4**	**239**	**787,744**
Frigatebirds	**18**	**7**	**4**		**41**	**30,499**
Great frigatebird	10	3	2		21	24,339
Magnificent frigatebird	8	4	2		20	6,160
Herons, egrets, bitterns	**1,410**	**185**	**187**	**193**	**8,873**	**14,961,461**
Herons, egrets, bitterns	2					
Herons	55	13	10	4	100	4,363
Gray heron	1	1	1			
Great blue heron	345	72	58	8	3,822	6,609,231
Blk-crowned night-heron	70	8	4	4	111	379,130
Little blue heron	8					300
Green heron	17			1		
Yel-crowned night-heron	24	6	4	2	54	590,934
Tricolored heron	2					
American bittern	10	3	2		646	55,694
Yellow bittern	93		1	6		
Least bittern	1					
Egrets	331	33	52	87	3,623	4,624,118
Cattle egret	335	32	44	70	253	155,789
Great egret	85	13	8	10	165	2,494,160
Intermediate egret	1					
Snowy egret	30	4	3	1	99	47,742
Storks	**17**	**6**	**3**	**3**	**24**	**22,818**
White stork	1	1				
Wood stork	16	5	3	3	24	22,818
Ibises, spoonbills	**42**	**11**	**11**	**9**	**148**	**61,378**
Ibises	5		1	1		
Glossy ibis	2	1	1	1		2,108
White ibis	20	3	4	2	132	59,270
White-faced ibis	13	7	4	5	15	
Roseate spoonbill	2		1		1	
Waterfowl	**4,675**	**1,932**	**984**	**1,629**	**180,516**	**233,983,442**
Ducks, geese, swans	141	69	32	56	823	1,424,290
Ducks	798	277	127	258	9,827	8,766,365

Table 17. Continued (Page 3 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
American wigeon	65	27	9	21	5,061	1,995,144
Northern pintail	136	65	37	61	1,986	2,571,081
Green-winged teal	56	14	7	17	774	912,101
Blue-winged teal	38	15	7	11	339	1,162,514
Eurasian wigeon	1			1		
Mallard	806	186	104	187	12,718	20,049,766
Common eider	3	2	1	1		
Ring-necked duck	24	8	4	7	1,188	92,859
Greater scaup	11	3	3	5		
Wood duck	51	16	6	9	517	163,444
Muscovy duck	2	1			120	608,279
Common goldeneye	6	2	1			2,470
Red-breasted merganser	7	1		1	2	
Hooded merganser	8	3		1	54	260,631
Common merganser	4	2	2	1	120	3,812
Northern shoveler	65	26	9	23	2,292	2,748,552
Gadwall	66	24	13	20	793	8,891,563
Canvasback	22	11	4	8	603	2,653,028
American black duck	57	5	2	16	2,400	74,080
Mottled duck	26	4	4	5	25	
Lesser scaup	46	18	11	14	1,479	266,213
Ruddy duck	54	12	4	8	164	101,142
Redhead	6	2		2	17	55,560
Bufflehead	16	2	3	1	376	12,601
Long-tailed duck	5	4	3	1	19	47,022
Philippine duck	1	1	1	1	96	11,987,748
Blk-bellied whistling-duck	5	2	1	1	48	
Cinnamon teal	4	1		1	20	6,831
White-winged scoter	2	1	1	1	1,400	517,133
Hawaiian duck	13			4		
Harlequin duck	1					
Barrow's goldeneye	1					
Surf scoter	1					
Geese	359	210	89	129	27,929	3,364,362
Snow goose	124	95	50	72	13,533	32,153,812
Canada goose	1,527	758	421	633	94,043	125,396,346
Brant	31	11	5	8	120	100,444
Gr white-fronted goose	48	30	11	29	914	5,754,159

Table 17. Continued (Page 4 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Emperor goose	2	1				10,325
Cackling goose	9	6	1	3	149	175,684
Hawaiian goose	2	1	1	1	9	
Swans	2	1				
Mute swan	8	2	1	2		
Tundra swan	13	11	7	8	486	482,685
Trumpeter swan	2	2	2	1	72	1,171,396
Hawks, eagles, vultures	**5,470**	**1,332**	**868**	**184**	**125,481**	**104,181,129**
Hawks, eagles, vultures	30	17	7	1	2,559	24,088
New World Vultures	308	182	90	28	27,542	12,339,858
Black vulture	127	80	49	11	11,522	5,599,881
Turkey vulture	585	296	195	34	37,955	12,432,485
Osprey	292	64	39	4	3,158	802,661
White-tailed kite	37	4	2		46	6,173,797
Black kite	3	2	1			
Mississippi kite	2					
Swallow-tailed kite	4		1		1	37
Eagles	8	3	2	1		
Bald eagle	202	82	61	14	8,730	25,277,678
White-bellied sea-eagle	1	1	1			
Golden eagle	18	3	5	1	3,724	969,202
Hawks	1,281	249	173	33	12,692	5,548,894
Northern goshawk	3					
Red-tailed hawk	2,038	298	213	47	13,278	23,649,229
Rough-legged hawk	88	8	3		21	64,649
Red-shouldered hawk	48	4	5		210	3,960
Swainson's hawk	116	15	10	2	1,072	566,637
Sharp-shinned hawk	27	2			1,048	409,624
Cooper's hawk	78	3	3	1	5	
Ferruginous hawk	26	5	1		88	3,869,795
Broad-winged hawk	20	8	3	3	1,563	60,556
Harris's hawk	2					
Hawaiian hawk	1		1		2	
White-tailed hawk	2					
Eurasian buzzard	3	1			24	
Northern harrier	117	3	2	3	1	289,575
Old world vultures	2	1		1		
Lappet-faced vulture	1	1	1		240	6,098,523

Table 17. Continued (Page 5 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Falcons and Caracaras	**4,497**	**56**	**98**	**195**	**1,755**	**3,238,035**
Falcons	47	3	4	2	82	56,591
Peregrine falcon	274	21	15	13	210	676,574
Gyrfalcon	2					
Merlin	78	1	3	3	23	527,821
Prairie falcon	23	1	2	2		6,112
American kestrel	4,052	26	72	175	1,399	1,970,937
Eurasian kestrel	5	1	1			
Crested caracara	16	3	1		41	
Gallinaceous birds	**258**	**64**	**51**	**53**	**3,416**	**1,255,479**
Grouse	5	2		3		
Greater sage-grouse	34	12	6	13	556	507,388
Sharp-tailed grouse	6	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	9		3	2		
Northern bobwhite	10	2	3	2	73	1,157
Scaled quail	3					
Ring-necked pheasant	81	17	13	5	883	110,628
Red-legged partridge	1					
Gray partridge	19	3	3	7	28	214
Chukar	3		1	1		
Gray francolin	3					
Black francolin	4					
Helmeted guineafowl	1	1		1		
Wild turkey	67	21	19	13	1,627	425,338
Cranes	**127**	**52**	**32**	**37**	**2,415**	**405,732**
Sandhill crane	126	51	32	37	2,367	345,239
Whooping crane	1	1			48	60,493
Rails, gallinules	**280**	**56**	**30**	**15**	**4,135**	**7,680,053**
Rails	5	1	1	1		
Sora	36	3	1	4	68	20,023
Common moorhen	7	1	1		24	1,289
American coot	210	50	25	10	3,962	7,628,134
Eurasian coot	1					

Table 17. Continued (Page 6 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Purple gallinule	5	1	1		72	30,607
Virginia rail	10		1		9	
Clapper rail	6					
Shorebirds	**6,483**	**134**	**167**	**956**	**3,281**	**6,404,176**
Shorebirds	23			9		
American oystercatcher	22			2		
Plovers, lapwings	1			1		
Plovers	66	3	4	9	24	
European golden-plover	5			1		
American golden-plover	141	5	5	40	86	114,141
Black-bellied plover	118	7	5	20	28	203,788
Snowy plover	3			2	1	
Killdeer	3,894	46	70	391	859	4,097,477
Pacific golden-plover	869	8	12	122	209	335,483
Semipalmated plover	74			21		
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, misc. allies	259	15	26	84	181	208,033
Upland sandpiper	205	7	6	19	16	2,607
Spotted sandpiper	25	2	1	4		
Willet	6			2		
Common snipe	7			1		
American woodcock	80	2	3	5	20	11,882
Dunlin	67	5	4	23	513	261,363
Baird's sandpiper	28			3		
Western sandpiper	101	4	5	65	112	147,007
Pectoral sandpiper	28	2	2	9	2	361
Sanderling	24	1	3	9	6	
Buff-breasted sandpiper	34	1		8		
Ruddy turnstone	19			1		
Bar-tailed godwit	1					
Least sandpiper	114	1	5	34	8	
Semipalmated sandpiper	67		1	29	1	
Lesser yellowlegs	16	2		3	2	
Short-billed dowitcher	11	3		3	6	10,541
Hudsonian godwit	5	1	1	2	96	34,889

Table 17. Continued (Page 7 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Solitary sandpiper	4	1		2		
Greater yellowlegs	7	2		1	48	9,127
Long-billed dowitcher	8			3	1	
Red knot	4		1			
White-rumped sandpiper	8			1		
Black turnstone	1					
Marbled godwit	2	1	1	1	48	173,258
Wilson's snipe	66	4	3	5	27	17,958
Rock sandpiper	1			1		
South American snipe	1					
Stilt sandpiper	1					
Eurasian curlew	1					
Whimbrel	16	2	1	3	360	54,114
Long-billed curlew	7	1	1	1	504	698,163
Red-necked phalarope	9	2	1	3	60	
Wilson's phalarope	11	2	3	5	36	13,071
Red phalarope	1					
American avocet	6	1	1	3		
Black-necked stilt	9			3		
Double-striped thick-knee	1					
Jaegers	**4**					
Parasitic jaeger	2					
Long-tailed jaeger	2					
Gulls	**10,107**	**1,408**	**1,162**	**2,128**	**63,162**	**57,053,422**
Gulls	6,428	1,080	869	1,591	44,413	29,293,899
Herring gull	1,134	110	102	120	2,294	4,808,045
Mew gull	63	6	4	10	28	104,003
Ring-billed gull	1,418	114	97	249	8,750	4,569,273
Glaucous-winged gull	112	22	14	15	301	1,810,776
Great black-backed gull	103	11	8	9	124	446,431
Franklin's gull	102	6	9	36	44	210,889
Laughing gull	404	18	23	50	737	730,533
Bonaparte's gull	39	2	3	11		94,012
Lesser black-backed gull	6	2	1	1		
Western gull	118	13	8	11	203	2,026,376
California gull	150	18	18	18	5,061	712,198
Heermann's gull	1			1		
Black-headed gull	6	1	1		250	8,918

Table 17. Continued (Page 8 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Thayer's gull	3					
Yellow-legged gull	3	3	3	3	456	11,913,382
Glaucous gull	17	2	2	3	501	324,687
Terns, kittiwakes	**184**	**6**	**5**	**33**	**57**	**95,117**
Terns	49	2		16		
White-winged tern	2			1		
Little tern	2			1		
Caspian tern	21			1		
Common tern	18	1		3		79,117
Sandwich tern	2					
Gull-billed tern	4					
Black tern	2				2	
Fairy tern	3					
White tern	5		1	1		
Arctic tern	5	1		2		
Roseate tern	1					
Forster's tern	11		1	2	4	
Least tern	22			2		
Black noddy	6			2		
Brown noddy	8		1	1		
Royal tern	4		1		3	
Sooty tern	4	1	1		48	16,000
Black-legged kittiwake	3					
Red-legged kittiwake	1					
Black skimmer	11	1		1		
Puffins	**2**		**1**		**1**	**103**
Pigeons, doves	**1,254**	**481**	**608**	**2,268**	**53,355**	**21,737,259**
Pigeons, doves	25	3	3	12	1,636	678
Pigeons	13	1	1	5	6	
Common wood-pigeon	6			1		
Band-tailed pigeon	17	5		3	183	193,902
Rock pigeon	2,728	245	256	876	14,475	12,010,191
Doves	1,021	45	87	235	637	648,790
Eurasian collared dove	13			1	24	1,000
Mourning dove	6,873	171	246	1,094	36,095	8,522,514
Spotted dove	189	4	8	10	136	356,965
Zebra dove	282	3	7	26	32	1,111
Inca dove	15			1		

Table 17. Continued (Page 9 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Island turtle-dove	5					
White-winged dove	56	3		4	102	2,108
Common ground-dove	7					
Zenaida dove	3	1			29	
Ruddy ground-dove	1					
Parrots	**22**					
Parrots	3			1		
Budgerigar	13					
Monk parakeet	4			1		
Olive-throated parakeet	1			1		
Nanday parakeet	1					
Cuckoos, roadrunners	**47**	**6**	**1**	**6**	**38**	**130,972**
Cuckoos	5	2		2	12	78,538
Yellow-billed cuckoo	34	4	1	4	25	52,434
Common cuckoo	1					
Black-billed cuckoo	5				1	
Philippine drongo-cuckoo	1					
Greater roadrunner	1					
Owls	**2,346**	**133**	**83**	**26**	**2,967**	**9,714,892**
Owls	293	30	19	5	962	502,372
Barn owl	1,027	38	26	14	369	3,066,004
Snowy owl	174	17	11	1	858	1,797,664
Little owl	1					
Short-eared owl	432	10	13	3	131	1,548,246
Long-eared owl	15	3	1		24	52,707
Northern saw-whet owl	7	1			96	
Burrowing owl	163	1	1	2	8	827
Barred owl	23	1	1			167
Northern pygmy-owl	1					
Great gray owl	1					
Eastern screech-owl	4	2			24	13,498
Western screech-owl	2					
Great horned owl	202	30	11	1	495	2,733,407
Northern hawk-owl	1					
Nightjars	**521**	**3**	**3**	**27**	**69**	
Nightjars	9					
Whip-poor-will	8			2		
Common poorwill	11			1		

Table 17. Continued (Page 10 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Lesser nighthawk	11					
Chuck-will's-widow	11		1		1	
Common nighthawk	464	3	2	24	68	
Common pauraque	6					
Nacunda nighthawk	1					
Swifts	**510**	**9**	**11**	**43**	**1,248**	**14,565**
Swifts	13	1	1	2	1	
Black swift	3					
Chimney swift	415	6	8	39	1,221	14,565
Common swift	7	1		1		
Vaux's swift	39				24	
White-throated swift	33	1	2	1	2	
Hummingbirds	**38**			**1**		
Hummingbirds	1					
Ruby-thrted hummingbird	18					
Rufous hummingbird	8			1		
Anna's hummingbird	8					
Blk-chinned hummingbird	1					
Allen's hummingbird	1					
Calliope hummingbird	1					
Belted kingfisher	**10**					
Woodpeckers	**168**	**10**	**7**	**7**	**182**	**36,160**
Woodpeckers	10		1			
Northern flicker	94	6	1	2	10	2,298
Yellow-bellied sapsucker	52	3	2	5	171	14,846
Hairy woodpecker	3					
Red-naped sapsucker	2	1	2			19,016
Downy woodpecker	2		1		1	
Red-bellied woodpecker	2					
Red-breasted sapsucker	2					
Red-headed woodpecker	1					
Unidentified passeriforms	**534**	**16**	**14**	**39**	**129**	**119,736**
Flycatchers	**546**	**6**	**8**	**40**	**16**	**18,287**
Tyrant flycatchers	35			6	1	513
Eastern wood-pewee	7			1		
Great crested flycatcher	10					
Eastern kingbird	32	1	1			13,446
Scissor-tailed flycatcher	176	1	4	11		652

Table 17. Continued (Page 11 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Acadian flycatcher	4					
Say's phoebe	5					
Western kingbird	210	3	2	15	3	1,540
Ash-throated flycatcher	4					
Western wood-pewee	4					
Sulphur-bellied flycatcher	1					
Eastern phoebe	17			2		
Yellow-bellied flycatcher	6			2		616
Least flycatcher	6					
Hammond's flycatcher	3					
Pacific-slope flycatcher	10			1	10	1,500
Gray flycatcher	3			1	1	20
White-crested elaenia	1					
Willow flycatcher	3			1		
Alder flycatcher	6	1				
Cordilleran flycatcher	2				1	
Dusky flycatcher	1		1			
Larks	**3,261**	**17**	**35**	**543**	**242**	**914,450**
Sky lark	72			3		
Horned lark	3,189	17	35	540	242	914,450
Swallows	**6,672**	**35**	**115**	**1,438**	**512**	**213,327**
Swallows	940	7	40	288	60	186
Purple martin	157	8	3	36	60	96,006
Bank swallow	334	2	6	126	13	8,122
Barn swallow	3,480	14	48	653	315	85,565
Cliff swallow	1,126	3	12	180	48	20,813
Tree swallow	554		6	147	14	2,635
Violet-green swallow	21			1		
N rough-winged swallow	50	1		3	2	
Cave swallow	10			4		
Black drongo	**11**			**2**		
Starlings, mynas	**3,755**	**127**	**179**	**1,316**	**3,096**	**7,068,897**
European starling	3,663	125	173	1,291	3,053	7,068,897
Common myna	92	2	6	25	43	
Crows, ravens	**671**	**64**	**57**	**85**	**9,670**	**2,681,140**
Crows, ravens	2	1		1		
Crows	191	20	13	34	18	126,078
American crow	424	32	37	45	6,463	1,833,405

Table 17. Continued (Page 12 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Carrion crow	2					
Hooded crow	1	1	1			
Northwestern crow	7			1		
Rook	1					
Common raven	43	10	6	4	3,189	721,657
Jays, magpies	**44**	**2**	**2**	**6**	**2**	**940**
Blue jay	24			1	1	
Gray jay	1					
Yellow-billed magpie	8			2		
Black-billed magpie	11	2	2	3	1	940
Chickadees, nuthatches	**29**	**1**		**9**		
Chickadees	1					
Black-capped chickadee	22	1		6		
Mountain chickadee	1			1		
Gray-headed chickadee	1			1		
Carolina chickadee	2			1		
Bushtit	1					
White-breasted nuthatch	1					
Red-vented bulbul	**3**			**1**		
Wrens	**116**	**1**	**3**	**12**	**2**	**513**
Wrens	51	1	2	10		
Marsh wren	15		1	1		
House wren	29			1	1	513
Carolina wren	5					
Rock wren	1					
Cactus wren	4					
Winter wren	8				1	
Bewick's wren	1					
Sedge wren	2					
Mimics	**212**	**3**	**2**	**12**	**110**	**2,001,604**
Brown thrasher	17	1		1	103	2,000,226
Sage thrasher	2					
Curve-billed thrasher	1					
Long-billed thrasher	1			1		
Northern mockingbird	95	2	2	2		
Tropical mockingbird	1					
Gray catbird	95			8	7	1,378

Table 17. Continued (Page 13 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Thrushes	**1,263**	**87**	**48**	**98**	**3,022**	**3,465,013**
Thrushes	42	3	1	2	7	33,191
Western bluebird	4				3	
Swainson's thrush	138	11	5	12	58	2,553,118
Redwing	1					
American robin	820	58	33	58	2,860	830,742
Song thrush	1			1		
Hermit thrush	128	5	3	8	59	11,597
Eastern bluebird	7			1		
Gray-cheeked thrush	16		2	3		
Varied thrush	42	10	1	6	32	36,010
Wood thrush	25		1	4		355
Mountain bluebird	22			3		
Veery	17		2		3	
Wrentits, gnatcatchers	**15**		**1**	**1**	**2**	
Wrentit	1					
Blue-gray gnatcatcher	14		1	1	2	
Kinglets	**91**		**2**	**6**	**7**	**300**
Golden-crowned kinglet	23			2		
Ruby-crowned kinglet	68		2	4	7	300
Pipits	**104**					
American pipit	100		2	22	4	
Sprague's pipit	4					
Waxwings	**148**	**7**	**5**	**32**	**310**	**355,761**
Bohemian waxwing	2			1		
Cedar waxwing	146	7	5	31	310	355,761
Loggerhead shrike	**18**		**1**	**1**		
Vireos	**112**	**2**	**2**	**7**	**10**	**10,312**
Vireos	4					
White-eyed vireo	3				2	
Blue-headed vireo	8			1		
Yellow-throated vireo	1					
Warbling vireo	18	1		1	3	8,712
Red-eyed vireo	72	1	2	5	5	1,600
Cassin's vireo	2					
Philadelphia vireo	4					
Japanese white-eye	**2**					

Table 17. Continued (Page 14 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Warblers	**815**	**7**	**13**	**58**	**249**	**20,555**
Wood warblers	73	1		8		1,939
Canada warbler	18		2		2	105
Yellow-breasted chat	10					
Pine warbler	15			2		
Black-and-white warbler	21			1		
Northern parula	10			1	24	2,165
Ovenbird	54	1	2	2	8	1,928
Wilson's warbler	40			1	4	5,918
Common yellowthroat	61	1	1	2	2	257
Yellow-rumped warbler	143		2	10	7	52
Blackpoll warbler	45			4	2	505
Mourning warbler	6					
American redstart	26	1	1	3	12	
Orange-crowned warbler	19					
Yellow warbler	37	2		4	168	
Cape May warbler	3					
Hooded warbler	2	1				
Prairie warbler	5					
Northern waterthrush	24			2	5	
Nashville warbler	21		1	1		
Townsend's warbler	15		1	1		102
Palm warbler	34		2	4	3	7,379
Magnolia warbler	30		1	2	6	205
Blk-throated blue warbler	13					
Prothonotary warbler	2					
MacGillivray's warbler	5					
Yellow-throated warbler	19			3		
Blk-throated gray warbler	2				2	
Blk-thrted green warbler	11			1		
Hermit warbler	1					
Tennessee warbler	15			2	2	
Chestnut-sided warbler	8			1		
Blackburnian warbler	6					
Bay-breasted warbler	5			1		
Connecticut warbler	1					
Kentucky warbler	14			2	2	
Worm-eating warbler	1					

Table 17. Continued (Page 15 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Meadowlarks	**2,786**	**24**	**50**	**264**	**410**	**1,007,019**
Meadowlarks	454	3	11	43	15	732
Eastern meadowlark	1,425	9	24	122	175	634,247
Western meadowlark	907	12	15	99	220	372,040
Blackbirds, grackles	**2,176**	**111**	**128**	**530**	**1,610**	**1,779,599**
Blackbirds	1,277	81	89	365	609	1,464,254
Red-winged blackbird	275	5	13	33	36	21,702
Yellow-headed blackbird	11	1	1	2		
Brewer's blackbird	53	1	1	9	1	
Brown-headed cowbird	185	2	3	51	11	6,200
Bobolink	28		1	3	2	
Rusty blackbird	3					
Tricolored blackbird	1					
Grackles	142	11	5	30	728	213,036
Common grackle	140	7	11	30	175	74,407
Boat-tailed grackle	23	2	3	2	48	
Great-tailed grackle	38	1	1	5		
Orioles	**35**	**1**	**3**	**2**	**2**	**216**
Orioles	4					
Baltimore oriole	21	1	2	2	2	216
Orchard oriole	3					
Bullock's oriole	5		1			
Hooded oriole	2					
Tanagers	**30**	**1**	**1**	**3**	**77**	
Scarlet tanager	15	1		2	73	
Western tanager	11		1		4	
Summer tanager	4			1		
Finches	**913**	**12**	**39**	**252**	**241**	**33,123**
Finches	82	1	5	20	7	
Lapland longspur	48	1	4	19	25	
Chest.-collared longspur	2					
Dark-eyed junco	123	2	2	7	75	11,470
Rose-breasted grosbeak	8			1	1	527
Common Chaffinch	1					
Island canary	1					
Pine siskin	16	1		7	1	
Purple finch	4					
Red crossbill	2			1		

Table 17. Continued (Page 16 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Evening grosbeak	1					
American goldfinch	52		2	2	3	
House finch	106	1	2	8	15	50
Smith's longspur	6			1		
Dickcissel	14	1		2		1,127
White-winged crossbill	1					
Red avadavat	5			3		
McCown's longspur	1					
Lesser goldfinch	4					
Black-headed grosbeak	5					
Cassin's finch	1					
Pine grosbeak	1					
Gr-crowned Rosy-Finch	1					
Blue grosbeak	3					
Hoary redpoll	2			1		
Red-crested cardinal	6			1	1	
Northern cardinal	12					
Snow bunting	259	4	21	157	107	19,949
Indigo bunting	22		2	2	4	
Lazuli bunting	4					
Lark bunting	115	1		18	2	
McKay's bunting	1		1	1		
Painted bunting	3					
Black-faced bunting	1			1		
Sparrows	**4,154**	**65**	**126**	**805**	**16,138**	**889,718**
Sparrows	3,025	48	112	720	663	76,454
Harris's sparrow	5			1		
Swamp sparrow	47			2	1	1,000
Savannah sparrow	403	5	5	24	31	18,863
Fox sparrow	41	3	1	2	25	59,630
White-throated sparrow	160	2	3	18	26	3,269
Golden-crowned sparrow	5			1		
Field sparrow	36			2		
Lark sparrow	20	1		2	15,000	
White-crowned sparrow	59	4	2	4	371	679,000
Grasshopper sparrow	58	1	1	3	9	33,884
Java sparrow	3			1		
Vesper sparrow	35			2		

Table 17. Continued (Page 17 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Chipping sparrow	52	1		6		105
Lincoln's sparrow	39		2	2	4	16,427
Song sparrow	116			13	6	607
Sage sparrow	7				1	
American tree sparrow	16			1		257
Nelson's s-tailed sparrow	4				1	222
Black-throated sparrow	1					
Brewer's sparrow	11			1		
Le Conte's sparrow	3					
Cassin's sparrow	3					
Clay-colored sparrow	4					
Baird's sparrow	1					
Towhees	**31**	**1**		**1**	**9**	**15,003**
Eastern towhee	21	1		1	9	15,003
Green-tailed towhee	3					
California towhee	1					
Spotted towhee	6					
Waxbills, mannikins	**264**		**1**	**75**	**13**	**5,088**
Waxbills, mannikins	3					
Common waxbill	6			1		
Mannikins	126			14		
Nutmeg mannikin	73			34	11	1,874
Tricolored munia	50		1	22	2	3,214
White-throated munia	6			4		
House sparrow	**197**	**3**	**3**	**23**	**30**	**2,226**
Total known birds	77,983	6,653	5,278	13,533	502,631	504,726,487
Total unknown birds	73,284	6,329	4,086	7,445	163,231	138,790,663
Unknown bird-?size	5,407	390	353	312	9,629	3,394,340
Unknown bird - large	2,682	1,044	509	284	44,810	50,398,934
Unknown bird - medium	34,190	3,990	2,089	2,683	88,032	66,673,871
Unknown bird - small	31,005	905	1,135	4,166	20,760	18,323,518
Total birds[3]	**151,267**	**12,982**	**9,364**	**20,978**	**665,861**	**643,517,150**
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 (Pteropus spp)	1					

Table 17. Continued (Page 18 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Microbats (echo-locating)	**1,245**	**8**	**9**	**89**	**110**	**19,161**
Microbats (unk spp)	620	5	5	50	42	1,232
Vesper bats (unk spp)	50			1	1	308
Red bat	97	2		7	50	13,016
Hoary bat	40			2	7	2,853
East. small-footed myotis	1					
Little brown bat	83			4		
Big brown bat	61		2	6		
Silver-haired bat	37			2	2	316
Seminole bat	3					
Eastern pipistrelle	11					
Northern yellow bat	3					
Evening bat	3					
Indiana bat	2					
Yuma myotis	1					
Long-eared myotis	1					
Western yellow bat	1					
Common pipistrelle	1					
Long-legged myotis	1					
Free-tailed bats (unk spp)	53			6	2	308
Brazilian free-tailed bat	167	1	2	10	6	1,128
Pocketed free-tailed bat	2					
Big free-tailed bat	1					
Western mastiff bat	1					
Florida bonneted bat	1					
Gray sac-winged bat	1					
Jamaican fruit bat	3			1		
Total known bats	**1,259**	**10**	**11**	**93**	**209**	**4,581,803**
Total unkn-Mega or Micro	**5**	**1**				**9,823**
Total bats[4]	**1,264**	**11**	**11**	**93**	**209**	**4,591,626**
Terrestrial mammals						
Marsupials (Vir. opossum)	**179**	**1**		**1**		
Xenarthyras (armadillo)	**31**	**1**	**4**		**11**	**1,302**
Lagomorphs	**506**	**8**	**10**	**7**	**21**	**130,571**
Lagomorphs	1	1				
Hares	6		1		1	
Black-tailed jackrabbit	256	4	2	1	12	34,260

Table 17. Continued (Page 19 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
White-tailed jackrabbit	41		1	2	1	
Antelope jackrabbit	1					
Rabbits	101		2	4	1	
Eastern cottontail	73	3	4		6	96,311
Desert cottontail	27					
Rodents	**250**	**2**	**8**	**5**	**6**	**488**
North American beaver	2					
Black-tailed prairie dog	48		1	2		
White-tailed prairie dog	5					
Gunnison's prairie dog	15		1	3		
Woodchuck	138	2	6		6	488
Yellow-bellied marmot	1					
Fox squirrel	1					
Muskrat	25					
N. American porcupine	15					
Carnivores	**1,230**	**72**	**141**	**18**	**17,235**	**4,297,193**
Canids	3		1			
Coyote	469	42	92	5	14,135	3,775,695
Domestic dog	45	15	24	1	559	400,700
Foxes	64	4	7	1	10	1,085
Red fox	142	4	10		364	59,326
Common gray fox	9	2	2		5	526
Kit fox	4					
Raccoon	102	4	4	4	2,160	59,861
White-nosed coati	1					
Ringtail	1					
Skunks	55		1	2	2	
Striped skunk	291			5		
River otter	2	1				
Badger	4					
Mink	4					
Domestic cat	31					
Small Indian mongoose	3					
Artiodactyls	**1,136**	**960**	**527**	**91**	**296,846**	**55,645,480**
Deer	16	14	8		696	275,936
White-tailed deer	1,001	839	460	80	246,053	45,477,313
Mule deer	77	69	35	3	21,404	1,474,032
Wapiti (elk)	11	11	5	1	11,660	7,627,167

Table 17. Continued (Page 20 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
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	**3,336**	**1,048**	**693**	**122**	**315,127**	**60,112,366**
Unkn terrestrial mammals	**24**	**7**	**8**	**1**		
Total t. mammals[5]	**3,360**	**1,055**	**701**	**123**	**315,127**	**60,112,366**
Reptiles						
Turtles	**183**	**1**	**4**	**2**		
Turtles	54		2			
Florida soft shell turtle	10	1	1			
Pond slider	2					
Eastern mud turtle	1					
Chicken turtle	1					
Eastern box turtle	11					
Common snapping turtle	25		1			
Diamondback terrapin	42			2		
Painted turtle	19					
Florida red-bellied cooter	1					
Gopher tortoise	13					
Alligator snapping turtle	1					
Coastal plain cooter	3					
American alligator	**19**	**1**	**2**		**3**	
Green iguana	**10**		**4**			
Snakes	**11**					
Snakes	4					
Bull snake	4					
Northern water snake	2					
E. diamondbk rattlesnake	1					
Total reptiles[6]	**223**	**2**	**10**	**2**	**3**	

Table 17. Continued (Page 21 of 21)

Wildlife group or species	25-year totals (1990–2014)					
	Number of reported strikes				Reported economic losses[1]	
	Total	With dam-age	With neg. EOF	With multiple animals[2]	Aircraft down time (hrs)	Reported costs ($)
Total known (all species)	**82,801**	**7,713**	**5,992**	**13,750**	**817,970**	**569,420,656**
Total (unknown species)	**73,313**	**6,337**	**4,094**	**7,446**	**163,231**	**138,800,486**
Grand total	**156,114**	**14,050**	**10,086**	**21,196**	**981,200**	**708,221,142[7]**

[1] 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, 1990–2014. Furthermore, of the 14,050 reports indicating damage to the aircraft, only 27 percent (3,731) also provided an estimate of repair costs, and only 35 percent (8,219) of the 23,055 strikes indicating an adverse effect estimated the downtime (see Tables 22, 23). Finally, even when cost estimates were provided, some reports were filed before aircraft damage had been fully assessed. See Tables 22 and 23 for a more detailed projection of actual economic losses.

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

[3] Of the 151,267 reported bird strikes, 59,354 (39 percent) identified the bird to exact species (518 species total of which 240 caused damage) and an additional 18,629 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 56-61 percent in 2013-2014 (Figure 7).

[4] Of the 1,264 reported bat strikes, 522 (41 percent) identified the bat to exact species (21 species total of which 2 caused damage) and 737 (58 percent) identified the bat to species group (14 megabats [old world fruit bats], 723 microbats [echo-locating bats]). There were 5 bat strikes classified as unknown bat (either megabat or microbat).

[5] Of the 3,360 reported terrestrial mammal strikes, 3,090 (92 percent) identified the mammal to exact species (41 species total of which 22 caused damage) and 246 (8 percent) identified the mammal at least to species group.

[6] All of the 223 reported reptile strikes were identified to species group and 165 (74 percent) were identified to exact species (17 species total of which 2 caused damage).

[7] Reported costs of $708,221,142 include $631,840,101 in direct repair costs and $76,381,041 in other costs.

Table 18. 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, 1990–2014.

	Reported strikes		Strikes with damage		Strikes with >1 animal	
Species group[1]	25-year total	% of total known	25-year total	% of total known	25-year total	% of total known
Birds						
Doves/pigeons	11,254	14	481	7	2,268	17
Gulls	10,107	13	1,408	21	2,128	16
Raptors[2]	9,967	13	1,388	21	379	3
Shorebirds	6,483	8	134	2	956	7
Waterfowl	4,675	6	1,932	29	1,629	12
All other known	35,497	46	3,411	51	5,731	42
Total known birds	**77,983**	**100**	**6,653**	**100**	**13,533**	**100**
Unknown birds	**73,284**		**6,329**		**7,445**	
Total birds	**151,267**		**12,982**		**20,978**	
Terrestrial mammals						
Carnivores	1,230	37	72	7	18	15
Artiodactyls	1,136	34	960	92	91	75
Lagomorphs	506	15	8	1	7	6
All other known	464	14	8	1	6	5
Total known t. mammals	**3,336**	**100**	**1,048**	**100**	**122**	**100**
Unknown t. mammals	**24**		**7**		**1**	
Total t. mammals	**3,360**		**1,055**		**123**	

[1] See Table 17 for listing of species within each species group and Table 19 for the most frequently struck species.

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

Table 19. The 30 species of birds identified most frequently as struck by civil aircraft in USA, 1990–2014 and 2014 only. See Figure 13 for relation between mean body mass of species and percent of strikes causing damage.

	Strikes (1990–2014)[1]			Strikes (2014 only)[1]		
Rank	Bird species	Num-ber	% causing damage	Bird species	Num-ber	% causing damage
1	Mourning dove	6,873	2.5	Mourning dove	744	1.3
2	American kestrel	4,052	0.6	Barn swallow	611	0.3
3	Killdeer	3,894	1.2	Killdeer	523	0.8
4	European starling	3,663	3.4	Horned lark	517	0.0
5	Barn swallow	3,480	0.4	American kestrel	456	0.4
6	Horned lark	3,189	0.5	European starling	308	2.9
7	Rock pigeon	2,728	9.0	Eastern meadowlark	240	0.4
8	Red-tailed hawk	2,038	14.6	Rock pigeon	216	3.7
9	Canada goose	1,527	49.6	Cliff swallow	185	0.0
10	Eastern meadowlark	1,425	0.6	Red-tailed hawk	163	9.8
11	Ring-billed gull	1,418	8.0	American robin	131	6.1
12	Herring gull	1,134	9.7	Western meadowlark	127	0.8
13	Cliff swallow	1,126	0.3	Ring-billed gull	122	5.7
14	Barn owl	1,027	3.7	Savannah sparrow	89	1.1
15	Western meadowlark	907	1.3	Chimney swift	87	0.0
16	Pacific golden-plover	869	0.9	Tree swallow	79	0.0
17	American robin	820	7.1	Herring gull	70	10.0
18	Mallard	806	23.1	Bank swallow	63	0.0
19	Turkey vulture	585	50.6	Pacific golden-plover	61	0.0
20	Tree swallow	554	0.0	Barn owl	60	1.7
21	Common nighthawk	464	0.6	Common nighthawk	58	0.0
22	Short-eared owl	432	2.3	Canada goose	57	47.4
23	American crow	424	7.5	White-throated sparrow	56	1.8
24	Chimney swift	415	1.4	Mallard	54	29.6
25	Laughing gull	404	4.5	Hermit thrush	51	3.9
26	Savannah sparrow	403	1.2	Snowy owl	50	8.0
27	Great blue heron	345	20.9	Turkey vulture	48	41.7
28	Cattle egret	335	9.6	Yellow-rumped warbler	47	0.0
29	Bank swallow	334	0.6	Red-winged blackbird	46	0.0
30	Osprey	292	21.9	Cattle egret	45	11.1

[1] Actual number struck was higher for each species because only 39% and 56% of the bird strike reports from 1990–2014 and in 2014, respectively, identified the bird to species. For example, there were 6,428 gull strikes reported from 1990-2014 in which the species of gull was not determined (Table 17).

Table 20. Number of strikes to civil aircraft causing human fatality or injury and number of injuries and fatalities by wildlife species, USA, 1990–2014.

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		Western grebe	2	3
Red-tailed hawk	1	8		Snow goose	3	3
A. white pelican	1	5		American coot	3	3
Canada goose	1	2		Herring gull	3	3
White-tailed deer	1	1		Rock pigeon	3	3
Brown pelican	1	1		Domestic dog	1	2
Turkey vulture	1	1		Mule deer	1	2
Total fatalities	**12**	**26**		Red-throated loon	1	2
Strikes causing injuries				Sharp-tailed grouse	1	2
Canada goose	15	117		Eastern cottontail	1	1
Unknown bird	44	53		Horse	1	1
White-tailed deer	19	27		Horned grebe	1	1
Ducks	17	20		Sharp-tailed grouse	1	1
Turkey vulture	15	18		Tropicbirds	1	1
Black vulture	8	13		Red-tailed tropicbird	1	1
New World Vultures	10	10		Great frigatebird	1	1
Gulls	8	9		Magnificent frigatebird	1	1
Red-tailed hawk	6	8		Egrets	1	1
Ring-billed gull	2	8		Snowy egret	1	1
Geese	7	7		White ibis	1	1
Bald eagle	4	7		Long-tailed duck	1	1
Mallard	5	6		Cackling goose	1	1
D-crsted cormorant	4	5		Sandhill crane	1	1
Hawks	3	5		Franklin's gull	1	1
American kestrel	1	5		Doves	1	1
Anhinga	3	4		Mourning dove	1	1
Lesser scaup	4	4		Owls	1	1
Golden eagle	2	4		American robin	1	1
Eurasian kestrel	1	4		Baltimore oriole	1	1
Spotted dove	1	4		Great-tailed grackle	1	1
Osprey	3	3		Sparrows	1	1
Cattle	2	3		**Total injuries**	**223**	**388**

Table 21. Number of civil aircraft lost (destroyed or damaged beyond repair) after striking wildlife by wildlife species and aircraft mass category, USA, 1990–2014[1]. See Figure 14 for number of lost aircraft by year, 1990–2014.

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	14	6	2		22
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	**42**	**16**	**7**	**2**	**67**

[1] Forty (60 percent) of the 67 wildlife strikes resulting in a destroyed aircraft occurred at general aviation airports, 15 occurred “enroute”, 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.

[2] Engine types on the 67 destroyed aircraft were piston (48), turbofan (8), turboprop (5), turbojet (3), and turboshaft (3). Aircraft operators were business (38), private (23), commercial transport (5), and government (1).

Table 22. 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, 1990–2014.

	Number of reports indicating:					Mean losses per report		
Year	Dam-age	Neg. EOF	Aircraft down time	Repair costs	Other costs	Down-time (hours)	Repair costs ($)	Other costs ($)
1990	372	146	61	33	16	55.6	216,810	62,238
1991	400	187	61	49	25	79.8	74,627	40,228
1992	367	219	81	51	28	111.9	107,131	5,391
1993	399	240	67	57	19	277.9	91,290	9,636
1994	462	274	103	73	29	388.4	78,548	93,798
1995	498	307	97	63	33	102.2	511,206	225,899
1996	502	355	144	86	39	137.3	86,998	26,034
1997	580	381	183	126	47	229.4	78,157	40,911
1998	586	400	205	135	54	119.5	203,741	29,049
1999	706	447	283	179	79	148.3	111,667	21,147
2000	764	477	352	206	93	195.0	157,032	116,380
2001	647	434	294	156	65	155.7	291,306	39,707
2002	671	498	385	166	63	134.9	152,429	64,633
2003	632	438	356	172	81	111.5	162,014	42,903
2004	626	429	325	213	92	166.3	105,648	22,806
2005	605	452	329	227	125	87.5	270,237	77,850
2006	597	429	333	172	102	116.8	217,940	13,553
2007	570	455	366	178	135	164.3	175,566	33,799
2008	526	408	371	156	141	116.2	121,366	14,416
2009	604	518	564	195	193	80.7	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	802	244	303	101.9	62,167	12,211
2014	581	569	716	213	273	118.2	132,303	10,444
Total	**14,050**	**10,088**	**8,219**	**3,731**	**2,671**			
Mean	**562**	**404**	**329**	**149**	**107**	**119.4**	**169,349**	**28,596**

Table 23. Minimum projected annual losses in aircraft downtime (hours) and in repair and other costs (inflation-adjusted U.S. dollars) caused by wildlife strikes with civil aircraft, USA, 1990–2014. Losses are projected from mean reported losses per incident (Table 22). (Page 1 of 2).

Year	No. of adverse incidents[3]	Minimum projected losses[1, 2]			
		Down-time (hours)	Repair costs (x $1 million)	Other costs (x $1 million)	Total costs (x $1 million)
1990	427	23,758	93	27	120
1991	486	38,760	36	20	56
1992	495	55,403	53	3	56
1993	509	141,456	46	5	51
1994	585	227,236	46	55	101
1995	657	67,143	336	148	484
1996	684	93,891	60	18	77
1997	786	180,312	61	32	94
1998	808	96,558	165	23	188
1999	983	145,769	110	21	131
2000	1,114	217,274	175	130	305
2001	979	152,444	285	39	324
2002	1,104	148,928	168	71	240
2003	998	111,288	162	43	205
2004	950	158,029	100	22	122
2005	975	85,290	263	76	339
2006	941	109,910	205	13	218
2007	981	161,216	172	33	205
2008	906	105,243	110	13	123
2009	1,185	95,607	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	1,443	147,028	90	18	107
2014	1,456	172,151	193	15	208
Total	**23,055**	**2,991,119**	**3,928**	**884**	**4,813**
Mean	**922**	**119,645**	**157**	**36**	**193**

Table 23. Continued (Page 2 of 2).

[1] Minimum values are based on the assumption that all 23,055 reported strikes (mean of 922/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, 1990–2014.

[2] 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.

[3] Number of reports indicating 1 or more of the following: damage, negative effect on flight (EOF), downtime, repair costs, other costs.

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Figures

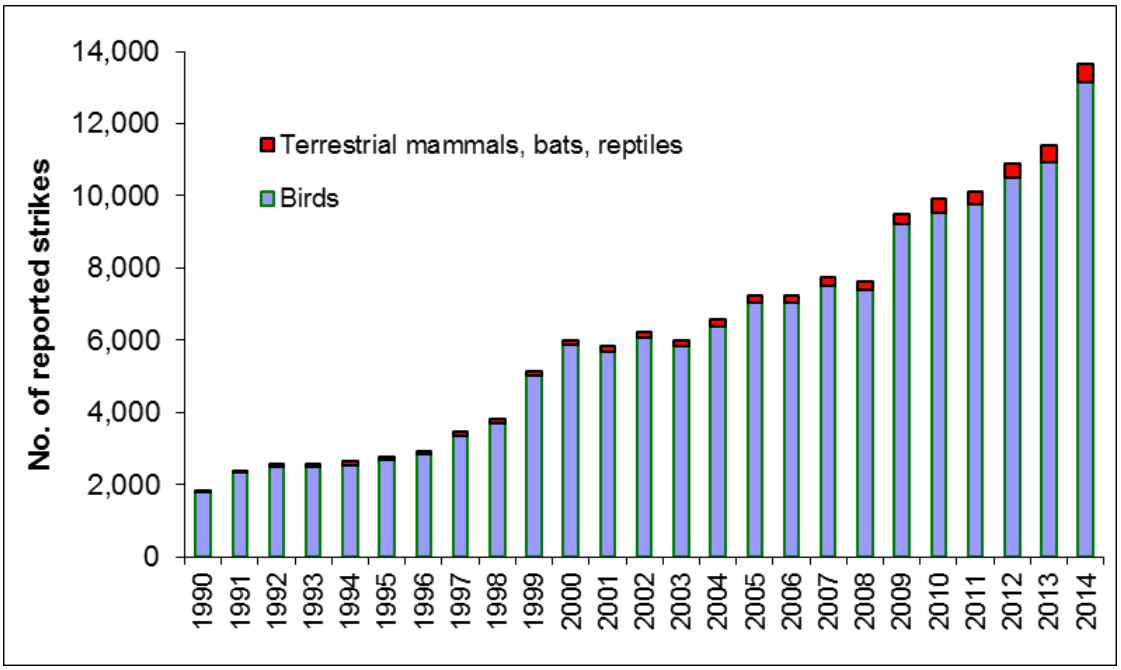


Figure 1. Number of reported wildlife strikes with civil aircraft, USA, 1990–2014. The 156,114 strikes involved birds (151,267), terrestrial mammals (3,360), bats (1,264), and reptiles (223, see Tables 1 and 17).

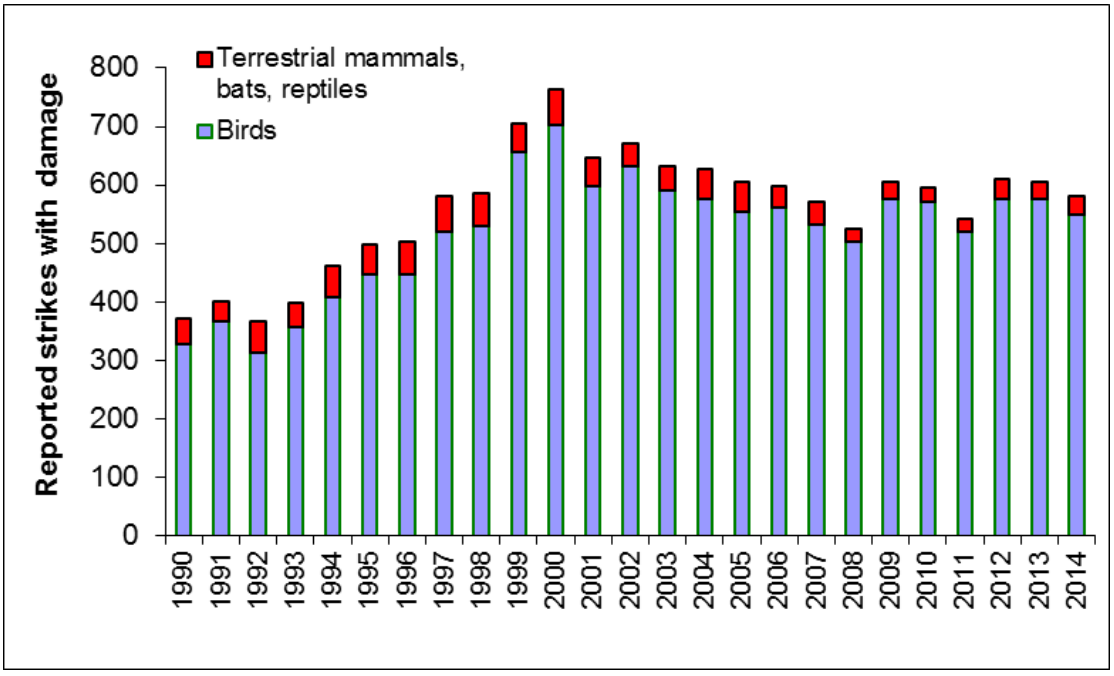


Figure 2. Number of reported wildlife strikes causing damage to civil aircraft, USA, 1990–2014. The 14,050 damaging strikes involved birds (12,982), terrestrial mammals (1,055), bats (11), and reptiles (2, see Tables 1 and 17).

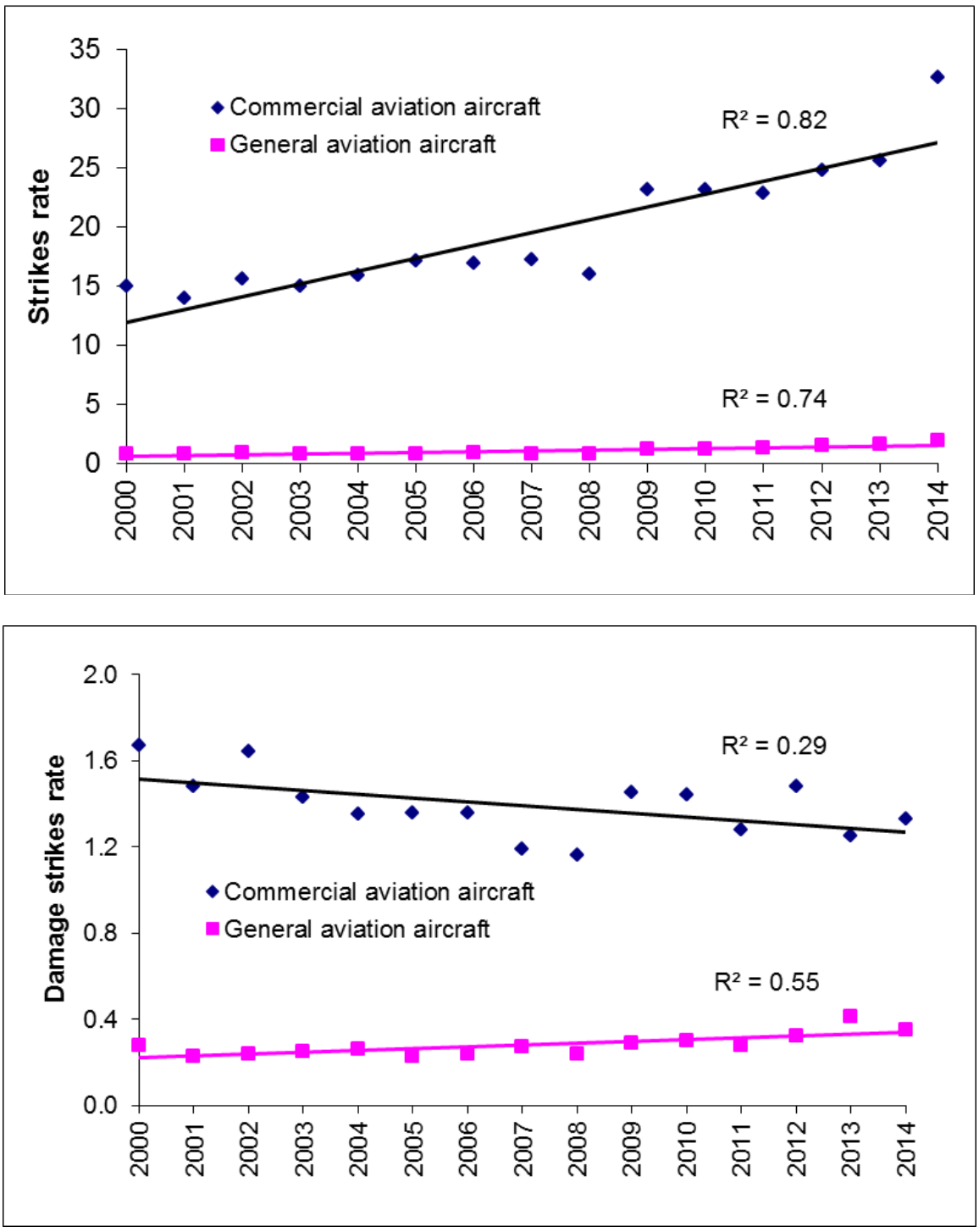
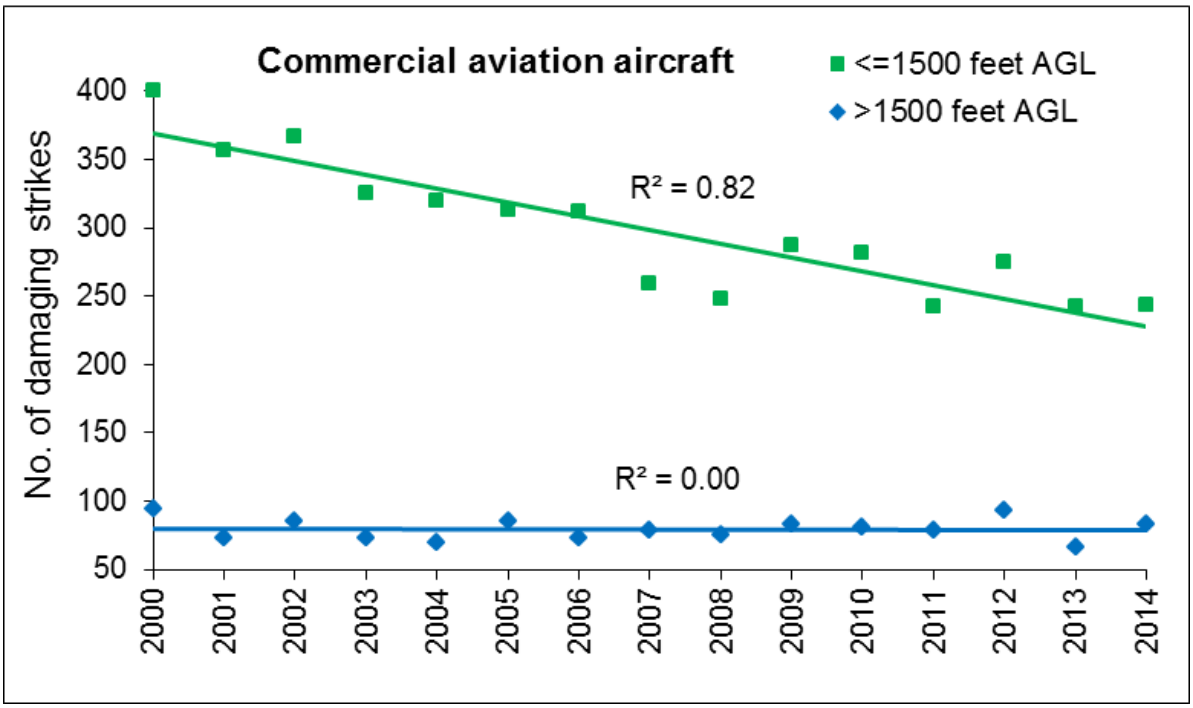


Figure 3. The strike rate (number of reported wildlife strikes per 100,000 aircraft movements, top graph) and damaging strike rate (number of reported damaging wildlife strikes per 100,000 aircraft movements, bottom graph) for commercial (air carrier, commuter, and air taxi service) and general aviation aircraft, USA, 2000–2014. R^2 values greater than 0.23 and 0.37 indicate significant trends at the 0.05 and 0.01 levels of probability, respectively (Steel and Torrie 1960) (see Tables 2 and 3 for complete data from 1990-2014).



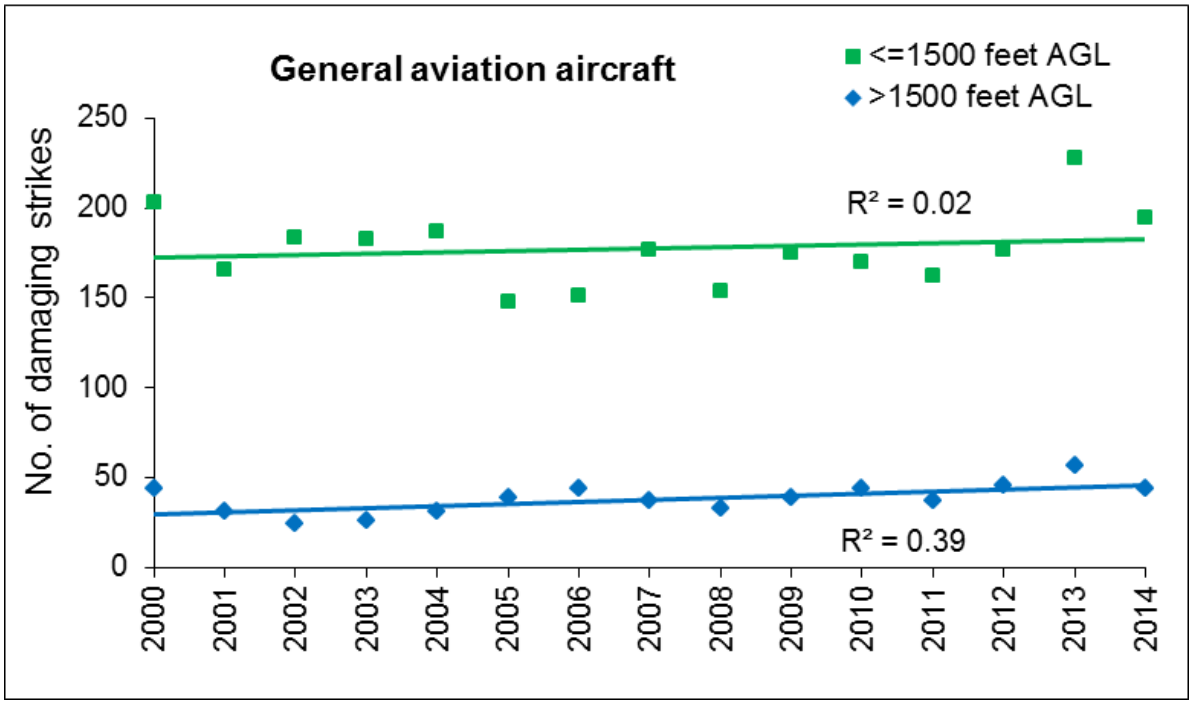


Figure 4. Number of damaging strikes with commercial (top graph) and general aviation (bottom graph) aircraft occurring at < and >1500 feet above ground level (AGL) for all wildlife species, 2000–2014. Strikes with unknown height AGL are included with strikes at <1500 feet AGL. Strikes involving U.S. aircraft in foreign countries are excluded. R2 values greater than 0.23 and 0.37 indicate significant trends at the 0.05 and 0.01 levels of probability, respectively (Steel and Torrie 1960).

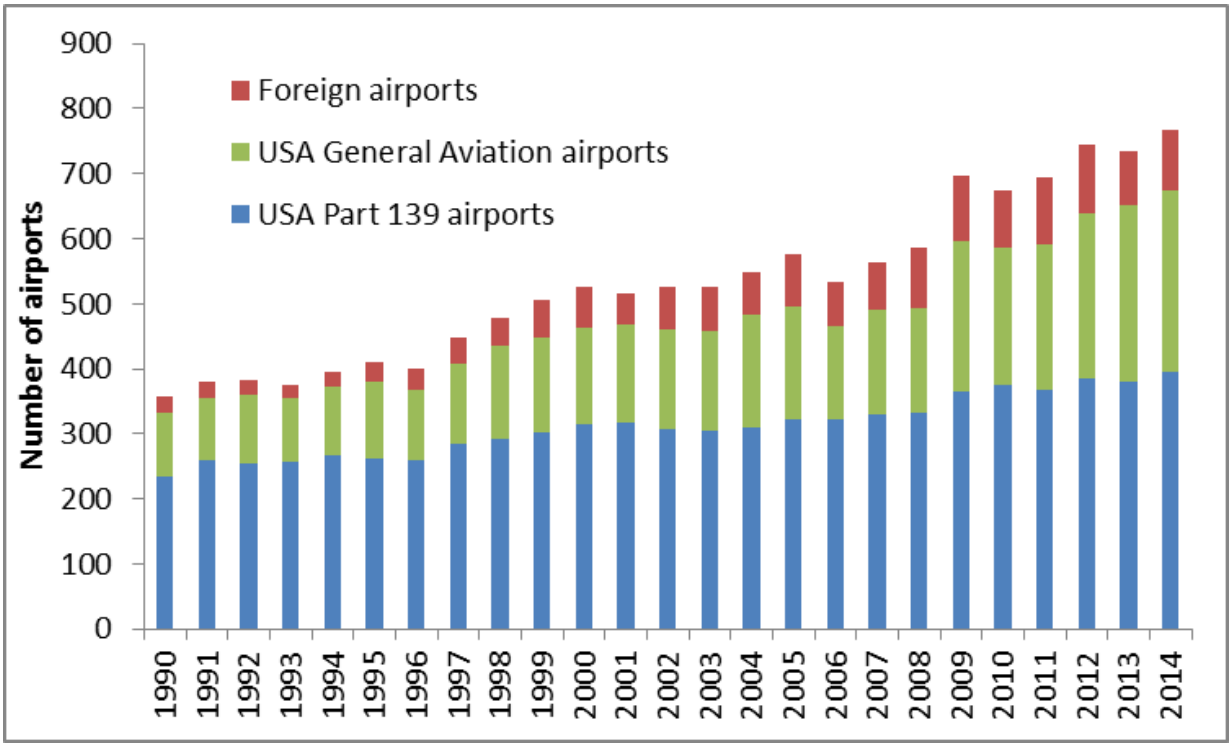
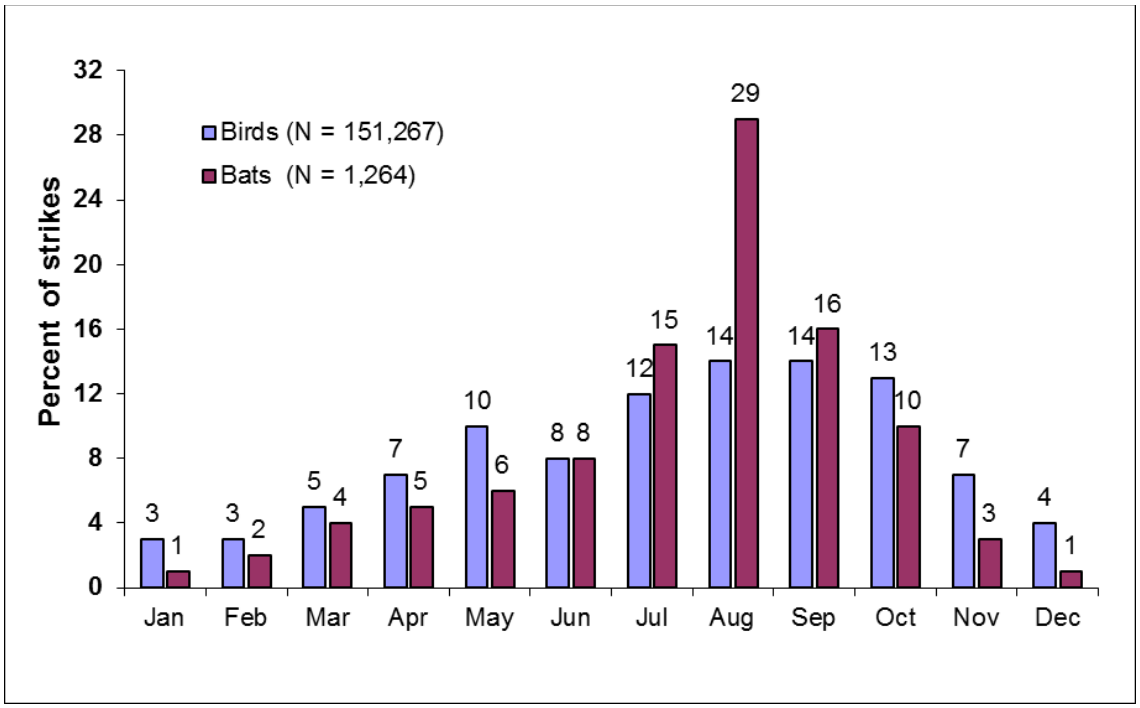


Figure 5. Number of Part 139-certificated airports and general aviation (GA) airports in USA with reported wildlife strikes and number of foreign airports at which strikes were reported for USA-registered civil aircraft, 1990–2014. Strikes were reported from 1,871 USA airports (527 Part 139-certificated, 1,344 GA) and 286 foreign airports in 106 countries, 1990-2014 (Table 7).



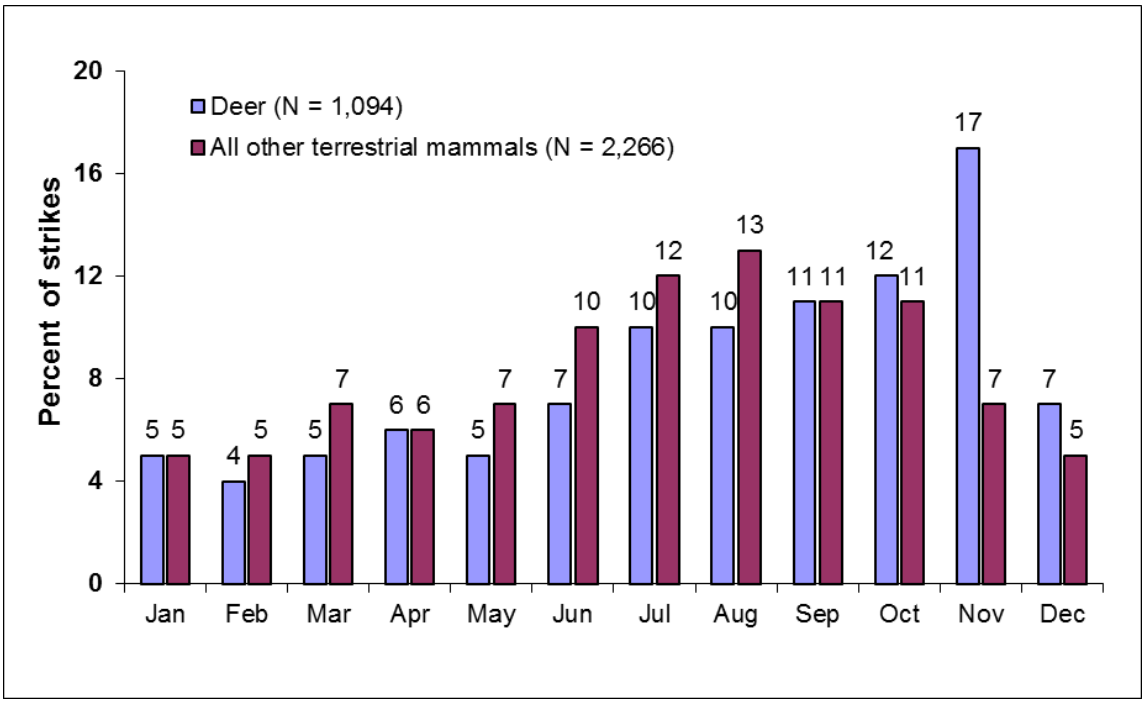
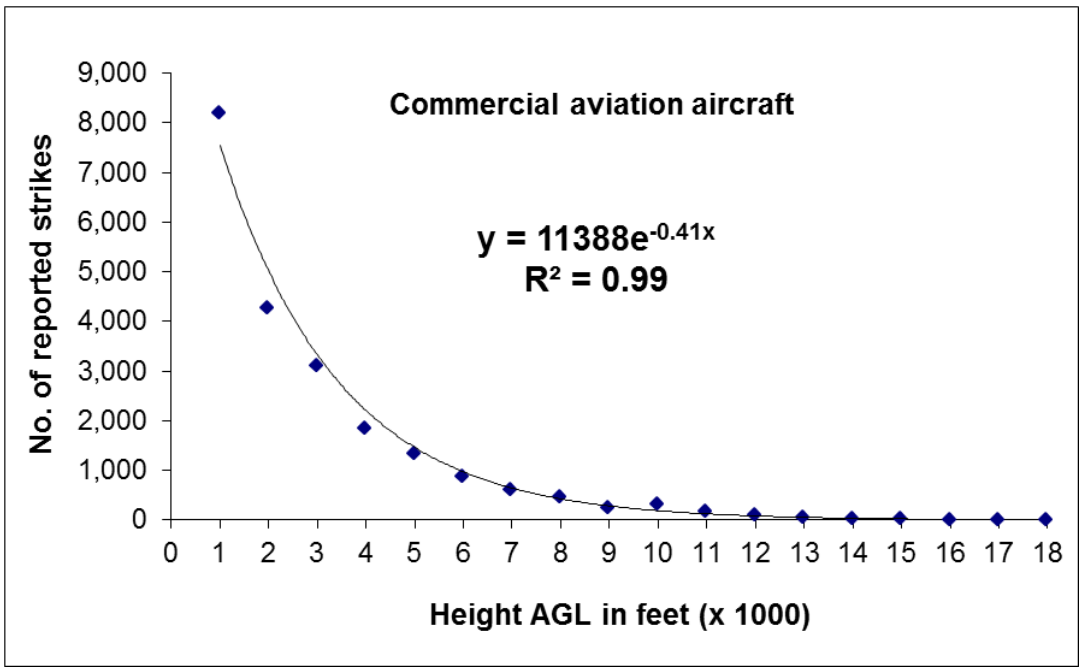


Figure 6. Percentage of reported bird and bat strikes (top graph) and deer and other terrestrial mammal strikes (bottom graph) with civil aircraft by month, USA, 1990–2014. In addition, 223 strikes with reptiles were reported of which 59 percent occurred in May - July. Deer strikes comprised 1,001 white-tailed deer, 77 mule deer, and 16 deer not identified to species (Table 17). Biondi et al. (2011) provide a more detailed analysis of deer strikes with civil aircraft in the USA.



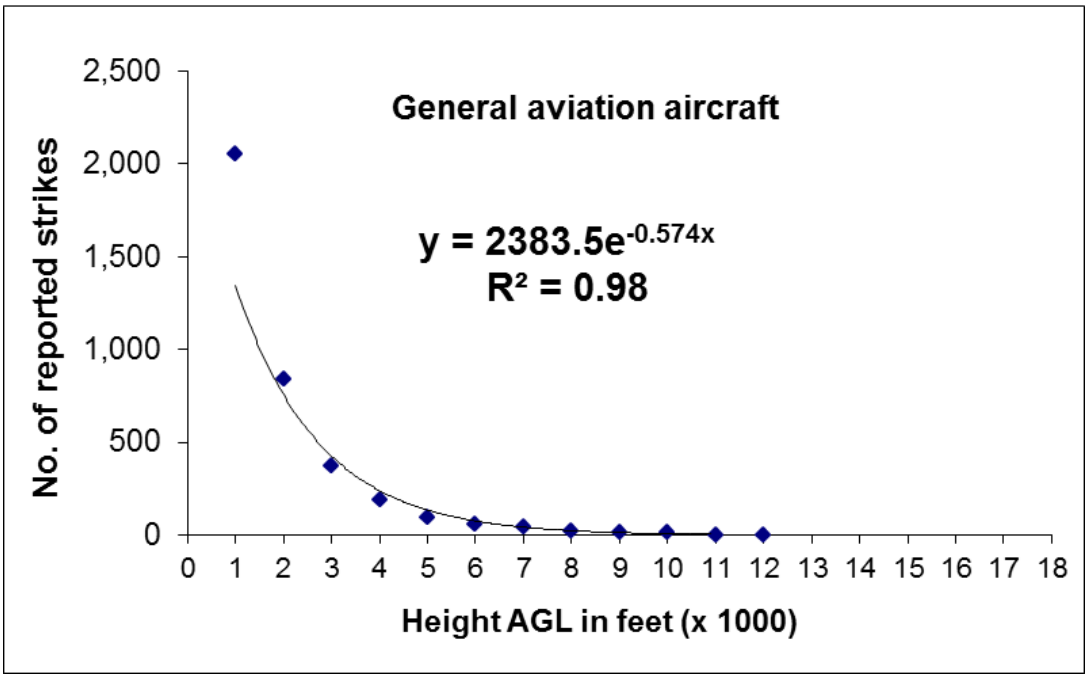
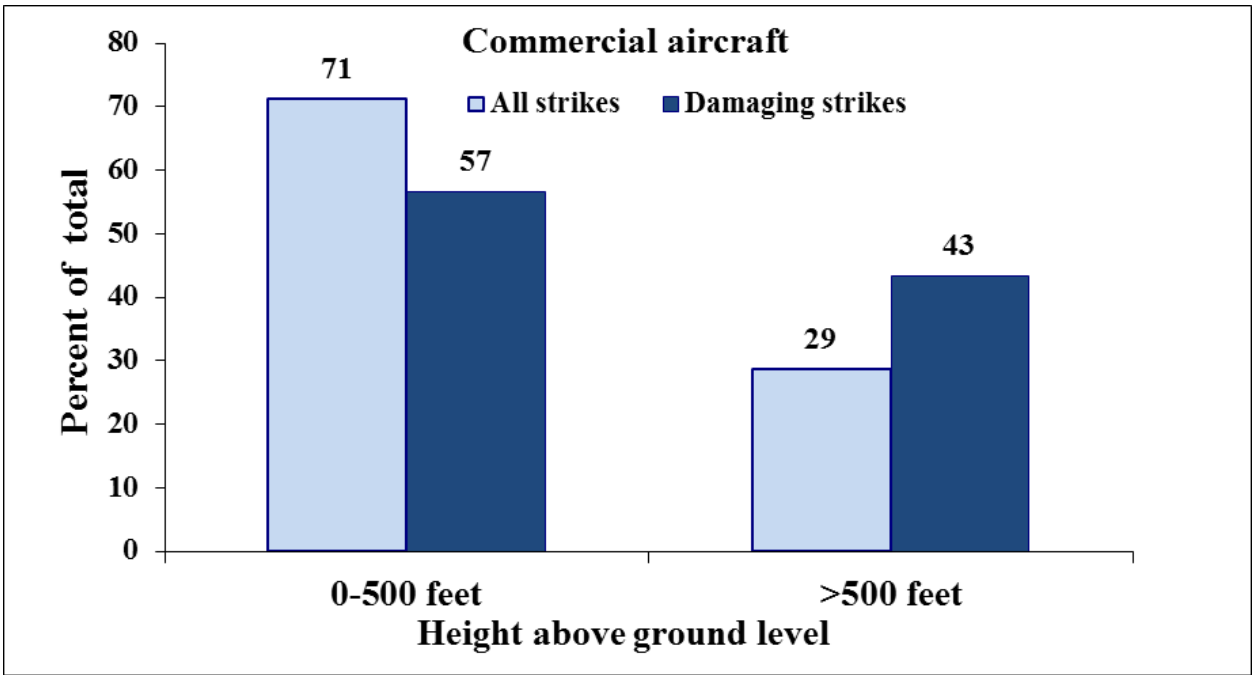


Figure 7. Number of reported bird strikes with commercial (top graph) and general aviation (GA) aircraft (bottom graph) in USA from 1990-2014 by 1,000-foot height intervals above ground level from 501—1,500 feet (interval 1) to 17,501—18,500 feet (interval 18) for commercial aircraft and to 11,501—12,500 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 98 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 10 and 11 for sample sizes.



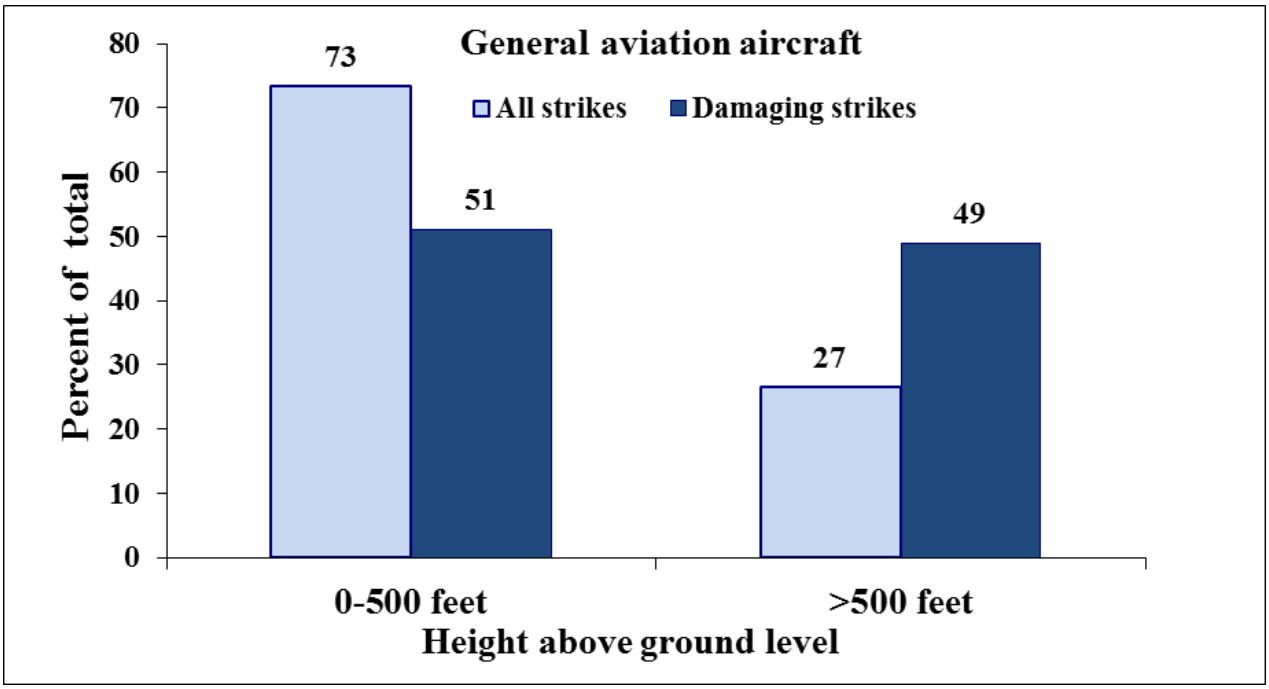
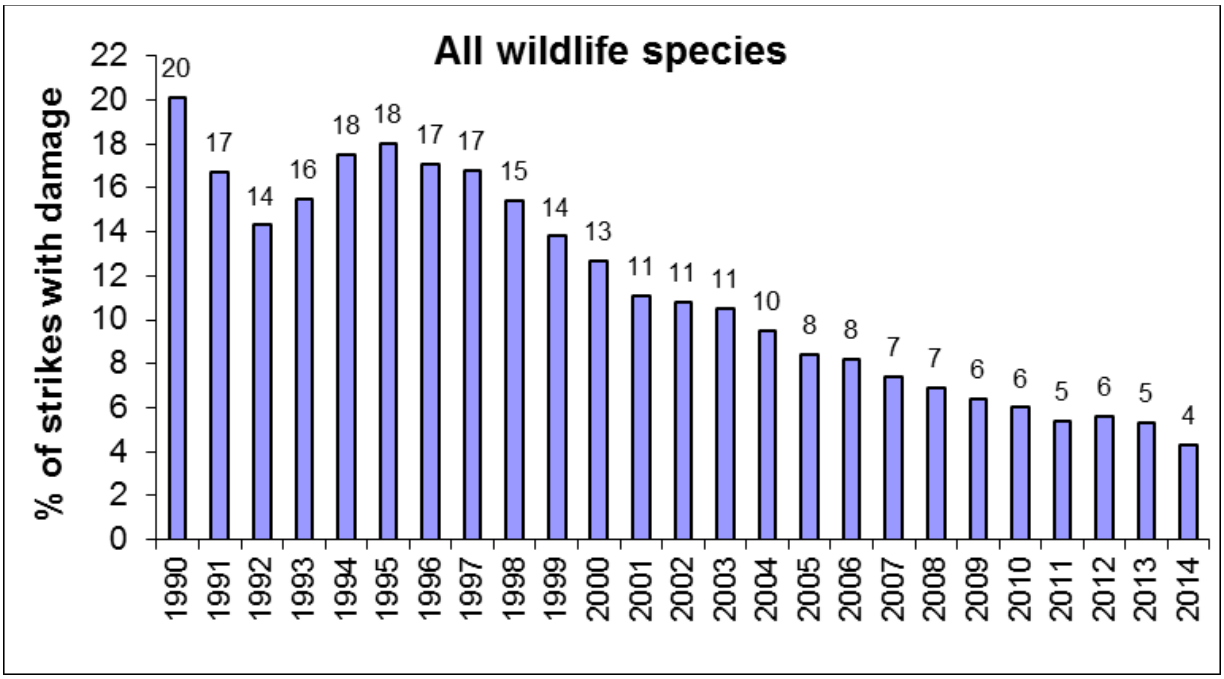


Figure 8. Percentage of total strikes and percentage of total damaging strikes occurring at 500 feet or less and above 500 feet for commercial (top graph) and general aviation (bottom graph) aircraft in USA, 1990–2014. See Tables 10 and 11 for sample sizes.



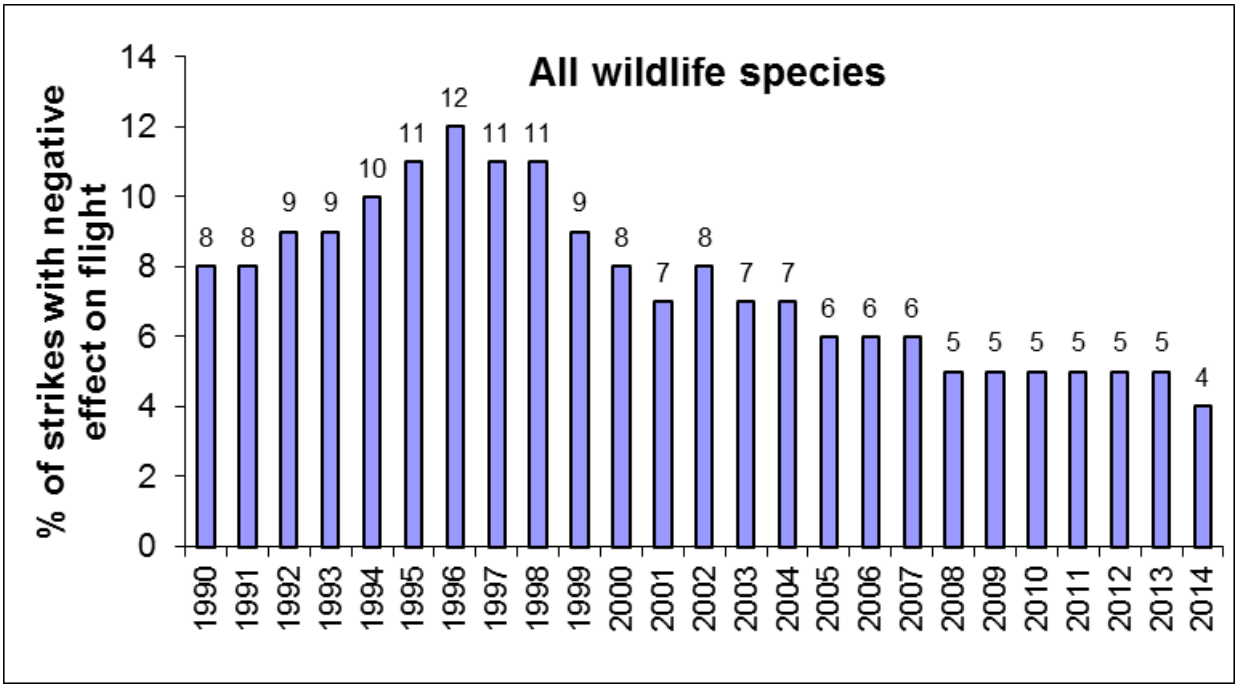


Figure 9. Percentage of reported strikes that indicated damage to the civil aircraft (top graph) or a negative effect-on-flight (bottom graph), USA, 1990–2014. See Tables 1, 13, and 14 for sample sizes and classifications of damage and negative effects-on-flight.

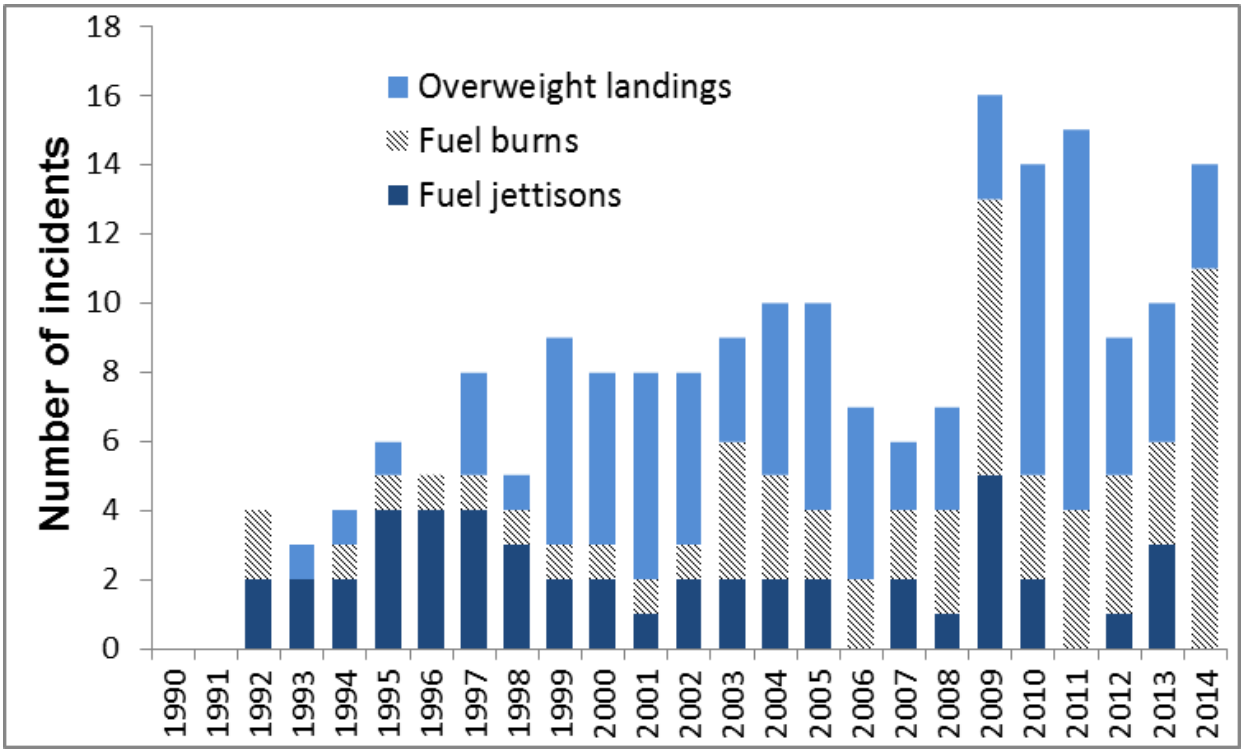


Figure 10. Number of reported incidents where pilot made an emergency or precautionary landing after striking birds during departure in which fuel was jettisoned or burned (circling pattern) to lighten aircraft weight or in which an overweight (greater than maximum landing weight) landing was made (no fuel jettison or burn), USA civil aircraft, 1990–2014. See Table 15 for details on aircraft involved and amount of fuel jettisoned.

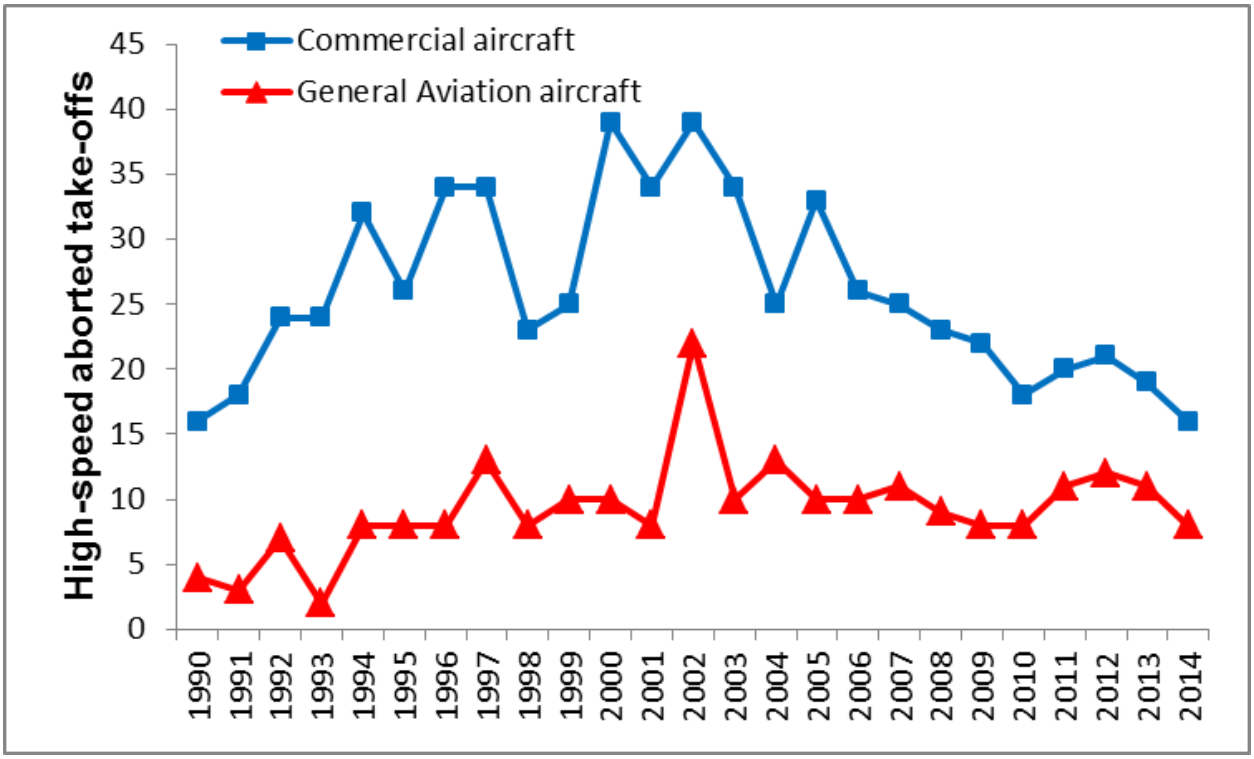


Figure 11. Number of reported incidents in which pilot made an aborted take-off at ≥80 knots after striking birds or other wildlife during take-off run, USA civil aircraft, 1990–2014. See Table 16 for classification of aborted take-offs by speed of aircraft.

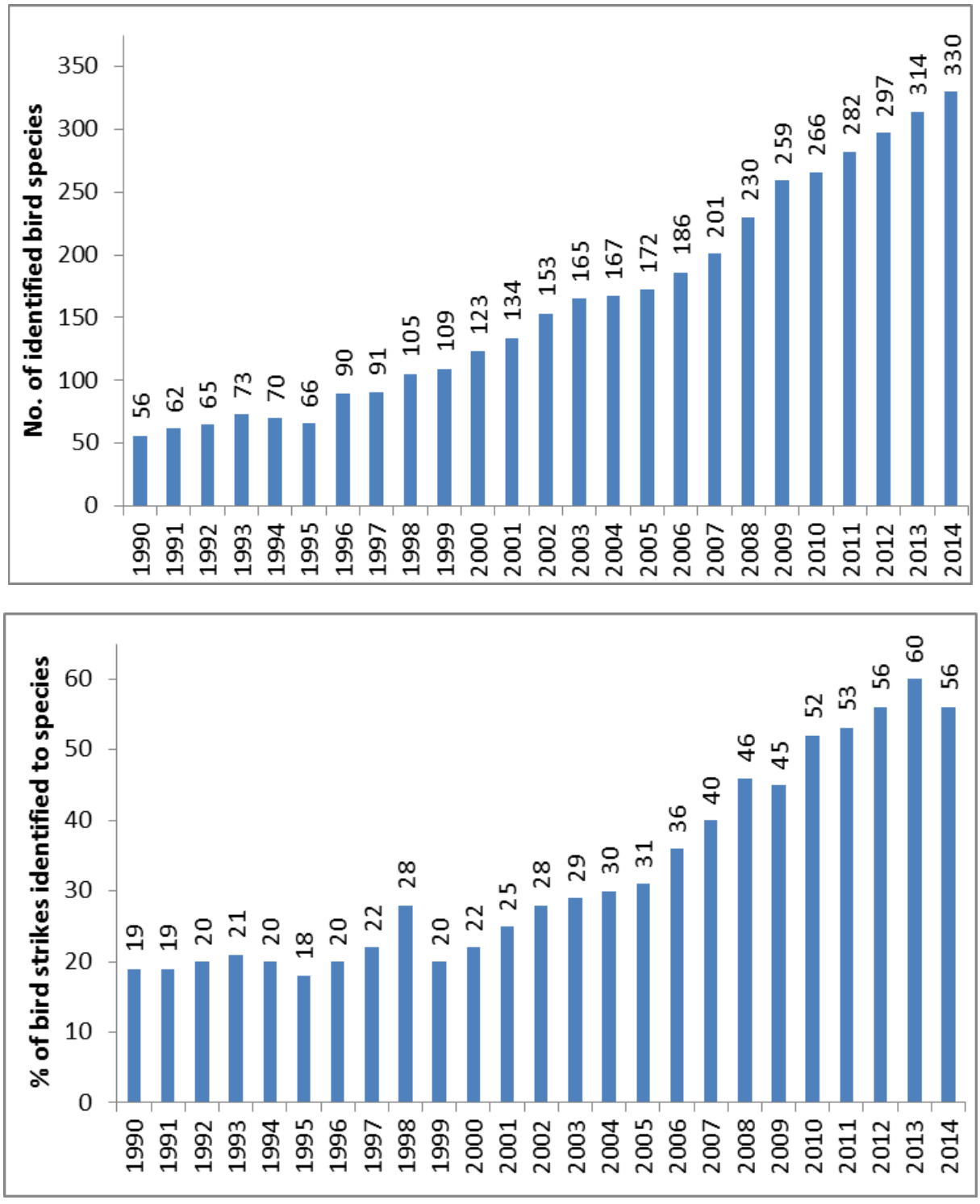


Figure 12. Number of identified bird species struck by civil aircraft each year (top graph) and the percentage of reported bird strikes in which the bird was identified to species (bottom graph), USA, 1990–2014. From 1990 through 2014, 518 different species of birds have been identified. See Tables 1 and 17 for sample sizes and list of species.

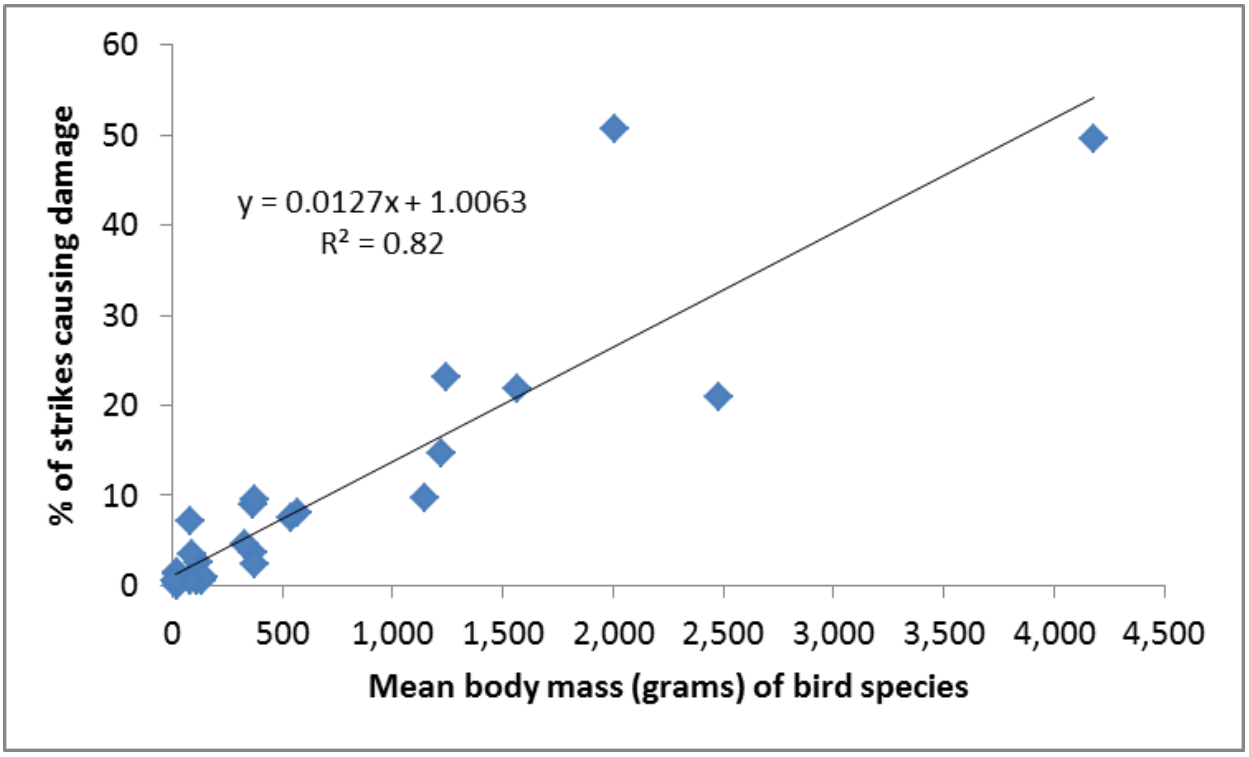


Figure 13. Relation between mean body mass (Dunning 2008) and likelihood of a strike causing damage to aircraft for the 30 species of birds most frequently identified as struck by civil aircraft in USA, 1990–2014 (Table 19). The linear regression equation explained 82% of the variation in the likelihood 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.

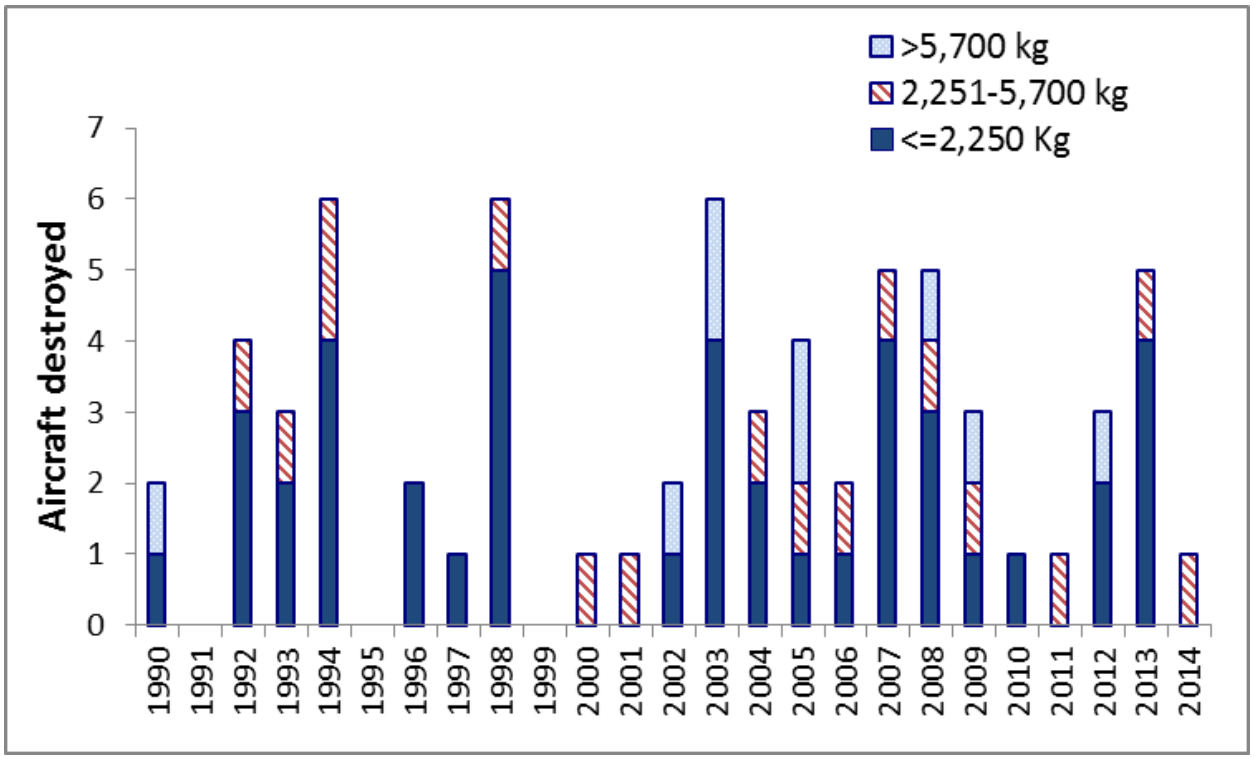


Figure 14. Number of aircraft destroyed or damaged beyond repair after striking wildlife by weight class of aircraft (maximum take-off mass), USA, 1990–2014. From 1990 - 2014, 67 aircraft have been lost. See Table 21 for wildlife species and types of aircraft and airports associated with these events.

PART 2: FAA ACTIVITIES FOR MITIGATING WILDLIFE STRIKES

In 2014, 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 550 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.

The FAA continued to distribute the latest *Report Wildlife Strikes* awareness poster. Designed in 2013, it is being distributed throughout 2014. Overall, more than 36,000 posters have been distributed to 4,000+ Part 139 airports, General Aviation (GA) airports, aviation flight schools and the aviation industry in the last four years. The renewal of strike awareness posters is one of several outreach efforts to improve strike reporting and safety at certificated and GA airports. As an extension to the mobile application software developed by the FAA to make strike reporting easier, the FAA also placed a QR code on the bottom of the "Report Wildlife Strikes" posters which allows anyone to report a wildlife strike via the web or their personal data devices. Outreach materials such as informational placards and quick-reference thumb guides are also being developed for distribution.

Inaugural "Excellence in Strike Reporting" Award 2014

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 recognizes those airports that have exhibited a noteworthy strike reporting program. The number of US airports with strikes reported has increased from 331 in 1990 to a record 649 in 2013. The 649 airports with strikes reported in 2013 were comprised of 379 airports

certificated for passenger service under 14 CFR Part 139 and 270 general aviation (GA) airports. From 1990 - 2013, strikes have been reported from 1,821 US airports.

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

Cathy Boyles receiving DFW Airport's inaugural "Doing it Wright" award from the FAA.

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

It should be noted that the criteria for determining who has won the award does not include an evaluation of the actual wildlife management program at an airport. Also, even though the award is specifically for the voluntary strike reporting programs in 2013, data from previous years is necessary to determine consistency or improvements in an airport's strike reporting program.

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), Portland (PDX), Seattle (SEA) and Denver (DEN). Honorable mentions go to Minneapolis-Saint Paul (MSP) and Orlando (MCO). The Top 5 GA airports were Morristown Municipal Airport (MMU), Centennial (APA), Van Nuys (VNY), Addison (ADS) and Dupage (DPA). Honorable mention went to Fort Lauderdale Executive Airport (FXE).

For their commitment to the identification and documentation of wildlife / aircraft strike information, the FAA proudly recognizes the superior strike reporting programs at **Dallas-Fort Worth International Airport** and **Morristown Municipal Airport** as the winners of the 2014 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.

Finally, 2015 marks the 50th anniversary of an 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.

FAA Guidance

Advisory Circular No: 150/5200-32B (AC-32B) *Reporting Wildlife Aircraft Strikes* was updated and published May 31, 2013. The AC provided clarification that a wildlife strike should be reported when 1) a strike between wildlife and aircraft has been witnessed; 2) evidence or damage from a strike has been identified on an aircraft or; 3) bird or other wildlife remains, whether in whole or in part, are found within 250 feet of a runway centerline or within 1,000 feet of a runway end unless another reason for the animal's death is identified or suspected. 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* (01/31/2012) received minor updates on January 31, 2013. The primary change added language requiring certificated airports to maintain documentation of airport wildlife biologist qualifications. 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 2015. 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.

The FAA funded and assisted with the development of two new Airport Cooperative Research Program (ACRP) reports to aid airports with the mitigation of wildlife hazards. ACRP Synthesis 39 report *Airport Wildlife Population Management* (2013) and

Synthesis 52 report *Habitat Management to deter Wildlife at Airports* (2014) are available from the Transportation Research Board (TRB) of the National Academies at http://www.trb.org/Publications/Publications.aspx. 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.

Wildlife Hazard Mitigation Research

For the last 19 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,
- 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.

Many species of raptors represent a hazard to safe air operations both in and out of the airport's environment. Six of the top 20 avian threats with at least 100 documented strikes to civil aircraft are raptors. Although successful low-tech solutions to mitigate this hazard have included capture-relocation, harassment, prey removal, and perch excluders, the USDA NWRC and Purdue University have teamed up to study the feasibility of exploiting avian vision with aircraft lighting to reduce bird strikes. Photo 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.

The initial avian radar systems have involved Accipiter Radar Technologies Inc. and were deployed at Seattle-Tacoma and Whidbey Island Naval Station in 2007, Chicago O'Hare in 2009, and John F. Kennedy and Dallas-Fort Worth in 2010.

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. The effort brings together experts in wildlife biology, ornithology, radar engineering, and system integration from government, industry, and academia to evaluate the MERLIN Avian Radar System by DeTect, Inc., one of several radar systems used to detect birds at and near airports. The assessment effort is part of the FAA's overall investigation into the effectiveness of commercially available avian radar detection systems at U.S. civil airports when used in conjunction with other known wildlife management and control techniques. 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. These studies involve 1) a technical evaluation of the candidate radar system, including sensor components and associated data delivery systems, 2) field evaluations of system accuracy using remote controlled aircraft and wild birds, 3) an assessment of the integration of radar technology with other, more traditional aspects of wildlife hazard management at airports, and 4) a behavioral study on the potential effects of radar energy on bird behavior.

Carcasses found on airports represent limited information on an individual strike event but provide crucial information recognizing hazardous species. Species identified above are from left to right: Short-eared owl, Eastern meadowlark and Barn owl. Photos courtesy John R Weller.

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 has encouraged all certificated airports to conduct Assessments and develop Plans regardless if they have experienced a triggering event under 14 CFR Part 139. To date, 100% of Part 139 airports have completed an Assessment, are in the process of conducting an Assessment, or have taken a Federal grant to conduct an Assessment. 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*"

In response to this recommendation the FAA initiated the modification of AC 150/5200-33B to encourage federally obligated National Plan of Integrated Airport System/General Aviation (NPIAS/GA) airports, to conduct Assessments and Site Visits. The FAA has established a program and schedule that outlines the implementation of these assessments based on the number of operations and based jet aircraft. It will take several years to complete Assessments and Site Visits at the more than 2,700 GA

airports. To assist the GA airports in conducting Assessments, we will make AIP grant funds available to them.

Management of deer and other large mammals at airports relies heavily on adequate exclusionary fencing. AIP funds are made available to airports to exclude hazardous wildlife as part of a wildlife management program Photo courtesy Amy Reed.

Mitigating Strikes at GA Airports

The FAA funded and assisted with the development of two ACRP reports to aid GA airports with the mitigation of wildlife hazards. From October 2011 to early 2012, 2,770 copies of 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. The reports, published in 2010 and 2011 respectively, provide practical guidance and specific techniques on how to address wildlife strikes at airports with a specific emphasis on the general aviation community 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.

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 764 in 2000 to 581 in 2014. Further analysis of strike reporting trends will be completed in 2015 following completion of 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 2011, 2012, 2013, 2014 and future years. The table below depicts the results of calculating the data for the five year period 2010 - 2014.

	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%

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 civilian 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 thereafter.

Metric 3: We 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.

APPENDIX A.

SELECTED SIGNIFICANT WILDLIFE STRIKES TO U.S. CIVIL AIRCRAFT, 2014

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 2014, 156,114 strike reports from 1,871 USA airports and 286 foreign airports have been entered in the database (13,668 strikes from 673 USA and 93 foreign airports in 2014 alone, Tables 1, 7; Figure 5). The following 25 examples from the database in 2014 are presented to show the serious impact that strikes by birds or other wildlife can have on aircraft. These examples, from throughout the USA, 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:	19 January 2014
Aircraft	Cessna 195B
Airport:	Winchester Regional (VA)
Phase of Flight:	Landing roll
Effect on Flight:	Evasive maneuver
Damage:	Wing, landing gear
Wildlife Species:	White-tailed deer
Comments from Report: While practicing touch and go landings, the aircraft veered off the runway and into a rut. Damage to left wing and the left landing gear was torn off. Pilot stated he tried to avoid three deer. Airport was closed for four hours and at least two flights were diverted.	

Date:	19 January 2014
Aircraft	EMB-135
Airport:	Lafayette Regional (LA)
Phase of Flight:	Approach (2,000 feet AGL)
Effect on Flight:	Engine shut down
Damage:	Nose, engine
Wildlife Species:	Snow goose
Comments from Report: Multiple birds were struck on approach resulting in the failure of the #1 engine and skin damage to the nose. An emergency was declared. One hit the windshield but did not cause any damage. Passengers were deplaned normally. The engine was replaced. ID by Smithsonian, Division of Birds.	

Date:	9 February 2014
Aircraft	B-737-300
Airport:	Cleveland Hopkins International (OH)
Phase of Flight:	Take-off run
Effect on Flight:	Aborted take-off
Damage:	Engine
Wildlife Species:	Snowy owl
Comments from Report: Bird was struck during take-off run. Pilot aborted take-off. A complete fan blade change was made. Borescope and high energy stop inspections were done. Costs estimated as $22,895 for repair, parts, inspection and labor. ID by Smithsonian, Division of Birds.	

Date:	22 February 2014
Aircraft	Piper PA-32
Airport:	Page Field (FL)
Phase of Flight:	Approach (1,000 feet AGL)
Effect on Flight:	Emergency landing
Damage:	Windshield
Wildlife Species:	Red-shouldered hawk
Comments from Report: About 10 miles out from Page Field, a hawk shattered the windshield cutting the pilot on his forehead. A mayday call was made and the aircraft landed safely. The incident was videotaped. Remains were collected. ID by Smithsonian, Division of Birds. Time out of service was about 1 week and costs for repair totaled approximately $2400.	

Date:	13 March 2014
Aircraft	BE-400
Airport:	Greater Rochester International (NY)
Phase of Flight:	Climb (400 feet AGL)
Effect on Flight:	Engine shut down, precautionary landing
Damage:	Aircraft destroyed
Wildlife Species:	Herring gull
Comments from Report: After liftoff, the crew caught a glimpse of what appeared to be a large bird go past them and immediately afterwards, they felt a high vibration and the loss of the right engine power. They declared an emergency and returned to the departure airport for a safe landing. Estimated cost of aircraft was $1.5 million. ID by Smithsonian, Division of Birds.	

Date:	25 April 2014
Aircraft	Hawker 800
Airport:	Philadelphia International (PA)
Phase of Flight:	Climb (700 feet AGL)
Effect on Flight:	Engine shut down, precautionary landing
Damage:	Nose, engine #1, fuselage
Wildlife Species:	Double-crested cormorant
Comments from Report: Airport Ops responded to Alert 1 and accompanied aircraft back to hangar. Costs reported as $800,000. Aircraft out of service approximately one week. ID by Smithsonian, Division of Birds.	

Date:	13 May 2014
Aircraft	BE-400
Airport:	Sugar Land Regional (TX)
Phase of Flight:	Take-off run
Effect on Flight:	Aborted take-off
Damage:	Engine #1, wing, fuselage
Wildlife Species:	Yellow-crowned night-heron
Comments from Report: Pilots were about to call out V-Speed V1 when Captain saw the bird which looked like it hit the side of the nose below his side window. If flew back and through the engine. Pilots aborted take-off successfully. They received warning of a fire in the engine compartment, deployed fire extinguisher bottles and put the fire out. Sugar Land FD responded. Fuel was leaking from wing and engine nacelle. Absorbent material was laid down to prevent further contamination of pavement. Metal debris was retrieved from runway. Damage to engine was severe. A hole on top and two holes on side of engine cowling looked burnt. Fuselage damage from metal debris from the engine looks like scratches. Aircraft was repositioning to another airport and was empty. NTSB investigated.	

Date:	27 May 2014
Aircraft	A-320
Airport:	Logan International (MA)
Phase of Flight:	Climb (88 feet AGL)
Effect on Flight:	Precautionary landing
Damage:	Engine #2
Wildlife Species:	Mallard
Comments from Report: Pilot reported striking birds just after rotation and returned to land. Aircraft taken out of service for inspection. Maintenance reported 14 damaged fan blades and damage to fan case liners resulting in an engine swap. Borescope found core compressor damage. Engine was sent to factory in Germany for a complete overhaul. Estimated cost of repair reported as $3,000,000. Aircraft out of service 36 hours. ID by Smithsonian, Division of Birds.	

Date:	28 May 2014
Aircraft	EMB-135
Airport:	Cherry Capital (MI)
Phase of Flight:	Approach (3,500 feet AGL)
Effect on Flight:	Schedule interruption
Damage:	Windshield, radome, nose, instrument panel
Wildlife Species:	Common loon
Comments from Report: During approach at about 10 miles out, a bird penetrated the forward pressure bulkhead and went into the back of the instrument panel. Pilots were struck with bird remains. A safe landing was made. Partial instrument panel loss. The aircraft was patched and ferried to complete the final repairs. Aircraft out of service 3.9 months. NTSB investigated. ID by Smithsonian, Division of Birds.	

Date:	10 June 2014
Aircraft	B-767-300
Airport:	Denver International (CO)
Phase of Flight:	Climb (400 feet AGL)
Effect on Flight:	Engine shutdown, precautionary landing
Damage:	Engine #1, wing
Wildlife Species:	Canada goose
Comments from Report: Pilot reported seeing 5 geese on climb out from runway 8. One bird was ingested with engine vibration reported. Engine was shut down and aircraft returned to airport. Damage to leading edge of right wing and to 25-30 fan blades. Remains of two birds, ingested bird and whole bird, collected from runway safety area along with pieces of fan blades. Costs reported as $3.9 million. ID by Smithsonian, Division of Birds.	

Date:	7 July 2014
Aircraft:	B-737-800
Airport:	Pohnpei International (Micronesia)
Phase of Flight:	Landing roll
Effect on Flight:	Schedule interruption
Damage:	Engine #2
Wildlife Species:	Ruddy turnstone
Comments from Report: Engine #2 struck by birds and as a result eight fan blades were dented. Cancelled departure due to substantial engine damage. Based on the feather collected assumed to be ruddy turnstone.	

Date:	9 August 2014
Aircraft:	A-321
Airport:	Luis Munoz Marin International (PR)
Phase of Flight:	Take-off run
Effect on Flight:	Aborted take-off, engine failure
Damage:	Engine #1
Wildlife Species:	Red-tailed hawk
Comments from Report: Ingestion resulted in engine failure, rejected take-off and evacuation on adjacent taxiway. Multiple minor injuries sustained during evacuation. Engine replacement required. Costs reported as $6,500,000. Aircraft out of service 5 days. ID by Smithsonian, Division of Birds.	

Date:	10 August 2014
Aircraft:	Bombardier de Havilland Dash 8
Airport:	Harrisburg International (PA)
Phase of Flight:	Take-off run
Effect on Flight:	Aborted take-off
Damage:	Passenger window, engine #2 and propeller
Wildlife Species:	Canada goose
Comments from Report: At the start of take-off, aircraft struck several Canada geese. One goose broke a passenger window on right side of aircraft after hitting and damaging the right propeller. ID by Smithsonian, Division of Birds.	

Date:	25 September 2014
Aircraft:	Cessna 208B
Airport:	Kenai Municipal (AK)
Phase of Flight:	Climb (1,100 feet AGL)
Effect on Flight:	Precautionary landing, declared emergency
Damage:	Landing gear
Wildlife Species:	Bald eagle
Comments from Report: Declared an emergency for priority landing and emergency services. Nose gear spring bar was disconnected making steering difficult. Cost of repairs $2,315. Aircraft out of service for 18 hours.	

Date:	26 September 2014
Aircraft:	Cessna 172S
Airport:	15 miles west of Rochester (NY)
Phase of Flight:	En Route
Effect on Flight:	Precautionary landing
Damage:	Windshield
Wildlife Species:	Double-crested cormorant
Comments from Report: Bird went through windshield and was inside the aircraft after landing. Half of windshield was blown out. Emergency declared. ID by Smithsonian, Division of Birds.	

Date:	2 October 2014
Aircraft:	Eurocopter AS 350
Airport:	11NM SE Levelland, TX
Phase of Flight:	En Route (1,500 feet AGL)
Effect on Flight:	Precautionary landing
Damage:	Nose
Wildlife Species:	Mallard
Comments from Report: Hole in nose of aircraft and cabin floor.	

Date:	2 October 2014
Aircraft:	Challenger 604
Airport:	Portland International (OR)
Phase of Flight:	Approach (1,000 feet AGL)
Effect on Flight:	None
Damage:	Wing
Wildlife Species:	Osprey
Comments from Report: Struck bird on 2 mile final. Damage to leading edge of left wing. Costs of repairs ($71,000) to replace a wing fairing and a wing rib. Crew lodging ($6,050), lost revenue ($61,000), temporary repair at airport ($17,000), cost to ferry aircraft to St Louis for repairs ($20,000). Aircraft was out of service for 14 days. ID by Smithsonian, Division of Birds.	

Date:	20 November 2014
Aircraft:	A-320
Airport:	San Francisco International (CA)
Phase of Flight:	Take-off
Effect on Flight:	Aborted take-off
Damage:	Engine #1, engine #2
Wildlife Species:	Dunlin
Comments from Report: Both engines ingested birds and have bent fan blades.	

Date:	22 November 2014
Aircraft:	B-737-700
Airport:	Sacramento International (CA)
Phase of Flight:	Approach (1,800 feet AGL)
Effect on Flight:	None
Damage:	Radome, nose
Wildlife Species:	Snow goose
Comments from Report: Pilot saw a flock of large birds on seven mile final. Strike occurred on right side of the radome just below the First Officer causing a 2- foot dent. Engine ingestion. Aircraft was out of service for one day. ID by Smithsonian, Division of Birds.	

Date:	22 November 2014
Aircraft:	A-320
Airport:	Sacramento International (CA)
Phase of Flight:	Approach (1,100 feet AGL)
Effect on Flight:	Engine shutdown
Damage:	Engine #1, left wing, fuselage
Wildlife Species:	Snow goose
Comments from Report: Numerous bird strikes on approach at approximately 1,100 feet agl. At 600 feet engine #1 began overheating due to ingestion and the pilot shut it down. Damage to compressor was beyond limits and necessitated engine removal for repair. ID by Smithsonian, Division of Birds.	

Date:	27 November 2014
Aircraft:	A-330
Airport:	Miami International (FL)
Phase of Flight:	Climb (300 feet AGL)
Effect on Flight:	Engine shutdown, precautionary landing
Damage:	Engine #2
Wildlife Species:	Turkey vulture
Comments from Report: One bird suddenly appeared after liftoff. Aircraft returned single engine to land back at MIA as Alert II. Six fan blades damaged. Damage to rear acoustic panels. Aircraft was out of service for 12 days. ID by Smithsonian, Division of Birds.	

Date:	28 November 2014
Aircraft:	A-330
Airport:	Charlotte/Douglas International (NC)
Phase of Flight:	Climb (1,500 feet AGL)
Effect on Flight:	Precautionary landing, burn off fuel
Damage:	Engine #1
Wildlife Species:	Diving duck
Comments from Report: Engine ingestion 2nm from airport. Ingestion caused the engine to stall. Flight crew decided to return to KCLT but had to burn off fuel for approximately two hours to reach landing weight. Aircraft landed without incident. Multiple fan blades damaged. Fan rotor replacement and balance and thrust reverser change. Aircraft was out of service for 2 days. ID by Smithsonian. Division of Birds.	

Date:	3 December 2014
Aircraft:	CRJ-200
Airport:	Sacramento International (CA)
Phase of Flight:	Approach (1,500 feet AGL)
Effect on Flight:	None
Damage:	Radome, left wing flaps, fuselage
Wildlife Species:	Snow goose
Comments from Report: Major bird strike while on approach. Blood smears, feathers and bird remains visible on the nose, windshield, leading edge of both wings, flaps and in both engines. Remains were embedded in the nose. Time out of service was 8 days. Total costs were $213,598. ID by Smithsonian, Division of Birds.	

Date:	12 December 2014
Aircraft:	B-737-700
Airport:	Baltimore/Washington International (MD)
Phase of Flight:	Approach (3,000 feet AGL)
Effect on Flight:	Emergency landing
Damage:	Radome, nose, engine #1, engine #2, wing, fuselage, tail
Wildlife Species:	Canada goose
Comments from Report: Hit a flock of birds with several impacts. Ingested into both engines.. Emergency declared due to control issues after the strike. Observers on the ground reported seeing flames coming from the #2 engine. ID by Smithsonian, Division of Birds.	

Date:	12 December 2014
Aircraft:	B-737-700
Airport:	Sacramento International (CA)
Phase of Flight:	Approach (2,000 feet AGL)
Effect on Flight:	Emergency landing
Damage:	#2 engine, engine cowling
Wildlife Species:	Greater white-fronted goose
Comments from Report: Hit a flock of birds on approach. Ingested at least one into the #2 engine. Emergency declared due to compressor stalls, asymmetrical thrust and flames coming from back of engine. 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 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 2014 was 3,209 with 3,460 separate identifications of species (some cases involved remains from multiple impact points). This compares to 2,474 cases in 2013, 2,072 cases in 2012, 1,580 cases in 2011 and 1,268 cases in 2010 (Dove et al. 2015). In addition, the Lab processed 5,003 identifications for the U.S. Air Force and 693 identifications for the U.S. Navy (not discussed in this report). DNA analysis (Dove et al. 2008) was used in 1,556 (45 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"):

Members of the Feather Lab and officials from the Air National Guard (ANG) surround a newly acquired DNA extraction machine in December 2014. The machine, purchased by the ANG, allows the Feather Lab to process DNA samples more efficiently at the Natural History Building. Photo by Smithsonian Institution.

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.

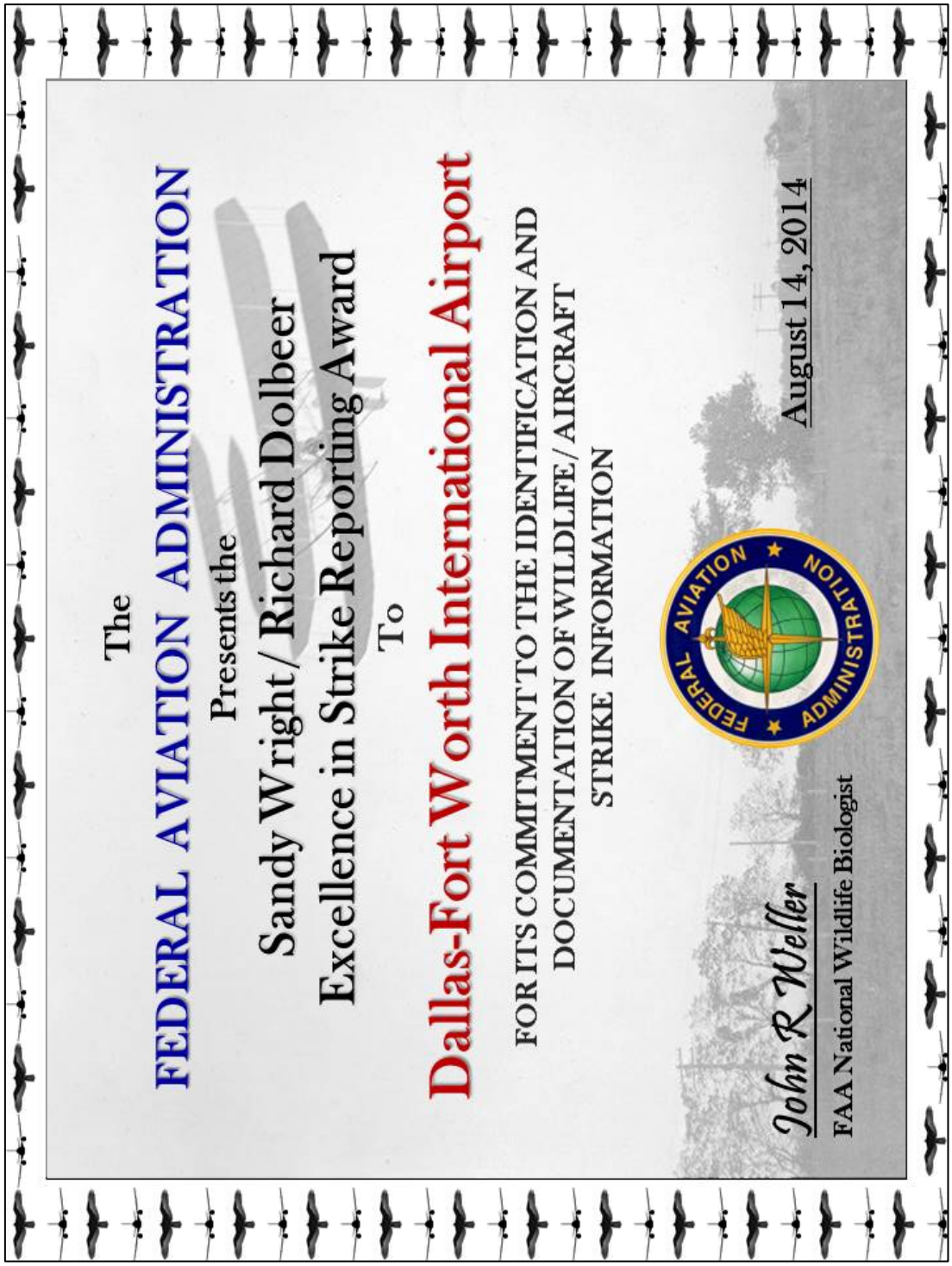
FTA® Micro Card and Sterile Applicators
If you send a lot of fresh blood/ tissue samples for DNA identification, you may want to consider getting Whatman FTA® DNA cards. The material is sampled with a sterile applicator and placed onto the surface of the card that "fixes" the DNA in the sample. For more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

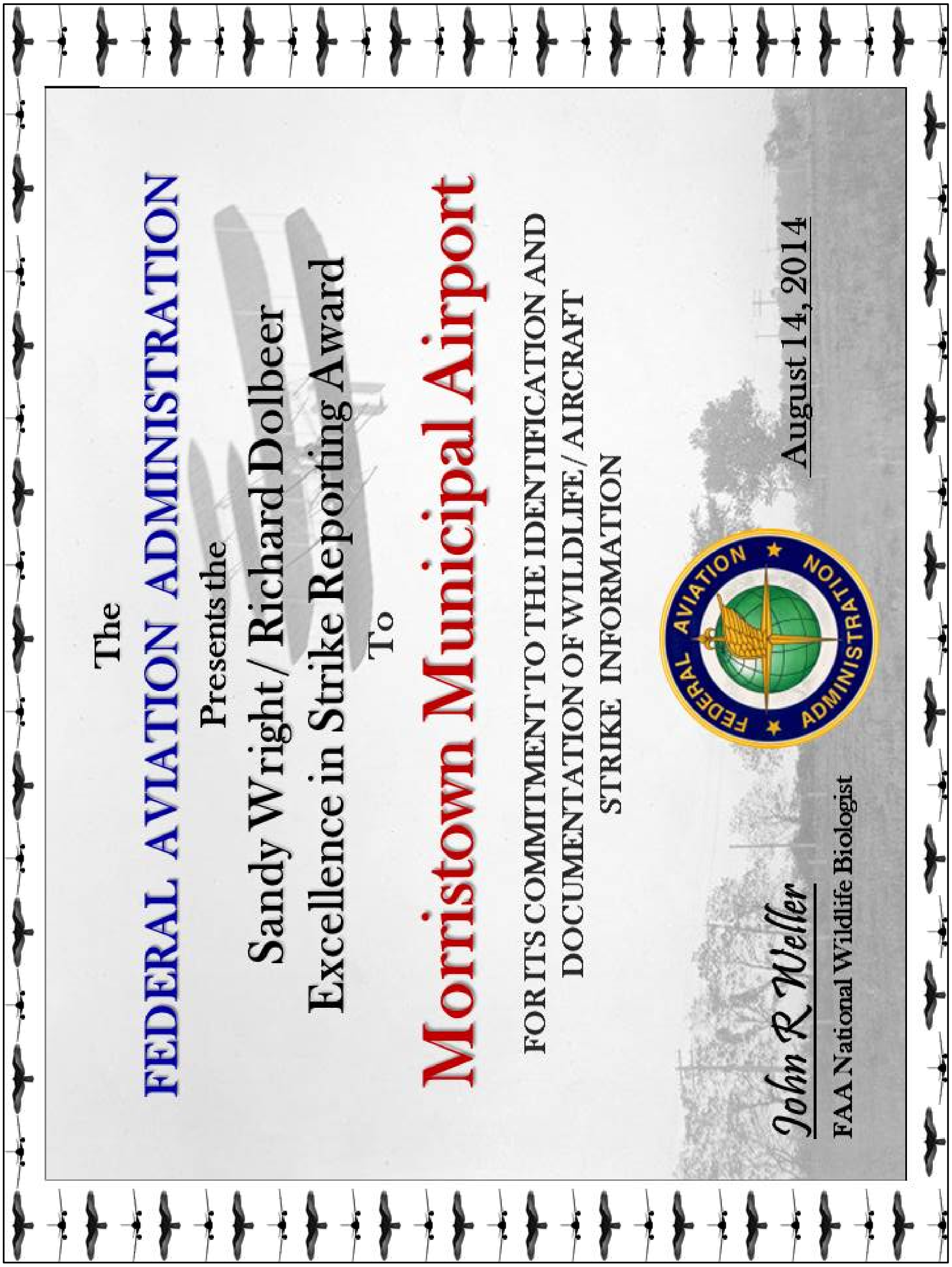
Note: If you only occasionally send blood/ tissue samples, a paper towel with alcohol or alcohol wipe is still a good option for this type of material.

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

APPENDIX C.

"EXCELLENCE IN STRIKE REPORTING" AWARD




The
FEDERAL AVIATION ADMINISTRATION
Presents the
Sandy Wright / Richard Dolbeer
Excellence in Strike Reporting Award
To
Morristown Municipal Airport
FOR ITS COMMITMENT TO THE IDENTIFICATION AND
DOCUMENTATION OF WILDLIFE / AIRCRAFT
STRIKE INFORMATION
FEDERAL AVIATION ADMINISTRATION
John R Weller
FAA National Wildlife Biologist
August 14, 2014