WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES 1990–2011

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

U.S. DEPARTMENT OF AGRICULTURE

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

WILDLIFE SERVICES

FEDERAL AVIATION ADMINISTRATION
NATIONAL WILDLIFE STRIKE DATABASE
SERIAL REPORT NUMBER 18

REPORT OF THE ASSOCIATE ADMINISTRATOR OF AIRPORTS
OFFICE OF AIRPORT SAFETY AND STANDARDS
AIRPORT SAFETY & CERTIFICATION
WASHINGTON, DC

JULY 2012

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The Federal Aviation Administration produced this report in cooperation with the U. S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), Wildlife Services.

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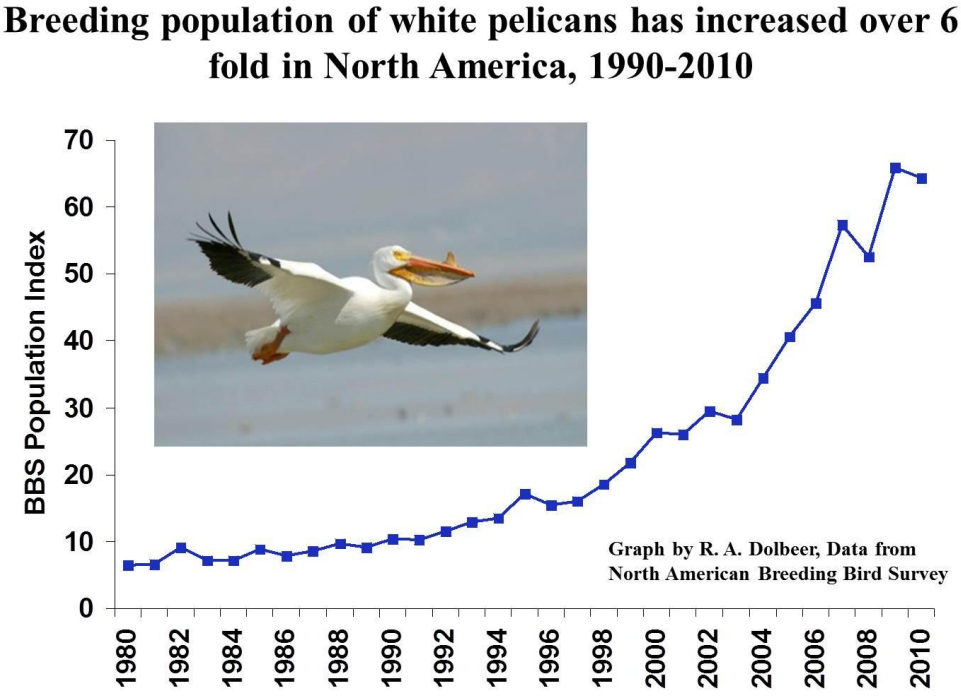
COVER

A CRJ 200 struck a flock of white pelicans at 5,000 feet above ground level during descent at about 20 miles from an airport in Arkansas, 1 April 2011. The radome, radar, electronic equipment, and both engines sustained damage. The #1 engine was shut down and an emergency was declared. The aircraft landed safely.



Anyone with quality photographs of aircraft damage resulting from wildlife strikes or of wildlife-related issues or activities at airports is encouraged to submit them to one of the authors for consideration in future publications.

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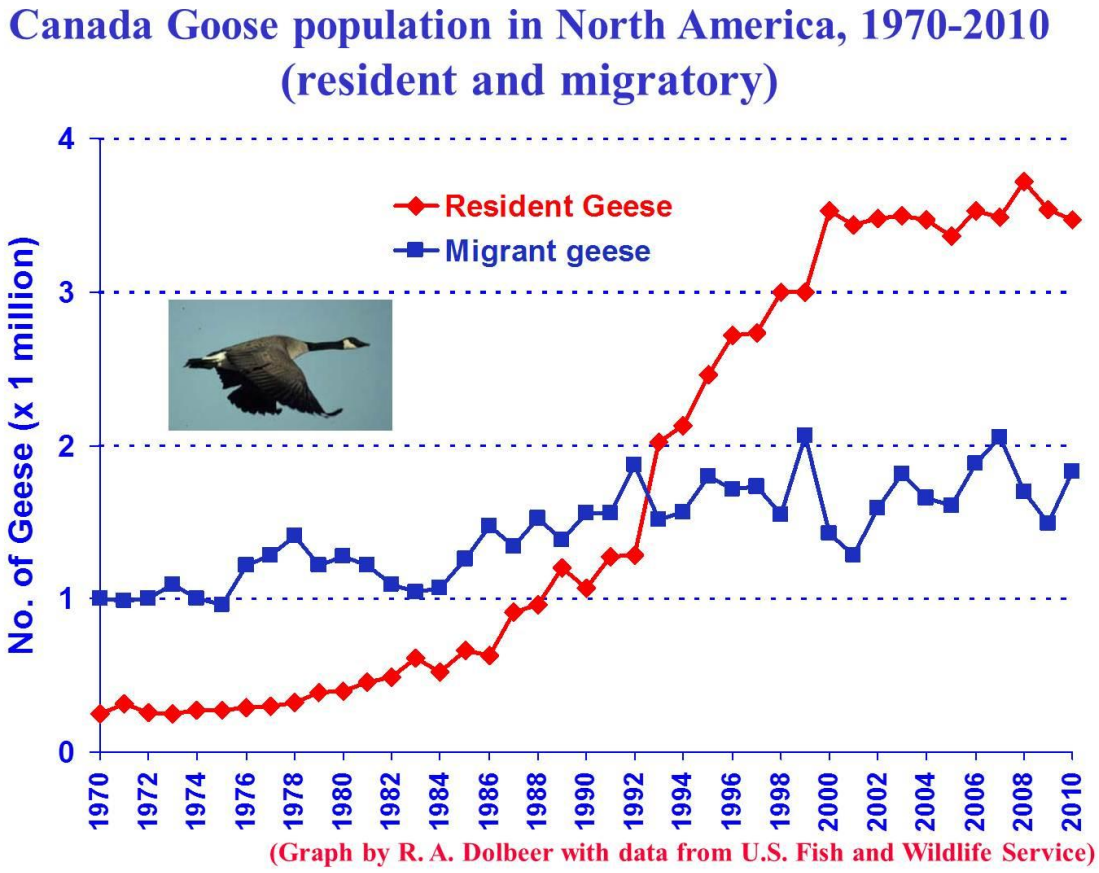
ACKNOWLEDGMENTS

We acknowledge and thank all of the people who took the time and effort to report wildlife strikes – 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, the Airports Research and Development Branch, FAA William J. Hughes Technical Center, Atlantic City, NJ and the Office of the APHIS WS Deputy Administrator, Washington, DC.



The resident (non-migratory) population of Canada geese, which increased dramatically during the 1980s and 1990s, appears to have stabilized at about 3.5 million birds during the last decade. Early-season (September) hunting combined with various management actions in urban areas (e.g., egg oiling, goose removals during the molting season) are the likely reasons for this stabilization (Dolbeer 2011). Reported Canada goose strikes with civil aircraft in USA have declined from a high of 87 in 1998 to 45 in 2011.

EXECUTIVE SUMMARY

In 2011, the FAA and USDA continued to make great progress with its multifaceted approach for mitigating wildlife strikes. We have expanded outreach to increase general aviation strike reporting, continued a robust research program, and incorporated new technology to allow simplified and paperless strike reporting. The FAA also continued to provide Airport Improvement Program (AIP) funding to airports to conduct Wildlife Hazard Assessments (WHAs) and develop Wildlife Hazard Management Plans (WHMPs). These efforts have led to increased strike reporting in both commercial and general aviation. While strike reporting has increased, significant, damaging strikes have remained stable.

The FAA developed a new *Report Wildlife Strikes* awareness poster and distributed 12,000 posters to more than 4,000 Part 139 airports, General Aviation airports, aviation flight schools and the aviation industry in 2011. The distribution of strike awareness posters is one of several outreach activities to improve strike reporting and safety at airports.

In August 2011, Embry Riddle Aeronautical University (ERAU) surveyed wildlife strike reporters to better understand their demographics and improve the strike reporting system based on their feedback. The study was initiated through the interagency agreement between the FAA and USDA and collaborative efforts with ERAU. Subsequent recommendations to improve outreach and the ease and accessibility of strike reporting have been implemented while methods to improve communication, feedback, cooperative efforts between agencies and reporting parties and training are being investigated.

The FAA continues work with industry to encourage all certificated airports to conduct WHAs, even if the certificated airport has not experienced one of the triggering events specified in Part 139. The FAA also encourages federally obligated GA airports to conduct WHAs or Wildlife Hazard Site Visits (WHSV) to provide fundamental wildlife and habitat information for an effective, airport-specific, wildlife hazard mitigation program.

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

- Alternatives to habitat management to reduce attraction to hazardous species
- Techniques for controlling species by restricting access to attractive features like storm water ponds
- Technologies for harassing and deterring hazardous species
- Evaluation of avian radar systems for detecting and tracking birds on or near airports
- Aircraft-mounted alternating, pulse lights to enhance aircraft detection and deter wildlife strikes

The FAA continues 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 wild birds, there is little published information concerning the accuracy and detection capabilities related to range, altitude, target size, and effects of weather for avian radar systems.

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

The FAA funded and assisted with the development of two new Airport Cooperative Research Program (ACRP) reports to aid General Aviation airports with the mitigation of wildlife hazards. Two-thousand seven hundred and seventy 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 in October 2011 to all federally obligated National Plan of Integrated Airport System (NPIAS) General Aviation 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.

In 2010 and continuing through 2011, the FAA, USDA, Airlines for America (i.e., formerly the Air Transport Association) and the Air Line Pilots Association 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. The JIMDAT group is collaborating with FAA AAS and USDA to refine database query methods to increase efficiency and better reporting on the issue to the CAST.

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 “Report Wildlife Strikes” poster 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, 84 percent of the 10,083 strike reports were filed electronically.

Increased media attention to wildlife strikes with aircraft, such as 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, has dramatically demonstrated to the public that wildlife strikes are a serious but manageable aviation safety issue. However, the civil and military aviation communities have long recognized that the threat from aircraft collisions with wildlife is real and increasing. Globally, wildlife strikes have killed more than 231 people and destroyed over 220 aircraft since 1988. Factors that contribute to this increasing threat are increasing populations of large birds and increasing air traffic by quieter, turbofan-powered aircraft.

This report presents a summary analysis of data from the National Wildlife Strike Database for the 22-year period 1990 through 2011. A sample of significant wildlife strikes to civil aircraft in the USA during 2011 is also included as an appendix.

This annual report is based on information from a portion of the available data fields contained in the NWSD. These reports provided summary information on the nature of wildlife strikes in a format that continues to be found useful by the aviation industry. The NWSD is available to the public. Interested parties can query and examine the data independently at the FAA wildlife strike database website (http://faa.gov/go/wildlife). The web site has search fields that 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.

Although wildlife strike reporting is voluntary, and in some cases uneven, it has steadily increased. It continues to provide adequate data to determine national trends and for the development of national policy. Analyses of the database can produce dissimilar comparisons that involve subject matter such as airports and airlines. Disparities that contribute to this variability include the presence/ absence of an airport-based wildlife hazard management program, integration of internal airline and airport strike reporting

with the NWSD, variability in geography and topography of the airport, on-site and off-site habitats and wildlife attractants, aircraft type, number and time of day of aircraft movements, and the proximity of seasonal avian migration routes. Although the largest single-year increase for reported strikes occurred in 2009 and continued to increase in 2011, there continues to be a need for increased reporting from GA airports, various certificated airports, and airlines and more detailed reporting of information (i.e., species identification, damage incurred, estimated costs) about wildlife strikes.

The number of strikes annually reported has increased over 5-fold from 1,804 in 1990 to 10,083 in 2011 (119,917 for 1990-2011). Prior to the emergency forced landing of US Airways Flight 1549 in the Hudson River there was an average of 20 reported wildlife strikes/ day within the five years between 2004 and 2008. This increased to an average of 26 reported strikes per day in 2009; a 25-percent rise from 2008. This trend continued throughout 2011 with 27.6 strikes per day reported. A comparison of strikes specifically reported from known commercial air carrier aircraft and general aviation aircraft operators showed that the former increased 29.2 percent from 2008 to 2011 (4,623 strikes per year to 5,973, respectively) while the latter increased 38.5 percent from 2008 to 2011 (648 strikes per year to 898, respectively). Birds were involved in 97.1 percent of the strikes, terrestrial mammals in 2.3 percent, bats in 0.5 percent and reptiles in 0.1 percent. Although the number of reported strikes has steadily increased, the number of reported damaging strikes has actually declined from 765 in 2000 to 541 in 2011.

The number of USA airports with strikes reported increased from 333 in 1990 to a record 597 in 2011. The 597 airports with strikes reported in 2011 were comprised of 369 airports certificated for passenger service under 14 CFR Part 139 and 228 general aviation airports. From 1990 - 2011, strikes have been reported from 1,714 USA airports.

Fifty-two percent of bird strikes occurred between July and October; 30 percent of deer strikes occurred in October - November. Terrestrial mammals are more likely to be struck at night (63 percent) whereas birds are struck more often during the day (62 percent). Both birds (60 percent) and terrestrial mammals (64 percent) are more likely to be struck during the landing (i.e., descent, approach or landing roll) phase of flight compared to take-off and climb (37 percent and 34 percent, respectively).

For commercial and general aviation (GA) aircraft, 72 and 75 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 33 percent for each 1,000-foot gain in height for commercial aircraft, and by 41 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 2011, 462 species of birds and 38 species of terrestrial mammals 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 bird strikes with reported damage has averaged 10 percent for the 22-year period, this number has declined from 19 percent in 1990 to 5 percent in 2011. For

terrestrial mammals (22-year average of 35 percent), the decline has been from 83 percent in 1990 to 10 percent in 2011.

Also noted from 1990 to 2011, a negative effect-on-flight was reported in 7 percent and 23 percent of the bird and terrestrial mammal strike reports, respectively. Precautionary/emergency landing after striking wildlife was the most commonly reported negative effect (4,353 incidents), including 46 incidents in which the pilot dumped fuel (an average of 13,070 gallons) to lighten aircraft weight and 76 incidents in which an overweight (heavy) landing was made. Aborted takeoff was the second most commonly reported negative effect (1,922 incidents). These negative incidents included 805 aborted takeoffs at ≥80 knots.

Fifty-seven strikes have resulted in a destroyed aircraft; thirty-two (56 percent) of these occurred at a general aviation airport. The hazard level for 108 bird species with 30 or more strikes, based on a composite of the percent of strikes causing damage, major damage, and a negative effect-on-flight, ranged from less than 1 percent for 23 species to 52 percent for snow geese.

This analysis of 22 years of strike data documents the progress being made in reducing damaging strikes. 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 from 2000-2011 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 (Table 19) observed in the aircraft operating area.

The successful mitigation efforts at airports that have reduced damaging strikes in recent years have done little to reduce strikes outside the airport boundaries. 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, Part 139 certificated airports, general aviation facilities, aircraft operators and the aviation industry should continue to provide as much detailed information as possible about wildlife strikes, such as species identification and number of wildlife struck, time and altitude of strike, and damage costs.

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WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES, 1990–2011

A B-737-800 departing Washington National Airport ingested a Canada goose into the #1 engine at 1,200 feet above ground level, 28 February 2011. The engine was shut down and the flight diverted to nearby Washington Dulles International Airport where a safe landing was made. Aircraft was out of service for 110 hours; repair costs were about $800,000. Photo, A. Coe, USDA.

INTRODUCTION

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 (National Transportation Safety Board 2010, Marra et al. 2009) dramatically demonstrated to the public at large that bird strikes are a serious aviation safety issue. However, the civil and military aviation communities have long recognized that the threat to human health and safety from aircraft collisions with wildlife (wildlife strikes) is real and increasing (Dolbeer 2000, MacKinnon et al. 2001). Globally, wildlife strikes have killed more than 231 people and destroyed over 220 aircraft since 1988 (Richardson and West 2000; Thorpe 2003; 2005; 2010, 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 0.5 million to 3.5 million from 1980 to 2000, a level that has stabilized over the past decade (Dolbeer 2011). Other large-bird species that have shown significant population increases from 1980 to 2010 include bald eagles (6.4 percent annual rate of increase), wild turkeys (9.9 percent), turkey vultures (2.6 percent), American white pelicans (7.7 percent), double-crested cormorants (6.1 percent), sandhill cranes (5.9 percent), osprey (3.3 percent), and red-tailed hawks (1.8 percent, Sauer et al. 2011). Thirteen of the 14 bird species in North America with mean body masses greater than 8 pounds (3,6 kilograms) 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 in 2010 (McCabe and McCabe 1997, VerCauteren et al. 2011).

A turkey hen leads her young across a road near an airport in New Hampshire. The hen wears a tag and transmitter to help biologists track movements and devise plans to keep the birds off airports. Photo, D. Bargeron, USDA.

2. Concurrent with population increases of many large bird species, air traffic has increased since 1980. Passenger enplanements in the USA increased from about 310 million in 1980 to 715 million in 2011 (2.7 percent per year), and commercial air traffic increased from about 17.8 million aircraft movements in 1980 to 25.2 million in 2011 (1.1 percent per year, Federal Aviation Administration 2012*a*). Commercial air traffic in the USA is predicted to continue growing at a rate of about 1.2 percent per year to 37 million movements 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 90 percent of the 2,100 USA passenger aircraft had three or four engines. In 2005, the USA passenger fleet had grown to about 8,200 aircraft, and only about 10 percent had three or four engines (U.S. Department of Transportation 2009). With the steady advances in technology over the past several decades, today's two-engine aircraft are more powerful than yesterday's three and four-engine aircraft, and they are more reliable. However, in the event of a multiple ingestion event (e.g., the US Airways Flight 1549 incident on 15 January 2009), aircraft with two engines may have vulnerabilities not shared by their three or four engine-equipped counterparts. In addition, previous research has indicated that birds are less able to detect and avoid modern jet aircraft with quieter turbofan engines (Chapter 3, International Civil

Aviation Organization 1993) than older aircraft with noisier (Chapter 2) engines (Burger 1983, Kelly et al. 1999).

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

The FAA has initiated several programs to address this important safety issue. Among the various programs is the collection and analysis of data from wildlife strikes. The FAA began collecting wildlife strike data in 1965. However, except for cursory examinations of the strike reports to determine general trends, the data were never submitted to rigorous analysis until the 1990s. In 1995, the FAA, through an interagency agreement with the USDA, Wildlife Services, (USDA/WS), initiated a project to obtain more objective estimates of the magnitude and nature of the national wildlife strike problem for civil aviation. This project involves having specialists from the USDA/WS: (1) edit all strike reports (FAA Form 5200-7, *Bird/Other Wildlife Strike Report*) received by the FAA since 1990 to ensure consistent, error-free data; (2) enter all edited strike reports in the FAA National Wildlife Strike Database; (3) supplement FAA-reported strikes with additional, non-duplicated strike reports from other sources; (4) provide the FAA with an updated computer file each month containing all edited strike reports; and (5) assist the FAA with the production of annual and special reports summarizing the results of analyses of the data from the National Wildlife Strike Database. Such analyses are critical to determining the economic cost of wildlife strikes, the magnitude of safety issues, and most important, the nature of the problems (e.g., wildlife species involved, types of damage, height and phase of flight during which strikes occur, and seasonal patterns). The information obtained from these analyses provides the foundation for FAA policies and guidance and for refinements in the development, implementation, and justification of integrated research and management efforts to reduce wildlife strikes.

The first annual report on wildlife strikes to civil aircraft in the USA, covering 1994, was completed in November 1995 (Dolbeer et al. 1995). Since then we have published 16 subsequent annual reports covering the years from 1990 to the present. This is the 18th report in the series and covers the 22-year period, 1990-2011. Current and historic annual reports are accessible as PDF files at:
http://www.faa.gov/airports/airport_safety/wildlife/

This report presents a summary analysis of data from the FAA's National Wildlife Strike Database for the 22-year period 1990 through 2011. Unless noted otherwise, all totals are for the 22-year period, and percentages are of the total known. Because of the large amount of data, some of the tables do not display data for individual years, 1990 through 2011; however, Figures 1-4 and 8-11 display trends in strikes for the 22-year period.

To supplement the statistical summary of data presented in tables and graphs, a sample of significant wildlife strikes to civil aircraft in the USA during 2011 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, 1990-2011, is available at http://www.faa.gov/airports/airport_safety/wildlife/.

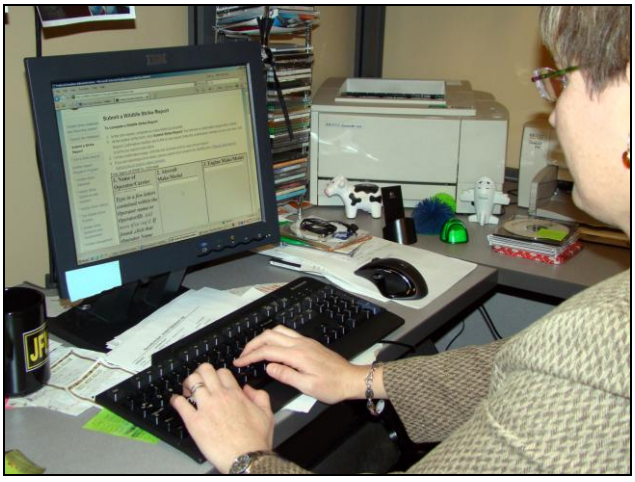
RESULTS

NUMBER OF REPORTED STRIKES

For the 22-year period (1990-2011), 119,917 strikes were reported to the FAA. Birds were involved in 97.1 percent of the reported strikes, terrestrial mammals in 2.3 percent, bats in 0.5 percent and reptiles in 0.1 percent (Table 1).

The number of strikes annually reported has increased 5.6-fold from 1,804 in 1990 to a record 10,083 in 2011 (Table 1, Figure 1). The 25 percent increase in reported strikes from 2008 to 2009-2011 was likely a result of an increased awareness of the wildlife strike issue and cooperation within the aviation industry to report strikes following the Airbus 320 forced-landing in the Hudson River in January 2009 (NTSB 2010). Prior to the emergency forced landing of US Airways Flight 1549 in the Hudson River there was an average of 20 reported wildlife strikes/ day within the five years between 2004 and 2008 that subsequently increased to an average of 26 reported strikes per day in 2009. This trend continued throughout 2011 with 27.6 strikes per day reported. A comparison of strikes specifically reported from known commercial air carrier aircraft (Table 2) and general aviation aircraft operators (Table 3) omitting "unknown operators" and "carcass found" strikes showed that the former increased 29.2 percent from 2008 to 2011 (4,623 strikes per year to 5,973, respectively) while the latter increased 38.5 percent from 2008 to 2011 (648 strikes per year to 898, respectively).

Although the number of reported strikes has steadily increased, it is important to note that the number of reported damaging strikes has actually declined in recent years. The number of reported strikes with damage to aircraft increased from 372 in 1990 to a peak of 765 in 2000. This number has subsequently declined by 29 percent to 541 in 2011 (Table 1, Figure 2). For commercial aircraft, the rate of damaging strikes (number per 100,000 aircraft movements) has also declined (from 1.74 to 1.36) since 2000 (Table 2, Figure 3). The rate of damaging strikes with General Aviation (GA) aircraft has remained relatively stable since 1994, ranging from 0.22-0.30 (Table 3, Figure 3). These declines in damaging strikes for commercial aviation have occurred in spite of an increase in populations of hazardous wildlife species (Dolbeer 2000, Dolbeer and Eschenfelder 2003) and demonstrate the success of wildlife



Electronic (on-line) reporting of wildlife strikes has increased from less than 1 percent in 2001 to 84 percent in 2011. Photo, L. Francoeur, PANYNJ

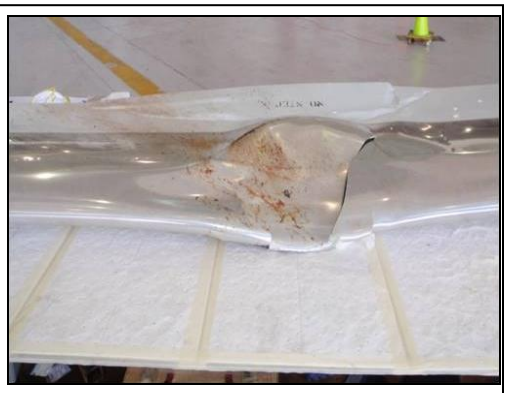
hazard management programs at airports certificated for passenger traffic under 14 CFR-Part 139 regulations (Dolbeer 2011).

METHODS OF REPORTING STRIKES

In 2011, 84 percent and 6 percent of the 10,083 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 remaining 10 percent of strike reports filed in 2011 were obtained from various sources (Table 4).

SOURCE OF REPORTS

In 2011, airport operations personnel filed 60 percent of the strike reports, followed by pilots (21 percent), airlines operations personnel (13 percent), Air Traffic Control personnel (5 percent), and other (1 percent, Table 5). In 2011, about 87 percent of the reported strikes involved commercial aircraft; the remainder involved business, private, and government aircraft (Table 6).



A B-757 departing Toncontin International Airport, Honduras struck a black vulture at 2,000 feet, 6 May 2011. The aircraft continued to Miami where a dent in the wing was noted. The aircraft was taken out of service for repairs. Wildlife strikes involving U.S. air carriers were reported from 259 foreign airports, 1990-2011. Photo, F. Bostick.

The number of USA airports with strikes reported has increased steadily from 333 in 1990 to a record 597 in 2011 (Table 7, Figure 4). The 597 airports with strikes reported in 2011 were comprised of 369 airports certificated for passenger service under 14 CFR Part 139 and 228 General Aviation airports. From 1990 - 2011, strikes have been reported from 1,714 USA airports. In addition, strikes involving USA-registered aircraft were reported from 259 foreign airports in 1990 - 2011.

TIMING OF OCCURRENCE AND PHASE OF FLIGHT OF STRIKES

From 1990 – 2011, most bird strikes (52 percent) occurred between July and October (Figure 5); 62 percent occurred during the day (Table 8); 60 percent occurred during the landing (descent, approach, or landing roll) phase of flight; and 37 percent occurred during takeoff run and climb (Table 9).

From 1990 – 2011, most terrestrial mammal strikes occurred between July and November; with 30 percent of deer strikes concentrated in October-November (Figure 5). Most terrestrial mammal strikes (63 percent) occurred at night (Table 8), 64 percent occurred during the final approach or landing roll, and 34 percent occurred during the takeoff run or initial climb (Table 9).

HEIGHT ABOVE GROUND LEVEL (AGL) OF STRIKES

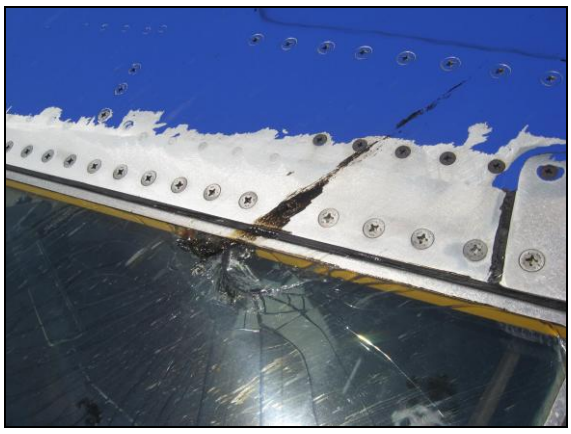
Bird strikes with commercial aircraft- From 1990 – 2011, about 41 percent of the bird strikes with commercial aircraft occurred when the aircraft was at 0 feet AGL, 72 percent occurred at 500 feet or less AGL, and 92 percent occurred at or below 3,500 feet AGL (Table 10). Less than 1 percent of bird strikes occurred above 9,500 feet AGL. Above 500 feet AGL, the number of reported strikes declined consistently by 33 percent for each 1,000-foot gain in height (Figure 6). 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 28 percent of the reported strikes were above 500 feet AGL, these strikes represented 42 percent of the damaging strikes (Figure 7).

Bird strikes with general aviation (GA) aircraft- From 1990 – 2011, about 38 percent of the bird strikes with GA aircraft occurred when the aircraft was at 0 feet AGL, 75 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 7,500 feet AGL. Above 500 feet AGL, the number of reported strikes declined consistently by 41 percent for each 1,000-foot gain in height (Figure 6). The record height for a reported bird strike involving a GA aircraft in USA is 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 for commercial aircraft above. Although only 25 percent of the reported strikes were above 500 feet AGL, these strikes represented 48 percent of the damaging strikes (Figure 7).

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).



A B-737 hit an unknown species of bird at 300 feet on climb from an airport in Arkansas, causing damage to the windshield, 5 Oct 2011. Radomes/noses and windshields are the 2 aircraft components most commonly struck by birds. Photo. B. Guillot.

AIRCRAFT COMPONENTS DAMAGED

The aircraft components most commonly reported as struck by birds from 1990 – 2011 were the nose/radome, windshield, engine, wing/rotor, and fuselage (Table 12). Aircraft engines were the component most frequently reported as being damaged by bird strikes (30 percent of all

damaged components). There were 13,509 strike events in which a total of 14,167 engines were reported as struck (12,875 events with one engine struck, 616 with two engines struck, 12 with three engines struck, and 6 with four engines struck). In 3,935 damaging bird-strike events involving engines, a total of 4,066 engines was damaged (3,807 events with one engine damaged, 126 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, propeller, and wing/rotor. These same components ranked highest for the parts most often reported as damaged by mammals (Table 12).

REPORTED DAMAGE

For the 116,408 strike reports involving birds from 1990-2011, 11,315 (10 percent) indicated damage to the aircraft (Table 13). When classified by level of damage, 6,071 (7 percent) indicated the aircraft suffered minor damage; 2,847 (3 percent) indicated the aircraft suffered substantial damage; 2,365 (3 percent) reported an uncertain level of damage; and 32 reports (less than 1 percent) indicated the aircraft was destroyed as a result of the strike (Table 13).

A Cessna 560 on final approach to an airport in Texas hit a large raptor at 2,400 feet on 27 July 2011, causing damage to nose and fuselage. Photo, M. Gardner.

For the 2,754 terrestrial mammal strikes reported, 966 (35 percent) indicated damage to the aircraft. When classified by level of damage; 502 (18 percent) indicated the aircraft suffered minor damage; 374 (14 percent) indicated the aircraft suffered substantial damage; 65 (2 percent) reported an uncertain level of damage; and 25 (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 (35 percent) resulted in aircraft damage than did bird strikes (10 percent). Deer (1,014 strikes, of which 853 caused

damage; Table 17) were involved in 37 percent of the strikes and 88 percent of the damaging strikes involving terrestrial mammals.

Although the percentage of bird strikes with reported damage has averaged 10 percent for the 22-year period, this number has declined from 19 percent in 1990 to 5 percent in 2011 (Figure 8). For terrestrial mammals (22-year average of 35 percent), the decline has been from 83 percent in 1990 to 10 percent in 2011.

REPORTED NEGATIVE EFFECT-ON-FLIGHT

A negative effect-on-flight was reported in 7 percent and 23 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 (4,353 incidents, 4 percent of strike reports). These precautionary landings included 163 incidents in which the pilot dumped fuel (46) or burned fuel in a circling pattern (41) to lighten aircraft weight or in which a heavy landing was made (76, Table 15, Figure 9). In the 46 reported incidents in which fuel was dumped, an average of 88,878 pounds (13,070 gallons) of fuel was dumped per incident (range 515 – 39,706 gallons).

Diamondback terrapins can disrupt air traffic operations when they move from wetlands onto runways looking for sites to lay eggs. These terrapins were collected from runways at JFK International Airport in June 2011 and released off airport after tagging. Research is underway to document movement patterns and to develop methods to exclude these reptiles from runways. Photo, L. Francoeur, PANYNJ.

Aborted takeoff after striking wildlife was the second most commonly reported negative effect (1,922 incidents, 2 percent of strike reports, Table 14). These negative incidents included 805 aborted takeoffs in which the pilot initiated the abort at an aircraft speed of 80 knots (92 miles per hour) or greater (Table 16, Figure 10). In 140 incidents, the aircraft speed at the time of abort was 120 knots (138 miles per hour) or greater.

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 - 2011. 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 Table 19).

Of the 116,408 reported bird strikes, 39,103 (34 percent) identified the bird to exact species and an additional 16,288 strikes (14 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 53 percent in 2011 (Figure 11). In all, 462 species of birds have been identified as struck by aircraft, and 208 of these species were reported as causing damage, 1990-2011.

Gulls (16 percent), doves/pigeons (15 percent), raptors (13 percent), and waterfowl (7 percent) were the most frequently struck bird groups (Table 18). Gulls were involved in 2.4 times more strikes than waterfowl (8,881 and 3,877, respectively). Waterfowl, however, were involved in 1.3 times more damaging strikes (1,679 or 30 percent of all damaging strikes in which the bird type was identified) than were gulls (1,282 or 23 percent of all damaging strikes in which the bird type was identified). Gulls and pigeons/doves were responsible for the greatest number of bird strikes (1,976 and 1,872, respectively) that involved multiple birds.

The most frequently struck terrestrial mammals were Artiodactyls – primarily deer (39 percent) – and Carnivores – primarily coyotes (34 percent) (Tables 17, 18). Artiodactyls were responsible for 93 percent of the mammal strikes that resulted in damage and 78 percent of the mammal strikes that involved multiple animals. In all, 38, 14 and 9 identified species of terrestrial mammals, bats, and reptiles, respectively, were reported struck; 21, 2 and 1 identified species of these respective wildlife taxa caused damage to aircraft (Table 17).

HAZARD LEVEL OF WILDLIFE SPECIES

Table 19 ranks the hazard level of 108 species of birds and 12 species of terrestrial mammals with 30 or more reported strikes (from Table 17). The ranking is based on a composite of the percent of strikes causing damage, major damage, and a negative effect-on-flight. For birds, the hazard rating ranged from 52 percent for snow geese to <1 percent for 23 species. This ranking provides a means to objectively estimate the relative hazard level of species to aircraft operations and can be useful in prioritizing management actions at airports to mitigate risk from wildlife (Dolbeer and Wright 2009).

Turkey vultures, because of their large size and soaring behavior, are one of the most hazardous bird species for aircraft. Carcasses of wildlife struck by aircraft or vehicles at airports should be removed immediately to eliminate feeding attractions for vultures. Photo, T. DeVault, USDA.

HUMAN FATALITIES AND INJURIES DUE TO WILDLIFE STRIKES

For the 22-year period, reports were received of 10 wildlife strikes that resulted in 24 human fatalities (Table 20). Five of these strikes resulting in 7 fatalities involved unidentified species of birds. Red-tailed hawks (8 fatalities), American white pelicans (5), Canada geese (2), white-tailed deer (1), and brown-pelicans (1) were responsible for the other 17 fatalities. Reports were received of 199 strikes that resulted in 256 human injuries (Table 20). Waterfowl (ducks and geese; 49 strikes, 56 humans injured), vultures (29 strikes, 32 injuries), and deer (19 strikes, 27 injuries) caused 97 (60 percent) of the 161 strikes resulting in injuries in which the species or species group was identified.

AIRCRAFT DESTROYED DUE TO WILDLIFE STRIKES

For the 22-year period, reports were received of 57 aircraft destroyed or damaged beyond repair due to wildlife strikes (Tables 13, 21). The majority (36; 63 percent) were small (≤2,250 kg maximum takeoff mass) general aviation (GA) aircraft. Terrestrial mammals (primarily white-tailed deer) were responsible for 25 (44 percent) of the incidents. Canada geese (5 incidents) and vultures (3 incidents) were responsible for 42 percent of the 19 incidents involving birds in which the species or species group was identified.

The installation of snow fencing as a visual barrier from October 2011 - March 2012 in a grassy open space at JFK International Airport completely eliminated grazing and loafing by geese and gulls. This is an excellent example of a creative approach to managing wildlife risks as part of an integrated management program. Photo, L. Francoeur, PANYNJ.

Thirty-two (56 percent) of the 57 wildlife strikes resulting in a destroyed aircraft occurred at general aviation (GA) airports, 15 occurred away from an airport, 8 occurred at USA airports certificated for passenger service under 14 CFR Part 139, and 2 occurred at a foreign airport certificated for passenger service (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).

ECONOMIC LOSSES DUE TO WILDLIFE STRIKES

Of the 18,913 reports from 1990 – 2012 that indicated the strike had an adverse effect on the aircraft and/or flight, 6,015 provided an estimate of the aircraft downtime (760,896 hours, mean = 126.5 hours/incident, Tables 17, 22). Regarding monetary losses, 3,194 reports provided an estimate of direct aircraft repair costs ($431.5 million, mean = $135,092/incident), and 1,722 reports gave an estimate of other monetary losses ($49.4 million, mean = $28,662/incident). Other monetary losses include such expenses as lost revenue, the cost of putting passengers in hotels, re-scheduling aircraft, and flight cancellations.

Analysis of 14 groups of strike reports from 3 Part 139 airports certificated for passenger service and 3 airlines for the years 1991-2004 indicated that 11-21 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). Analyses of strike data from 2004-2008 indicated strike reporting at Part 139 airports had improved to 39 percent (Dolbeer 2009). Strike reporting for general aviation (GA) aircraft is estimated at less than 5 percent (Dolbeer et al. 2008, Dolbeer 2009). In addition to the underreporting of strikes, only 32 percent of the 18,913 reports from 1990-2011 indicating an adverse effect provided estimates of aircraft downtime, 17 percent provided estimates of direct costs, and 9 percent provided estimates of other (indirect) costs (Tables 22, 23). Furthermore, many 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 underestimate the magnitude of the problem.

Assuming (1) all 18,913 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, 117,234 hours of aircraft downtime and $144 million in monetary losses ($115 million in direct costs and $29 million in other costs), 1990-2011, (Table 23).

Further, if we assume that the 18,913 reported strikes indicating an adverse effect represent, on average, 20 percent of the total strikes that occurred with commercial and GA aircraft from 1990-2011, the annual cost of wildlife strikes to the USA civil aviation industry is estimated to be 586,170 hours of aircraft downtime and $718 million in direct and other monetary losses (Table 23).

CONCLUSIONS

This analysis of 22 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 a significant economic and safety risk for civil aviation in the USA, management actions to mitigate the risk have been implemented at many airports in the past decade (e.g., Wenning et al. 2004, DeFusco et al. 2005, Dolbeer 2006*a*, Human Wildlife Conflicts Journal 2009, Human-Wildlife Interactions Journal 2011, Dolbeer 2011). These efforts are likely responsible for the general decline in reported strikes with damage from 2000-2011 (Table 1, Figures 2, 3, 8 and Dolbeer 2011) in spite of continued increases in populations of many large bird species. For example, USDA Wildlife Services biologists provided assistance at 785 airports nationwide in 2011 to mitigate wildlife risks to aviation compared to only 42 airports in 1991 and 193 in 1998 (Begier and Dolbeer 2012). However, much work remains to be done to reduce wildlife strikes.

To address the problem, 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 19) 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). Dolbeer (2011) conducted a trend analysis of bird strike data involving commercial air carriers that indicated the percentage of all strikes that occurred at more than 500 feet increased significantly from about 25 percent in 1990 to 30 percent in 2009. The percentage of all damaging strikes that occurred at more than 500 feet increased at a greater rate, from

A remotely-controlled aircraft approaches a group of captive Canada geese in an experiment in Ohio in 2010 to determine if aircraft lighting systems can be modified to enhance bird detection and avoidance of aircraft (Blackwell et al. 2012). Photo, G. Keirn, USDA.

about 37 percent in the early 1990s to 45 percent in 2005 to 2009. Dolbeer (2011) also examined trends in strike rates (strikes/1 million commercial aircraft movements) for strikes occurring at less than or equal to and more than 500 feet. From 1990 to 2009, the damaging strike rate at more than 500 feet increased from about 2.5 to 4.0, whereas the damaging strike rate for strikes at 500 or less feet has remained stable since 2000. The successful mitigation efforts at airports that have reduced damaging strikes 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).

Converting airport grasslands to biofuel, solar or wind production may not only provide alternative energy sources, but also increase revenue for airports and reduce the local abundance of wildlife hazardous to aircraft. USDA research is exploring this promising concept. Photo, D. Bergman, USDA.

To address this trend in 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. 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 altitude of strike, and damage costs.

Dolbeer (2009) concluded that strike reporting at Part 139 airports has increased from about 20 percent in the 1990s to 39 percent in 2004 to 2008. The percentage of bird strikes in which the bird was identified to species has improved from less than 20 percent in the early 1990s to over 53 percent in 2011. Overall, only 17 percent of strike reports indicating an adverse effect on the aircraft or flight provided at least a partial estimate of economic losses resulting from the strike, 1990-2011.

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 2011 was 1,580 with 1,683 separate identifications of species. This compares to 983 cases with 1,064 separate identifications of species in 2009 (Dove et al. 2012; unpublished data). In addition, the Lab processed 4,361 identifications for the U.S. Air Force and 525 identifications for the Navy (not discussed in this report). DNA analysis was used in 959 (57 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 very useful supplemental documentation.

Guidelines for Collecting Bird Strike Material

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

Feathers:

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

Tissue/blood ("Snarge"):

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

FTA® Micro Card and Sterile Applicators

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

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

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

FAA Activities for Mitigating Wildlife Strikes

In 2011, the FAA continued a multifaceted approach for mitigating wildlife strikes. This included continuing a robust research program, making improvements to the 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 (WHAs) and develop Wildlife Hazard Management Plans (WHMPs).

Strike Reporting

As there is still room for improvement, the FAA retooled the existing wildlife strike database website (http://wildlife.faa.gov) to make it more user-friendly and to allow more advanced data mining. The new site (http://faa.gov/go/wildlife) has search fields that 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.

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. The wireless link created in 2010 for reporting strikes (http://www.faa.gov/wireless) has also been updated to http://www.faa.gov/mobile to adhere to FAA new guidelines. When airline and airport employees report a wildlife strike, the information is automatically sent to the FAA's wildlife strike database.

The FAA distributed 12,000 new Report Wildlife Strike posters to more than 4,000 Part 139 and General Aviation airports and the aviation industry.

The FAA developed a new *Report Wildlife Strikes* awareness poster and distributed 12,000 to more than 4,000 Part 139 airports, General Aviation airports, aviation flight schools and the aviation industry in October 2011. The renewal of strike awareness posters is one of several outreach efforts to improve strike reporting and safety at certificated and General Aviation 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 2011 - 2012 "Report Wildlife Strikes" poster 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.

In August 2011, Embry Riddle Aeronautical University (ERAU) conducted a survey to collect information from wildlife strike reporters. The study was initiated through the

interagency agreement between the FAA and USDA and collaborative efforts with ERAU. The goals of the survey were to learn more about the demographics of strike submitters, determine how people learned about strike reporting, and collect feedback on the strike submission form and on ways to enhance the system. Subsequent recommendations to improve outreach and the ease and accessibility of strike reporting have been implemented while methods to improve communication, feedback, cooperative efforts between agencies and reporting parties and training are being investigated. Specific recommendations included:

1. Cooperation with Other Organizations – Avoid duplication of reporting.
2. Communication and Feedback – Improve communication throughout aviation industry and provide regular feedback to strike reporters.
3. Wildlife Strike Reporting Form Changes
4. Multiple Versions of Strike Forms – Provide specific strike form relevant to individual reporting strike.
5. Website Changes - Dynamic online form, prepopulated fields and increased availability of website linked to aviation industry websites.
6. Training and Education – More information regarding what and how to collect strike remains and report the strike.
7. Funding - Prepaid kits addressed to the Smithsonian.
8. Miscellaneous - Add iPhone / iPad application and / or toll free number to report strikes.

Wildlife Hazard Mitigation Research

For the last 16 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:

The FAA provides up-to-date technical guidance concerning best management practices for wildlife hazards and effective mitigation techniques of zero-tolerance species like the Sandhill cranes pictured above. Photo courtesy J. Weller.

- Alternatives to habitat management to reduce attraction to hazardous species
- Techniques for controlling species by restricting access to attractive features like storm water ponds
- Technologies for harassing and deterring hazardous species

- Evaluation of avian radar systems for detecting and tracking birds on or near airports
- Aircraft-mounted alternating, pulse lights to enhance aircraft detection and deter wildlife strikes

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 wild 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. NWRC researchers are leading the effort involving experts from the National Center for Atmospheric Research and several universities. Efforts 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.

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 will begin the end of 2011

that will examine the feasibility and practicality of pilots and air traffic controllers using bird radar data.

Wildlife Hazard Assessments and Wildlife Hazard Management Plans

The FAA is encouraging all certificated airports to conduct WHAs and develop WHMPs regardless if they have experienced a triggering event under part 139. 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)

A WHA provides fundamental wildlife and habitat information for an effective, airport-specific WHMP. The WHMP 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, WHMPs 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 wildlife hazard assessments and wildlife hazard management plans by providing financial assistance from the AIP.

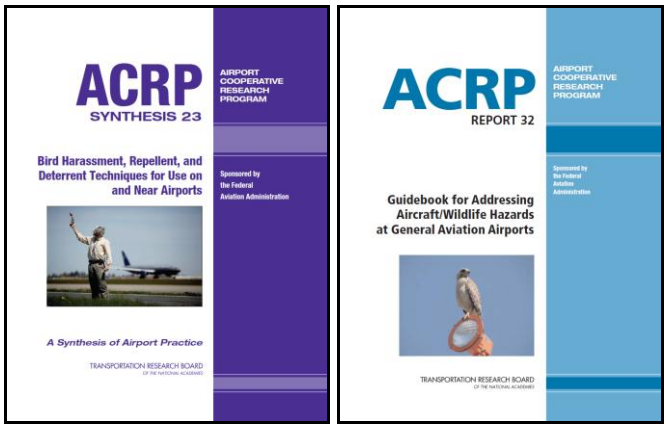
WHMPs detail mitigation priorities for an airports hazardous species such as the relocation of gopher tortoises at a southeastern airport. The tortoises have burrowed under perimeter fences and throughout the Runway Safety Area (RSA). Photo courtesy G. Speake.

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 and clarification of grant assurances to clarify the responsibility of federally obligated National Plan of Integrated Airport System/General Aviation (NPIAS/GA) airports, to conduct WHAs. The FAA continues to encourage federally obligated GA airports to conduct WHAs and Wildlife Hazard Site Visits (WHSV) and has established a program and schedule that outlines the implementation of the new processes. It will take several years to complete WHAs and WHSVs at the more than 2,700 GA airports. To assist the airports in conducting the WHAs, we will make AIP grant funds available to them.



The FAA distributed 2,770 copies each of ACRP Synthesis 23 *Bird Harassment, Repellent, and Deterrent Techniques for Use on and Near Airports* report and ACRP Report 32 *Guidebook for Addressing Aircraft/ Wildlife Hazards at General Aviation Airports* to General Aviation airports.

Mitigating Strikes at GA Airports

The FAA funded and assisted with the development of two new Airport Cooperative Research Program (ACRP) reports to aid General Aviation airports with the mitigation of wildlife hazards. Two-thousand seven hundred and seventy 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 in October 2011 to all federally obligated National Plan of Integrated Airport System (NPIAS) General Aviation 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.

Bird Strike Committee USA

The FAA cosponsors 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 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. The JIMDAT group is collaborating with FAA AAS and USDA to refine database query methods to increase efficiency and better reporting on the issue to the CAST.

Performance Metrics

Starting in FY 2013 the FAA will adopt the following performance metrics that will measure program effectiveness under a voluntary strike reporting environment where the absolute number of bird strikes is not known.

Metric 1. Monitor the ratio between the number 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.

Metric 2. Monitor strike reporting of GA airports to determine percent of airports reporting strikes. This metric will aid the evaluation of the FAA outreach program's effectiveness to increase overall strike reporting at GA airports.

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TABLES

Table 1. Number of reported wildlife strikes to civil aircraft by wildlife group, USA, 1990–2011 (see Figures 1 and 2).

Year	Birds	Bats	Terrestrial mammals[1]	Reptiles[1]	Total strikes	Strikes with damage
1990	1,748	4	52	0	1,804	372
1991	2,266	3	54	0	2,323	401
1992	2,360	2	73	1	2,436	368
1993	2,409	6	67	0	2,482	399
1994	2,472	2	82	1	2,557	464
1995	2,679	5	84	8	2,776	500
1996	2,856	1	91	3	2,951	505
1997	3,353	1	95	14	3,463	582
1998	3,691	3	111	7	3,812	588
1999	5,022	7	96	1	5,126	706
2000	5,870	16	124	3	6,013	765
2001	5,676	8	140	8	5,832	650
2002	6,104	19	119	15	6,257	675
2003	5,886	20	127	5	6,038	635
2004	6,411	27	129	6	6,573	628
2005	7,092	27	132	7	7,258	609
2006	7,053	49	142	10	7,254	599
2007	7,538	53	175	7	7,773	571
2008	7,417	46	183	5	7,651	528
2009	9,229	67	232	10	9,538	607
2010	9,546	113	247	11	9,917	598
2011	9,730	139	199	15	10,083	541
Total	**116,408**	**618**	**2,754**	**137**	**119,917**	**12,291**

[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, 1990–2011 (see Figure 3).

	No. of reported strikes[1]			Strikes/100,000 movements	
Year	All strikes	Strikes with damage	Aircraft movements (x 1 million)[2]	All strikes	Strikes with damage
1990	1,347	215	23.26	5.79	0.92
1991	1,791	251	24.78	7.23	1.01
1992	1,815	212	25.17	7.21	0.84
1993	1,784	229	25.56	6.98	0.90
1994	1,907	283	26.58	7.17	1.06
1995	2,023	321	27.04	7.48	1.19
1996	2,092	313	27.57	7.59	1.14
1997	2,460	363	27.76	8.86	1.31
1998	2,514	361	28.00	8.98	1.29
1999	3,858	476	28.74	13.42	1.66
2000	4,481	514	29.53	15.17	1.74
2001	4,178	447	29.15	14.33	1.53
2002	4,445	469	27.61	16.10	1.70
2003	4,303	420	27.89	15.43	1.51
2004	4,698	407	28.87	16.27	1.41
2005	5,184	419	29.24	17.73	1.43
2006	4,927	407	28.30	17.41	1.44
2007	5,027	358	28.46	17.66	1.26
2008	4,623	336	27.97	16.53	1.20
2009	6,155	391	25.47	24.16	1.53
2010	6,051	381	25.12	24.09	1.52
2011	5,973	342	25.19	23.65	1.36
Total	**81,636**	**7,915**	**597.26**	**13.67**	**1.33**

[1] Strikes involving an unknown operator (24,796 of which 22,968 were “Carcass Found” reports--see Tables 5 and 6) were excluded from this analysis.

[2] Departures and arrivals by air carrier, commuter, and air taxi service (Federal Aviation Administration 2012*a*).

Table 3. Number and rate of reported wildlife strikes and strikes with damage for general aviation aircraft, USA, 1990–2011 (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	324	130	77.55	0.42	0.17
1991	401	128	83.54	0.48	0.15
1992	432	144	82.34	0.52	0.17
1993	445	158	80.41	0.55	0.20
1994	477	175	79.20	0.60	0.22
1995	482	169	77.22	0.62	0.22
1996	509	181	79.02	0.64	0.23
1997	507	190	80.00	0.63	0.24
1998	579	207	84.33	0.69	0.25
1999	618	212	85.43	0.72	0.25
2000	674	244	87.17	0.77	0.28
2001	685	194	85.99	0.80	0.23
2002	768	204	85.85	0.89	0.24
2003	681	209	83.52	0.82	0.25
2004	700	217	82.76	0.85	0.26
2005	658	189	81.22	0.81	0.23
2006	677	192	80.24	0.84	0.24
2007	657	210	80.31	0.82	0.26
2008	648	190	78.13	0.83	0.24
2009	846	215	73.81	1.15	0.29
2010	819	214	71.46	1.15	0.30
2011	898	199	70.84	1.26	0.28
Total	**13,485**	**4,171**	**1,770.34**	**0.76**	**0.24**

[1] Strikes involving an unknown operator (24,796 of which 22,968 were “Carcass Found” reports--see Tables 5 and 6) were excluded from this analysis.

[2] Itinerant and local departures and arrivals by general aviation aircraft (Federal Aviation Administration 2012*a*).

Table 4. Source of information for reported wildlife strikes to civil aircraft, USA, 1990–2011, and 2011 only.

	1990-2011		2011 only	
Source	Total	% of total	Total	% of total
FAA Form 5200-7E[1] (Electronic)	44,073	37	8,441	84
FAA Form 5200-7[1] (Paper)	41,105	34	557	6
Airline report	14,194	12	306	3
Multiple[2]	9,793	8	378	4
Airport report	5,398	5	264	3
Other[3]	1,709	1	115	1
Preliminary Aircraft Incident Report	886	1	1	<1
Daily Report (FAA)	879	1	19	<1
Engine manufacturer	822	1	0	0
Aircraft Incident Report	712	1	1	<1
Aviation Safety Reporting System	198	<1	0	0
National Transportation Safety Board	81	<1	0	0
Aircraft Incident Preliminary Notice	67	<1	1	0
Total	119,917	100	10,083	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 20, 28, 32, 38, 46, 62, 67, 71, 78, and 84 percent in 2002-2011, respectively. The paper version of FAA Form 5200-7 (mailed to FAA headquarters) declined from 57 percent of all reports in 2001 to 6 percent in 2011.

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

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

Table 5. Person filing report of wildlife strike to civil aircraft, USA, 1990–2011, and 2011 only.

	1990-2011		2011 only	
Person filing report	Total	% of total	Total	% of total
Airline Operations	25,357	25	1,246	13
Pilot	23,358	23	1,901	21
Airport Operations (carcass found)[1]	22,968	23	3,123	34
Airport Operations (strike reported)	15,039	15	2,422	26
Tower	10,787	11	476	5
Other	2,665	3	115	1
Total known	**100,174**	**100**	**9,283**	**100**
Unknown	**19,743**		**800**	
Total	**119,917**		**10,083**	

[1] Airport personnel found wildlife remains within 200 feet of a runway centerline that appeared to have been struck by aircraft, but no strike was observed or reported by pilot, tower, or airline.

Table 6. Number of reported wildlife strikes to civil aircraft by type of operator, USA, 1990–2011, and 2011 only.

	1990-2011		2011 only	
Type of operator	Total	% of total	Total	% of total
Commercial[1]	**81,636**	**86**	**5,973**	**87**
General aviation	**13,485**	**14**	**898**	**13**
Business	10,634	11	739	11
Private	2,204	2	80	1
Government/ Police[2]	647	1	79	1
Total known	**95,121**	**100**	**6,871**	**100**
Unknown[3]	**24,796**		**3,212**	
Total	**119,917**		**10,083**	

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

[2] U.S. Coast Guard aircraft were involved in 36 percent (230) of the 647 Government/police strikes.

[3] Ninety three percent (22,968) of the 24,796 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, civil aircraft, 1990–2011 (see also Figure 4)[2].

	Part 139 airports		GA airports		All USA airports	
Year	Airports	Strikes	Airports	Strikes	Airports	Strikes
1990	241	1,469	92	157	333	1,626
1991	263	1,945	92	171	355	2,116
1992	259	2,076	104	206	363	2,282
1993	262	2,157	94	188	356	2,345
1994	271	2,195	103	202	374	2,397
1995	264	2,344	116	206	380	2,550
1996	263	2,521	106	191	369	2,712
1997	286	2,916	122	201	408	3,117
1998	294	3,232	145	270	439	3,502
1999	305	3,829	144	257	449	4,086
2000	316	4,501	148	253	464	4,754
2001	318	4,452	148	287	466	4,739
2002	311	4,806	151	297	462	5,103
2003	309	4,702	149	318	458	5,020
2004	314	5,230	171	308	485	5,538
2005	324	5,519	173	327	497	5,846
2006	324	5,935	141	263	465	6,198
2007	331	6,570	161	321	492	6,891
2008	333	6,636	162	307	495	6,943
2009	367	8,047	230	449	597	8,496
2010	379	8,316	209	458	588	8,774
2011	369	8,417	228	508	597	8,925
Total	**531**	**97,815**	**1,183**	**6,145**	**1,714**	**103,960**

[1] There are about 550 airports in USA certificated for passenger service under CFR Part 139 regulations (FAA 2012*b*).

[2] In addition, 2,627 strikes involving USA-registered aircraft were reported from 259 foreign airports. Furthermore, 13,329 strikes were reported in which aircraft was en route when strike occurred (see Table 10), evidence of strike was discovered on aircraft after landing but phase of flight where strike occurred could not be determined, or airport was not named on reporting form.

Table 8. Reported time of occurrence of wildlife strikes with civil aircraft, USA, 1990–2011[1].

	Birds		Terrestrial mammals	
Time of day	22-year total	% of total known	22- year total	% of total known
Dawn	2,897	4	50	3
Day	47,593	62	398	25
Dusk	3,609	5	139	9
Night	22,044	29	1,012	63
Total known	**76,143**	**100**	**1,599**	**100**
Unknown[2]	**40,265**		**1,155**	
Total	**116,408**		**2,754**	

[1] In addition, 618 strikes with bats were reported from 1990-2011: time not reported (459), night (125), dusk (12), day (20), and dawn (2). Also, 137 strikes with reptiles were reported from 1990-2011: time not reported (117), day (13), night (4), dusk (2), and dawn (1).

[2] Unknowns include 22,968 “Carcass Found” reports (Tables 5).

Table 9. Reported phase of flight at time of occurrence of wildlife strikes with civil aircraft, USA, 1990–2011[1].

	Birds		Terrestrial mammals	
Phase of flight	22- year total	% of total known	22- year total	% of total known
Parked	55	<1	2	<1
Taxi	289	<1	38	2
Take-off Run	15,473	19	559	32
Climb	14,545	18	35[2]	2
En Route	2,084	3	0	0
Descent	2,838	3	0	0
Approach	32,887	40	121[2]	7
Landing Roll	13,940	17	993	57
Total known	**82,111**	**100**	**1,748**	**100**
Unknown	**34,297**		**1,006**	
Total	**116,408**		**2,754**	

[1] In addition, 618 strikes with bats were reported from 1990-2011: phase of flight not reported (464), approach (104), landing roll (16), climb (19), descent (5), take-off run (5), and en route (5). Also, 137 strikes with reptiles were reported: phase of flight not reported (108), take-off run (11), taxi (6), approach (5; pilot had a missed approach because reptile was on the runway), and landing roll (7).

[2] Terrestrial mammal (e.g., deer or 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

Table 10. Number of reported bird strikes to commercial civil aircraft[1] by height above ground level (AGL), USA, 1990–2011. See Figures 6 and 7 for graphic analysis of strike data from 501 to 18,500 feet AGL[2].

Height of strike (feet AGL)	All reported strikes			Strikes with damage		
	22-year total	% of total known	% cum-ulative total	22-year total	% of total known	% cum-ulative total
0	24,960	41	41	1,588	29	29
1-500	18,621	31	72	1,528	28	58
501-1500	6,432	11	82	778	14	72
1501-2500	3,283	5	88	472	9	81
2501-3500	2,451	4	92	299	6	86
3501-4500	1,441	2	94	173	3	89
4501-5500	1,066	2	96	137	3	92
5501-6500	720	1	97	107	2	94
6501-7500	489	1	98	72	1	95
7501-8500	367	1	99	64	1	96
8501-9500	197	<1	99	29	<1	97
9501-10,500	260	<1	99	46	<1	98
10,501-11,500	141	<1	>99	38	<1	99
>11,500[3]	236	<1	100	77	1	100
Total known	**60,664**	**100**		**5,408**	**100**	
Unknown height	**19,975**			**2,308**		
Total	**80,639**			**7,716**		

[1] Air carrier, commuter, and air taxi service with 3-letter Operator Code (see Table 6); 1,074 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 strikes involving commercial aircraft (8 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, 1990–2011. See Figures 6 and 7 for graphic analysis of strike data from 501 to 18,500 feet AGL[1].

Height of strike (feet AGL)	All reported strikes			Strikes with damage		
	22-year total	% of total known	% cum-ulative total	22-year total	% of total known	% cum-ulative total
0	4,245	38	38	546	18	18
1-500	4,146	37	75	1,033	34	52
501-1500	1,521	14	88	750	25	77
1501-2500	650	6	94	337	11	88
2501-3500	290	3	97	158	5	94
3501-4500	143	1	98	77	3	96
4501-5500	75	1	99	38	1	97
5501-6500	45	<1	99	21	1	98
6501-7500	41	<1	99	17	1	99
7501-8500	13	<1	>99	7	<1	99
8501-9500	15	<1	>99	9	<1	99
9501-10,500	12	<1	>99	8	<1	>99
10,501-11,500	4	<1	>99	2	<1	>99
>11,500[2]	18	<1	100	12	<1	100
Total known	**11,218**	**100**		**3,015**	**100**	
Unknown height	**1,289**			**399**		
Total	**12,507**			**3,414**		

[1] Private, Business, and Government/Police aircraft (see Table 6); 1,074 strikes in which height of strike was reported but type of operator was unknown were excluded from analysis.

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

[2] Three strikes involving general aviation aircraft (all 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, 1990–2011.

	Birds (22-year total)				Terrestrial mammals (22-year total)			
Aircraft component	Number struck	% of total	Number damaged	% of total	Number struck	% of total	Number damaged	% of total
Windshield	17,577	17	806	6	7	<1	15	1
Engine(s)[1]	14,167	13	4,066	30	171	7	170	10
Nose	15,084	14	829	6	93	4	92	5
Wing/rotor	13,991	13	3,097	23	258	11	271	15
Radome	13,182	13	1,317	10	14	1	15	1
Fuselage	13,069	12	536	4	125	5	133	8
Other	8,866	8	1,021	8	306	13	263	15
Landing gear	4,693	4	434	3	950	41	412	23
Propeller	2,487	2	229	2	287	12	278	16
Tail	1,380	1	535	4	59	3	78	4
Light	734	1	562	4	37	2	44	2
Total[2]	**105,230**	**100**	**13,432**	**100**	**2,307**	**100**	**1,771**	**100**

[1] For birds, 14,167 engines were reported as struck in 13,509 strike events involving engines (12,875 events with one engine struck, 616 with two engines struck, 12 with three engines struck, and 6 with four engines struck). A total of 4,066 engines were damaged in 3,935 bird-strike events with engine damage (3,807 events with one engine damaged, 126 with two engines damaged, 1 with three engines damaged, and 1 with 4 engines damaged). For terrestrial mammals, 171 engines were reported as struck in 161 strike events (151 events with one engine struck and 10 with two engines struck). A total of 170 engines were damaged in 151 terrestrial mammal strike events with engine damage (132 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 241 and 10 components reported as struck and damaged, respectively: radome/nose (74, 2), windshield (47, 1), engine (22, 3), propeller (1, 0), wing/rotor (42, 3), fuselage (19, 0), tail (7, 0), other (17, 0), landing gear (10, 0), light (2, 1). For reptile strikes, there were 24 and 5 components reported struck and damaged, respectively: windshield (1, 1), wing/rotor (1, 1), fuselage (1, 1), landing gear (19, 0); tail (1, 1), other (1, 1).

Table 13. Number of civil aircraft with reported damage resulting from wildlife strikes, USA, 1990–2011. See Tables 1, 2 and 3 and Figure 8 for trends in damaging strikes from 1990-2011.

	Reported strikes					
	Birds		Terrestrial mammals		Total[1]	
Damage category[2]	22-year total	% of total[3]	22-year total	% of total[3]	22-year total	% of total[3]
None	**76,112**	**65**	**705**	**26**	**77,036**	**64**
Unknown	**28,981**	**25**	**1,083**	**39**	**30,589**	**26**
Damage	**11,315**	**10**	**966**	**35**	**12,291**	**10**
Minor	6,071	5	502	18	6571	5
Uncertain	2,365	2	65	2	2431	2
Substantial	2,847	2	374	14	3225	3
Destroyed	32	<1	25	1	57	<1
Total	**116,408**	**100**	**2,754**	**100**	**119,917**	**100**

[1] Included in totals are 618 and 137 strikes involving bats and reptiles, respectively. For bats, 201 reports indicated no damage, 408 failed to report if damage occurred, and 9 reported damage (5 minor, 1 uncertain level, 3 substantial). For reptiles, 19 reports indicated no damage, 117 failed to report if damage occurred, and 1 reported substantial damage.

[2] The damage codes and descriptions follow the *International Civil Aviation Organization Bird Strike Information System (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 30,589 reports that did not indicate if damage occurred or not (Unknown). “Carcass found” reports (see Table 5) comprised 22,961 (75 percent) of these 30,589 reports. If the Unknown reports are excluded from the calculations, then 13, 58, and 14 percent of the strikes caused damage for birds, terrestrial mammals, and all species, respectively.

Table 14. Reported effect-on-flight (EOF) of wildlife strikes to civil aircraft, USA, 1990–2011.

	Reported strikes					
	Birds		Terrestrial mammals		Total[1]	
Effect-on-flight[2]	22-year total	% of total	22-year total	% of total	22-year total	% of total
None	**62,637**	**54**	**645**	**23**	**63,485**	**53**
Unknown	**45,877**	**39**	**1,471**	**53**	**47,886**	**40**
Negative effect	**7,894**	**7**	**638**	**23**	**8,546**	**7**
Precautionary landing	4,253	4	95	3	4,353	4
Aborted takeoff	1,720	1	202	7	1,922	2
Engine shutdown	359	<1	29	1	388	<1
Other	1,562	1	312	11	1,883	2
Total	**116,408**	**100**	**2,754**	**100**	**119,917**	

[1] Included in totals are 618 and 137 strikes involving bats and reptiles, respectively. For bats, 181 reports indicated no effect-on-flight, 431 failed to report if an effect-on-flight occurred, and 6 reported a negative effect (4 precautionary landings, 2 “Other”). For reptiles, 22 reports indicated no effect-on-flight, 107 failed to report if an effect-on-flight occurred, and 8 reported a negative effect (1 precautionary landing, 7 “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 takeoff 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 47,886 reports that did not indicate if a negative effect occurred or not (Unknown). “Carcass found” reports (see Table 5) comprised 22,780 (48 percent) of these 47,886 reports. If the Unknown reports are excluded from the calculations, then 11, 50, and 12 percent of the strikes caused a negative effect-on-flight for birds, terrestrial mammals, and all species, respectively.

Table 15. Number of reported incidents where pilot made a precautionary or emergency landing after striking birds during departure in which fuel was dumped or burned (circling pattern) to lighten aircraft weight or in which a heavy (overweight) landing was made (no fuel dump or burn), USA civil aircraft, 1990-2011. See Figure 9 for trend in incidents, 1990-2011.

Action taken after bird strike on departure	Number of incidents	Comments and number of incidents by aircraft model
Fuel dump	46	A mean of 88,878 lbs (13,070 gallons) of fuel dumped per incident (range 3,500 – 270,000 lbs; 515 - 39,706 gallons). Aircraft: B-747 (17), B-737 (8), B-767 (7), DC-10/MD-11 (7), B-777 (2), Learjet 31/35 (2), L-1011 (1), DA-2000 (1), unknown (1).
Fuel burn	41	Aircraft: CL-RJ 100/700/900 (7), EMB-120/145/170 (5), A-319/320 (4), B-737 (3); B-747, DHC8-Dash 8, MD-80/88, and PA-28 (2 each); and 14 other aircraft types with 1 each.
Heavy landing	76	Aircraft: B-727 (21), A-320/330 (14), B-757 (13), B-767 (8), MD-80/82 (8), EMB-145/170 (3), A-300 (2), C-500/600 (2), and CL-RJ 900, CRJ-400, DA-50 Falcon, Dornier 328, and MD-11 (1 each).
Total	163	A mean of 7.4 (range 0 – 15) incidents (fuel dump, fuel burn, or heavy landing) per year, 1990 – 2011.

Table 16. Aircraft speed (nautical miles [knots])[1] at time pilot aborted takeoff after striking or observing a bird or other wildlife species on runway, civil aircraft, USA, 1990–2011. See Figure 10 for trend in aborted take-offs at ≥80 knots caused by birds or other wildlife, 1990-2011.

	Commercial aircraft[2]		General aviation aircraft[3]		All aircraft[4]	
Aircraft speed (knots)	22-year total	% of total known	22-year total	% of total known	22-year total	% of total known
1-39	15	2	24	6	40	3
40-79	121	17	193	46	318	27
80-119	487	66	172	41	665	57
≥120	110	15	27	7	140	12
Total known	**733**	**100**	**416**	**100**	**1,163**	**100**
Unknown	**498**		**241**		**763**	
Total	**1,231**		**657**		**1,926[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 38 aborted takeoffs in which type of operator was unknown. For these 38 events, the speed was unreported (24), 1-39 knots (1), 40-79 knots (4), 80-120 knots (6), and ≥120 knots (3).

[5] Includes 4 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, 1990–2011 (page 1 of 19).

Wildlife group or species	22-year totals (1990-2011)					
	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	**30**	**18**	**13**	**0**	**3,077**	**2,517,450**
Loons	2	1	1			
Common loon	24	15	10		2,837	2,514,200
Red-throated loon	3	1	2		48	2,000
Pacific loon	1	1			192	1,250
Grebes	**61**	**12**	**8**	**9**	**1,608**	**2,605,470**
Grebes	11	2	1	1	1,440	496,000
Eared grebe	6	1		1	10	100,000
Western grebe	16	6	5	6	86	1,900,000
Pied-billed grebe	17	1	1			
Horned grebe	8	2	1	1	72	109,470
Red-necked grebe	2					
Clark's grebe	1					
Albatrosses/shearwaters	**61**	**8**	**6**	**2**	**197**	**62,500**
Laysan albatross	33	7	5	1	197	62,500
Black-footed albatross	5	1				
Bonin petrel	7			1		
Wedge-tailed shearwater	10		1			
Townsend's shearwater	5					
Fork-tailed storm-petrel	1					
Tropicbirds	**15**	**8**	**7**	**0**	**172**	**75,300**
Tropicbirds	7	5	4		124	40,200
White-tailed tropicbird	5	2	2		48	29,500
Red-tailed tropicbird	3	1	1			5,600
Pelicans	**71**	**36**	**31**	**13**	**4,806**	**9,195,332**
Pelicans	3	2			80	
Australian pelican	1	1	1			
Brown pelican	55	24	20	7	496	315,132
American white pelican	12	9	10	6	4,230	8,880,200
Red-footed booby	**1**					
Cormorants	**97**	**33**	**22**	**14**	**402**	**2,988,722**
Cormorants	4					
Great cormorant	2	1		2		
Double-crstd cormorant	90	32	22	12	402	2,988,722
Pelagic cormorant	1					

Table 17. Continued (Page 2 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Anhinga	**23**	**10**	**8**	**3**	**125**	**257,800**
Frigatebirds	**13**	**5**	**2**	**0**	**21**	**18,400**
Frigatebirds	3	2	1		18	13,500
Great frigatebird	8	2	1		3	4,900
Magnificent frigatebird	2	1				
Herons/bitterns	**455**	**80**	**62**	**17**	**3,739**	**5,318,253**
Herons	51	13	9	4	99	3,200
Gray heron	1	1	1			
Great blue heron	273	56	46	7	2,927	4,972,667
Blk-crowned night-heron	47	4	2	2	49	281,200
Little blue heron	5					
Green heron	11			1		
Ylw-crowned night-heron	13	3	2	1	18	17,000
Tricolored heron	2					
American bittern	6	3	2		646	44,186
Yellow bittern	45			2		
Least bittern	1					
Egrets	**634**	**69**	**93**	**147**	**3,924**	**5,387,497**
Egrets	308	31	47	81	3,489	3,465,140
Cattle egret	240	25	37	56	227	70,575
Great egret	59	10	8	9	158	1,851,782
Snowy egret	27	3	1	1	50	
Storks	**13**	**5**	**2**	**2**	**24**	**20,000**
White stork	1	1				
Wood stork	12	4	2	2	24	20,000
Ibises/spoonbills	**25**	**6**	**7**	**6**	**9**	**220**
Ibises	5		1	1		
Glossy ibis	1			1		
White ibis	8	1	2	1	4	220
White-faced ibis	9	5	3	3	4	
Roseate spoonbill	2		1		1	
Waterfowl	**3,877**	**1,679**	**848**	**1,393**	**132,033**	**164,102,483**
Ducks, geese, swans	136	65	31	54	763	847,075
Ducks	742	259	123	241	5,854	4,391,196
American wigeon	43	19	8	13	5,055	1,362,647
Northern pintail	101	55	34	52	1,761	1,977,039
Green-winged teal	38	12	7	14	737	688,642
Blue-winged teal	19	10	4	8	193	609,440

Table 15. Continued (Page 3 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Eurasian wigeon	1			1		
Mallard	633	151	77	149	9,996	12,966,763
Common eider	3	2	1	1		
Ring-necked duck	13	5	3	4	1,080	78,468
Greater scaup	6	2	2	2		
Wood duck	35	12	5	7	300	86,704
Muscovy duck	1	1			120	443,332
Common goldeneye	5	2	1			2,000
Red-breasted merganser	4	1		1	2	
Hooded merganser	5	2		1	30	27,023
Common merganser	3	2	2	1	120	2,500
Northern shoveler	38	18	5	12	1,758	1,368,428
Gadwall	39	13	6	12	590	7,689,006
Canvasback	16	8	3	6	575	2,209,077
American black duck	36	4	2	12	2,388	66,500
Mottled duck	17	4	4	5	25	
Lesser scaup	25	14	9	9	1,263	165,000
Ruddy duck	31	10	2	5	81	85,258
Redhead	4	2		2	17	50,000
Bufflehead	7	1	2	1	40	4,874
Long-tailed duck	3	2	2	1	3	1,100
Philippine duck	1	1	1	1	96	9,456,000
Blk-bellied whistling-duck	2	1	1			
Cinnamon teal	4	1		1	20	6,147
White-winged scoter	1	1	1	1	1,400	430,000
Hawaiian duck	5			1		
Harlequin duck	1					
Barrow's goldeneye	1					
Geese	326	198	86	113	25,407	1,899,833
Snow goose	101	79	38	55	8,525	20,426,186
Canada goose	1,351	677	371	574	62,456	90,354,931
Brant	26	10	3	7	108	51,271
Gr white-fronted goose	28	17	6	15	675	4,903,600
Emperor goose	1	1				
Cackling goose	3	3		2	101	122,500
Swans	2	1				
Mute swan	8	2	1	2		

Table 17. Continued (Page 4 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Tundra swan	10	9	5	6	422	379,943
Trumpeter swan	2	2	2	1	72	950,000
Hawks, eagles, vultures	**4,194**	**1,056**	**699**	**146**	**97,177**	**72,208,800**
Hawks, eagles, vultures	29	16	7	1	2,559	17,550
Vultures	282	163	81	27	24,787	9,382,091
Black vulture	74	47	30	7	5,395	2,120,925
Turkey vulture	444	224	155	25	26,250	7,551,605
Osprey	214	49	31	4	2,553	300,973
White-tailed kite	23	4	2		46	5,000,000
Black kite	2	1	1			
Mississippi kite	1					
Swallow-tailed kite	1					
Eagles	6	3	2	1		
Bald eagle	147	61	42	10	6,749	21,879,181
White-breasted sea-eagle	1	1	1			
Golden eagle	12	2	4		3,696	801,000
Hawks	1,137	229	159	30	11,642	4,139,148
Northern goshawk	2					
Red-tailed hawk	1,471	230	164	35	10,935	12,812,260
Rough-legged hawk	60	4	3			40,167
Red-shouldered hawk	23	2	3		41	1,200
Swainson's hawk	72	9	7	2	981	397,500
Eurasian sparrowhawk	1					
Sharp-shinned hawk	13	1			1,000	360,000
Cooper's hawk	51	2	2	1	3	
Ferruginous hawk	15	2	1		26	3,200,200
Broad-winged hawk	12	2	1	1	250	5,000
Harris's hawk	2					
White-tailed hawk	2					
Eurasian buzzard	2	1			24	
Northern harrier	94	2	2	2		200,000
Lappet-faced vulture	1	1	1		240	4,000,000
Falcons/caracaras	**3,116**	**44**	**65**	**138**	**1,587**	**1,822,443**
Falcons	44	3	3	2	82	30,100
Peregrine falcon	201	15	11	8	146	355,500
Gyrfalcon	2					
Merlin	52		2	2	23	630
Crested caracara	6	1	1			

Table 17. Continued (Page 5 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Prairie falcon	17	1		2		5,500
American kestrel	2,789	23	47	124	1,336	1,430,713
Eurasian kestrel	5	1	1			
Gallinaceous birds	**204**	**58**	**44**	**41**	**2,260**	**747,952**
Grouse	6	2		3	2	
Greater sage-grouse	31	12	6	11	554	381,242
Sharp-tailed grouse	2	1	1		24	500
Ruffed grouse	1					
Ptarmigans	6	4	1	2	57	57,500
Black francolin	4					
Quails	9		3	2		
Northern bobwhite	9	2	3	1	73	800
Scaled quail	3					
Ring-necked pheasant	66	17	13	5	883	94,500
Red-legged partridge	1					
Gray partridge	6	3	2	4	24	120
Chukar	2		1	1		
Gray francolin	3					
Guineafowl	1	1		1		
Wild turkey	54	16	14	11	643	213,290
Cranes	**109**	**44**	**29**	**34**	**2,411**	**184,560**
Sandhill crane	108	43	29	34	2,363	134,260
Whooping crane	1	1			48	50,300
Rails/gallinules	**159**	**30**	**15**	**8**	**2,955**	**1,245,207**
Rails	4	1	1	1		
Sora	16	1	1	1	68	18,500
Common moorhen	3	1	1		24	990
American coot	121	26	11	6	2,788	1,200,267
Purple gallinule	4	1	1		72	25,450
Virginia rail	6				3	
Clapper rail	5					
Shorebirds	**4,386**	**101**	**130**	**702**	**2,297**	**4,356,754**
Shorebirds	21			9		
American oystercatcher	22			2		
Plovers, lapwings	1			1		
Plovers	45	3	4	8	24	
European golden-plover	5					
American golden-plover	101	3	4	29	16	2,000

Table 17. Continued (Page 6 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Black-bellied plover	87	6	5	18	27	164,254
Snowy plover	1			1		
Killdeer	2,583	39	51	278	734	3,170,233
Pacific golden-plover	646	5	10	100	76	301,668
Semipalmated plover	53			17		
Piping plover	1	1		1	2	200
Wilson's plover	3					
Northern lapwing	1	1	1	1	25	
Southern lapwing	1	1	1			8,000
Sandpipers	217	13	24	79	179	146,560
Upland sandpiper	144	5	6	14	16	2,000
Spotted sandpiper	15	2	1	3		
Willet	6			2		
Common snipe	2					
American woodcock	44	2	2	3	17	10,898
Dunlin	30	3	3	9	506	205,300
Baird's sandpiper	14			1		
Western sandpiper	58	3	3	41	93	106,566
Pectoral sandpiper	10	1	1	3		300
Sanderling	21	1	2	8		
Buff-breasted sandpiper	19			5		
Ruddy turnstone	9			1		
Least sandpiper	69	1	4	25	8	
Semipalmated sandpiper	39	1	1	18	1	
Lesser yellowlegs	6			1		
Short-billed dowitcher	5	1		1		
Hudsonian godwit	5	1	1	2	96	23,495
Solitary sandpiper	3			1		
Greater yellowlegs	3	1			48	8,000
Long-billed dowitcher	7			3	1	
Red knot	3		1			
White-rumped sandpiper	5					
Black turnstone	1					
Marbled godwit	2	1	1	1	48	144,065
Wilson's snipe	43	3	3	4	20	13,215
Rock sandpiper	1			1		
Curlews	1			1		
Eurasian curlew	1					

Table 17. Continued (Page 7 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Whimbrel	13	2	1	2	360	50,000
Long-billed curlew	3					
Dble-striped thick-knee	1					
Red-necked phalarope	3			1		
Wilson's phalarope	2			1		
American avocet	5	1		3		
Black-necked stilt	5			3		
Gulls/jaegers	**8,881**	**1,282**	**1,060**	**1,976**	**56,516**	**39,394,374**
Parasitic jaeger	2					
Long-tailed jaeger	2					
Gulls	5,960	1,011	816	1,531	41,169	19,527,536
Herring gull	949	94	87	101	2,071	1,782,615
Mew gull	56	6	4	8	28	87,717
Ring-billed gull	1,100	95	85	206	5,956	3,342,270
Glaucous-winged gull	77	17	10	13	292	1,598,545
Great black-backed gull	92	9	6	8	113	271,200
Franklin's gull	79	4	8	30	20	139,200
Laughing gull	316	17	19	46	731	534,336
Bonaparte's gull	29	2	3	8		65,000
Lesser black-backed gull	3	1	1	1		
Western gull	88	11	7	8	188	1,683,857
California gull	101	11	9	9	4,992	408,048
Heermann's gull	1			1		
Black-headed gull	4					
Thayer's gull	3					
Yellow-legged gull	3	3	3	3	456	9,906,050
Glaucous gull	16	1	2	3	500	300,000
Terns/kittiwakes	**141**	**5**	**3**	**28**	**4**	**71,200**
Terns	40	2		13		
Little tern	1					
Caspian tern	19			1		
Common tern	14	1		3		71,200
Sandwich tern	1					
Gull-billed tern	4					
Black tern	1					
Fairy tern	2					
White tern	4		1	1		
Arctic tern	4	1		2		

Table 17. Continued (Page 8 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Roseate tern	1					
Forster's tern	9		1	2	4	
Least tern	16			2		
Black noddy	3			2		
Brown noddy	7		1	1		
Royal tern	2					
Sooty tern	3					
Black-legged kittiwake	2					
Red-legged kittiwake	1					
Black skimmer	7	1		1		
Pigeons/doves	**8,113**	**422**	**493**	**1,872**	**23,374**	**15,219,640**
Pigeons, doves	21	2	3	12	36	400
Pigeons	20	3	2	6	9	300
Common wood-pigeon	3					
Band-tailed pigeon	8	3		3	114	71,000
Doves	831	40	69	210	398	375,110
Rock pigeon	2,158	222	211	744	14,235	8,542,640
Eurasian collared dove	1					
Mourning dove	4,733	145	197	869	8,352	5,954,785
Spotted dove	125	3	6	8	133	274,405
Zebra dove	159	2	5	19	25	1,000
Inca dove	11					
Island turtle-dove	4					
White-winged dove	33	2		1	72	
Common ground-dove	6					
Parrots	**17**	**0**	**0**	**2**	**0**	**0**
Parrots	5			2		
Budgerigar	9					
Monk parakeet	2					
Nanday parakeet	1					
Cuckoos	**23**	**3**	**0**	**4**	**26**	**13,760**
Cuckoos	3	1		1	6	13,760
Yellow-billed cuckoo	17	2		3	20	
Common cuckoo	1					
Black-billed cuckoo	1					
Greater roadrunner	1					
Owls	**1,670**	**104**	**67**	**16**	**1,599**	**5,599,042**
Owls	289	31	18	4	973	296,875

Table 17. Continued (Page 9 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Barn owl	726	30	22	7	252	1,900,310
Snowy owl	73	6	6		84	331,053
Little owl	1					
Short-eared owl	295	8	10	2	83	1,269,421
Long-eared owl	11	2	1			
Northern saw-whet owl	6					
Burrowing owl	105	2		2	8	750
Barred owl	15	1	1			150
Northern pygmy-owl	1					
Eastern screech-owl	3	2			24	7,558
Western screech-owl	2					
Great horned owl	142	22	9	1	175	1,792,925
Northern hawk owl	1					
Nightjars	**299**	**2**	**1**	**20**	**7**	**0**
Nightjars	4					
Whip-poor-will	4			1		
Common poorwill	8					
Lesser nighthawk	7					
Chuck-will's-widow	5					
Common nighthawk	271	2	1	19	7	
Swifts	**251**	**6**	**5**	**20**	**35**	**950**
Swifts	13	1		2		
Black swift	3					
Chimney swift	198	3	4	18	10	950
Common swift	2	1				
Vaux's swift	19				24	
White-throated swift	16	1	1		1	
Hummingbirds	**11**	**0**	**0**	**0**	**0**	**0**
Hummingbirds	2					
Ruby-thrtd hummingbird	3					
Anna's hummingbird	3					
Bk-chinned hummingbird	1					
Allen's hummingbird	1					
Calliope hummingbird	1					
Belted kingfisher	**8**					
Woodpeckers	**88**	**5**	**6**	**3**	**1**	**15,000**
Woodpeckers	10		1			
Northern flicker	56	3		1		

Table 17. Continued (Page 10 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Yellow-bellied sapsucker	15	1	2	2		
Hairy woodpecker	3					
Red-naped sapsucker	2	1	2			15,000
Downy woodpecker	2		1		1	
Unidentified passiformes	**226**	**12**	**7**	**26**	**72**	**91,455**
Flycatchers	**279**	**1**	**4**	**20**	**2**	**9,892**
Tyrant flycatchers	20			4	1	
Eastern wood-pewee	3					
Great crested flycatcher	3					
Eastern kingbird	16	1	1			9,800
Scissor-tailed flycatcher	97		2	5		92
Acadian flycatcher	1					
Say's phoebe	5					
Western kingbird	117		1	9	1	
Ash-throated flycatcher	1					
Western wood-pewee	1					
Sulphur-bellied flycatcher	1					
Eastern phoebe	3					
Yellow-bellied flycatcher	1			1		
Least flycatcher	2					
Hammond's flycatcher	1					
Pacific-slope flycatcher	3					
Gray flycatcher	2			1		
Olive-sided flycatcher	1					
White-crested elaenia	1					
Larks	**1,747**	**16**	**27**	**346**	**181**	**576,233**
Sky lark	48			1		
Horned lark	1,699	16	27	345	181	576,233
Swallows	**3,890**	**25**	**71**	**900**	**263**	**58,893**
Swallows	730	6	29	225	48	75
Purple martin	116	3	2	29	3	
Bank swallow	190	2	4	81	6	
Barn swallow	1,862	10	26	357	182	43,811
Cliff swallow	612	3	7	103	15	14,942
Tree swallow	334		3	101	7	65
Violet-green swallow	13			1		
N. rough-winged swallow	25	1		1	2	
Cave swallow	8			2		

Table 17. Continued (Page 11 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Black drongo	**6**					
Starlings/mynas	**2,888**	**108**	**148**	**1,075**	**2,633**	**5,036,105**
European starling	2,823	107	146	1,054	2,629	5,036,105
Mynas	5			2		
Common myna	60	1	2	19	4	
Crows/ravens	**557**	**56**	**51**	**78**	**6,610**	**1,577,655**
Crows	176	18	14	32	18	81,250
American crow	343	29	31	42	6,451	1,327,873
Carrion crow	2					
Hooded crow	1	1	1			
Northwestern crow	3			1		
Rook	1					
Common raven	31	8	5	3	141	168,532
Jays/magpies	**31**	**2**	**2**	**4**	**1**	**555**
Blue jay	13					
Gray jay	1					
Yellow-billed magpie	8			2		
Black-billed magpie	9	2	2	2	1	555
Chickadees/nuthatches	**28**	**0**	**0**	**8**	**0**	**0**
Chickadees	1					
Black-capped chickadee	20			5		
Mountain chickadee	2			1		
Gray-headed chickadee	1			1		
Carolina chickadee	2			1		
Bushtit	1					
White-breasted nuthatch	1					
Red-vented bulbul	**3**			**1**		
Wrens	**68**	**1**	**2**	**9**	**0**	**0**
Wrens	44	1	1	9		
Marsh wren	7		1			
House wren	9					
Carolina wren	2					
Rock wren	1					
Cactus wren	3					
Winter wren	1					
Bewick's wren	1					
Mimics	**109**	**1**	**2**	**4**	**0**	**620**
Brown thrasher	10					120

Table 17. Continued (Page 12 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Curve-billed thrasher	1					
Northern mockingbird	59	1	2			
Tropical mockingbird	1					
Gray catbird	38			4		500
Thrushes	**674**	**50**	**30**	**59**	**1,953**	**2,523,962**
Thrushes	17	2	1	1	7	25,500
Western bluebird	4				3	
Swainson's thrush	54	5	2	6	27	2,002,225
Redwing	1					
American robin	502	36	22	40	1,863	476,252
Hermit thrush	40	1		3	22	3,800
Eastern bluebird	4					
Gray-cheeked thrush	6			1		
Varied thrush	25	6	2	4	31	15,905
Wood thrush	8		1	2		280
Mountain bluebird	7			2		
Veery	6		2			
Wrentits/gnatcatchers	**7**	**0**	**1**	**0**	**2**	**0**
Wrentit	1					
Blue-gray gnatcatcher	6		1		2	
Kinglets	**20**	**0**	**1**	**2**	**0**	**0**
Golden-crowned kinglet	6					
Ruby-crowned kinglet	14		1	2		
Pipits	**37**	**0**	**0**	**9**	**0**	**0**
American pipit	36			9		
Sprague's pipit	1					
Waxwings	**55**	**1**	**2**	**10**	**48**	**161,500**
Bohemian waxwing	1			1		
Cedar waxwing	54	1	2	9	48	161,500
Loggerhead shrike	**12**		**1**			
Vireos	**31**	**2**	**1**	**3**	**7**	**2,200**
Vireos	3					
White-eyed vireo	1				2	
Yellow-throated vireo	1					
Warbling vireo	8	1		1	2	2,200
Red-eyed vireo	16	1	1	2	3	
Cassin's vireo	2					
Japanese white-eye	**2**					

Table 17. Continued (Page 13 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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	**264**	**4**	**7**	**18**	**72**	**8,954**
Wood warblers	42	1		4		1,700
Canada warbler	7					
Yellow-breasted chat	5					
Pine warbler	5			1		
Black-and-white warbler	8					
Northern parula	4			1	24	2,000
Ovenbird	20	1	2		1	100
Wilson's warbler	17			1	4	4,569
Common yellowthroat	16		1		2	
Yellow-rumped warbler	39			4	3	43
Blackpoll warbler	17			2	2	450
Mourning warbler	2					
American redstart	5	1		2	11	
Orange-crowned warbler	6					
Yellow warbler	13	1		1	17	
Northern waterthrush	4					
Nashville warbler	11		1	1		
Townsend's warbler	4		1	1		92
Palm warbler	7		1			
Magnolia warbler	12		1		6	
Blk-throated blue warbler	4					
Prothonotary warbler	1					
MacGillivray's warbler	2					
Yellow-throated warbler	4					
Blk-throated gray warbler	2				2	
Blk-thrted green warbler	2					
Hermit warbler	1					
Tennessee warbler	2					
Chestnut-sided warbler	1					
Blackburnian warbler	1					
Meadowlarks	**1,674**	**20**	**35**	**174**	**360**	**396,452**
Meadowlarks	371	2	9	32	14	
Eastern meadowlark	742	6	13	68	128	130,000
Western meadowlark	561	12	13	74	218	266,452
Blackbirds/orioles	**1,829**	**102**	**118**	**475**	**1,526**	**1,050,402**
Blackbirds	1,230	77	88	355	606	864,297
Red-winged blackbird	161	5	8	19	7	2,750

Table 17. Continued (Page 14 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Yellow-headed blackbird	9	1	1	2		
Brewer's blackbird	36	1	1	6		
Brown-headed cowbird	126	2	3	41	11	5,155
Bobolink	12		1	2	1	
Rusty blackbird	1					
Tri-colored blackbird	1					
Orioles	5					
Baltimore oriole	12		1	2	2	200
Orchard oriole	3					
Bullock's oriole	3					
Grackles	97	8	3	21	728	133,000
Common grackle	97	5	9	23	123	45,000
Boat-tailed grackle	10	2	2		48	
Great-tailed grackle	26	1	1	4		
Tanagers	**10**	**1**	**1**	**0**	**3**	**0**
Scarlet tanager	3	1				
Western tanager	7		1		3	
Finches	**534**	**8**	**32**	**176**	**168**	**21,200**
Finches	69	1	5	19	5	
Lapland longspur	16		1	6		
Chest.-collared longspur	2					
Dark-eyed junco	51	3	3	5	75	9,000
Rose-breasted grosbeak	3					
Island canary	1					
Pine siskin	3			2	1	
Purple finch	3					
Evening grosbeak	1					
American goldfinch	38		2	2	3	
House finch	48		1	6		
Smith's longspur	2					
Dickcissel	6			1		
White-winged crossbill	1					
Red avadavat	5			3		
McCown's longspur	1					
Lesser goldfinch	2					
Black-headed grosbeak	1					
Cassin's finch	1					
Pine grosbeak	1					

Table 17. Continued (Page 15 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Red-crested cardinal	4			1	1	
Northern cardinal	6					
Snow bunting	187	3	18	118	78	12,200
Indigo bunting	7		1	1	3	
Lazuli bunting	1					
Lark bunting	72	1		11	2	
McKay's bunting	1		1	1		
Painted bunting	1					
Sparrows	**3,104**	**52**	**105**	**695**	**690**	**94,613**
Sparrows	2,619	47	100	654	639	52,825
Harris's sparrow	1					
Swamp sparrow	16					
Savannah sparrow	188	2	1	16	13	6,738
Fox sparrow	20	1			1	4,100
White-throated sparrow	54	1	1	5	10	650
Golden-crowned sparrow	3			1		
Field sparrow	18					
Lark sparrow	16			2		
White-crowned sparrow	19		1	1	18	
Grasshopper sparrow	28	1	1	2	4	29,700
Java sparrow	2			1		
Vesper sparrow	21			1		
Chipping sparrow	19			2		
Lincoln's sparrow	10					
Song sparrow	50			8	3	400
Sage sparrow	6				1	
American tree sparrow	10		1	2		
Nelson's s.-tailed sparrow	2				1	200
Black-throated sparrow	1					
Brewer's sparrow	1					
Towhees	**9**	**1**	**0**	**0**	**9**	**13,151**
Eastern towhee	7	1			9	13,151
Green-tailed towhee	1					
California towhee	1					
Waxbills/mannikins	**133**	**0**	**2**	**62**	**10**	**3,600**
Waxbills, mannikins	3					
Common waxbill	4					
Mannikins	24			11		

Table 17. Continued (Page 16 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Nutmeg mannikin	54		1	28	8	1,600
Black-headed munia	45		1	21	2	2,000
White-throated munia	3			2		
House sparrow	**118**	**3**	**2**	**13**	**28**	**2,050**
Total known birds	**55,391**	**5,566**	**4,307**	**9,883**	**354,761**	**345,251,708**
Total unknown birds	**61,017**	**5,718**	**3,515**	**6,482**	**126,692**	**90,767,176**
Unknown bird -? size	2,003	166	151	118	2,950	827,084
Unknown bird - large	2,309	929	445	252	39,626	32,429,534
Unknown bird - medium	32,538	3,856	1,997	2,578	72,777	44,429,000
Unknown bird - small	24,167	767	922	3,534	11,339	13,081,558
Total birds	**116,408**	**11,284**	**7,822**	**16,365**	**481,453**	**436,018,884**
Flying mammals (bats)						
Microbats (echo-locating)	**601**	**6**	**4**	**38**	**9**	**270**
Microbats (unkn species)	374	3	1	32	4	
Vesper bats	10	1			1	
Red bat	38	1		1	1	
Hoary bat	13				1	
E. small-footed myotis	1					
Little brown bat	33			1		
Big brown bat	13		1			
Silver-haired bat	10					
Seminole bat	2					
Eastern pipistrelle	3					
Northern yellow bat	3					
Evening bat	2					
Free-tailed bats	20			2		270
Brazilian free-tailed bat	76	1	2	2	2	
Pocketed free-tailed bat	2					
Big free-tailed bat	1					
Megabats (fruit bats)	**6**	**1**	**2**	**1**	**72**	**3,069,400**
Total known bats	**607**	**7**	**6**	**39**	**81**	**3,069,670**
Total unkn-Mega or Micro	**11**	**2**		**2**	**27**	**106,440**
Total bats	**618**	**9**	**6**	**41**	**108**	**3,176,110**
Terrestrial mammals						
Marsupials (Vir. opossum)	**125**	**1**				
Xenarthyras (armadillo)	**25**	**1**	**4**		**11**	**1,000**

Table 17. Continued (Page 17 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Lagomorphs	**403**	**7**	**8**	**7**	**20**	**104,484**
Lagomorphs	1	1				
Hares	5					
Black-tailed jackrabbit	162	3	2	1	12	26,384
White-tailed jackrabbit	36			2	1	
Rabbits	119		2	4	1	100
Eastern cottontail	60	3	4		6	78,000
Desert cottontail	20					
Rodents	**191**	**2**	**5**	**5**	**3**	**0**
North American beaver	2					
Pocket gophers	3					
Prairie dog	9		1	1		
Black-tailed prairie dog	27			1		
Gunnison's prairie dog	12			3		
Woodchuck	105	2	4		3	
Yellow-bellied marmot	1					
Woodrats	2					
Muskrat	19					
N. American porcupine	11					
Carnivores	**932**	**55**	**119**	**13**	**14,351**	**3,175,026**
Canids	3		1			
Coyote	376	32	78	5	11,741	2,776,090
Domestic dog	35	11	19	1	96	311,000
Foxes	76	4	7	1	10	750
Red fox	96	3	8		340	52,000
Common gray fox	5	1	1		2	186
Raccoon	75	3	3	2	2,160	35,000
White-nosed coati	1					
Ringtail	1					
Skunks	100		1	2	2	
Striped skunk	126			2		
River otter	2	1				
Badger	4					
Mink	3					
Domestic cat	25					
Small Indian mongoose	3					
American black bear	1		1			

Table 17. Continued (Page 18 of 19)

Wildlife group or species	22-year totals (1990-2011)					
	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 ($)
Artiodactyls	**1,055**	**890**	**492**	**88**	**263,666**	**38,280,692**
Deer	26	24	13		696	197,000
White-tailed deer	925	772	423	77	219,217	31,094,261
Mule deer	63	57	31	3	17,748	895,127
Wapiti (elk)	11	11	6	1	11,660	5,581,204
Moose	5	4	4			
Caribou	2	2	1			
Cattle	11	11	8	4	9,215	357,000
Pronghorn	9	8	5	2	5,130	156,100
Swine (pigs)	1					
Collared peccary	2	1	1	1		
Perissodactyls	**4**	**4**	**3**	**0**	**1,008**	**23,849**
Horse	3	3	3		1,008	23,849
Burro	1	1				
Total known t. mammals	**2,735**	**960**	**631**	**113**	**279,059**	**41,585,051**
Total unknown t. mammals	**19**	**6**	**7**	**1**		
Total terrestrial mammals[5]	**2,754**	**966**	**638**	**114**	**279,059**	**41,585,051**
Reptiles						
Turtles	**114**		**2**	**2**		
Turtles (unkn species)	65		2	1		
Florida soft shell turtle	4					
Eastern box turtle	7					
Common snapping turtle	4					
Diamondback terrapin	29			1		
Painted turtle	3					
Florida red-bellied cooter	1					
Gopher tortoise	1					
American alligator	**15**	**1**	**2**		**3**	
Green iguana	**8**		**4**			
Total reptiles[6]	**137**	**1**	**8**	**2**	**3**	**0**
Total known (all species)	**58,870**	**6,565**	**5,023**	**10,937**	**634,167**	**389,965,322**
Total (unknown species)	**61,047**	**5,726**	**3,523**	**6,485**	**126,719**	**90,873,616**
Grand total	**119,917**	**12,291**	**8,546**	**17,422**	**760,886**	**480,838,938[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 and about 39 percent from 2004-2008. General aviation reporting rates are much lower than for commercial aviation. In addition, only about 48

Table 17. Continued (Page 19 of 19)

percent of reported strikes identified the wildlife species or species group responsible, 1990-2011. Furthermore, of the 12,291 reports indicating damage to the aircraft, only 26 percent (3,194) also provided an estimate of repair costs, and only 49 percent (6,015) estimated the downtime (see Table 22). Finally, even when cost estimates were provided, many 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 116,408 reported bird strikes, 39,103 (34 percent) identified the bird to exact species (462 species total of which 209 caused damage) and an additional 16,288 strikes (14 percent) identified the bird at least to species group. Species identification has improved from less than 20 percent in the early 1990s to 53 percent in 2011 (Figure 7).

[4] Of the 618 reported bat strikes, 207 (33 percent) identified the bat to exact species (14 species total of which 2 caused damage) and 400 (65 percent) identified the bat to species group (6 megabats [old world fruit bats], 394 microbats [echo-locating bats]). There were 11 bat strikes classified as unknown bat (either megabat or microbat).

[5] Of the 2,754 reported terrestrial mammal strikes, 2,391 (87 percent) identified the mammal to exact species (38 species total of which 21 caused damage) and 344 (12 percent) identified the mammal at least to species group.

[6] All of the 137 reported reptile strikes were identified to species group and 72 (53 percent) were identified to exact species (9 species total of which 1 caused damage).

[7] Reported costs of $480,838,938 include $431,483,316 in direct repair costs and $49,355,622 in other costs (see Tables 22 and 23).

Table 18. Number of reported strikes, strikes with damage, and strikes involving multiple animals for the four most commonly struck bird groups and three most commonly struck terrestrial mammal groups, civil aircraft, USA, 1990–2011.

	Reported strikes		Strikes with damage		Strikes with >1 animal	
Species group[1]	22-year total	% of total known	22-year total	% of total known	22-year total	% of total known
Birds						
Gulls	8,881	16	1,282	23	1,976	18
Pigeons/ doves	8,113	15	422	8	1,872	17
Raptors[2]	7,310	13	1,100	20	284	3
Waterfowl	3,877	7	1,679	30	1,393	13
All other known	27,210	49	1,114	20	5,258	49
Total known birds	**55,391**	**100**	**5,597**	**100**	**10,783**	**100**
Unknown birds	**61,017**		**5,718**		**6,482**	
Total birds	**116,408**		**11,315**		**17,265**	
Terrestrial mammals						
Artiodactyls	1,055	39	890	93	88	78
Carnivores	932	34	55	6	13	12
Lagomorphs	403	15	7	1	7	6
All other known	345	13	8	1	5	4
Total known t. mammals	**2,735**	**100**	**960**	**100**	**113**	**100**
Unknown t. mammals	**19**		**6**		**1**	
Total t. mammals	**2,754**		**966**		**114**	

[1] See Table 17 for listing of species within each species group.

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

Table 19. Ranking of hazard level of 108 bird and 12 terrestrial mammal species with 30 or more reported strikes with civil aircraft in USA, 1990-2011 (Table 17), based on a composite of the percent of strikes causing damage, major damage, and a negative effect-on-flight (EOF) (page 1 of 4)[1, 2].

Hazard rank	Wildlife species	Total reported strikes	Percent of strikes with:			Mean hazard level[3]
			Damage	Major damage	Neg. EOF	
	Birds					
1	Snow goose	101	78.2	40.6	37.6	52.1
2	Black vulture	74	63.5	32.4	40.5	45.5
3	Northern pintail	101	54.5	19.8	33.7	36.0
4	Turkey vulture	444	50.5	17.8	34.9	34.4
5	Canada goose	1,351	50.1	16.5	27.5	31.4
6	Brown pelican	55	43.6	12.7	36.4	30.9
7	Bald eagle	147	41.5	11.6	28.6	27.2
8	Northern shoveler	38	47.4	18.4	13.2	26.3
9	Sandhill crane	108	39.8	12.0	26.9	26.2
10	American wigeon	43	44.2	14.0	18.6	25.6
11	Double-crested cormorant	90	35.6	15.6	24.4	25.2
12	Greater sage-grouse	31	38.7	12.9	19.4	23.7
13	Wood duck	35	34.3	14.3	14.3	21.0
14	Wild turkey	54	29.6	3.7	25.9	19.8
15	Ring-necked pheasant	66	25.8	13.6	19.7	19.7
15	Gadwall	39	33.3	10.3	15.4	19.7
17	Green-winged teal	38	31.6	5.3	18.4	18.4
18	Common raven	31	25.8	9.7	16.1	17.2
19	Ruddy duck	31	32.3	9.7	6.5	16.1
20	Mallard	633	23.9	9.0	12.2	15.0
20	Osprey	214	22.9	7.5	14.5	15.0
22	Great blue heron	273	20.5	5.9	16.8	14.4
23	Glaucous-winged gull	77	22.1	3.9	13.0	13.0
24	American coot	121	21.5	5.8	9.1	12.1
24	Laysan albatross	33	21.2	0.0	15.2	12.1
26	Great egret	59	16.9	3.4	13.6	11.3
27	Red-tailed hawk	1,471	15.6	4.9	11.1	10.6
28	Cattle egret	240	10.4	3.3	15.4	9.7
29	Western gull	88	12.5	8.0	8.0	9.5
30	California gull	101	10.9	6.9	8.9	8.9
31	Great horned owl	142	15.5	3.5	6.3	8.5
32	Swainson's hawk	72	12.5	2.8	9.7	8.3
33	Herring gull	949	9.9	4.8	9.2	8.0
34	Rock pigeon	2,158	10.3	3.7	9.8	7.9
35	Dunlin	30	10.0	3.3	10.0	7.8

Table 19. Continued (page 2 of 4).

Hazard rank	Wildlife species	Total reported strikes	Percent of strikes with:			Mean hazard level[3]
			Damage	Major damage	Effect on flight	
	Birds (continued)					
36	Great black-backed gull	92	9.8	6.5	6.5	7.6
37	American black duck	36	11.1	5.6	5.6	7.4
38	Snowy owl	73	8.2	4.1	8.2	6.8
38	American crow	343	8.5	2.9	9.0	6.8
38	Franklin's gull	79	5.1	5.1	10.1	6.8
41	Ring-billed gull	1,100	8.6	3.4	7.7	6.6
42	Mew gull	56	10.7	1.8	7.1	6.5
43	Blck-crowned night-heron	47	8.5	4.3	4.3	5.7
44	Common grackle	97	5.2	1.0	9.3	5.2
45	Peregrine falcon	201	7.5	2.0	5.5	5.0
46	Swainson's thrush	54	9.3	1.9	3.7	4.9
47	Wilson's snipe	43	7.0	0.0	7.0	4.7
48	Black-bellied plover	87	6.9	1.1	5.7	4.6
48	Dark-eyed junco	51	5.9	2.0	5.9	4.6
50	Rough-legged hawk	60	6.7	1.7	5.0	4.4
50	Laughing gull	316	5.4	1.9	6.0	4.4
52	American robin	502	7.2	0.8	4.4	4.1
53	Snow bunting	187	1.6	0.5	9.6	3.9
54	Western sandpiper	58	5.2	0.0	5.2	3.4
54	European starling	2,823	3.8	1.2	5.2	3.4
56	American woodcock	44	4.5	0.0	4.5	3.0
56	Upland sandpiper	144	3.5	1.4	4.2	3.0
56	Barn owl	726	4.1	1.8	3.0	3.0
59	Spotted dove	125	2.4	1.6	4.8	2.9
60	Mourning dove	4,733	3.1	1.0	4.2	2.7
60	Red-winged blackbird	161	3.1	0.0	5.0	2.7
62	American golden-plover	101	3.0	1.0	4.0	2.6
62	Cooper's hawk	51	3.9	0.0	3.9	2.6
64	Short-eared owl	295	2.7	1.4	3.4	2.5
65	Least sandpiper	69	1.4	0.0	5.8	2.4
66	White-winged dove	33	6.1	0.0	0.0	2.0
67	Cedar waxwing	54	1.9	0.0	3.7	1.9
67	Brewer's blackbird	36	2.8	0.0	2.8	1.9
67	White-throated sparrow	54	1.9	1.9	1.9	1.9
70	Northern flicker	56	5.4	0.0	0.0	1.8
70	Western meadowlark	561	2.1	0.9	2.3	1.8
70	Northern harrier	94	2.1	1.1	2.1	1.8
70	American goldfinch	38	0.0	0.0	5.3	1.8

Table 19. Continued (page 3 of 4).

Hazard rank	Wildlife species	Total reported strikes	Percent of strikes with:			Mean hazard level[3]
			Damage	Major damage	Effect on flight	
	Birds (continued)					
74	Semipalmated sandpiper	39	2.6	0.0	2.6	1.7
74	Northern mockingbird	59	1.7	0.0	3.4	1.7
74	Zebra dove	159	1.3	0.6	3.1	1.7
74	Common myna	60	1.7	0.0	3.3	1.7
78	Brown-headed cowbird	126	1.6	0.8	2.4	1.6
79	Purple martin	116	2.6	0.0	1.7	1.4
79	House sparrow	118	2.5	0.0	1.7	1.4
81	Merlin	52	0.0	0.0	3.8	1.3
81	Killdeer	2,583	1.5	0.3	2.0	1.3
83	Chimney swift	198	1.5	0.0	2.0	1.2
84	Bank swallow	190	1.1	0.0	2.1	1.1
85	Eastern meadowlark	742	0.8	0.5	1.8	1.0
86	American kestrel	2,789	0.8	0.3	1.7	0.9
86	Lark bunting	72	1.4	1.4	0.0	0.9
86	Horned lark	1,699	0.9	0.2	1.6	0.9
89	Hermit thrush	40	2.5	0.0	0.0	0.8
89	Pacific golden-plover	646	0.8	0.0	1.5	0.8
91	Black-headed munia	45	0.0	0.0	2.2	0.7
91	House finch	48	0.0	0.0	2.1	0.7
91	Scissor-tailed flycatcher	97	0.0	0.0	2.1	0.7
91	Barn swallow	1,862	0.5	0.1	1.4	0.7
95	Burrowing owl	105	1.9	0.0	0.0	0.6
95	Nutmeg mannikin	54	0.0	0.0	1.9	0.6
95	Cliff swallow	612	0.5	0.2	1.1	0.6
98	Savannah sparrow	188	1.1	0.0	0.5	0.5
99	Common nighthawk	271	0.7	0.0	0.4	0.4
100	Tree swallow	334	0.0	0.0	0.9	0.3
100	Western kingbird	117	0.0	0.0	0.9	0.3
102	Semipalmated plover	53	0.0	0.0	0.0	0.0
102	American pipit	36	0.0	0.0	0.0	0.0
102	Song sparrow	50	0.0	0.0	0.0	0.0
102	Gray catbird	38	0.0	0.0	0.0	0.0
102	Yellow-rumped warbler	39	0.0	0.0	0.0	0.0
102	Yellow bittern	45	0.0	0.0	0.0	0.0
102	Sky lark	48	0.0	0.0	0.0	0.0

Table 19. Continued (page 4 of 4).

Hazard rank	Wildlife species	Total reported strikes	Percent of strikes with:			Mean hazard level[3]
			Damage	Major damage	Effect on flight	
	Terrestrial mammals					
1	Mule deer	63	90.5	34.9	49.2	58.2
2	White-tailed deer	925	83.5	34.8	45.7	54.7
3	Domestic dog	35	31.4	17.1	54.3	34.3
4	Coyote	376	8.5	1.6	20.7	10.3
5	Eastern cottontail	60	5.0	1.7	6.7	4.4
6	Red fox	96	3.1	0.0	8.3	3.8
7	Raccoon	75	4.0	2.7	4.0	3.6
8	Woodchuck	105	1.9	0.0	3.8	1.9
9	Black-tailed jackrabbit	162	1.9	0.6	1.2	1.2
10	Virginia opossum	125	0.8	0.0	0.0	0.3
11	White-tailed jackrabbit	36	0.0	0.0	0.0	0.0
11	Striped skunk	126	0.0	0.0	0.0	0.0

[1] See Dolbeer and Wright (2009) for a more detailed discussion of the use of wildlife strike data to rank species as to their hazard level to air operations and for use in airport Wildlife Hazard Management Plans and Safety Management Systems.

[2] Wildlife species with fewer than 30 reported strikes are not listed in this table. This does not imply that unlisted species are not hazardous to aircraft. If a species not on this list is located at an airport, the hazard level of the species can be approximated by using the hazard level of a similar species in this table.

[3] Based on the mean value for percent of strikes with damage, major damage (substantial damage or destroyed, Table 13), and negative effect-on-flight (Table 14).

Table 20. Number of strikes to civil aircraft causing human fatality or injury and number of injuries and fatalities by wildlife species, USA, 1990–2011.

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	5	7		Turkey vulture	13	16
White-tailed deer	1	1		Osprey	2	2
Brown pelican	1	1		Bald eagle	3	5
Amer. white pelican	1	5		Golden eagle	2	4
Canada goose	1	2		Hawks	3	5
Red-tailed hawk	1	8		Red-tailed hawk	5	6
Total (fatalities)	**10**	**24**		American kestrel	1	5
				Eurasian kestrel	1	4
Strikes causing injuries				Sharp-tailed grouse	1	2
Unknown bird	38	48		Sandhill crane	1	1
Grebes	1	2		American coot	3	3
Western grebe	1	1		Gulls	8	9
Horned grebe	1	1		Herring gull	3	3
Tropicbirds	1	1		Ring-billed gull	2	8
Red-tailed tropicbird	1	1		Franklin's gull	1	1
D.-crstd cormorant	3	3		Doves	1	1
Anhinga	3	4		Rock pigeon	3	3
Great frigatebird	1	1		Mourning dove	1	1
Egrets	1	1		Spotted dove	1	4
Snowy egret	1	1		Owls	1	1
Ducks	14	17		Great-tailed grackle	1	1
Mallard	5	6		Sparrows	1	1
Lesser scaup	2	2		Eastern cottontail	1	1
Long-tailed duck	1	1		Domestic dog	1	2
Geese	7	7		White-tailed deer	18	25
Snow goose	3	3		Mule deer	1	2
Canada goose	16	19		Cattle	2	3
Cackling goose	1	1		Horse	1	1
Vultures	10	10				
Black vulture	6	6		**Total (injuries)**	**199**	**256**

Table 21. Number of civil aircraft lost (destroyed or damaged beyond repair) after striking wildlife by wildlife species and aircraft mass category, USA, 1990-2011[1].

	Aircraft[2] mass category (Maximum takeoff mass)				Total aircraft lost
Wildlife species or species group	≤2,250 kg	2,251-5,700 kg	5,701-27,000 kg	>27,000 kg	
White-tailed deer	12	5	1	0	18
Unknown bird	10	2	1	0	13
Canada goose	1	3		1	5
Cattle	2	1		0	3
Hawks	2			0	2
Turkey vulture	2			0	2
Amer. white pelican		1		0	1
Bald eagle	1			0	1
Brown pelican	1			0	1
Coyote			1	0	1
Domestic dog	1			0	1
D.-crested cormorant	1			0	1
Ducks	1			0	1
Eastern cottontail	1			0	1
Eurasian kestrel				1	1
Mourning dove			1	0	1
Red-tailed hawk		1		0	1
Ring-billed gull		1		0	1
Vultures	1			0	1
Wapiti (elk)			1	0	1
Total	**36**	**14**	**5**	**2**	**57**

[1] Thirty-two (56 percent) of the 57 wildlife strikes resulting in a destroyed aircraft occurred at General Aviation airports, 15 occurred away from an airport, 8 occurred at USA airports certificated for passenger service under 14 CFR Part 139, and 2 occurred at a foreign airport certificated for passenger service.

[2] Engine types on the 57 destroyed aircraft were piston (42), turbofan (6), turbojet (2), turboprop (5), and turboshaft (2). Aircraft operator was business (30), private (22), and commercial transport (5).

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 U.S. dollars, for civil aircraft, USA, 1990–2011.

	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	115,168	33,060
1991	401	187	61	51	23	79.8	39,123	23,560
1992	368	221	80	53	27	113.3	57,746	3,093
1993	399	240	67	58	19	277.9	51,677	5,524
1994	464	274	103	75	26	388.4	45,150	61,682
1995	500	311	95	63	30	104.3	309,806	150,581
1996	505	373	145	84	39	136.4	52,000	16,199
1997	582	388	184	128	47	228.2	49,157	26,114
1998	588	404	205	140	54	119.5	130,022	19,053
1999	706	448	284	179	79	147.8	74,754	14,240
2000	765	477	352	225	84	195.6	100,017	88,425
2001	650	437	293	166	57	156.2	194,407	31,959
2002	675	505	387	175	58	134.2	105,478	50,878
2003	635	443	360	193	64	110.5	107,701	40,495
2004	628	434	325	226	83	172.2	79,200	19,280
2005	609	460	329	239	115	87.5	202,359	66,584
2006	599	434	332	176	99	117.2	172,559	11,193
2007	571	459	367	185	131	163.9	140,440	28,948
2008	528	413	372	168	136	113.7	96,073	12,747
2009	607	522	563	210	182	80.7	300,544	13,242
2010	598	470	528	182	159	64.2	110,592	12,537
2011	541	500	522	185	194	67.1	207,914	14,822
Total	**12,291**	**8,546**	**6,015**	**3,194**	**1,722**			
22-yr mean	**559**	**388**	**273**	**145**	**78**	**126.5**	**135,092**	**28,662**

Table 23. Projected annual losses in aircraft downtime (hours) and in repair and other costs (U.S. dollars) caused by wildlife strikes with civil aircraft, USA, 1990–2011. Losses are projected from mean reported losses per incident (see Table 22).

		Minimum projected losses[1]				Maximum projected losses[2]	
Year	No. of adverse incidents[3]	Down-time (hours)	Repair costs (x $1 million)	Other costs (x $1 million)	Total costs (x $1 million)	Down-time (hours)	Total costs (x $1 million)
1990	427	23,758	49	14	63	118,790	316
1991	487	38,840	19	11	31	194,201	153
1992	496	56,203	29	2	30	281,015	151
1993	509	141,456	26	3	29	707,282	146
1994	586	227,624	26	36	63	1,138,120	313
1995	660	68,828	204	99	304	344,138	1,519
1996	692	94,374	36	11	47	471,872	236
1997	792	180,718	39	21	60	903,590	298
1998	812	97,036	106	15	121	485,180	605
1999	983	145,259	73	14	87	726,295	437
2000	1,119	218,911	112	99	211	1,094,554	1,054
2001	984	153,742	191	31	223	768,712	1,114
2002	1,112	149,261	117	57	174	746,304	869
2003	1,006	111,135	108	41	149	555,675	745
2004	957	164,775	76	18	94	823,874	471
2005	983	85,990	199	65	264	429,950	1,322
2006	946	110,824	163	11	174	554,122	869
2007	983	161,124	138	28	167	805,618	833
2008	913	103,787	88	12	99	518,937	497
2009	1,191	96,158	358	16	374	480,790	1,869
2010	1,133	72,739	125	14	140	363,697	698
2011	1,142	76,606	237	17	254	383,029	1,272
Total	**18,913**	**2,579,150**	**2,521**	**636**	**3,157**	**2,895,748**	**15,787**
22-yr mean	**860**	**117,234**	**115**	**29**	**144**	**586,170**	**718**

[1] Minimum values are based on the assumption that all 18,913 reported strikes (mean of 860/year) indicating an adverse effect (see footnote 3) incurred similar amounts of damage and/or downtime and

Table 23. Continued (Page 2 of 2).

that these reports are all of the adverse-effect strikes that occurred, 1990-2011.

[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). Analyses of strike data from 2004-2008 indicated strike reporting at Part 139 airports had improved to 39 percent (Dolbeer 2009). Strike reporting for General Aviation (GA) aircraft is estimated at less than 5 percent (Dolbeer et al. 2008, Dolbeer 2009). Maximum values for reported losses are based on the assumption that the 18,913 reported strikes indicating an adverse effect represent, on average, 20 percent of the total strikes that occurred with commercial and GA aircraft from 1990-2011.

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

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Figures

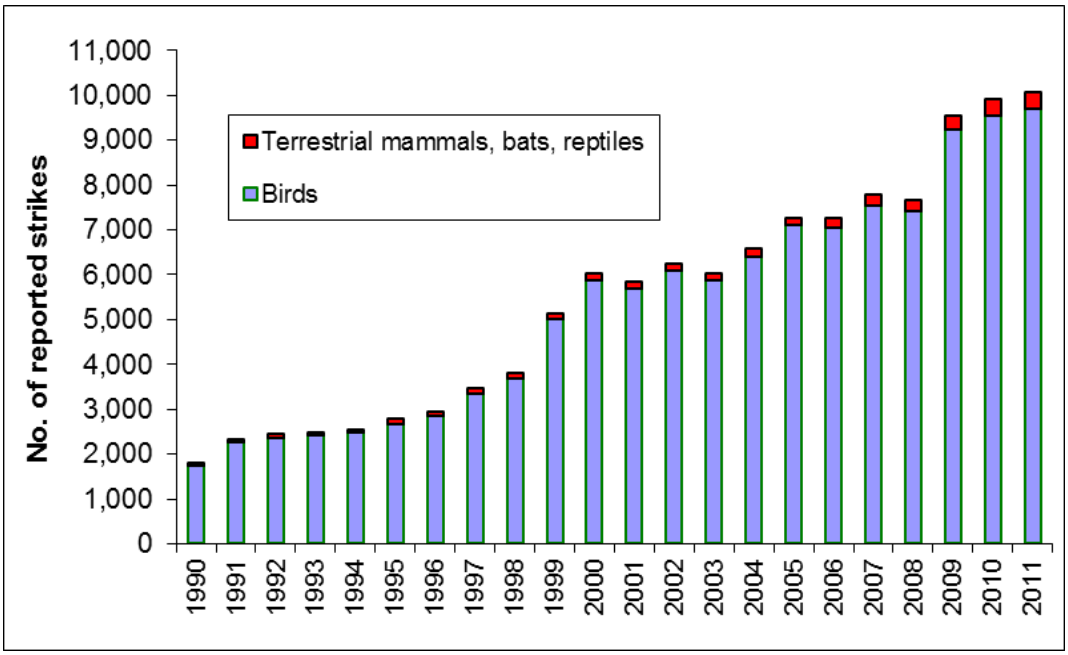


Figure 1. Number of reported wildlife strikes with civil aircraft, USA, 1990–2011. The 119,917 strikes involved birds (116,408), terrestrial mammals (2,754), bats (618), and reptiles (137, see Table 1).

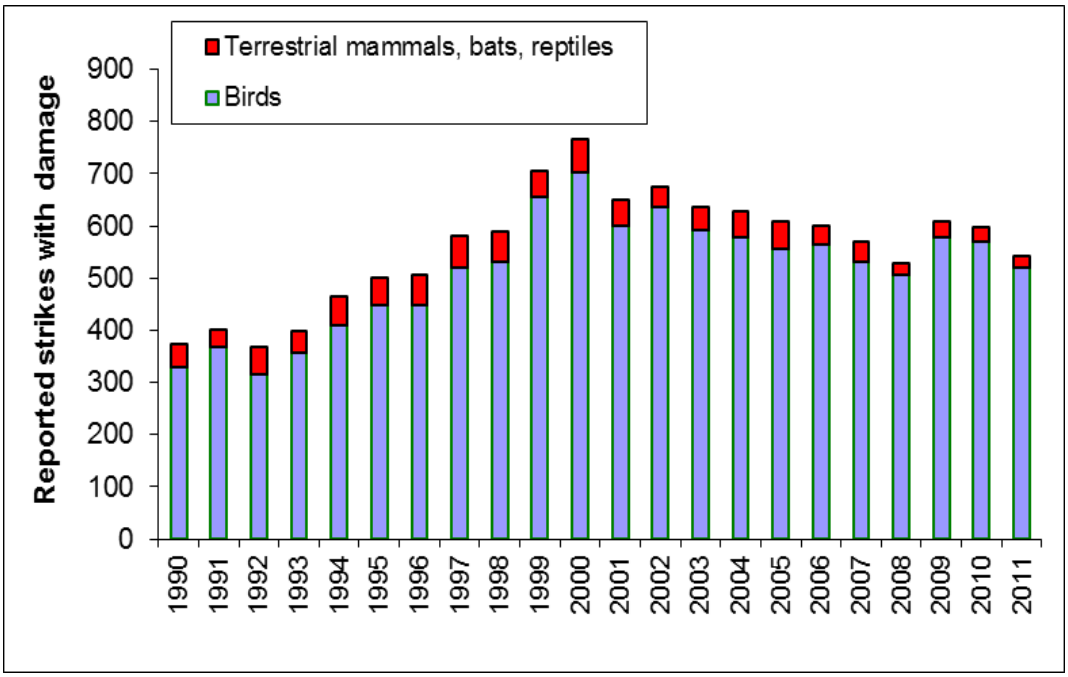


Figure 2. Number of reported wildlife strikes causing damage to civil aircraft, USA, 1990–2011. The 12,291 damaging strikes involved birds (11,315), terrestrial mammals (966), bats (9), and reptiles (1, see Table 1).

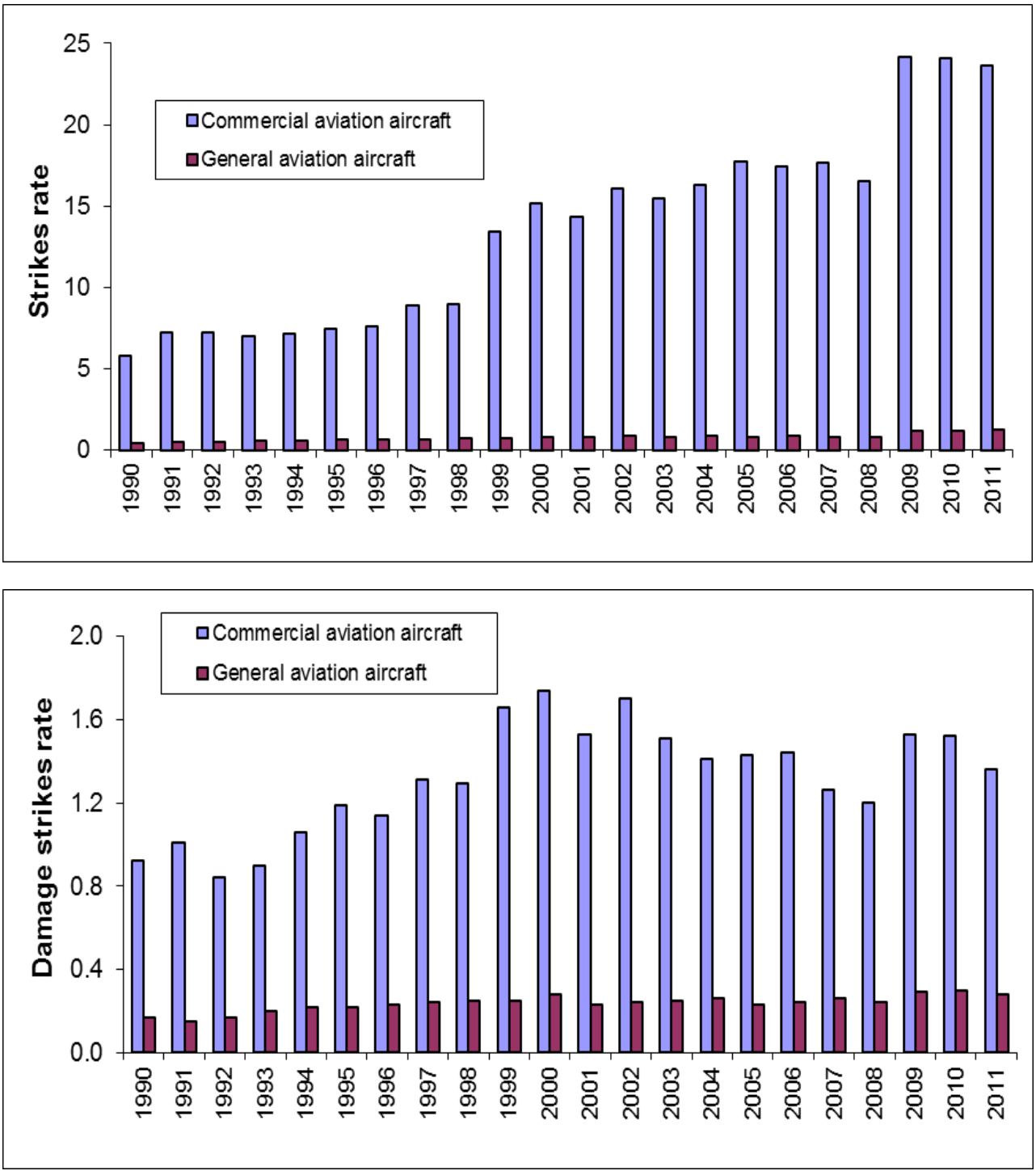


Figure 3. The strike rate (number of reported wildlife strikes per 100,000 aircraft movements, top graph) and damaging strike rate (number of reported damaging wildlife strikes per 100,000 aircraft movements, bottom graph) for commercial (air carrier, commuter, and air taxi service) and general aviation aircraft, USA, 1990–2011 (see Tables 2 and 3).

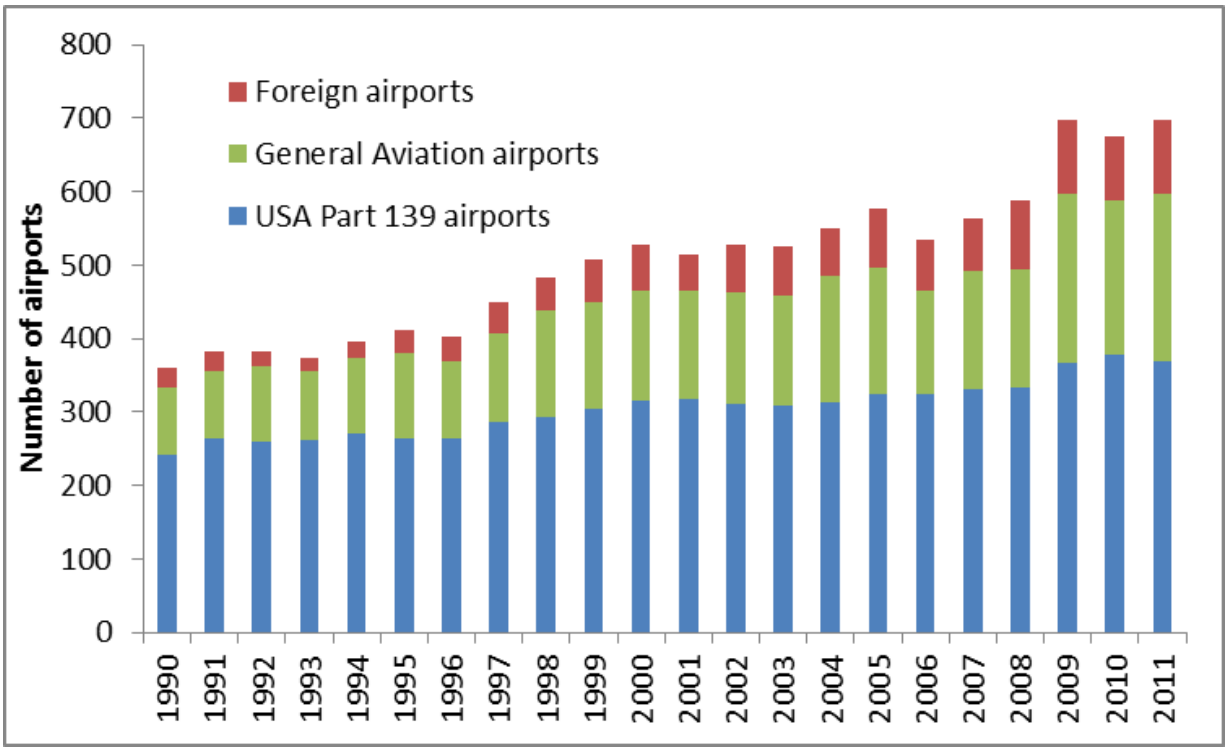
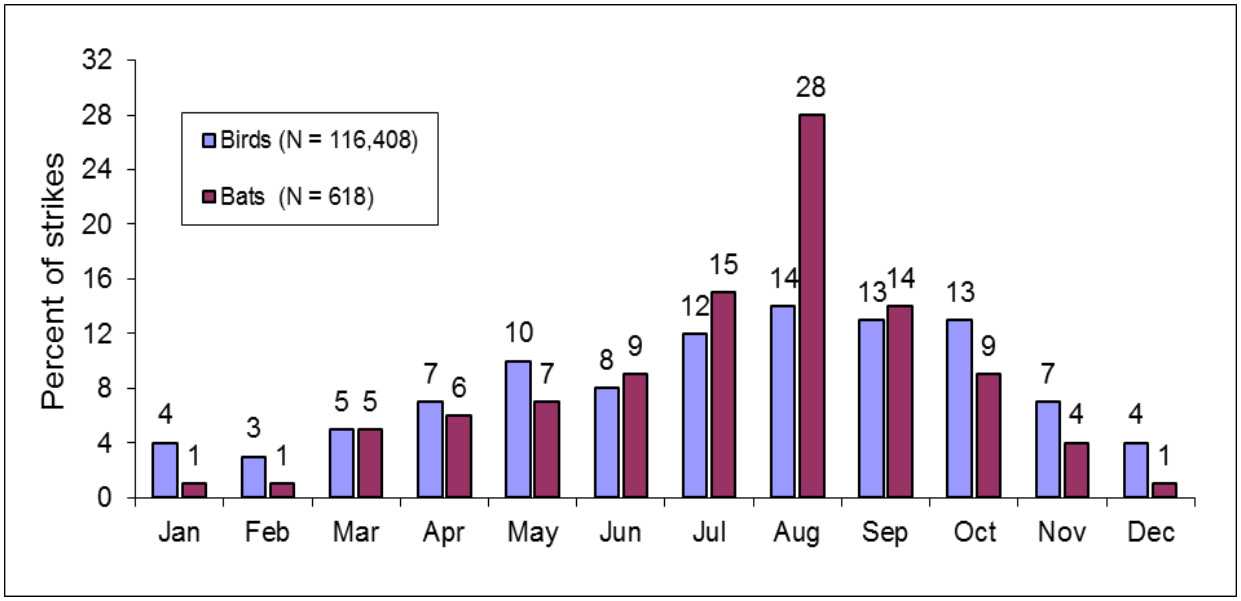


Figure 4. Number of Part 139-certificated airports and General Aviation airports in USA with reported wildlife strikes and number of foreign airports at which strikes were reported for USA-registered civil aircraft, 1990–2011. Strikes were reported from 1,714 USA airports and 259 foreign airports, 1990 - 2011 (Table 7).



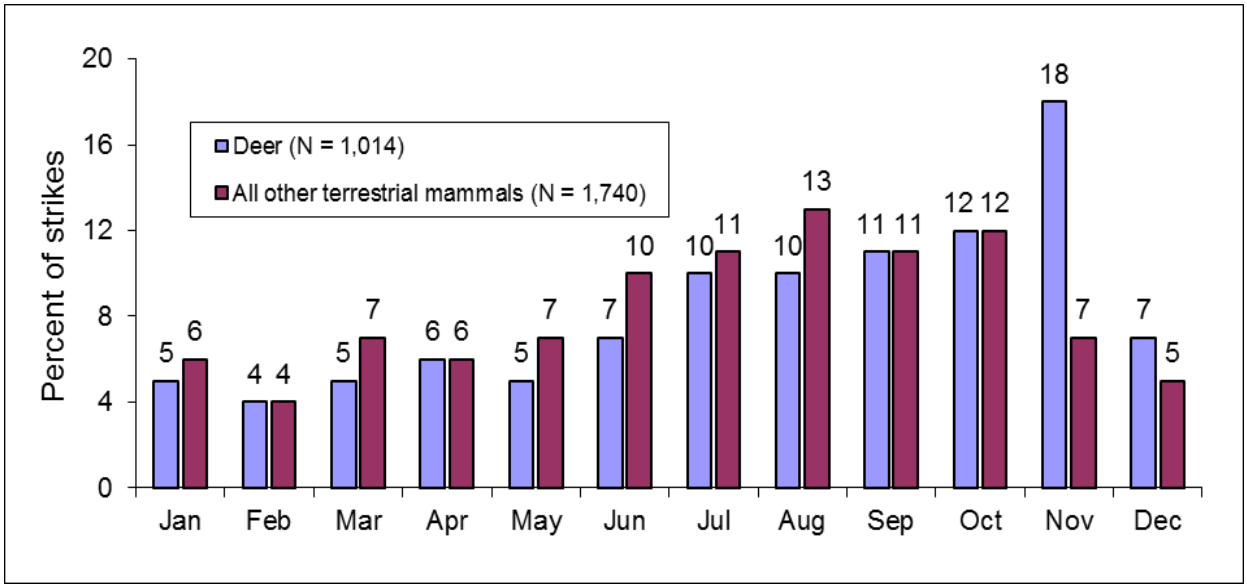
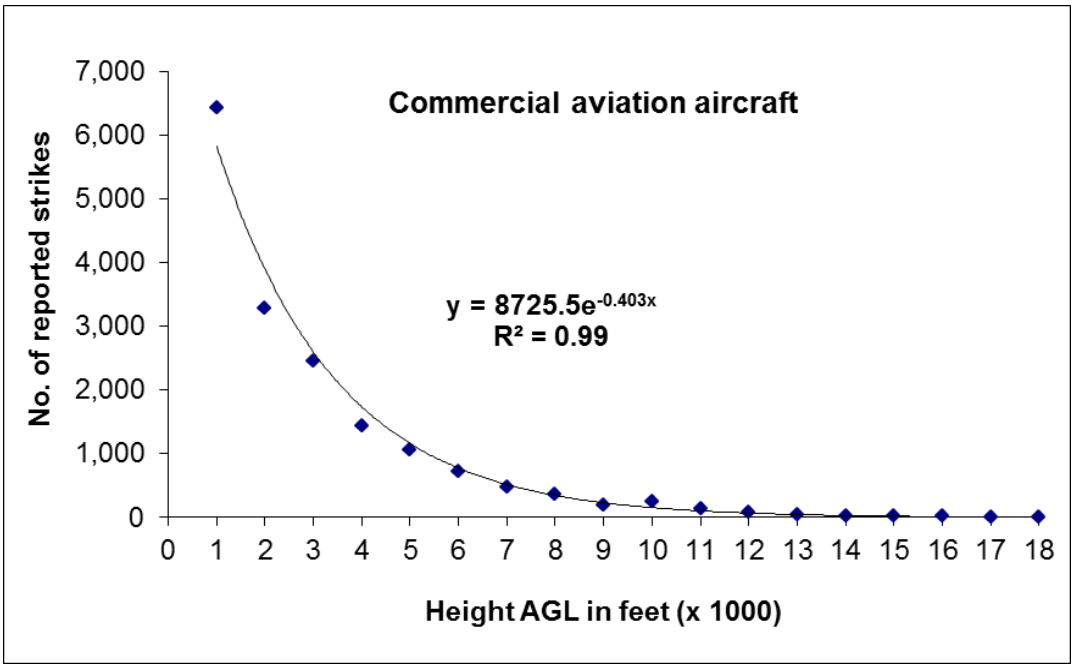


Figure 5. The percentage of reported bird and bat strikes (top graph) and deer and other terrestrial mammal strikes (bottom graph) with civil aircraft by month, USA, 1990–2011. In addition, 137 strikes with reptiles were reported of which 67 percent occurred in May - June. Deer strikes were comprised of 925 white-tailed deer, 63 mule deer, and 26 deer not identified to species. Biondi et al (2011) provide a detailed analysis of deer strikes with civil aircraft in the USA.



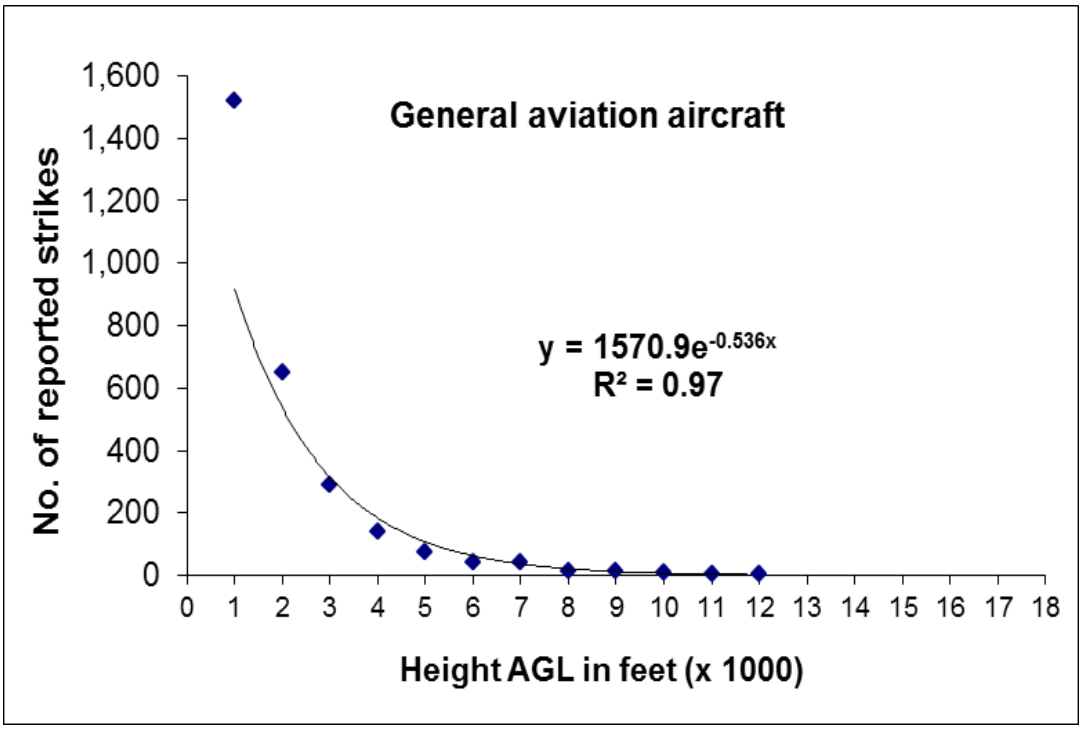


Figure 6. Number of reported bird strikes with commercial (top graph) and general aviation aircraft (bottom graph) in USA from 1990—2011 by 1,000-foot height intervals above ground level from 501—1,500 feet (interval 1) to 17,501—18,500 feet (interval 18). These graphs exclude strikes occurring at 500 feet or less. Above 500 feet, the number of reported strikes declined consistently by 33 percent and 41 percent for each 1,000 foot gain in height for commercial and general aviation aircraft, respectively. The negative exponential equations explained 97 to 99 percent of the variation in number of strikes by 1,000-foot intervals from 500 to 18,500 feet. See Tables 10 and 11 for sample sizes.

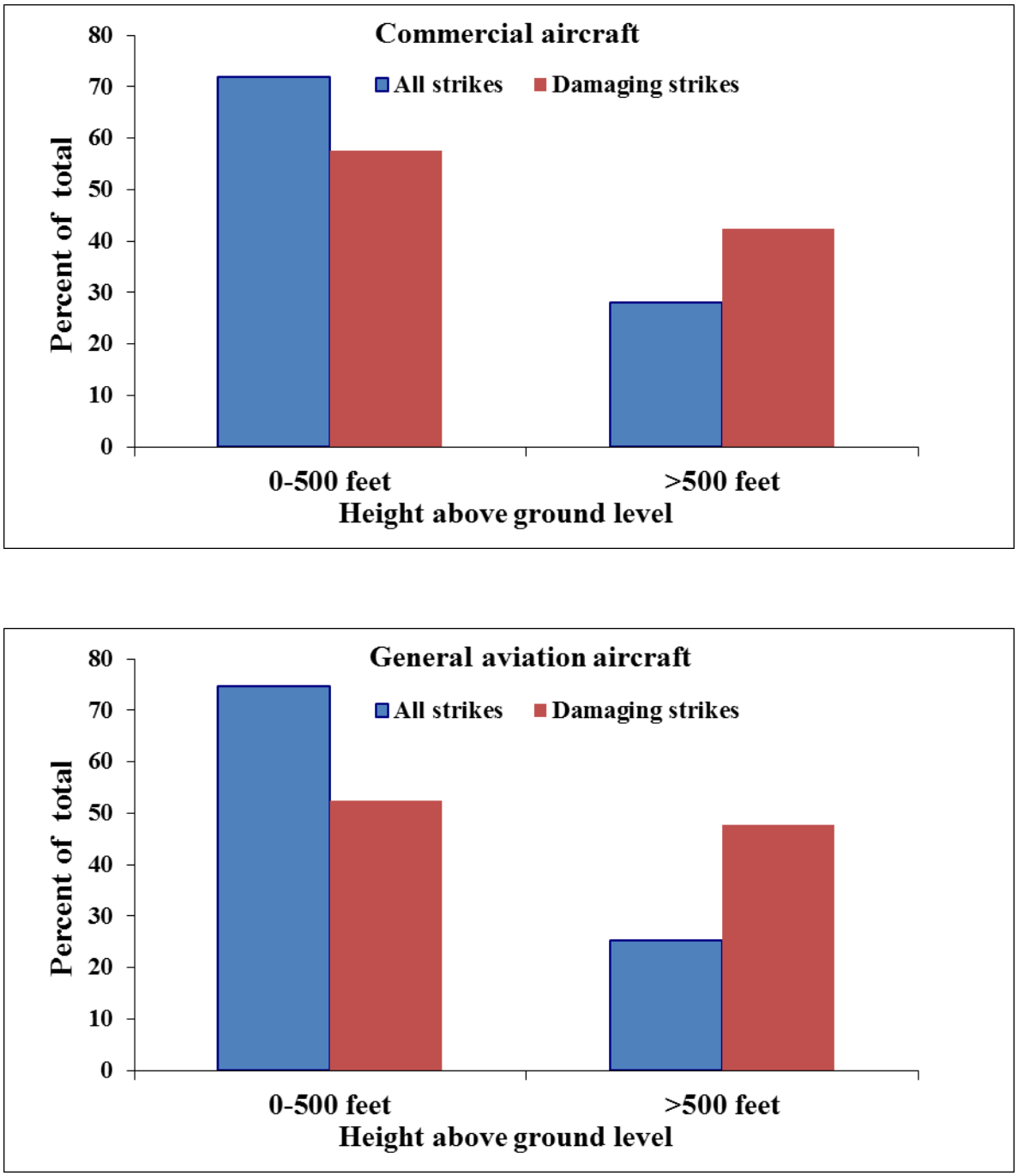


Figure 7. Percentage of total strikes and percentage of total damaging strikes occurring at 500 feet or less and above 500 feet for commercial (top graph) and general aviation (bottom graph) aircraft. See Tables 10 and 11 for sample sizes.

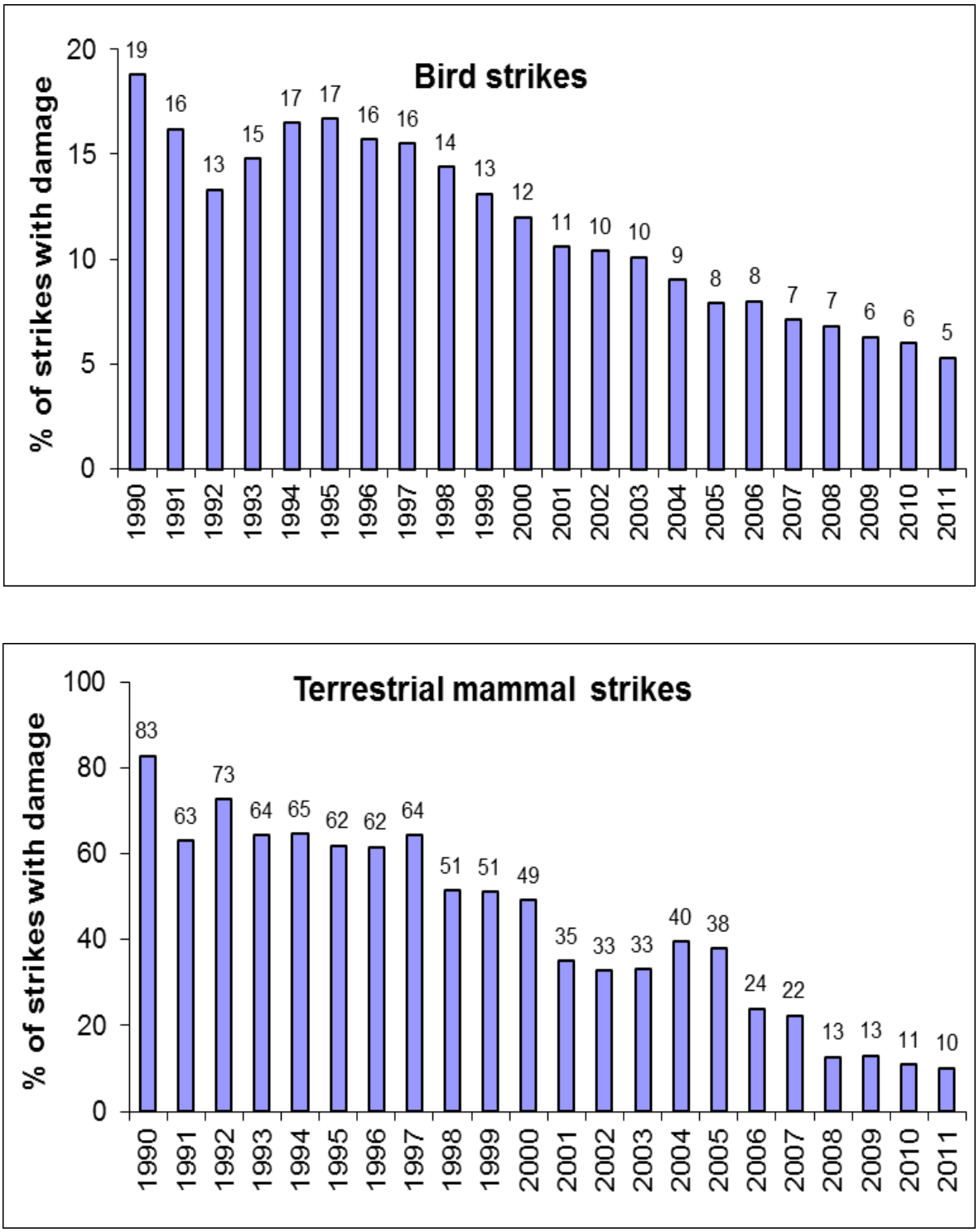


Figure 8. The percentage of reported bird strikes (top graph) and terrestrial mammal strikes (bottom graph) that indicated damage to the civil aircraft, USA, 1990-2011. See Tables 1 and 13 for sample sizes and classifications of damage.

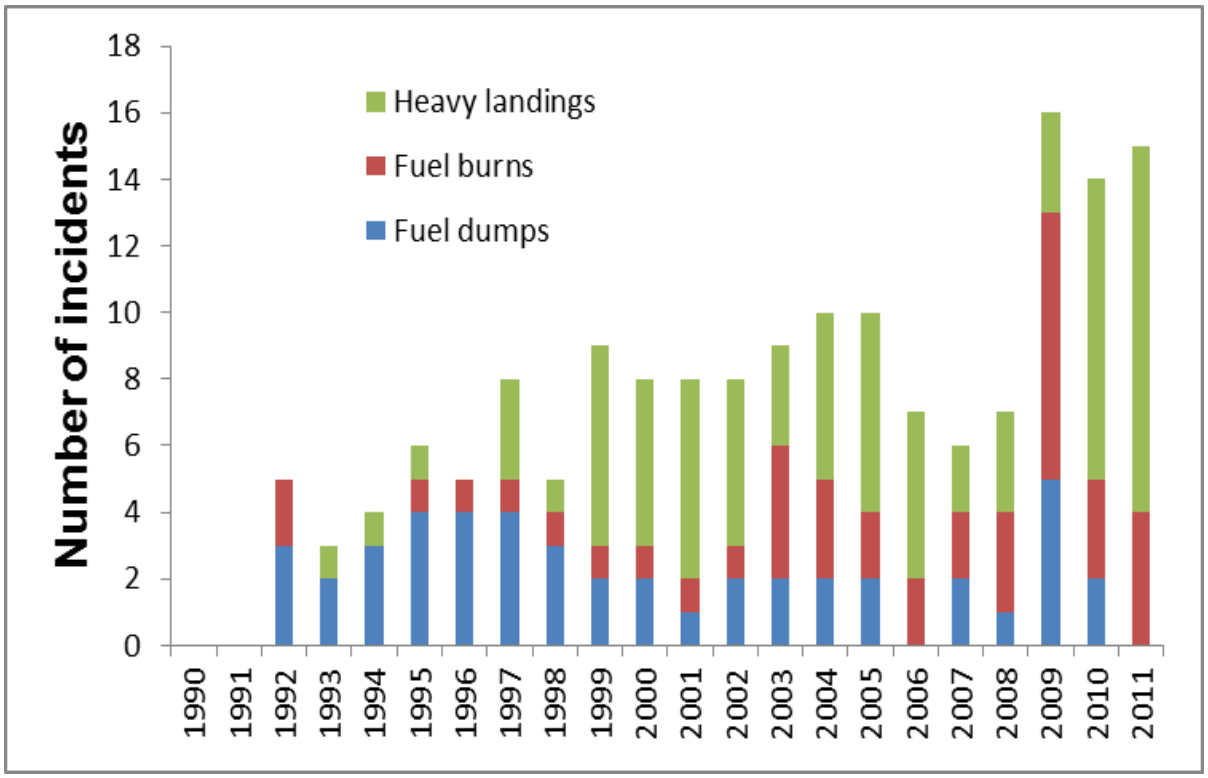


Figure 9. Number of reported incidents where pilot made an emergency or precautionary landing after striking birds during departure in which fuel was dumped or burned (circling pattern) to lighten aircraft weight or in which a heavy (overweight) landing was made (no fuel dump or burn), USA civil aircraft, 1990-2011. See Table 15 for details on aircraft involved and amount of fuel dumped.

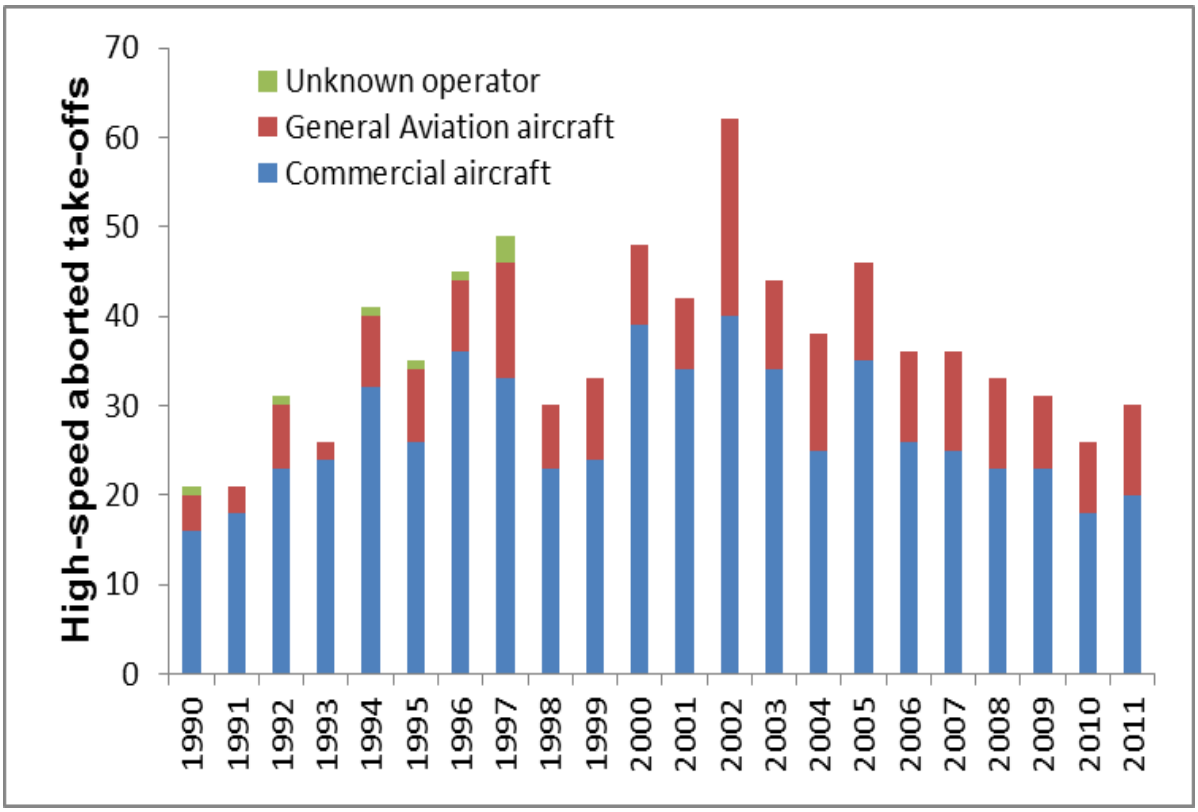


Figure 10. Number of reported incidents in which pilot made an aborted take-off at ≥80 knots after striking birds or other wildlife during take-off run, USA civil aircraft, 1990-2011. See Table 16 for classification of aborted take-offs by speed of aircraft.

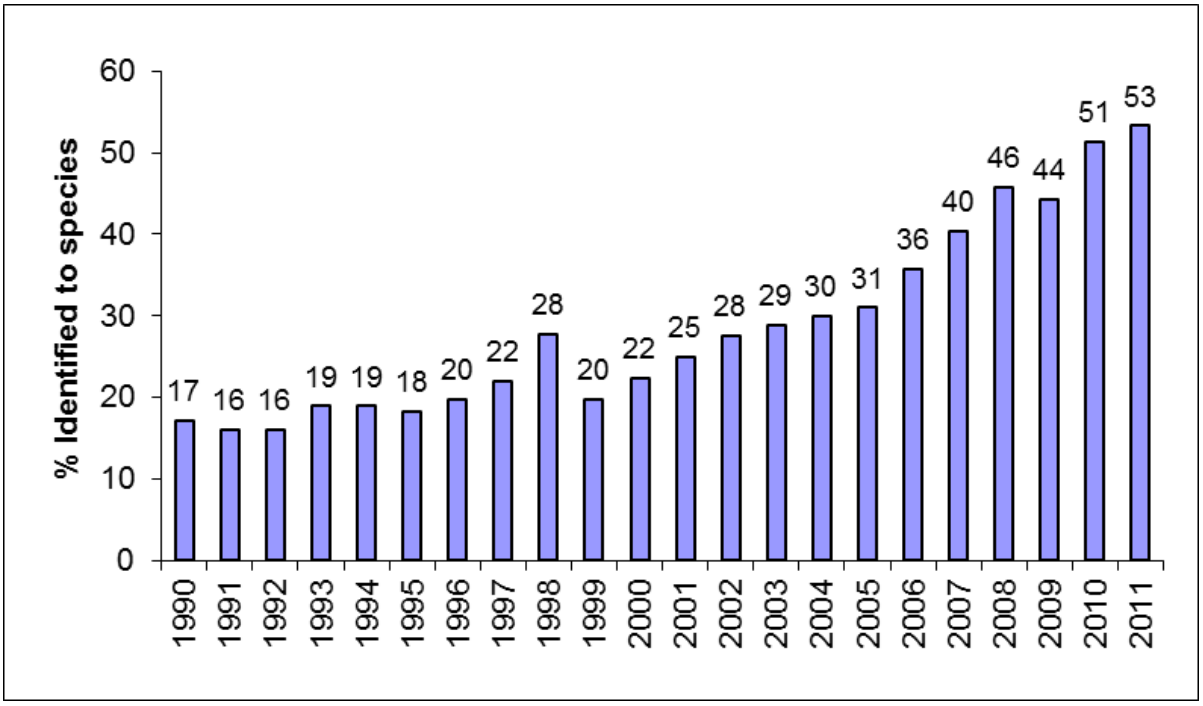


Figure 11 The percentage of reported bird strikes with civil aircraft in which the bird was identified to exact species, USA, 1990-2011. See Tables 1 and 17 for sample sizes.

APPENDIX A.

SELECTED SIGNIFICANT WILDLIFE STRIKES TO U.S. CIVIL AIRCRAFT, 2011

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. We compiled 119,917 strike reports from 1,714 USA airports and 259 foreign airports for 1990 through 2011 (10,083 strikes from 597 airports in 2011, Tables 1, 7; Figure 4). The following examples from the database in 2011 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:	7 January 2011
Aircraft:	MD-10-30
Airport:	Sacramento International (CA)
Phase of Flight:	Climb (2,000' AGL)
Effect on Flight:	Precautionary landing
Damage:	Engine, nose cowl and radome
Wildlife Species:	Greater white-fronted goose
Comments from Report: Aircraft diverted to OAK after the strike. Pilot reported striking ducks or geese. The #3 engine was removed along with the nose cowl, both thrust reversers and the radome. ID by Smithsonian, Division of Birds. Costs estimated at $3.2 million and time out of service was 6 days.	

Date:	9 January 2011
Aircraft:	Bell 427
Airport:	La Isabela International (Dominican Republic)
Phase of Flight:	Climb (90' AGL)
Effect on Flight:	Impacted terrain
Damage:	Destroyed?
Wildlife Species:	Mallard and gadwall
Comments from Report: At least 2 birds struck the tail rotor causing the aircraft to crash about 2 miles from the airport. Both pilots were injured. The aircraft broke into two pieces. The cause of the accident was unknown at first. ID by Smithsonian, Division of Birds. Aircraft may or may not be repaired. Cost estimated at $1.5 million. U.S.-registered aircraft.	

Date:	28 February 2011
Aircraft:	B-737-800
Airport:	Ronald Reagan Washington National (DC)
Phase of Flight:	Climb (1,200' AGL)
Effect on Flight:	Emergency landing, engine shut down
Damage:	Engine
Wildlife Species:	Canada goose
Comments from Report: Just after takeoff, pilot reported striking birds flying in "V" formation at approximately 1200' over the Potomac River. Aircraft diverted to IAD due to possible engine shutdown and precautionary landing. Engine was reduced to idle but not shut down. ID by Smithsonian, Division of Birds. Time out of service 110 hours. Cost reported as $793,776.	

Date:	15 March 2011
Aircraft:	Airbus 300
Airport:	Tulsa International (OK)
Phase of Flight:	Climb (25' AGL)
Effect on Flight:	Precautionary landing
Damage:	Engine #1 and #2, wing
Wildlife Species:	Gadwall
Comments from Report: Aircraft hit a flock of large birds during rotation. They returned to land. Damage included engine fan blade and outlet guide vanes in the #1 engine, #2 engine fan cowl and right wing inboard flap track fairing. ID by Smithsonian, Division of Birds. Time out of service 85 hours. Cost reported as $5,871,028.	

Date:	31 March 2011
Aircraft:	Robinson R44
Airport:	San Antonio International (TX)
Phase of Flight:	Approach
Effect on Flight:	Emergency landing on highway
Damage:	Windshield
Wildlife Species:	Great-tailed grackle
Comments from Report: During approach to landing, a bird broke through the passenger side of the windshield injuring the passenger. The pilot made an emergency landing on Highway I-37 around 9 p.m. A tow truck was called to remove the aircraft.	

Date:	1 April 2011
Aircraft:	CRJ 200
Airport:	Adams Field (AR)
Phase of Flight:	Descent (5,000' AGL)
Effect on Flight:	Engine shut down, emergency landing
Damage:	Radome, engine #1 and #2, pylon
Wildlife Species:	American white pelican
Comments from Report: About 20 miles out, during descent, the radome, radar, electronic equipment, and both engines sustained damage when struck by a flock of white pelicans. The #1 engine was shut down and an emergency was declared. Remains were imbedded in the radome. ID by Smithsonian, Division of Birds. Aircraft was out of service for 47 days. Costs totaled $830,000.	

Date:	20 April 2011
Aircraft:	B-767-300
Airport:	Orlando-Sanford (FL)
Phase of Flight:	Climb (10’ AGL)
Effect on Flight:	Precautionary landing
Damage:	Engine
Wildlife Species:	Bald eagle
Comments from Report: Bird was ingested at rotation. Aircraft leveled off at 3,000’. Kept engine running and returned for a safe landing about 20 minutes later. Passenger heard a big bang and smelled a burning odor. Fire crews met the aircraft. Bald eagle remains were recovered from the runway. Passengers were taken to hotels and departed the next day. ID by Smithsonian, Division of Birds. Time out of service 120 hours, Cost estimated at $4,570,000.	

Date:	14 May 2011
Aircraft:	A-320
Airport:	John F. Kennedy International (NY)
Phase of Flight:	Climb (300’ AGL)
Effect on Flight:	Precautionary landing
Damage:	Engine
Wildlife Species:	Herring gull
Comments from Report: Bird was ingested during climb at mid-field. An emergency was declared and the aircraft returned to make an overweight landing. Some remains were found on the runway. Passengers were put on another aircraft and departed a few hours later. Aircraft was out of service for 3 days and the engine was replaced. ID by Smithsonian, Division of Birds.	

Date:	5 June 2011
Aircraft:	PA-32
Airport:	Hefner-Easley (OK)
Phase of Flight:	Landing roll
Effect on Flight:	Nose gear collapsed
Damage:	Landing gear, propeller, firewall
Wildlife Species:	White-tailed deer
Comments from Report: During landing flare and touchdown, 2 deer ran onto the runway. The aircraft hit 1 deer, separating the landing gear. The nose of the aircraft settled to the runway and the aircraft skidded 500 feet before stopping. NTSB investigated.	

Date:	18 June 2011
Aircraft:	B-737-400
Airport:	Orlando International (FL)
Phase of Flight:	Takeoff run
Effect on Flight:	Precautionary landing, engine shut down
Damage:	Engine
Wildlife Species:	Cattle egret
Comments from Report: Bird was ingested into the core of the #1 engine at rotation. The engine was shut down as a precaution and they returned to land. The engine was replaced. ID by airport biologist.	

Date:	30 June 2011
Aircraft:	Piper-31
Airport:	Natrona County International (WY)
Phase of Flight:	Approach (5' AGL)
Effect on Flight:	Hard landing, evasive maneuver, vision obscured
Damage:	Aircraft destroyed
Wildlife Species:	Unknown large bird
Comments from Report: Pilot was 5-10 feet above the runway when a large bird flew past the windshield. The pilot reacted to avoid the bird and the left wing came into contact with the runway causing the aircraft to nose into the ground. The wing was severely damaged, the left landing gear collapsed and both propellers were bent. NTSB investigated. Aircraft was damaged beyond repair.	

Date:	23 July 2011
Aircraft:	MD-82
Airport:	Memphis International (TN)
Phase of Flight:	Takeoff run
Effect on Flight:	Precautionary landing, emergency declared
Damage:	Engine
Wildlife Species:	Eastern meadowlark
Comments from Report: A bird or birds were ingested into the #1 engine at rotation. A bird smell was noted and the captain saw something pass by in front of the aircraft. Engine vibrations caused the pilot to reduce power and declare an emergency. The aircraft returned safely. There was severe damage to all fan blades. An Eastern meadowlark was found on the runway and remains scraped from the exhaust portion of the engine were also identified as an Eastern meadowlark by the Smithsonian, Division of Birds.	

Date:	5 August 2011
Aircraft	C-340
Airport:	East Hampton (NY)
Phase of Flight:	Landing roll
Effect on Flight:	Nose gear collapsed
Damage:	Radome, nose, engine, propeller, landing gear
Wildlife Species:	White-tailed deer
Comments from Report: During landing roll, 3 deer entered the runway at a fast pace moving toward the centerline. A few seconds later 1 deer was struck and the nose gear collapsed. The aircraft exited the runway and was evacuated. The runway was closed for over 3 hours. The right leading edge and the underside of the wing were covered in blood along with the right engine spinner and right landing gear. The deer was cut in half with body parts scattered along the runway. Time out of service was 33 days. Costs totaled $60,000.	

Date:	12 August 2011
Aircraft	MD-83
Airport:	Austin-Bergstrom International (TX)
Phase of Flight:	Climb (2,500' AGL)
Effect on Flight:	Precautionary landing
Damage:	Radome, pressure bulkhead
Wildlife Species:	Black vulture
Comments from Report: Crew saw 4 large black birds. Strike occurred 3-5 miles south of the airport. They returned for a safe landing. The nose cone was damaged beyond repair and the pressure bulkhead was torn away from the fuselage. Passengers were rebooked on other flights. Time out of service was 24 hours. Costs totaled $600,000.	

Date:	19 September 2011
Aircraft	B-757-200
Airport:	Salt Lake City International (UT)
Phase of Flight:	Climb (1000’ AGL)
Effect on Flight:	Precautionary landing
Damage:	Engine, spinner
Wildlife Species:	Northern pintail
Comments from Report: Engine ingested a bird or birds and stalled. Passenger saw flames coming from the engine. An emergency was declared and a safe landing was made. The spinner was damaged and 4 fan blades were replaced. Cost estimated at $50,000. ID by Smithsonian, Division of Birds.	

Date:	25 September 2011
Aircraft	B-737-800
Airport:	Metro Oakland International (CA)
Phase of Flight:	Climb (20’ AGL)
Effect on Flight:	Precautionary landing
Damage:	Engine
Wildlife Species:	Canada geese
Comments from Report: Numerous birds were struck and ingested into the #2 engine. Engine was turned back to idle to avoid overheating. A safe emergency landing was made. Engine was changed out. ID by Smithsonian, Division of Birds.	

Date:	26 September 2011
Aircraft	B-757
Airport:	Denver International (CO)
Phase of Flight:	Landing roll
Effect on Flight:	Engine shut down
Damage:	Engine #1 and #2, fuselage, landing gear
Wildlife Species:	Red-tailed hawk
Comments from Report: Aircraft ingested bird in #1 engine during landing roll. Internal and external damage. Per pilot, engines were at full reverse thrust causing debris to be thrown in front of aircraft and through #2 engine. Intact red-tailed hawk remains found on the runway. ID by Smithsonian, Division of Birds. Time out of service was 21 days. Cost of repairs was $4,533,289. Cost for time out of service was $560,700.	

Date:	9 October 2011
Aircraft	B-737-400
Airport:	Sitka Rocky Gutierrez (AK)
Phase of Flight:	Approach
Effect on Flight:	Flight cancelled
Damage:	Engine
Wildlife Species:	Glaucous-winged gull
Comments from Report: Aircraft ingested gull in the #1 engine during approach at runways threshold. Rotor blades were bent and titanium heat shield stripping broke from aircraft and was found on runway. Departing flight cancelled due to damage. ID by Smithsonian, Division of Birds. Cost of repairs was estimated at $1million.	

Date:	10 November 2011
Aircraft	A-320
Airport:	Minneapolis –St Paul International (MN)
Phase of Flight:	Climb (2,500' AGL)
Effect on Flight:	Precautionary landing, emergency declared
Damage:	Radome, nose, engine
Wildlife Species:	Tundra swan
Comments from Report: Bird hit right side of nose. The forward pressure bulkhead was damaged. Aircraft returned to land after declaring an emergency. Time out of service reported as about 10 days. ID by Smithsonian, Division of Birds. Event was reported to the NTSB.	

Date:	11 November 2011
Aircraft	C-550
Airport:	Warroad International. Memorial (MN)
Phase of Flight:	Landing roll
Effect on Flight:	Engine shut down
Damage:	Wing root, fuel tank
Wildlife Species:	White-tailed deer
Comments from Report: Aircraft hit a deer during landing roll. Pilot did not see the deer as landing was at night. Fuel tank was punctured. Pilot taxied to ramp. EPA will have to investigate.	

Date:	17 November 2011
Aircraft	Eurocopter EC135
Airport:	Near Jackson, MS
Phase of Flight:	En Route
Effect on Flight:	Emergency landing
Damage:	Windshield
Wildlife Species:	Lesser scaup
Comments from Report: While transporting a patient, 4 miles from KJAN, 2 birds hit the aircraft and broke through the right windshield injuring the pilot when it hit him in the face. The pilot made a safe landing at KJAN. ID by Smithsonian, Division of Birds.	

Date:	19 December 2011
Aircraft	B-737-700
Airport:	Metropolitan Oakland International (CA)
Phase of Flight:	Descent (7,500' AGL)
Effect on Flight:	None
Damage:	Wing
Wildlife Species:	Greater white-fronted goose
Comments from Report: Substantial damage to k-flaps, wing root, wing and body fairing and underlying structure. Aircraft was taken to SEA for repairs. Time out of service was 8 days. Cost reported as between $150,000 and $200,000. ID by Smithsonian, Division of Birds.	

Date:	31 December 2011
Aircraft	B-737
Airport:	Portland International (OR)
Phase of Flight:	Climb
Effect on Flight:	Emergency landing
Damage:	Engine
Wildlife Species:	Glaucous-winged gull
Comments from Report: During initial climb-out, the aircraft hit several gulls. One went through the engine. An emergency was declared and the aircraft returned to the airport safely. Twenty-four blades and the oil cooler were replaced. The flight was delayed 5.5 hours. Aircraft was out of service at least 24 hours. Remains were found on the runway. Cost estimated as $252,000.	


U.S. Department of Transportation
Federal Aviation Administration
Report Wildlife Strikes
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http://www.faa.gov/wireless
USDA
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