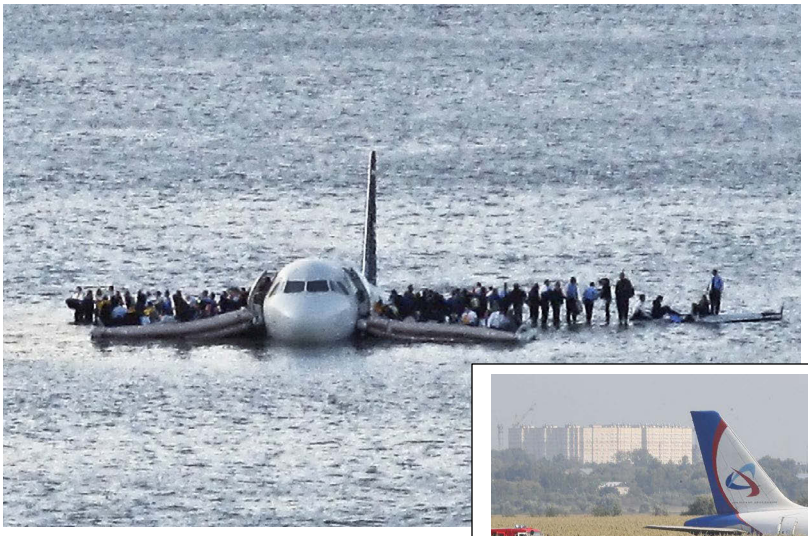
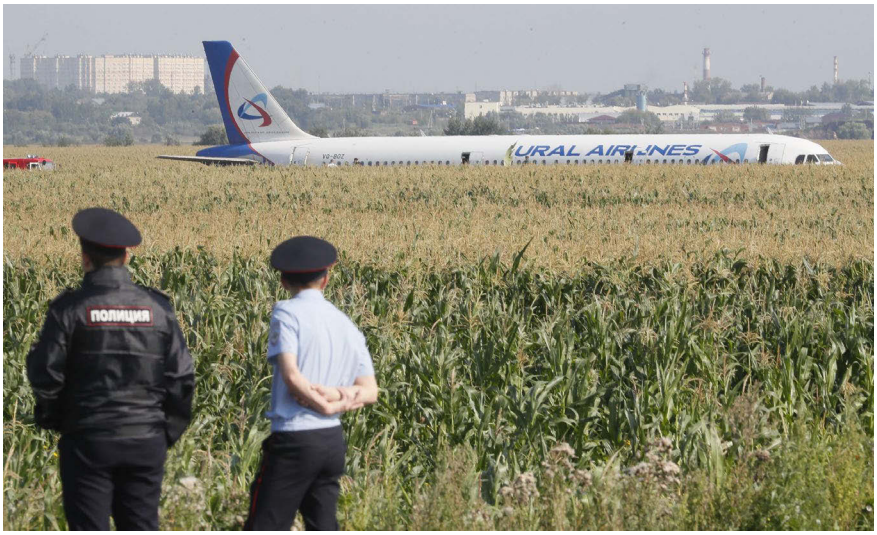
U. S. DEPARTMENT
OF TRANSPORTATION
FEDERAL AVIATION
ADMINISTRATION

Wildlife Strikes to Civil Aircraft in the United States 1990–2019

U. S. DEPARTMENT
OF AGRICULTURE
WILDLIFE SERVICES



Hudson River, New York, January 2009



Cornfield near Moscow, August 2019

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The Federal Aviation Administration produced this report in cooperation with the U. S. Department of Agriculture, Wildlife Services, under an interagency agreement (DTFACT-14-X-00007). The purpose of this agreement is to 1) document wildlife strikes to civil aviation through management of the FAA National Wildlife Strike Database and 2) research, evaluate, and communicate the effectiveness of various habitat management and wildlife control techniques for minimizing wildlife strikes with aircraft at and away from airports. These activities provide a scientific basis for FAA policies, regulatory decisions, and recommendations regarding airport safety and wildlife.

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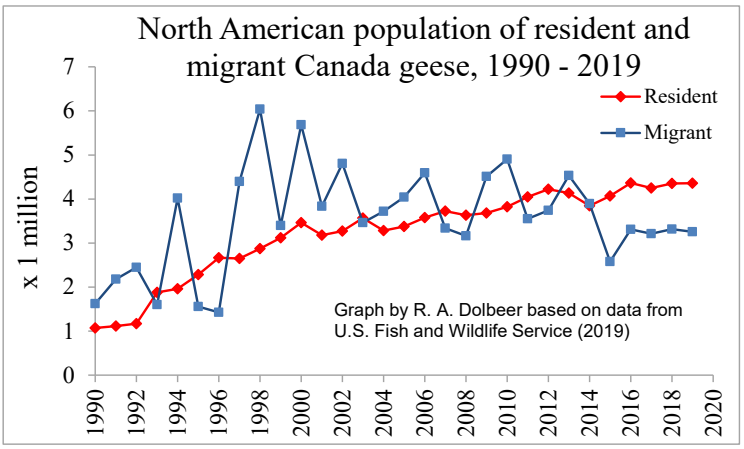
COVER PAGE

Two incidents in the past 10 years highlight the serious consequences that can occur when modern 2-engine, turbofan-powered aircraft collide with flocking birds. On 15 January 2009, US Airways Flight 1549 (Airbus 320) with 155 persons aboard made a forced landing in the Hudson River after ingesting Canada geese into both engines at 2900 feet above ground level after departure from LaGuardia Airport, New York (Marra et al. 2009, National Transportation Safety Board 2010). On 15 August 2019, Ural Airlines Flight 178 (Airbus 321) with 234 persons aboard made a forced landing in a corn field 3 miles from Zhukovsky International Airport, Moscow, Russia after ingesting gulls into both engines during take-off (Aviation Safety Network 2020). Incredibly, none of the 389 people were killed in these "Miracle on the Hudson" and "Miracle in the Corn Field" bird-strike events, even though both aircraft had been damaged beyond repair.

These 2 incidents exemplify the need to mitigate the risk of wildlife strikes both at airports and outside the airport boundaries. The Miracle on the Hudson event was caused by migratory geese about 5 miles from the airport. The Miracle in the Cornfield event was caused by gulls on the runway. Mitigating the risk in these 2 environments requires different management strategies as discussed at end of this report.



The population of resident (non-migratory) Canada geese in the USA increased 4-fold from about 1.1 million to 4.4 million birds, 1990 to 2019. The resident population now outnumbers the migratory population that nests primarily in northern Canada and winters in the USA. From 1990-2019, 1,854 strikes involving Canada geese and civil aircraft were reported (71 in 2019); resident geese comprised an estimated 76% of these strikes (Dolbeer 2020).

The National Wildlife Strike Database provides the scientific foundation for policies and management programs to mitigate the risk of bird strikes both on and off airports in ways compliant with the Migratory Bird Treaty Act and other environmental laws.

Photos: AP, Steven Day (New York); Washington Post (Moscow)

ACKNOWLEDGMENTS

The National Wildlife Strike Database (NWSD) office acknowledges the many people who took the time and effort to report the 231,320 wildlife strikes summarized in this report – pilots, mechanics, control tower and airport operations personnel, airline flight safety officers, airport wildlife biologists, and many others. We recognize **Mahalah Schank** (USDA) for her efforts in entering and editing data and **Jenny Washburn** and **Jason Kougher** for assistance and advice. We acknowledge **Ryan King, Michael DiPilato,** and **Wesley Major** (FAA) for their leadership and technical advice. **Heather Marriott** (Embry-Riddle Aeronautical University) provided invaluable assistance in various ways. Special recognition is given to **Sandra Wright**, who managed the NWSD from its inception in 1995 until her retirement in 2015. She set a high standard for data quality and consistency so that analyses such as presented in this report could be accomplished. We also acknowledge **Gene LeBoeuf** (FAA, retired) and **Edward Cleary** (FAA, deceased) for their leadership in initiating and developing the NWSD. Finally, the NWSD office acknowledges the suggestions and critiques made by various people over the years that have enhanced the usefulness and accuracy of the NWSD and annual reports such as presented here.

Sponsorship and funds for the ongoing maintenance and analysis of the NWSD are provided by the FAA, Office of Airport Safety and Standards, Washington, DC, and the Airport Technology Research and Development Branch, FAA William J. Hughes Technical Center, Atlantic City, NJ.

EXECUTIVE SUMMARY – PART 1: WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES, 1990–2019

Although birds are critical ecologic, economic, and esthetic components of the environment deserving rigorous international protection, they can at times conflict with human activities such as aviation. Aircraft collisions with birds and other wildlife (wildlife strikes) have become a growing concern for aviation safety in recent years. Factors that contribute to this threat are increasing populations of large birds and increased air traffic by quieter, turbofan-powered aircraft. Globally, wildlife strikes killed more than 292 people and destroyed over 271 aircraft from 1988 - 2019.

This report presents a summary analysis of data from the National Wildlife Strike Database (NWSD) for the 30-year period, 1990 through 2019. A sample of 20 significant wildlife strikes to civil aircraft in the USA during 2019 is also included as Appendix A. Appendix B explains how to report strikes and the role of the Smithsonian Institution Feather Lab in identifying bird and other wildlife species that are struck.

The number of strikes annually reported to the Federal Aviation Administration (FAA) increased 9.3-fold from 1,850 in 1990 to a record high of 17,228 in 2019. The 2019 total was an increase of 1,007 strikes (6 percent) compared to the 16,221 strikes reported in 2018. For 1990–2019, 231,320 strikes were reported (227,045 in USA and 4,275 strikes by U.S.-registered aircraft in foreign countries). In 2019, birds were involved in 94.0 percent of the reported strikes, bats in 3.2 percent, terrestrial mammals in 2.3 percent, and reptiles in 0.5 percent.

Although the number of reported strikes has dramatically increased, the number of reported damaging strikes has increased only slightly since 2010 and is still below the record number of 743 in 2000. Whereas the number of reported strikes in USA increased 190 percent from 5,874 in 2000 to 17,050 in 2019, the number of damaging strikes declined 4 percent from 743 in 2000 to 710 in 2019. The decline in damaging strikes has been most pronounced for commercial aircraft in the airport environment (at $\leq$1,500 feet above ground level [AGL]). Damaging strikes have not declined for general aviation (GA) aircraft.

In 2019, 84 percent and <1 percent of the 17,228 strike reports were filed using the electronic and paper versions, respectively, of FAA Form 5200-7, Bird/Other Wildlife Strike Report. Seven percent of the reports were submitted via the Air Traffic Organization Mandatory Occurrence Reporting system.

The number of USA airports with strikes reported increased from 335 in 1990 to a record high of 753 in 2019. The 753 airports with strikes reported were comprised of 420 airports certificated for passenger service under 14 CFR Part 139 and 333 GA airports. From 1990 - 2019, strikes have been reported from 2,091 different USA airports.

From, 1990 to 2019, 53 percent of bird strikes occurred between July and October; 29 percent of deer strikes occurred in October - November. Terrestrial mammals are more

likely to be struck at night (62 percent) whereas birds are struck more often during the day (62 percent). Birds, terrestrial mammals, and bats are all much more likely to be struck during the arrival phase of flight (62, 63, and 86 percent of strikes, respectively) compared to departure (35, 33 and 12 percent, respectively).

For commercial and GA aircraft, 71 and 72 percent of bird strikes, respectively, occurred at or below 500 feet AGL from 1990 to 2019. Above 500 feet AGL, the number of strikes declined by 34 percent for each 1,000-foot gain in height for commercial aircraft, and by 43 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 2019, 591 species of birds, 51 species of terrestrial mammals, 36 species of bats, and 23 species of reptiles were identified as struck by aircraft. Waterfowl, gulls, and raptors are the species groups of birds with the most damaging strikes; Artiodactyls (mainly deer) and carnivores (mainly coyotes) are the terrestrial mammals with the most damaging strikes. Although the percentage of wildlife strikes with reported damage has averaged 8 percent for the 30-year period, this number has declined from 20 percent in 1990 to 4 percent in 2019.

A negative effect-on-flight was reported in 5 percent and 17 percent of the bird and terrestrial mammal strike reports, respectively, 1990-2019. Precautionary/emergency landing after striking wildlife was the most commonly reported negative effect (6,993 incidents), including 267 incidents in which the pilot jettisoned fuel (61 incidents, mean of 13,876 gallons), made an overweight landing (107 incidents), or burned fuel in circling pattern (99 incidents). Aborted take-off was the second most commonly reported negative effect (2,630 incidents). These negative incidents included 564 aborted take-offs at $\geq$100 knots. Similar to the trend shown for the percentage of strikes causing damage, the percentage of strikes with a reported negative effect-on-flight has declined from a high of 12 percent in 1996 to 4 percent in 2014-2019. For commercial aircraft, the number of high-speed ($\geq$100 knots) aborted take-offs has declined from a high of 25 in 2000 to 6-9 in 2015-2019.

For the 20 species of birds most frequently identified as struck by civil aircraft in 2019, there was a strong correlation (R^2 = 0.96) between mean body mass and the likelihood of a strike causing damage to aircraft. For every 100-gram increase in body mass, there was a 1.15 percent increase in the likelihood of damage. Thus, body mass is a good predictor of relative hazard level among bird species.

Seventy-three strikes resulted in a destroyed aircraft from 1990-2019 (one in 2019); 41 (56 percent) of these occurred at GA airports. The annual cost of wildlife strikes to the USA civil aviation industry in 2019 was projected to be 116,984 hours of aircraft downtime and $205 million in direct and other monetary losses.

This analysis of 30 years of strike data documents the progress being made in reducing damaging strikes for commercial aircraft which primarily use Part 139-certificated airports.

Management actions to mitigate the risk have been implemented at many airports since the 1990s; these efforts are likely responsible for the general stabilization or decline in reported strikes with damage and a negative effect-on-flight at Part 139-certificated airports from 2000-2019 in spite of continued increases in populations of many large bird species. However, much work remains to be done to reduce wildlife strikes. Management actions at airports should be prioritized based on the hazard level of species observed in the aircraft operating area.

To address strikes outside the airport environment, the general public and aviation community must first widen its view of wildlife management to minimize hazardous wildlife attractants within 5 miles of airports. Second, the aviation community needs to broaden the view of wildlife strike risks from a ground-based wildlife management problem to an airspace management problem that also encompasses Air Traffic Control, flight crews, and aircraft manufacturers. Long-term goals include the integration of avian radar and bird migration forecasting into airspace management and the development of aircraft lighting systems to enhance detection and avoidance by birds. Finally, there continues to be a need for increased and more detailed strike reporting. When reports are filed, it is important that relevant information be provided whenever possible regarding species identification, number of wildlife struck, time and height of strike, phase of flight, and damage to aircraft components. A problem that is not well defined cannot be properly managed.

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

In 2019, the FAA continued a multifaceted approach for mitigating wildlife strikes. This included publishing new guidance, continuing a robust research program, making improvements to the NWSD and outreach, and providing Airport Improvement Program (AIP) funding to airports to conduct Wildlife Hazard Assessments (Assessments) and develop Wildlife Hazard Management Plans (Plans).

The emergency forced landing of US Airways Flight 1549 Airbus 320 into the Hudson River on January 15, 2009 demonstrated to the world the severity of aircraft collisions with birds and other wildlife. Migratory Canada geese were ingested into both engines at 3:27:11 p.m. at an altitude of 2,818 feet above ground level (AGL) and 4.5 miles north-northwest of the approach end of runway 22 at La Guardia International Airport (LGA). Three minutes 49 seconds later the aircraft successfully ditched into the Hudson River with 150 passengers and 5 crew; there were no fatalities.

Landmark events such as this necessitate outside scrutiny and comprehensive internal evaluations to ensure optimal guidance, compliance and risk reduction moving forward. Since the FAA's first Advisory Circular (AC) (AC 150 / 5200-1 *Bird Hazards to Aviation, Bird Hazard Research*) published March 1, 1965, these types of evaluations have allowed the FAA wildlife program to systematically improve its oversight to reduce risks within the safest aerospace system in the world. The results from reviews conducted following the

Flight 1549 event have enhanced existing regulations and provided beneficial layers of expansion throughout other key FAA wildlife-related areas (e.g., Data collection and analysis, Partnerships, Research, and Outreach).

In the eleven-year span 2009 – 2019, approximately $350 million of Airport Improvement Program (AIP) funds have been allocated for wildlife-related projects such as Assessments, Plans and airport perimeter fencing. All Part 139 certificated airports have successfully completed Assessments followed by Plans while 124 of the largest GA airports have voluntarily completed Assessments.

External reviews of the FAA wildlife program resulted in helpful recommendations from the National Safety Transportation Board (NTSB) and the DOT Office of Inspector General (OIG). The four recommendations issued by the NTSB in 2009 and 2010 respectively, have been successfully closed. Two of the recommendations were generated from a 2008 fatal accident involving a Cessna 500 that collided with a flock of white pelicans near the Wiley Post Airport in Oklahoma while the remaining recommendations addressed concerns raised from the US Airways Flight 1549 incident.

The FAA received ten additional recommendations within an OIG Audit Report on August 22, 2012. These recommendations covered a wide range of subjects including FAA oversight and enforcement, our policies and guidance for monitoring, reporting, and mitigating wildlife hazards, interagency cooperation, personnel training, communication, and mandatory strike reporting. The last of these extensive recommendations received final closure August 1, 2016.

Based on recommendations from NTSB, the FAA encouraged all certificated airports to conduct Assessments and develop Plans regardless if a triggering event under 14 CFR Part 139 had been experienced. To date, 100% of all required Part 139 airports have completed an Assessment and Plan. Joint-use facilities that maintain a Bird/wildlife Aircraft Strike Hazard (BASH) Plan also completed Assessments as a foundation for their BASH Plans. The FAA established a program and schedule that outlined the implementation of Assessments or Site Visits based on the number of operations and based jet aircraft at the GA airport. To date, 124 GA airports identified with the greatest need for wildlife data collection have conducted either Assessments or Site Visits. To assist the GA airports in conducting Assessments, we will continue to make AIP grant funds available to them.

The FAA dedicated over $25 million in research funds within the last decade to better understand the capabilities of advanced detection and monitoring systems such as avian radars, Foreign Object Debris (FOD) radars and infrared / electro-optical scanning systems. Other research initiatives included aircraft-mounted lighting systems to enhance bird detection and avoidance, wildlife control techniques, habitat management, Canada goose movement analyses, capture and relocation efficacy of raptors, DNA and molecular identifications, and systems integration (Wildlife Surveillance Concept -WiSC) which aims to determine the compatibility of avian radar or similar monitoring technologies warning notice in the Air Traffic Controller’s reach.

In addition, the FAA has published new and revised advisory circulars within the last year in order to assist airport sponsors with providing a safe airport environment. Following the publication of Advisory Circular 150/ 5200- 38 - *Protocol for the Conduct and Review of*

Wildlife Hazard Site Visits, Wildlife Hazard Assessments, and Wildlife Hazard Management Plans on August 20, 2018,

The FAA updated AC 150/5200-36B *Qualifications for Wildlife Biologist Conducting Wildlife Hazard Assessments and Training Curriculums for Airport Personnel Involved in Controlling Wildlife Hazards on Airports* January 24, 2019. This latest version provides for an alternative field experience option of Continual Monitoring to aid Qualified Airport Wildlife Biologists (QAWB) candidates in an era where all certificated airports have finished their initial Assessments and Plans.

On February 21, 2020, AC 150/5200-33C *Hazardous Wildlife Attractants On or Near Airports* was updated with significant changes. The updated language included clarification of separation criteria, new guidance on land-use practices (e.g., aquaculture, agriculture, dredge spoil, etc.), inclusion of general aviation (GA) airport wildlife responsibilities and a new section *Airport Procedures for Off-site Attractants* that provides step-by-step guidance when proposed land-use changes may provide an attractant to hazardous species.

The Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award was initiated in 2014 to recognize those airports that have exhibited a noteworthy strike-reporting program. The idea is to recognize the Top 5 reporting programs in both the Certificated and GA airport categories each year. In 2018, the Part 139 certificated airport winner was **Seattle / Tacoma International Airport (SEA)** and the General Aviation representative was **Page Field (FMY)**. For their commitment to the identification and documentation of wildlife / aircraft strike information, the FAA proudly recognizes the strike reporting programs at **Charlotte Douglas International Airport (CLT)** and **Kalaeloa Airport (John Rodgers Field) (JRF)** as the winners of the 2019 Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award.

This annual strike report contains the results of these, and many other, evaluations using the data from the NWSD. The 17,228 documented strikes in 2019 equates to roughly 47 wildlife strikes documented every day, only about 4 percent are damaging. In 2019, there were 710 damaging strikes; this averages about two damaging strikes per day or about 1 per 35,000 of the estimated 70,000 daily aircraft over US airspace. Overall, 82 percent of strikes occur at or below 1,500 feet Above Ground Level (AGL). This altitude falls within the 5-mile separation distance recommended for wildlife attractants, meaning that on-ground wildlife mitigation activities out to 5 miles can have a positive effect on risk reduction for 82 percent of all wildlife strikes.

Strikes occur every day, but when compared to the total number of flights in the system they are rare. Although it is impossible to eliminate all strikes at all times between aircraft and animals, comprehensive assessment, planning and management techniques have successfully mitigated damaging strikes on or near airports. Combined with systematic evaluation and adaptation of techniques, safety can be increased one less strike at a time.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

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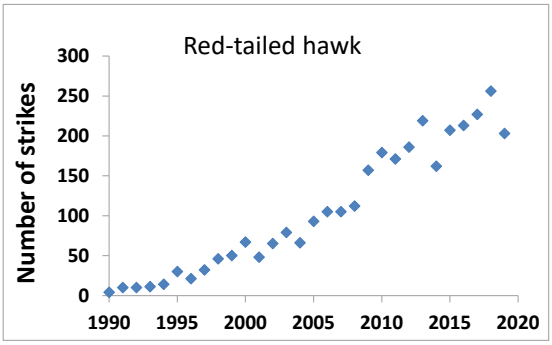
PART 1: WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES, 1990–2019

INTRODUCTION

The Migratory Bird Treaty Act (MBTA), originally signed by Great Britain (for Canada) and the USA in 1918, now includes Mexico, Russia, and Japan as signatories, and protects over 1,000 species of birds that migrate among the five countries (U.S. Fish and Wildlife Service 2020). The MBTA has been hailed by biologists and politicians alike as the most influential legislation ever enacted to protect birds, and it has served as a model for nations worldwide.

Although birds are critical ecologic, economic, and esthetic components of the environment deserving rigorous international protection (Sekercioglu et al. 2016), they can at times conflict with human activities such as agriculture (Linz et al. 2017) and aviation. Aircraft collisions with birds and other wildlife (wildlife strikes) have become an increasing concern for aviation safety in recent years (Bogaisky 2019, Koerner 2020).

The reasons for the increasing concern are complex. A major factor is that due to the MBTA, other environmental initiatives, and land-use changes, populations of most large bird species in North America have increased markedly in the last few decades and adapted to urban environments, including airports. Dolbeer (2019) examined the estimated population trends and numbers for the 20 species of birds in North America with mean body masses ≥4 lbs. and at least 20 reported strikes with civil aircraft, 1990-2019. Of these 20 species, 16 indicated population increases of greater than 10 percent, 3 were unchanged, and only 1 species showed a decline of greater than 10 percent. The net gain in numbers for the 20 species was an estimated 28 million birds (2.3-fold increase).

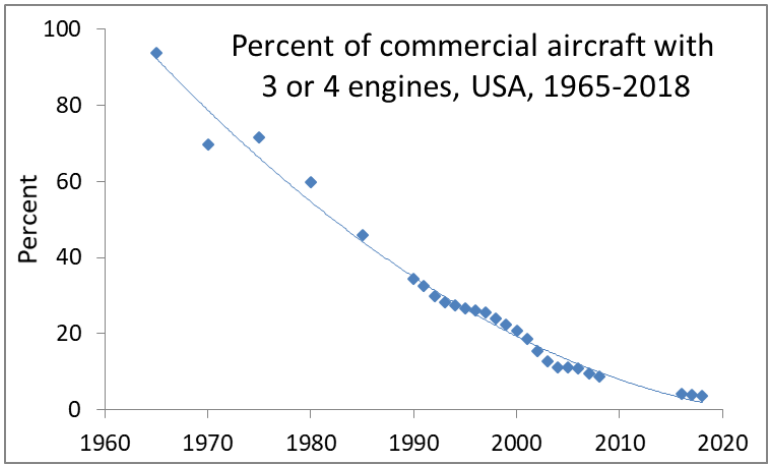


The red-tailed hawk population has more than doubled to over 3 million birds since 1990 (Partners in Flight 2019, Sauer et al. 2017, Dolbeer 2019) and expanded into urban environments. Capture-relocation of red-tailed hawks is done at many USA airports; juvenile hawks are less likely to return (Pullins et al. 2018). Photo, USDA.

As specific examples, the resident (non-migratory) Canada goose (mean body mass = 9 lbs.) population in North America increased from about 1 million to over 4 million from

1990 to 2018 (Dolbeer et al. 2014, U.S. Fish and Wildlife Service 2019). During the same time period, the North American snow goose (mean body mass = 6 lbs.) population increased from about 4 million to 15 million birds (U.S. Fish and Wildlife Service 2019).

A second factor is that concurrent with population increases of large bird species, commercial air traffic in the USA increased from about 23 million movements in 1990 to 28 million movements in 2008 (Table 3). From 2008 to 2019, commercial air traffic declined slightly to 26 million movements although passenger enplanements increased from about 748 million to 923 million (Federal Aviation Administration 2020*a*). Commercial air traffic in the USA is predicted to grow at a rate of about 1.2 percent per year to 30 million movements in 2030. Passenger enplanements are predicted to grow at a rate of about 2.2 percent per year to 1.19 billion in 2030 (Federal Aviation Administration 2020a).



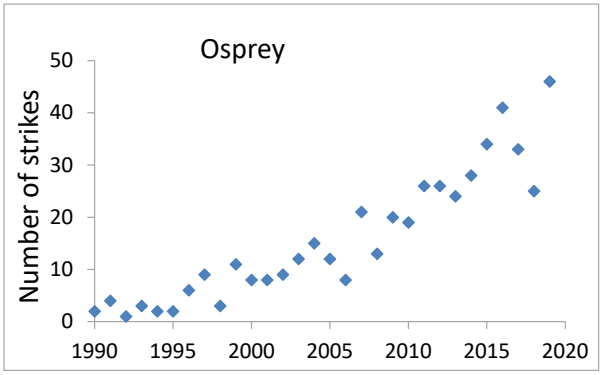
A third factor relates to aircraft and engine design. Commercial air carriers have replaced their older three or four-engine aircraft fleets with more efficient and quieter, two-engine aircraft. In 1965, about 94 percent of the 1,037 turbine-powered commercial transport aircraft in the USA had three or four engines compared to less than 4 percent of the 7,356 aircraft in 2018 (U.S. Department of Transportation 2020, Aeroweb 2020). With the steady advances in technology over the past several decades, today's two-engine aircraft are more powerful and reliable than yesterday's three and four-engine aircraft. However, in the event of multiple-engine ingestions, aircraft with two engines may have vulnerabilities not shared by their three or four engine-equipped counterparts (Langston 2019).

Two incidents in the past 10 years highlight these vulnerabilities. On 15 January 2009, US Airways Flight 1549 (Airbus 320) with 155 persons aboard made a forced landing in the Hudson River after ingesting Canada geese into both engines at 2900 feet above ground level after departure from LaGuardia Airport, New York (Marra et al. 2009, National Transportation Safety Board 2010). On 15 August 2019, Ural Airlines Flight 178 (Airbus 321) with 234 persons aboard made a forced landing in a corn field 3 miles from Zhukovsky International Airport, Moscow, Russia after ingesting gulls into both engines during take-off (Aviation Safety Network 2020). Incredibly, none of the 389 people was killed in these "Miracle on the Hudson" and "Miracle in the Corn Field" bird-strike events even though both aircraft had been damaged beyond repair.

Another complicating factor is that birds are less able to detect and avoid modern jet aircraft with quieter turbofan engines (Chapter 3, International Civil Aviation Organization

1993) compared to older aircraft with noisier (Chapter 2) engines (Burger 1983, Kelly et al. 1999). This is analogous to the demonstrated greater "strike rate" for pedestrians and bicyclists (increases of 35 percent and 57 percent, respectively) with electric vehicles compared to vehicles with internal combustion engines (Wu et al. 2011). In October 2017, the FAA adopted a rule requiring new transport aircraft to have noise levels further reduced by at least 7 decibels compared to the current fleet (Federal Register 2017).

As a result of these factors, experts within the Federal Aviation Administration (FAA), U.S. Department of Agriculture (USDA), and U.S. military (Air Force, Navy, Army, Coast Guard) expect the risk of bird and other wildlife strikes to be a continuing challenge over the next decade and beyond. Mitigating these risks presents many unique challenges because of the mobility and adaptability of birds, legal requirements of the MBTA, and overall public interest in the protection of birds. But these challenges must be met globally, bird and other wildlife strikes have killed more than 292 people and destroyed over 271 civil and military aircraft from 1988 – June 2020 (Richardson and West 2000; Thorpe 2012, Shaw and Dolbeer 2020).



An osprey flies over a coastal airport in North Carolina, 2019. A record 46 osprey-civil aircraft strikes were reported in 2019. The osprey population in North America has more than doubled to over 500,000 birds since 1990 (Partners in Flight 2019, Sauer et al. 2017, Dolbeer 2019). Photo, K. Severino, USDA.

The FAA has initiated several programs to address this important safety issue. Among the programs is the collection and analysis of data from wildlife strikes. The FAA began collecting bird and bat strike data in 1965 (expanded to include terrestrial mammals and reptiles in 1990). However, except for cursory examinations of 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 wildlife strike problem for civil aviation. Specialists from the USDA/WS: (1) research all strike reports (FAA Form 5200-7, *Bird/Other Wildlife Strike Report*) received by the FAA since 1990 to ensure consistent, high-quality data; (2) process all edited strike reports into the FAA National Wildlife Strike Database; (3) supplement FAA-reported strikes with additional, non-duplicated strike reports from other sources; and (4) 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, seasonal patterns, and long-term trends in strikes). The information obtained from these analyses provides the foundation for FAA national policies and guidance and for refinements in the development and implementation of integrated research and management efforts to reduce wildlife strikes. Data on the number of strikes causing damage to aircraft or other adverse effects (e.g., aborted take-off) also provide a benchmark for individual airports to evaluate and improve their Wildlife Hazard Management Plans in the context of a Safety Management System (Dolbeer and Begier 2012). Airport Wildlife Strike Summary and Risk Analysis Reports, which summarize strike data for the most current 5-year period, are available for most Part 139-certificated airports at http://wildlifecenter.pr.erau.edu/strikeInformation.html.

USDA biologists visited the Smithsonian Feather Lab in 2019 as part of training to maintain "Qualified Airport Wildlife Biologist" status (FAA Advisory Circular AC 150/5200-36B). The biologists were instructed in procedures to collect bird remains taken from aircraft and in the methods used by Feather Lab to identify the remains (see Appendix B). Photo, M. Begier, USDA.

The first annual report on wildlife strikes to civil aircraft in the USA was completed in November 1995 (Dolbeer et al. 1995). This is the 26th report in the series and covers the 30-year period, 1990–2019. Current and historic annual reports are accessible as PDF files at: http://www.faa.gov/airports/airport_safety/wildlife/

To supplement the statistical summary of data presented in tables and graphs, a sample of 20 significant wildlife strikes to civil aircraft in the USA during 2019 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, 1990–2019, is available at http://www.faa.gov/airports/airport_safety/wildlife/.

Appendix B explains how to report strikes and the role of the Smithsonian Institution Feather Lab in identifying bird and other wildlife species that are struck.

RESULTS

NUMBER OF REPORTED STRIKES AND STRIKES WITH DAMAGE

The number of strikes annually reported to the FAA has increased 830 percent (9.3-fold) from 1,850 in 1990 to a record high of 17,228 in 2019. The 2019 total was an increase of 1,007 strikes (6 percent) compared to the 16,221 strikes reported in 2018 (Table 1, Figure 1). For the 30-year period (1990–2019), 231,320 strikes were reported of which 227,045

(98 percent) occurred in the USA[1]. In 2019, birds were involved in 94.0 percent of the reported strikes in the USA, bats in 3.2 percent, terrestrial mammals in 2.3 percent, and reptiles in 0.5 percent (Table 2).

Although the number of reported strikes has steadily increased in the USA, it is important to note that the overall number of damaging strikes has increased only slightly since 2010 and is still below the record number of 743 in 2000 (Table 2, Figure 2). Whereas the number of reported strikes increased 190 percent from 5,874 in 2000 to 17,050 in 2019, the number of damaging strikes declined 4 percent from 743 in 2000 to 710 in 2019. The 710 damaging strikes reported in 2019 was an increase of 2 percent from 696 in 2018.

This stabilization of damaging strikes since 2000 has occurred in the commercial aviation sector and not the general aviation sector. While the commercial and general aviation sectors showed increases of 152 percent and 209 percent, respectively, in the rate (per 100,000 movements) of reported strikes from 2000 to 2019, there was a 7 percent decline in the damage strike rate for commercial aircraft (Tables 3, 4, Figure 3). However, there was a 57 percent increase in the damage strike rate for general aviation aircraft (Table 4, Figure 3).

A snowy plover, rests on a runway at a California airport, 2019. Snowy plovers are considered a threatened species in California and elsewhere, which illustrates the finesse which must be used by biologists in managing wildlife at airports. Photo, J. Psiropoulos, USDA.

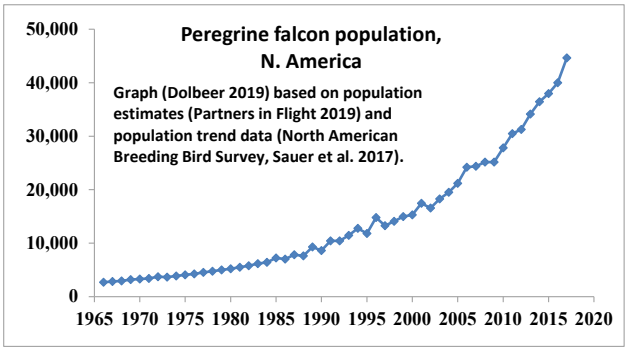
Furthermore, the overall stabilization in damaging strikes for commercial aircraft since 2000 can be attributed to a slight decline in damaging strikes in the airport environment (strikes occurring on departure or arrival at ≤1,500 feet above ground level [AGL]). Damaging strikes at >1,500 feet AGL have not shown a pattern of decline (Figure 4). This decline in damaging strikes for commercial aviation in the airport environment has occurred despite an increase in populations of hazardous wildlife species (Dolbeer and Eschenfelder 2003, Dolbeer 2019) and, as noted above, a major increase in reported strikes. These data demonstrate progress in wildlife hazard management programs at airports certificated for passenger traffic under 14 CFR-Part 139 regulations (Dolbeer 2011). The data also demonstrate the lack of progress in mitigating the risk of strikes outside the airport environment at certificated airports.

For general aviation aircraft, there has been an increase in damaging strikes in the airport environment (at ≤1,500 feet AGL), and at >1,500 feet AGL (Figure 4).

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

The 190 percent increase in the number of strikes reported in USA from 2000 to 2019, concurrent with the stabilization in damaging strikes, indicates that the aviation industry is doing a better job of documenting all wildlife that are struck. Many of these strikes involve small species that rarely cause damage. This premise is supported by the fact that the mean mass of birds reported as struck has declined 62 percent from 0.76 kg to 0.29 kg, 2000-2019 (Figure 5).

The North American peregrine falcon population, on the brink of extinction in the 1960s, has recovered dramatically. From 1990-2019, 461 peregrine strikes with civil aircraft were recorded (29 in 2019). Banded birds, almost all 3-5 months old when struck, were involved in 133 of these strikes. This banded peregrine was perched on an airport fence in California, 2019. Photo, J. Psiropoulos, USDA.



Methods of Reporting Strikes

In 2019, 84 percent and <1 percent of the 17,228 strike reports were filed using the electronic and paper versions, respectively, of FAA Form 5200-7, *Bird/Other Wildlife Strike Report* (Table 5). Three percent of reports came from multiple sources (i.e., more than one type of report was filed for same strike). Strike reports submitted to the FAA via the Air Traffic Organization (ATO) Mandatory Occurrence Reporting system comprised 7 percent of reports. Under FAA Order JO 7210.632, (effective 30 Jan 2012), ATO personnel are required to report all bird strikes of which they become aware.

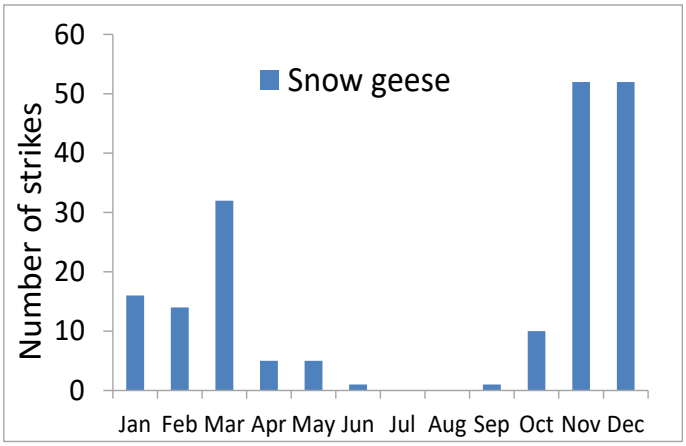
Source of Reports

In 2019, airport operations personnel filed 66 percent of the strike reports (including "Carcass Found" reports), followed by pilots (15 percent), Air Traffic Control personnel (11 percent), air transport operations personnel (5 percent), and other (2 percent, Table 6). In 2019, about 86 percent of the reported strikes involved commercial aircraft; the remainder involved business, private, and government aircraft (Table 7).

The number of USA airports with strikes reported has increased steadily from 335 in 1990 to a record high of 753 in 2019 (Table 8, Figure 6). Of the 753 airports with strikes reported in 2019, 420 were certificated for passenger service under 14 CFR Part 139 and 333 were general aviation airports. From 1990 - 2019, 198,996 strikes have been reported from 2,091 different USA airports. In addition, 4,275 strikes involving USA-registered civil

aircraft were reported at 315 foreign airports in 108 countries, 1990 – 2019. In 2019, 178 strikes were reported at 78 foreign airports in 48 countries.

TIMING OF OCCURRENCE AND PHASE OF FLIGHT OF STRIKES



Unlike Canada geese which are common in the USA year-round, snow geese nest in the arctic and migrate to the USA in winter. About 56 percent of the 188 snow goose strikes, 1990-2019, occurred in November-December.

From 1990 – 2019, most bird strikes (53 percent) occurred between July and October (Figure 7) which is when birds are migrating, and populations are at their annual peak in North America following the nesting season. Sixty-two percent of bird strikes occurred during the day and 30 percent at night (Table 9). Almost twice as many strikes (62 percent of total) occurred during the arrival (descent, approach, or landing roll) phase of flight compared to 35 percent during departure (take-off run and climb, Table 10).

Similar to the pattern shown with birds, most terrestrial mammal strikes occurred between July and November; with 29 percent of deer strikes concentrated in October-November and 39 percent of coyote strikes in August-October (Figure 8). Most terrestrial mammal strikes (62 percent) occurred at night (Table 9). As with birds, about twice as many strikes (63 percent of total) occurred during the arrival (final approach or landing roll) phase of flight compared to 33 percent during departure (take-off run and initial climb, Table 10).

For bats, 79 percent of strikes occurred at dawn, dusk, or night (Table 9). The difference in numbers of strikes during arrival compared to departure phase of flight was even greater for bats compared to birds and terrestrial mammals. Eighty-six percent of reported bat strikes occurred during arrival compared to only 12 percent during departure (Table 10).

HEIGHT ABOVE GROUND LEVEL (AGL) OF STRIKES

Bird strikes with commercial aircraft- From 1990 – 2019, about 41 percent of bird strikes with commercial aircraft occurred when the aircraft was at 0 feet AGL, 71 percent occurred at 500 feet or less AGL, and 92 percent occurred at or below 3,500 feet AGL (Table 11). About 1 percent of bird strikes occurred above 9,500 feet AGL. Above 500 feet AGL, the number of reported strikes declined consistently by 34 percent for each 1,000-foot gain in height (Figure 9). The record height for a reported bird strike involving a commercial aircraft in USA was 31,300 feet AGL.

Strikes occurring above 500 feet AGL had a greater probability of causing damage to the aircraft compared to strikes at 500 feet or less. Although only 29 percent of the reported strikes were above 500 feet AGL, these strikes represented 44 percent of the damaging strikes (Table 11, Figure 10).

A Bell 206 helicopter en route at 105 knots and 1,200 feet above ground level struck a soaring red-tailed hawk in Texas, January 2019. The hawk penetrated windshield. The pilot, with minor injuries, made an emergency landing at nearby airport with dead hawk in his lap. Photo, aircraft owner.

Bird strikes with general aviation (GA) aircraft- From 1990 – 2019, about 36 percent of the bird strikes with GA aircraft occurred when the aircraft was at 0 feet AGL, 72 percent occurred at 500 feet or less AGL, and 93 percent occurred at or below 3,500 feet AGL (Table 12). About 1 percent of bird strikes occurred above 8,500 feet AGL. Above 500 feet AGL, the number of reported strikes declined consistently by 43 percent for each 1,000-foot gain in height (Figure 9). The record height for a reported bird strike involving a GA aircraft in USA was 24,000 feet AGL.

Strikes occurring above 500 feet AGL had an even greater probability of causing damage to GA aircraft compared to strikes at 500 feet or less than was shown above for commercial aircraft. Although only 29 percent of the reported strikes were above 500 feet AGL, these strikes represented 51 percent of the damaging strikes (Table 12, Figure 10).

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

AIRCRAFT COMPONENTS DAMAGED

The aircraft components most commonly reported as struck by birds from 1990 – 2019 were the nose/radome, windshield, wing/rotor, engine, and fuselage (Table 13). Aircraft engines were the component most frequently reported as being damaged by bird strikes (26 percent of all damaged components). There were 20,520 strike events in which a total of 21,470 engines were reported as struck (19,600 events with one engine struck, 897 with two engines struck, 16 with three engines struck, and 7 with four engines struck). In 4,880 damaging bird-strike events involving engines, a total of 5,042 engines was damaged (4,721 events with one engine damaged, 157 with two engines damaged, 1 with three engines damaged, and 1 with four engines damaged).

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

“Other” components reported as struck (all wildlife species combined) include critical sensors such as Pitot tubes (717), antenna (communication, radar, global position, 250), temperature gauges (136) and Angle of Attack vanes (150).

REPORTED DAMAGE

For the 222,753 strike reports involving birds from 1990–2019, 16,164 (7 percent) indicated damage to the aircraft (Table 14). When classified by level of damage, 7,679 (3 percent) indicated the aircraft suffered minor damage; 4,812 (2 percent) indicated the aircraft suffered an uncertain level of damage; 3,631 (2 percent) reported substantial damage; and 42 reports (less than 1 percent) indicated the aircraft was destroyed as a result of the bird strike (Table 14).

Coyotes are the second-most frequently struck terrestrial mammal at civil airports in USA with 673 strikes reported, 1990-2019 (white-tailed deer, 1,109 strikes are #1). About 9 percent of coyote strikes cause damage to aircraft. Culverts under airport fencing must be screened to prevent mammals from gaining access to airport runways. Photo, 2019, D. Peloquin, USDA.

For the 4,774 terrestrial mammal strikes reported, 1,166 (24 percent) indicated damage to the aircraft. When classified by level of damage; 562 (12 percent) indicated the aircraft suffered minor damage; 431 (9 percent) indicated the aircraft suffered substantial damage; 142 (3 percent) reported an uncertain level of damage; and 31 (1 percent) indicated the aircraft was destroyed as a result of the strike (Table 14). Not surprisingly, a much higher percentage of terrestrial mammal strikes (24 percent) resulted in aircraft damage than did bird strikes (7 percent). Deer (1,211 strikes, of which 1,001 caused damage; Table 18) were involved in 25 percent of the strikes and 86 percent of the damaging strikes involving terrestrial mammals.

Although the percentage of wildlife strikes (all species) with reported damage has averaged 8 percent for the 30-year period (Table 14), this number has declined from 20 percent in 1990 to 4 percent in 2019 (Figure 11).

REPORTED NEGATIVE EFFECT-ON-FLIGHT

A negative effect-on-flight was reported in 5 percent and 17 percent of the bird and terrestrial mammal strike reports, respectively, (Table 15). Precautionary/ emergency landing after striking wildlife was the most commonly reported negative effect (6,993 incidents, 3 percent of strike reports). These precautionary landings included 267 incidents in which the pilot jettisoned fuel (61) or burned fuel in a circling pattern (99) to lighten aircraft weight or in which an overweight landing was made (107, Table 16, Figure 12). In the 61 reported incidents in which fuel was jettisoned, an average of 94,358 pounds (13,876 gallons) of fuel was dumped per incident (range 44 – 39,706 gallons).

This American alligator caused a runway closure for over 1 hour at a military airport in Florida, 2019. From 1990-2019, 27 alligators, 24 green iguanas, and 1 spectacled caiman have been struck by civil aircraft in USA (Table 18). Photo, K. McLellan, USDA.

Aborted take-off after striking wildlife was the second most commonly reported negative effect (2,630 incidents, 1 percent of strike reports, Table 15). These negative incidents included 564 aborted take-offs in which the pilot initiated the abort at an aircraft speed of 100 knots (115 miles per hour) or greater (Table 17). For commercial aircraft, the number of high-speed aborted take-offs has declined from a high of 25 in 2000 to a low of 6-9 in 2015-2019 (Figure 13). For general aviation aircraft, the number of high-speed aborted take-offs has averaged about 4 per year (2 in 2019).

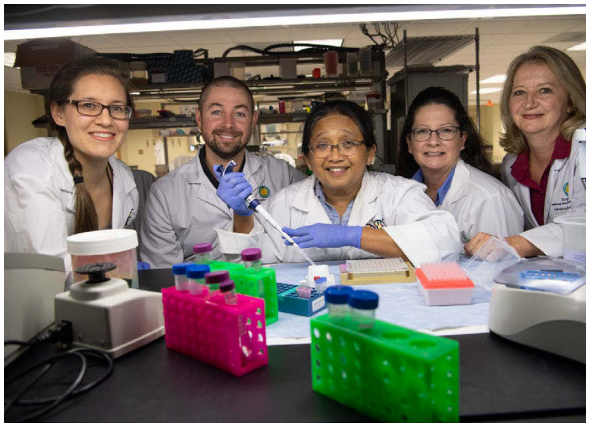
Similar to the trend shown for the percent of strikes causing damage, the percentage of wildlife strikes (all species) with a reported negative effect-on-flight has declined from a high of 12 percent in 1996 to 4 percent in 2014-2019 (Figure 11).

WILDLIFE SPECIES INVOLVED IN STRIKES

Table 18 shows the number of reported strikes, strikes causing damage, strikes having a negative effect-on-flight, strikes involving >1 animal, the reported aircraft down time, and the reported costs by identified wildlife species, 1990 - 2019. This information can be useful in comparing the relative hazard level of bird and other wildlife species encountered during Wildlife Hazard Assessments at airports and in the development of priorities for Wildlife Hazard Management Plans (see also Dolbeer and Wright 2009 and DeVault et al, 2011).

Birds- Of the 222,753 reported bird strikes, 101,834 (46 percent) identified the bird to exact species and an additional 22,553 strikes (10 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 around 60 percent in 2017-2019 (Figure 14). In all, 591 species of birds have been identified as struck by aircraft, and 298 of these species were reported as causing damage, 1990–2019. In 2019, 382 bird species were identified as struck by civil aircraft (Figure 14).



Scientists at the Smithsonian Feather Lab use a combination of forensic methods, including mitochondrial DNA analysis, to determine the species of birds, bats, and other wildlife involved in strikes with civil and military aircraft. In 2019, DNA analysis was used in 47 percent of civil aviation cases to identify the species and in an additional 21 percent of cases to supplement traditional identification methods (see Appendix B). Photo J. Kegley, Smithsonian.

Doves/pigeons (14 percent), raptors (12 percent), gulls (10 percent), shorebirds (9 percent), and waterfowl (5 percent) were the most frequently struck bird groups (Table 19). Doves/pigeons, raptors, and gulls each were involved in over twice as many strikes as waterfowl. Waterfowl, however, were involved in 4.1 times more damaging strikes than doves/pigeons and 1.2 to 1.5 times more damaging strikes than gulls or raptors. Waterfowl comprised 28 percent of all damaging strikes in which the bird type was identified, 1990–2019. Doves/pigeons and gulls were responsible for the greatest number of bird strikes (2,661 and 2,302, respectively) that involved multiple birds.

Table 20 lists the 33 species of birds identified most frequently as struck by civil aircraft for 1990–2019 and for 2019 only. Mourning doves, American kestrels, killdeer, barn swallows, and horned larks were the 5 most frequently identified species struck by civil aircraft overall from 1990–2019 and in 2019 only. Canada geese, the 12th most frequently identified species struck overall from 1990–2019, declined to the 25th most frequently struck species in 2019 in spite of the fact that the overall population in North America has increased over 2 fold, 1990–2018 (U.S. Fish and Wildlife Service 2019). This decline is likely related to the integrated management programs implemented in the past decade at many airports to dissuade feeding and nesting by Canada geese (Dolbeer et al. 2014, Rutledge et al. 2015).

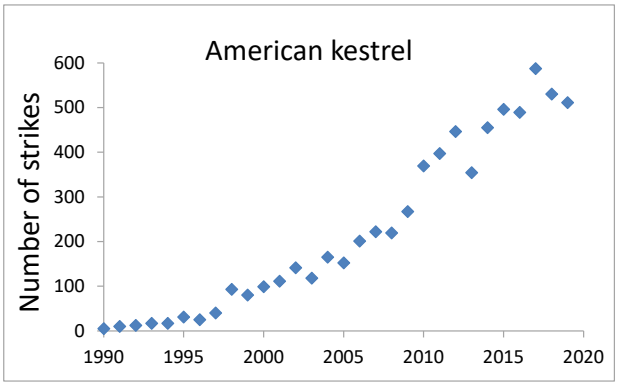
For the 20 species of birds most frequently identified as struck by civil aircraft in 2019, there was a strong correlation (R^2 = 0.96) between mean body mass and the likelihood of a strike causing damage to aircraft (Figure 15). For every 100-gram increase in body mass, there was a 1.15 percent increase in the likelihood of damage. Thus, body mass is a good predictor of relative hazard level among bird species, as noted previously by Dolbeer et al. (2000) and DeVault et al (2011).

Terrestrial mammals, bats, and reptiles- The most frequently struck terrestrial mammals were Carnivores (39 percent) and Artiodactyls (27 percent; Tables 18, 19). Coyotes were the most frequently struck Carnivore, and deer were the most frequently struck Artiodactyl. Artiodactyls were responsible for 90 percent of mammal strikes that resulted in damage and 56 percent of mammal strikes that involved multiple animals. In all, 51, 36, and 23 identified species of terrestrial mammals, bats, and reptiles, respectively, were reported struck; 24, 7, and 2 identified species of these respective wildlife taxa caused damage to aircraft (Table 18).

HUMAN FATALITIES AND INJURIES DUE TO WILDLIFE STRIKES

For the 30-year period, reports were received of 16 wildlife strikes that resulted in 36 human fatalities (Table 21). Six of these strikes, resulting in 8 fatalities, involved unidentified species of birds. Red-tailed hawks (8 fatalities), American white pelicans (5), bald eagles (4), snow geese (3), Canada geese and rock pigeon (2 each), and white-tailed deer, brown-pelicans, black vultures, and turkey vultures (1 each) were responsible for the other 28 fatalities. Reports were received of 251 strikes that resulted in 327 human injuries (Table 21). Waterfowl (ducks and geese; 58 strikes, 66 humans injured), vultures (36 strikes, 45 injuries), and deer (21 strikes, 30 injuries) caused 115 (57 percent) of the 202 strikes resulting in injuries in which the species or species group was identified.

AIRCRAFT DESTROYED DUE TO WILDLIFE STRIKES



American kestrels are the most frequently struck raptor at USA airports. From 1990-2019, 6,659 strikes involving kestrels and civil aircraft were reported, including 282 (4 percent) that involved multiple birds (Tables 18, 20). In 2019, 511 kestrel strikes were reported. Fortunately, kestrels have a mean body mass of only 132 g (0.3 lbs.), and less than 1 percent of strikes involving kestrels have caused aircraft damage. Photo, A. Sonnek, USDA.

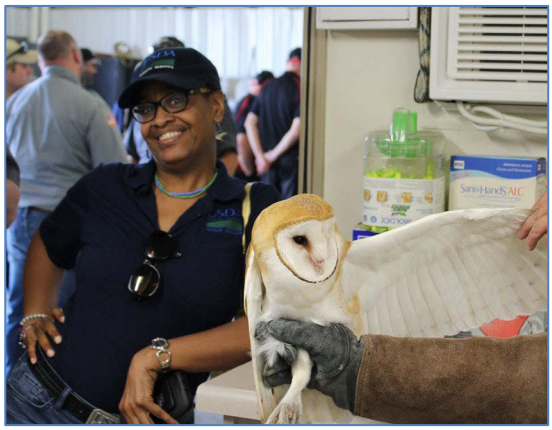
For the 30-year period, reports were received of 73 aircraft destroyed or damaged beyond repair due to wildlife strikes (range of 0 to 6 per year, Tables 14, 22, Figure 16). One aircraft was lost to wildlife strikes in 2019. The majority (46 aircraft; 63 percent of total) were small (≤2,250 kg maximum take-off mass) general aviation aircraft. Terrestrial mammals (primarily white-tailed deer) were responsible for 31 (42 percent) of the

incidents. Geese (6 incidents) and vultures (5 incidents) were responsible for 41 percent of the 27 incidents involving birds in which the species or species group was identified.

Forty-one (56 percent) of the 73 wildlife strikes resulting in a destroyed aircraft occurred at GA airports, 19 occurred en route, 8 occurred at USA airports certificated for passenger service under 14 CFR Part 139, and 3 occurred in miscellaneous situations (taking off from river, herding cattle, and aerial application of pesticides). Two occurred at a foreign airport (Table 22). General aviation 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 30,498 reports from 1990 – 2019 indicating the strike had an adverse effect on the aircraft and/or flight, 11,464 provided an estimate of the aircraft downtime (1,125,169 hours, mean = 98.1 hours/incident, Tables 18, 23, 24). Regarding monetary losses, 4,610 reports provided an estimate of direct aircraft repair costs ($748.5 million, mean = $162,364/incident), and 3,987 reports gave an estimate of other monetary losses ($98.7 million, mean = $24,768/incident)[2]. Other monetary losses include such expenses as lost revenue, the cost of putting passengers in hotels, re-scheduling aircraft, and flight cancellations.



This barn owl, captured at a western USA airport in 2019, was weighed, measured, and banded before being transported to an off-airport location for release. In 2019, USDA Wildlife Services biologists live-trapped and relocated raptors from 242 airports (Begier et al. 2020). In 2019, 98 barn owl strikes with civil aircraft were recorded. Photo, USDA.

Analysis of 14 groups of strike reports from three Part 139 airports certificated for passenger service and three airlines for the years 1991-2004 indicated that 11 to 21 percent of all strikes were reported to the FAA (Cleary et al. 2005, Wright and Dolbeer 2005). An independent analysis of strike data for a certificated airport in Hawaii in the 1990s indicated a similar reporting rate (Linnell et al. 1999). Strike reporting for aircraft at general aviation airports was estimated at less than 5 percent in the 1990s and early

[2] Costs from years prior to 2019 are inflation-adjusted to 2019 U.S. dollars.

2000s (Dolbeer et al. 2008, Dolbeer 2009). More recent analyses estimated that strike reporting for all civil aircraft combined (commercial and general aviation) at Part 139 airports had improved to 39 percent in 2004-2008 and to 47 percent in 2009-2013 (Dolbeer 2009, 2015). Strike reporting for commercial aircraft only at Part 139 airports was an estimated 79 percent in 2004-2008 and 91 percent in 2009-2013; reporting of strikes with damage was estimated at 78 percent and 93 percent for these respective time periods. In addition to the underreporting of strikes, only 38 percent of the 30,498 reports from 1990–2019 indicating an adverse effect provided estimates of aircraft downtime. For the 17,359 reports indicating damage, 27 percent provided estimates of repair (direct) costs, and 23 percent provided estimates of other (indirect) costs (these respective percentages were 23 and 34 for 2019 only, Tables 23, 24). Furthermore, some reports providing cost estimates were filed before aircraft damage and downtime had been fully

Canada geese are one of the few bird species that feed primarily on grass which is why they are attracted to airports and golf courses. Tall grass does not appear to deter this highly adaptable species from foraging. Geese also feed in harvested corn fields and wheat fields during winter. These crops should not be grown adjacent to airports. Photos, R. Dolbeer, Ohio, 2019).

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

Assuming (1) all 30,498 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, wildlife strikes annually cost the USA civil aviation industry, on average, 111,330 hours of aircraft downtime and $196 million in monetary losses ($162 million in direct costs and $34 million in other costs), 1990–2019 (Table 24). For 2019 only, the estimates would be 116,984 hours of downtime and $205 million in direct and indirect costs.

CONCLUSIONS

Standing water at airports is a strong attractant for gulls and other birds and should be eliminated. Photo, R. Dolbeer, USDA.

The analysis of 30 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 mitigating the risk. Although wildlife strikes continue to pose an economic and safety risk for civil aviation in the USA, management actions to mitigate these risks have been implemented at many airports, especially beginning in 2000 when the FAA's manual, Wildlife Hazard Management at Airports was initially available to airports nationwide (Cleary and Dolbeer 2005). These efforts are likely responsible for the stabilization in reported strikes with damage and negative effects-on-flight from 2000-2019 for commercial aircraft (Table 1, Figures 2, 3, 4, 9, 11) in the airport environment (<1,500 feet AGL) in spite of continued increases in populations of many large bird species. Examples of the work done to mitigate the risk of strikes at airports are documented in Wenning et al. 2004, DeFusco et al. 2005, Dolbeer 2006a, Human Wildlife Conflicts Journal 2009, Human-Wildlife Interactions Journal 2011, Dolbeer 2011, DeVault et al. 2013, Dolbeer et al. 2014, Rutledge et al. 2015, and Washburn 2019. As another measure of the increase in wildlife management activities, USDA Wildlife Services biologists provided assistance at 869 civil and military airports nationwide in 2019 to mitigate wildlife risks to aviation compared to only 42 airports in 1991 and 193 in 1998 (Begier et al. 2020). However, much work remains to be done to reduce wildlife strikes.

To address the problem in the airport environment, airport managers first need to assess the wildlife hazards on their airports with the help of qualified airport biologists (FAA Advisory Circular 150/5200-36B, Qualifications for Wildlife Biologist Conducting Wildlife Hazard Assessments and Training Curriculums for Airport Personnel Involved in Controlling Wildlife Hazards on Airports). They then must take appropriate actions, under the guidance of these biologists, to minimize risks posed by wildlife. Management actions should be prioritized based on the hazard level of species (Table 18, Figure 14) observed

in the aircraft operating area. The manual *Wildlife Hazard Management at Airports* (Cleary and Dolbeer 2005), available online in English, Spanish, and French at http://wildlife.faa.gov, provides guidance for conducting wildlife hazard assessments and in developing and implementing wildlife hazard management plans.

Management efforts to reduce the risks of bird strikes have primarily focused on airports since various historical analyses of bird strike data for civil aviation have indicated the majority of strikes occur in this environment (during take-off and landing at ≤1,500 feet AGL (see Tables 11, 12). However, the successful mitigation efforts at Part 139-certificated airports that have stabilized or reduced damaging strikes for commercial aviation in recent years have done little to reduce strikes outside the airport environment such as occurred with US Airways Flight 1549 in 2009 (Dolbeer 2011).

To mitigate the risk for strikes beyond the airport fence, the general public and aviation community must first widen its view of wildlife management to consider habitats and land uses within 5 miles (or sometimes greater distances) of airports (Pfeiffer et al. 2018). For example, wetlands, dredge-spoil containment areas, municipal solid waste landfills, and wildlife refuges typically attract hazardous wildlife. Such land uses, as discussed in FAA Advisory Circular 150/5200-33B, *Hazardous Wildlife Attractants on or Near Airports*, are often incompatible with aviation safety and should either be prohibited near airports or designed and operated in a manner that minimize the attraction of hazardous wildlife (e.g., Washburn et al. 2010, Beffre and Washburn 2020).

Blackbirds and starlings often gather in large nighttime roosts during fall, winter and spring. Flightlines of birds in dense flocks going to and from these roosts at dusk and dawn can pose a risk to aircraft. Roosts near airports need to be dispersed by harassment and habitat management (Linz et al. 2017). Photo, Ohio 2019, R. Dolbeer

Second, the aviation community needs to broaden the view of wildlife strike risks from a ground-based wildlife management problem solely dealt with by airports to an airspace management problem that also encompasses Air Traffic Control, flight crews, and aircraft manufacturers. Long-term goals include the integration of avian radar and bird migration forecasting into airspace management for civil aviation (Nohara et al. 2011, Gerringer et al. 2016). The further development of aircraft lighting systems to enhance detection and

avoidance by birds (Blackwell et al. 2012, DeVault et al. 2015, Dolbeer and Barnes 2017, Fedy 2018) is also needed as part of an integrated program.

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

PART 2: FAA ACTIVITIES FOR MITIGATING WILDLIFE STRIKES

In 2019, the FAA continued a multifaceted approach for mitigating wildlife strikes. This included publishing new guidance, 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 (Assessments) and develop Wildlife Hazard Management Plans (Plans).

The emergency forced landing of US Airways Flight 1549 Airbus 320 into the Hudson River on January 15, 2009 demonstrated to the world the severity of aircraft collisions with birds and other wildlife. Migratory Canada geese were ingested into both engines at 3:27.11 p.m. at an altitude of 2,818 feet above ground level (AGL) and 4.5 miles north-northwest of the approach end of runway 22 at La Guardia International Airport (LGA). Three minutes 49 seconds later the aircraft successfully ditched into the Hudson River with 150 passengers and 5 crew; there were no fatalities.

Landmark events such as this necessitate outside scrutiny and comprehensive internal evaluations to ensure optimal guidance, compliance and risk reduction moving forward. Since the first Advisory Circular 150 / 5200-1 Bird Hazards to Aviation, Bird Hazard Research published March 1, 1965, these types of evaluations have allowed the Federal Aviation Administration (FAA) wildlife program to systematically improve its oversight to reduce risks within the safest aerospace system in the world. The results from reviews conducted post-1549 have enhanced existing regulations and provided beneficial layers of expansion throughout other key FAA wildlife-related areas (e.g., Data collection and analysis, Partnerships, Research, and Outreach).

External reviews of the FAA wildlife program resulted in helpful recommendations from the National Safety Transportation Board (NTSB) and the DOT Office of Inspector General (OIG). The four recommendations issued by the NTSB in 2009 and 2010 respectively, have been successfully closed. Two of the recommendations were generated from a 2008 fatal accident involving a Cessna 500 that collided with a flock of white pelicans near the Wiley Post Airport in Oklahoma while the remaining recommendations addressed concerns raised from the US Airways Flight 1549 incident.

Ten additional recommendations were submitted on August 22, 2012 to the FAA within the OIG Audit Report: "*FAA Has Not Effectively Implemented Its Wildlife Hazard Mitigation Program*." These recommendations covered a wide range of subjects including FAA oversight and enforcement, our policies and guidance for monitoring, reporting, and mitigating wildlife hazards, interagency cooperation, personnel training, communication, and mandatory strike reporting. The last of these extensive recommendations received final closure August 1, 2016.

FAA Guidance

In the 11-year span 2009 – 2019, approximately $350 million of Airport Improvement Program (AIP) funds have been allocated for wildlife-related projects such as Wildlife Hazard Assessments (Assessments), Wildlife Hazard Management Plans (Plans) and

perimeter fencing. Title 14 Code of Federal Regulations, part 139.337, *Wildlife Hazard Management*, is supported by non-regulatory guidance such as Advisory Circulars (ACs) and CertAlerts. Advisory Circular 150/ 5200- 38 - *Protocol for the Conduct and Review of Wildlife Hazard Site Visits, Wildlife Hazard Assessments, and Wildlife Hazard Management Plans* was published August 20, 2018. This new AC defines the minimum acceptable standards for the conduct and preparation of Site Visits, Assessments and Plans. AC 150/5200-38 also clarifies the NEPA process for projects included in an airport's WHMP and provides protocol for the approval (or partial approval) of Plans with regard to NEPA and other environmental laws. The AC gives Airports and Biologists checklists for Assessments and Plans and provides Airport Certification Safety Inspectors guidelines/ templates to review those documents.

AC 150/5200-36B *Qualifications for Wildlife Biologist Conducting Wildlife Hazard Assessments and Training Curriculums for Airport Personnel Involved in Controlling Wildlife Hazards on Airports* was last updated January 24, 2019. This latest version provides for an alternative field experience option of Continual Monitoring to aid Qualified Airport Wildlife Biologists (QAWB) candidates in an era where all certificated airports have finished their initial Assessments and Plans.

On February 21, 2020, AC 150/5200-33C *Hazardous Wildlife Attractants On or Near Airports* was updated with significant changes. The updated language included clarification of separation criteria, new guidance on land-use practices (e.g., aquaculture, agriculture, dredge spoil, etc.), inclusion of general aviation (GA) airport wildlife responsibilities and a new section *Airport Procedures for Off-site Attractants* that provides step-by-step guidance when proposed land-use changes may provide an attractant to hazardous species.

Wildlife Hazard Assessments and Wildlife Hazard Management Plans

The FAA encouraged all certificated airports to conduct Assessments and develop Plans regardless if a triggering event under 14 CFR Part 139 had been experienced. All Part 139 airports have completed an Assessment and Plan and many have already updated their Assessments. Joint-use facilities that maintain a Bird/ wildlife Aircraft Strike Hazard (BASH) Plan also completed Assessments as a foundation for their BASH Plans. Wildlife Hazard Assessments are critical because they will allow an airport to:

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

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

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

Strike Reporting

Wildlife strikes continue to capture media attention. While impacted pilots and airports are reporting strikes, they might not know the critical role their reports play in understanding wildlife issues and developing wildlife policies. The FAA developed an educational video to provide guidance to pilots and airport operators on the role of wildlife strike reporting in preventing aviation accidents caused by birds and other animals. The video — titled the *2015 Wildlife Hazard Management and Strike Reporting Update* — is the second offering in the FAA's Office of Airports ongoing web-based series, http://www.faa.gov/airports/safety-video-series/. The video highlights the benefits of the collection of wildlife strike data since the FAA began compiling reports submitted by airports, pilots, controllers, and other parties in its NWSD.

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

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

"Excellence in Strike Reporting" Award

2014 was the inaugural year for the Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award. The award honors the incomparable dedication of Dr. Richard Dolbeer and Sandy Wright; each being exceptional in the management of the NWSD since the FAA first contracted the USDA in 1995 to oversee the collection, quality control, analysis and summation of strike reports.

The Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award recognizes those airports that have exhibited a noteworthy strike reporting program. The number of USA airports with strikes reported increased from 335 in 1990 to a record 714 in 2018. The 714 airports with strikes reported were comprised of 423 airports certificated for passenger service under 14 CFR Part 139 and 291 GA aviation airports. From 1990 - 2018, strikes have been reported from 2,047 USA airports.

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

1. Number of reports filed and completeness of reports

3. Percentage of reports identified to species

4. Percentage of reports filed on-line

5. Timeliness of reports being submitted

6. Remains collected when available or necessary

7. Consistency filing reports

Further evaluation of the finalist strike reporting programs may include:

1. Modification of filed reports online when new information is discovered

2. Airport follows up with airline or engine manufacturer for missing information

3. Airport has someone on "Notification" list to receive notice when strikes are filed for their airport

In 2018, the Part 139 certificated airport winner was Seattle / Tacoma International Airport (SEA) and the General Aviation representative was Page Field (FMY**)**. For their commitment to the identification and documentation of wildlife / aircraft strike information, the FAA proudly recognizes the strike reporting programs at **Charlotte Douglas International Airport (CLT)** and **Kalaeloa Airport (John Rodgers Field) (JRF)** as the winners of the 2019 Sandy Wright / Richard Dolbeer Excellence in Strike Reporting award.

	AWARD WINNERS	
	PART 139 AIRPORTS	**GA AIRPORTS**
2014	DALLAS / FORT WORTH - DFW	MORRISTOWN - MMU
2015	LAGUARDIA - LGA	VAN NUYS - VNY
2016	MINNEAPOLIS / ST. PAUL - MSP	CENTENNIAL - APA
2017	PORTLAND - PDX	HENDERSON FIELD (MIDWAY ATOLL) - MDY
2018	SEATTLE / TACOMA - SEA	PAGE FIELD - FMY
2019	Charlotte Douglas (CLT)	Kalaeloa Airport (John Rodgers Field) (JRF)

Airport Cooperative Research Program (ACRP) Reports

The FAA assisted with the development of two new Airport Cooperative Research Program (ACRP) reports to aid airports with the mitigation of wildlife hazards. The reports (ACRP Synthesis 92: Airport Waste Management and Recycling Practices and ACRP Research Report 174 Guidebook and Primer) were published in 2018. Other recent reports published were ACRP Report 122 Innovative Airport Responses to Threatened / Endangered Species (2015), ACRP Report 125 Balancing Airport Stormwater and Bird Hazard Management (2015) and ACRP Report 145 Applying an SMS Approach to Wildlife Hazard Management (2015). These, and other wildlife / aviation reports are available from the Transportation Research Board of the National Academies (TRB) at http://www.trb.org/Publications/Publications.aspx.

Wildlife Hazard Mitigation Research

FAA research funds dedicated over $25 million within the last decade to better understand the capabilities of advanced detection and monitoring systems such as avian radars, Foreign Object Debris (FOD) radars and infrared / electro-optical scanning systems. Other research initiatives included wildlife control techniques, avian visual acuity and aircraft lighting, habitat management, Canada goose movement analyses, capture and relocation efficacy of raptors, DNA and molecular identifications, and systems integration (Wildlife Surveillance Concept -WiSC) which aims to determine the compatibility of avian radar or similar monitoring technologies warning notice in the Air Traffic Controller's reach. The research efforts designed to improve wildlife management techniques and practices on and near airports include:

- Alternative habitat management strategies to reduce attraction to airports of hazardous wildlife species
- Techniques for restricting access of hazardous wildlife species to attractive features like storm water ponds

- Technologies for harassing and deterring hazardous species
- Movement patterns of red-tailed hawks following translocation from an airport
- Evaluation of translocation as a management tool for American kestrels at airports
- Aircraft-mounted lighting systems to enhance bird detection and avoidance of aircraft
- Landscape-level analysis of land cover and birdstrike rate across airports

Bird Strike Committee USA

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

Commercial Aviation Safety Team (CAST)

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

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

Performance Metrics

Starting in 2013 the FAA adopted the following performance metrics that will measure program efficacy under a voluntary strike reporting environment where the absolute number of bird strikes is not known. These three-performance metrics allow the FAA to monitor multiple factors that affect strike reporting and overall strike reporting trends and the effectiveness of GA wildlife mitigation programs. To date, strike reporting trends continue to show an increase in overall reporting contrasted with an actual decline in

damaging strikes from 762 in 2000 to 710 in 2019. Analyses of strike reporting trends will be continued (see Metric 2).

Metric 1: Monitor the ratio between the numbers of strikes with damage compared to total reported strikes. This ratio is independent of the total number of strikes reported and is a good measure of the effectiveness of overall mitigation procedures. We use 2010 as the baseline data and calculate the performance measure for following years. The table below depicts the results of calculating the data for the 9-year period 2010 - 2018.

Year	Total strikes reported	Damaging strikes reported	Percentage damaging strikes vs. total strikes
2010	9,905	597	6.0%
2011	10,119	542	5.4%
2012	10,918	612	5.6%
2013	11,417	609	5.3%
2014	13,694	584	4.3%
2015	13,808	619	4.5%
2016	13,454	596	4.4%
2017	14,664	658	4.5%
2018	16,020	697	4.4%
2019	17,228	710	4.1%

Metric 2: Monitor estimated reporting rate of wildlife strikes. In 2015, the original five-year study (Dolbeer 2009) that estimated the 39 percent reporting rate was updated to determine if our outreach efforts have increased the reporting rate (Dolbeer 2015). The estimated reporting rate has increased to 47 percent for all civil aircraft but has been estimated to be 91 percent for strikes involving commercial aircraft at certificated airports. Damaging strikes have continued to decline or remain stable. We will continue to update the study approximately every five years.

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

The 17,228 documented strikes in 2019 equates to roughly 47 wildlife strikes every day, of which only about 4% are damaging. In 2019, there were 710 damaging strikes; this averages about 2 damaging strikes per day or about 1 per 35,000 of the estimated 70,000

daily aircraft movements over US airspace. Overall, 82% of strikes occur at or below 1,500 feet AGL. This altitude falls within the 5-mile separation distance around airports recommended for wildlife attractants, meaning that on-ground wildlife mitigation activities out to 5 miles can have a positive effect on risk reduction for 82% of all wildlife strikes.

Wildlife strikes are rare events that occur every day. Although it is impossible to eliminate all strikes at all times, comprehensive assessment, planning and management techniques have successfully mitigated damaging strikes on or near airports. Combined with systematic evaluation and adaptation of techniques, safety can be increased one less strike at a time.

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TABLES

Table 1. Number of reported wildlife strikes to civil aircraft in USA and to U.S.-registered civil aircraft in foreign countries, 1990–2019.

	USA[1]		Foreign		Total	
Year	Strikes	Damage strikes	Strikes	Damage strikes	Strikes	Damage strikes
1990	1,816	366	34	6	1,850	372
1991	2,352	395	37	5	2,389	400
1992	2,530	360	37	5	2,567	365
1993	2,541	395	34	4	2,575	399
1994	2,600	453	35	7	2,635	460
1995	2,717	486	52	11	2,769	497
1996	2,885	492	51	10	2,936	502
1997	3,386	569	69	9	3,455	578
1998	3,733	574	67	10	3,800	584
1999	5,020	688	95	18	5,115	706
2000	5,874	743	128	21	6,002	764
2001	5,696	630	124	15	5,820	645
2002	6,075	659	141	11	6,216	670
2003	5,853	612	137	20	5,990	632
2004	6,396	612	159	16	6,555	628
2005	7,039	591	180	19	7,219	610
2006	7,071	581	162	18	7,233	599
2007	7,587	552	142	16	7,729	568
2008	7,429	512	186	14	7,615	526
2009	9,241	585	251	20	9,492	605
2010	9,660	577	229	18	9,889	595
2011	9,840	518	264	24	10,104	542
2012	10,637	592	266	21	10,903	613
2013	11,210	597	195	12	11,405	609
2014	13,454	571	228	15	13,682	586
2015	13,545	610	242	12	13,787	622
2016	13,185	577	167	11	13,352	588
2017	14,625	655	162	10	14,787	665
2018	15,998	696	223	13	16,221	709
2019	17,050	710	178	10	17,228	720
Total	**227,045**	**16,958**	**4,275**	**401**	**231,320**	**17,359**

[1] Includes strikes where airport is unknown because strike was en route or phase of flight was undetermined. See Table 2 for breakdown of strikes occurring in USA by type of wildlife.

Table 2. Number of reported wildlife strikes to civil aircraft in USA by wildlife group, 1990–2019.

Year	Birds	Bats	Terrestrial mammals[1]	Reptiles[1]	Total strikes	Strikes with damage
1990	1,758	3	55	0	1,816	366
1991	2,291	3	58	0	2,352	395
1992	2,454	2	73	1	2,530	360
1993	2,469	6	66	0	2,541	395
1994	2,515	2	82	1	2,600	453
1995	2,620	4	85	8	2,717	486
1996	2,792	1	89	3	2,885	492
1997	3,277	1	94	14	3,386	569
1998	3,612	3	111	7	3,733	574
1999	4,916	6	97	1	5,020	688
2000	5,733	15	123	3	5,874	743
2001	5,543	8	137	8	5,696	630
2002	5,922	19	119	15	6,075	659
2003	5,705	20	123	5	5,853	612
2004	6,237	27	126	6	6,396	612
2005	6,874	27	131	7	7,039	591
2006	6,874	46	141	10	7,071	581
2007	7,360	51	169	7	7,587	552
2008	7,198	44	182	5	7,429	512
2009	8,936	66	229	10	9,241	585
2010	9,291	112	246	11	9,660	577
2011	9,488	138	199	15	9,840	518
2012	10,254	161	203	19	10,637	592
2013	10,750	223	204	33	11,210	597
2014	12,944	253	222	35	13,454	571
2015	12,983	316	210	36	13,545	610
2016	12,679	246	224	36	13,185	577
2017	13,889	409	268	59	14,625	655
2018	15,140	507	302	49	15,998	696
2019	16,020	550	393	87	17,050	710
Total	**218,524**	**3,269**	**4,761**	**491**	**227,045**	**16,958[2]**

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

[2] Birds, terrestrial mammals, bats, and reptiles respectively accounted for 15,768, 1,165, 22, and 3 of the 16,958 damage strikes.

Table 3. Number and rate of reported wildlife strikes and strikes with damage for commercial air carrier aircraft, USA, 1990–2019 (see Figure 3).

	No. of reported strikes[1]			Strikes/100,000 movements	
Year	All strikes	Strikes with damage	Aircraft movements (x 1 million)[2]	All strikes	Strikes with damage
1990	1,347	219	23.22	5.80	0.94
1991	1,779	249	24.73	7.19	1.01
1992	1,797	207	25.13	7.15	0.82
1993	1,781	232	25.52	6.98	0.91
1994	1,893	279	26.55	7.13	1.05
1995	1,983	311	27.00	7.34	1.15
1996	2,057	310	27.54	7.47	1.13
1997	2,431	368	27.72	8.77	1.33
1998	2,484	361	27.97	8.88	1.29
1999	3,785	464	28.72	13.18	1.62
2000	4,381	494	29.51	14.85	1.67
2001	4,050	430	29.13	13.90	1.48
2002	4,269	450	27.60	15.47	1.63
2003	4,152	398	27.87	14.90	1.43
2004	4,550	392	28.84	15.77	1.36
2005	4,979	403	29.22	17.04	1.38
2006	4,757	386	28.28	16.82	1.36
2007	4,860	338	28.44	17.09	1.19
2008	4,442	324	27.94	15.90	1.16
2009	5,877	371	25.45	23.10	1.46
2010	5,787	358	25.10	23.05	1.43
2011	5,719	320	25.11	22.78	1.27
2012	6,146	369	24.88	24.70	1.48
2013	6,276	308	24.59	25.52	1.25
2014	7,966	328	24.41	32.63	1.34
2015	7,843	335	24.57	31.92	1.36
2016	7,662	345	24.82	30.88	1.39
2017	8,246	394	25.06	32.91	1.57
2018	9,131	435	25.59	35.68	1.70
2019	9,774	406	26.21	37.30	1.55
Total	**142,204**	**10,584**	**796.73**	**17.85**	**1.33**

[1] Strikes involving an unknown operator (60,382 of which 58,950 were “Carcass Found” reports--see Tables 6 and 7) were excluded from this analysis as were all strikes by USA-registered aircraft in foreign countries.

[2] Departures and arrivals by fiscal year (1 Oct-30 Sep) for air carrier, commuter, and air taxi service aircraft (Federal Aviation Administration 2020*a*).

Table 4. Number and rate of reported wildlife strikes and strikes with damage for general aviation aircraft, USA, 1990–2019 (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	334	134	77.21	0.43	0.17
1991	406	131	83.17	0.49	0.16
1992	432	142	81.98	0.53	0.17
1993	447	159	80.05	0.56	0.20
1994	475	172	78.85	0.60	0.22
1995	481	171	76.89	0.63	0.22
1996	505	179	78.63	0.64	0.23
1997	505	189	79.61	0.63	0.24
1998	567	204	83.90	0.68	0.24
1999	620	212	85.08	0.73	0.25
2000	673	246	86.81	0.78	0.28
2001	695	194	85.58	0.81	0.23
2002	782	209	85.51	0.91	0.24
2003	682	208	83.15	0.82	0.25
2004	693	217	82.39	0.84	0.26
2005	666	186	80.92	0.82	0.23
2006	687	195	79.95	0.86	0.24
2007	669	211	80.00	0.84	0.26
2008	627	186	77.81	0.81	0.24
2009	861	214	73.40	1.17	0.29
2010	845	216	71.03	1.19	0.30
2011	917	198	69.71	1.32	0.28
2012	1,029	223	69.39	1.48	0.32
2013	1,108	287	68.63	1.61	0.42
2014	1,338	241	68.01	1.97	0.35
2015	1,406	274	68.12	2.06	0.40
2016	1,382	229	67.39	2.05	0.34
2017	1,339	247	67.21	1.99	0.37
2018	1,623	256	67.93	2.39	0.38
2019	1,658	301	68.85	2.41	0.44
Total	**24,452**	**6,231**	**2,307.13**	**1.06**	**0.27**

[1] Strikes involving an unknown operator (60,382 of which 58,950 were “Carcass Found” reports--see Tables 6 and 7) were excluded from this analysis as were all strikes by USA-registered aircraft in foreign countries.

[2] Itinerant and local departures and arrivals by fiscal year (1 Oct-30 Sep) for general aviation aircraft (Federal Aviation Administration 2020*a*).

Table 5. Methods of reporting and source of information for reported wildlife strikes to civil aircraft, USA[1], 2019 only and 1990–2019.

	2019 only		1990-2019	
Source	Total	% of total	Total	% of total
FAA Form 5200-7-E[2]	14,399	84	129,942	56
MOR	1,270	7	7,098	3
Multiple[3]	519	3	22,853	10
Daily Report	423	2	2,073	1
Air Transport Report	383	2	16,338	7
FAA Form 5200-7 (Paper)	119	<1	41,630	18
Airport Report	114	<1	6,454	3
Other[4]	1	<1	4,932	2
Total	**17,228**	**100**	**231,320**	**100**

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

[2] Bird/Other Wildlife Strike Report. Electronic filing of reports (http://wildlife.faa.gov) began in April 2001.

[3] More than one type of report was filed for the same strike (many of these had at least one FAA Form 5200-7E report filed).

[4] Various sources such as news media, Preliminary Aircraft Incident Report, Aviation Safety Reporting System, National Transportation Safety Board, Transport Canada, Engine manufacturers.

Table 6. Person filing report of wildlife strike to civil aircraft, USA[1], 2019 only and 1990–2019.

	2019 only		1990-2019	
Person filing report	Total	% of total	Total	% of total
Airport Operations	11,414	66	106,682	51
Misc. reports[2]	5,949	52	47,732	45
Carcass Found[3]	5,465	48	58,950	55
Pilot	2,636	15	42,644	20
Tower	1,957	11	24,184	12
Air Transport Operations	844	5	31,575	15
Other	350	2	4,917	2
Total known	**17,201**	**100**	**210,002**	**100**
Unknown	**27**		**21,318**	
Total	**17,228**		**231,320**	

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

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

[3] Airport personnel found fresh wildlife remains within 250 feet of a runway centerline or elsewhere on or near airport that appeared to have been struck by aircraft, but no strike was observed or reported by pilot, tower, or airline (FAA Advisory Circular 150/5200-32B).

Table 7. Number of reported wildlife strikes to civil aircraft by type of operator, USA[1], 2019 only and 1990-2019.

	2019 only		1990-2019	
Type of operator	Total	% of total	Total	% of total
Commercial[2]	**9,948**	**86**	**146,311**	**86**
General Aviation	**1,661**	**14**	**24,627**	**14**
Business	1,378	12	19,469	11
Government/police[3]	154	1	1,831	1
Private	129	1	3,327	2
Total known	**11,609**	**100**	**170,938**	**100**
Unknown[4]	**5,619**		**60,382**	
Total	**17,228**		**231,320**	

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

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

[3] U.S. Customs and Border Protection (USCBP) and U.S. Coast Guard (USCG) aircraft were respectively involved in 27 percent (491) and 31 percent (572) of the 1,831 Government/police strikes, 1990–2019. For 2019 only, 8 percent (12) and 44 percent (67) of the 154 Government/police strikes involved USCBP and USCG aircraft, respectively.

[4] Ninety-eight percent (58,950) of the 60,382 strikes involving an unknown operator were “Carcass Found” reports, 1990–2019. For 2019 only, 99 percent (5,465) of the 5,619 strikes involving an unknown operator were “Carcass Found” reports (see Table 6).

Table 8. Number of Part 139-certificated airports[1] and general aviation (GA) airports with reported wildlife strikes and number of strikes reported for these airports, civil aircraft, USA, 1990–2019 (see Figure 6)[2].

	Part 139 airports		GA airports		All USA airports	
Year	Airports	Strikes	Airports	Strikes	Airports	Strikes
1990	236	1,508	99	163	335	1,671
1991	260	1,989	96	198	356	2,187
1992	255	2,173	108	228	363	2,401
1993	257	2,220	100	218	357	2,438
1994	264	2,220	111	247	375	2,467
1995	261	2,328	119	209	380	2,537
1996	259	2,497	109	194	368	2,691
1997	285	2,908	122	201	407	3,109
1998	292	3,216	144	269	436	3,485
1999	305	3,806	145	257	450	4,063
2000	312	4,466	153	279	465	4,745
2001	317	4,433	151	294	468	4,727
2002	309	4,764	154	308	463	5,072
2003	306	4,642	154	330	460	4,972
2004	307	5,203	177	323	484	5,526
2005	322	5,492	175	330	497	5,822
2006	322	5,915	144	273	466	6,188
2007	327	6,550	163	327	490	6,877
2008	333	6,610	162	309	495	6,919
2009	363	8,004	235	453	598	8,457
2010	375	8,292	216	461	591	8,753
2011	366	8,444	230	499	596	8,943
2012	384	8,906	255	576	639	9,482
2013	381	9,132	273	618	654	9,750
2014	397	11,017	279	699	676	11,716
2015	404	11,101	269	695	673	11,796
2016	404	10,805	262	783	666	11,588
2017	420	11,771	281	827	701	12,598
2018	423	12,870	292	861	715	13,731
2019	420	13,354	333	931	753	14,285
Total	**522**	**186,636**	**1,569**	**12,360**	**2,091**	**198,996**

[1] There were 521airports in USA certificated for passenger service under CFR Part 139 regulations in June 2020 (FAA 2020*b*).

[2] In addition, 4,275 strikes involving USA-registered aircraft were reported from 315 foreign airports in 108 countries. Furthermore, 4,191 strikes (4,169 bird and 22 bat strikes) were reported in which aircraft was en route (Table 10). An additional 23,806 strikes were reported in which either evidence of strike was discovered on aircraft after landing but phase of flight where strike occurred could not be determined or an airport was not named on reporting form.

Table 9. Reported time of occurrence of wildlife strikes with civil aircraft, USA[1], 1990–2019[2].

	Birds		Terrestrial mammals		Bats	
Time of day	30-year total	% of total known	30-year total	% of total known	30-year total	% of total known
Dawn	4,886	4	101	4	22	2
Day	84,383	62	633	26	232	22
Dusk	5,945	4	173	7	50	5
Night	39,976	30	1,483	62	770	72
Total known	**135,190**	**100**	**2,390**	**100**	**1,074**	**100**
Unknown[3]	**87,563**		**2,384**		**2,228**	
Total	**222,753**		**4,774**		**3,302**	

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

[2] In addition, 491 strikes with reptiles were reported from 1990–2019: time not reported (408), day (64), night (14), dusk (3), and dawn (2).

[3] Of the 92,583 strike reports with “Unknown” time of day (all species), 58,950 (64 percent) were “Carcass Found” reports (Table 6).

Table 10. Reported phase of flight at time of occurrence of wildlife strikes with civil aircraft, USA[1], 1990–2019[2].

	Birds		Terrestrial mammals[3]		Bats	
Phase of flight	30-year total	% of total known	30-year total	% of total known	30-year total	% of total known
Parked	96	<1	2	<1		
Taxi	449	<1	62	2		
Take-off Run	24,507	17	793	31	39	4
Climb	23,365	16	52	2	58	6
Departure[4]	1,736	1	4	<1	15	2
En Route	4,169	3			22	2
Arrival[4]	550	<1	4	<1	2	<1
Descent	1,881	1			14	2
Approach	61,509	43	194	7	655	71
Landing Roll	24,626	17	1,449	56	118	13
Local[4]	679	<1	28	1	3	<1
Total known	**143,567**	**100**	**2,588**	**100**	**926**	**100**
Unknown[5]	**79,186**		**2,186**		**2,376**	
Total	**222,753**		**4,774**		**3,302**	

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

[2] In addition, 491 strikes with reptiles were reported: phase of flight not reported (408), take-off run (31), landing roll (30), taxi (16), and approach (5; pilot missed approach because reptile was on the runway or hit reptile before aircraft touched down).

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

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

[5] Of the 84,156 strike reports with “Unknown” phase of flight (all species), 58,950 (70 percent) were “Carcass Found” reports (Table 6).

Table 11. Number of reported bird strikes to commercial aircraft[1] by height above ground level (AGL), USA[2], 1990–2019. See Figure 9 for graphic analysis of strike data from 501 to 18,500 feet AGL[3].

	All reported strikes			Strikes with damage		
Height of strike (feet AGL)	30-year total	% of total known	% cum-ulative total[4]	30-year total	% of total known	% cum-ulative total[4]
0	42,205	41	41	2,062	28	28
1-500	30,204	30	71	2,014	27	55
501-1500	11,173	11	82	1,117	15	70
1501-2500	5,912	6	88	687	9	79
2501-3500	4,306	4	92	462	6	85
3501-4500	2,593	3	94	279	4	89
4501-5500	1,808	2	96	207	3	92
5501-6500	1,209	1	97	150	2	94
6501-7500	826	1	98	98	1	95
7501-8500	628	1	99	91	1	96
8501-9500	333	<1	99	45	1	97
9501-10500	455	<1	99	73	1	98
10501-11500	225	<1	100	51	1	99
>11500[5]	383	<1	100	111	1	100
Total known	**102,260**	**100**		**7,447**	**100**	
Unknown height	**41,210**			**3,260**		
Total	**143,470**			**10,707**		

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

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

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

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

[5] Twenty-nine strikes involving commercial aircraft (11 with damage to aircraft) were reported at ≥20,000 feet AGL; the highest was 31,300 feet.

Table 12. Number of reported bird strikes to general aviation aircraft[1] by height above ground level (AGL), USA[2], 1990–2019. See Figure 9 for graphic analysis of strike data from 501 to 12,500 feet AGL[3].

	All reported strikes			Strikes with damage		
Height of strike (feet AGL)	30-year total	% of total known	% cum-ulative total[4]	30-year total	% of total known	% cum-ulative total[4]
0	6,978	36	36	736	16	16
1-500	6,745	35	72	1,523	33	49
501-1500	3,036	16	87	1,251	27	76
1501-2500	1,187	6	94	534	12	88
2501-3500	562	3	96	251	5	93
3501-4500	267	1	98	123	3	96
4501-5500	135	1	99	57	1	97
5501-6500	88	<1	99	44	1	98
6501-7500	66	<1	99	25	1	98
7501-8500	39	<1	100	20	<1	99
8501-9500	22	<1	100	13	<1	99
9501-10500	22	<1	100	14	<1	99
10501-11500	6	<1	100	2	<1	100
>11500[5]	34	<1	100	24	1	100
Total known	**19,187**	**100**		**4,617**	**100**	
Unknown height	**4,026**			**721**		
Total	**23,213**			**5,338**		

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

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

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

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

[5] Seven strikes involving general aviation aircraft (6 with damage to aircraft) were reported at ≥20,000 feet AGL; the highest was 24,000 feet.

Table 13. Civil aircraft components reported as being struck and damaged by wildlife, USA[1], 1990–2019.

	Birds (30-year total)				Terrestrial mammals (30-year total)			
Aircraft component	Number struck	% of total	Number damaged	% of total	Number struck	% of total	Number damaged	% of total
Windshield	29,563	15	1,203	6	9	<1	17	1
Nose	26,952	14	1,319	7	122	4	114	5
Wing/rotor	26,560	14	4,721	25	336	10	338	16
Radome	22,318	12	1,796	9	19	1	17	1
Engine(s)[2]	21,470	11	5,042	26	193	6	187	9
Fuselage	21,434	11	839	4	162	5	166	8
Landing gear	8,332	4	613	3	1,502	46	515	24
Propeller	3,790	2	299	2	357	11	317	15
Tail	2,363	1	793	4	62	2	84	4
Light	1,177	1	815	4	55	2	58	3
Other[3]	27,612	14	1,730	9	459	14	305	14
Total[4]	**191,571**	**100**	**19,170**	**100**	**3,276**	**100**	**2,118**	**100**

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

[2] For birds, 21,470 engines were reported as struck in 20,520 strike events involving engines (19,600 events with one engine struck, 897 with two engines struck, 16 with three engines struck, and 7 with four engines struck). A total of 5,042 engines was damaged in 4,880 bird-strike events with engine damage (4,721 events with one engine damaged, 157 with two engines damaged, 1 with three engines damaged, and 1 with four engines damaged). For terrestrial mammals, 193 engines were reported as struck in 183 strike events (173 events with one engine struck and 10 with two engines struck). A total of 187 engines was damaged in 168 terrestrial mammal strike events with engine damage (149 events with one engine damaged and 19 with two engines damaged). Some engines were damaged without being struck when the landing gear collapsed.

[3] "Other" parts reported struck included 717 Pitot tubes, 446 wiper blades, 250 antennae (communication, radar, or global position), 136 Total Air Temperature (TAT) probes, and 150 Angle of Attack (AOA) sensors.

[4] In addition, bat strikes had 1,810 and 27 components reported as struck and damaged, respectively: radome/nose (618, 4), windshield (291, 5), engine (127, 5), propeller (5, 0), wing/rotor (365, 7), fuselage (153, 0), tail (22, 1), other (150, 3), landing gear (71, 0), light (8, 2). For reptile strikes, there were 78 and 7 components reported struck and damaged, respectively: windshield (1, 1), wing/rotor (2, 2), fuselage (1, 1), landing gear (65, 1), tail (1, 1), nose (1, 0), other (7, 1).

Table 14. Number of civil aircraft with reported damage resulting from wildlife strikes, USA[1], 1990–2019. See Tables 1 - 4 and Figures 2 – 4, 11, and 16 for trends in damaging strikes, 1990–2019.

	Reported strikes					
	Birds		Terrestrial mammals		Total (all species)[2]	
Damage category[3]	30-year total	% of total[4]	30-year total	% of total[4]	30-year total	% of total[4]
None	**135,754**	**61**	**1,207**	**25**	**138,523**	**60**
Unknown	**70,835**	**32**	**2,401**	**50**	**75,438**	**33**
Damage	**16,164**	**7**	**1,166**	**25**	**17,359**	**8**
Minor	7,679	3	562	12	8,252	4
Uncertain	4,812	2	142	3	4,967	2
Substantial	3,631	2	431	9	4,067	2
Destroyed	42	<1	31	1	73	<1
Total	**222,753**	**100**	**4,774**	**100**	**231,320**	**100**

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

[2] Included in totals are 3,303 and 491 strikes involving bats and reptiles, respectively. For bats, 1,492 reports indicated no damage, 1,784 failed to indicate if damage occurred, and 26 indicated damage (9 minor, 13 uncertain level, 4 substantial [caused by megabats at foreign airports]). For reptiles, 70 reports indicated no damage, 418 failed to indicate if damage occurred, and 3 indicated damage (2 minor, 1 substantial).

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

[4] The percentage of strikes causing damage is calculated using the total strikes reported as the divisor, including the 75,438 reports that did not indicate if damage occurred or not (Unknown). “Carcass found” reports (see Table 6) comprised 58,950 (78 percent) of these 75,438 reports. If the Unknown reports are excluded from the calculations, then 11, 49, and 11 percent of the strikes caused damage for birds, terrestrial mammals, and all species, respectively.

Table 15. Reported effect-on-flight of wildlife strikes to civil aircraft, USA[1], 1990–2019. See Figure 11 for trend in strikes with a negative effect-on-flight, 1990-2019.

	Reported strikes					
	Birds		Terrestrial mammals		Total[2]	
Effect-on-flight[3]	30-year total	% of total[4]	30-year total	% of total[4]	30-year total	% of total[4]
None	**113,106**	**51**	**1,156**	**24**	**115,378**	**50**
Unknown	**97,558**	**44**	**2,792**	**58**	**102,999**	**45**
Negative effect	**12,089**	**5**	**826**	**18**	**12,943**	**5**
Precautionary landing	6,859	3	122	3	6,993	3
Aborted take-off	2,364	1	264	6	2,630	1
Engine shutdown	432	<1	38	1	470	<1
Other	2,434	1	402	8	2,850	1
Total	**222,753**	**100**	**4,774**	**100**	**231,320**	**100**

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

[2] Included in totals are 3,302 and 491 strikes involving bats and reptiles, respectively. For bats, 1,053 reports indicated no effect-on-flight, 2,233 failed to indicate if an effect-on-flight occurred, and 16 indicated a negative effect (11 precautionary landings, 5 “Other”). For reptiles, 63 reports indicated no effect-on-flight, 416 failed to indicate if an effect-on-flight occurred, and 12 indicated a negative effect (1 precautionary landing, 2 aborted take-off, 9 “Other”).

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

[4] The percentage of strikes causing negative effect-on-flight is calculated using the total strikes reported as the divisor, including the 102,999 reports that did not indicate if a negative effect occurred or not (Unknown). “Carcass found” reports (see Table 6) comprised 58,950 (57 percent) of these 102,999 reports. If the Unknown reports are excluded from the calculations, then 10, 42, and 10 percent of the strikes caused a negative effect-on-flight for birds, terrestrial mammals, and all species, respectively.

Table 16. Number of reported incidents where pilot made a precautionary or emergency landing after striking wildlife during departure in which fuel was jettisoned or burned (circling pattern) to lighten aircraft weight or in which an overweight (greater than maximum landing weight) landing was made (no fuel jettison or burn), civil aircraft, USA, 1990–2019[1]. See Figure 12 for trend in incidents, 1990–2019.

Action taken after bird strike on departure	Number of incidents	Comments and number of incidents by aircraft model
Fuel jettison	61	Aircraft: B-747 (21); B-767 (8); B-727 (7); DC-10/MD-11 (8); B-777 (4); B-787 (1); Learjet 31/35 (3); Airbus 330, Gulfstream 200, Gulfstream G150, L-1011, Lockheed P38, CL601, DA-2000, and unknown (1 each). A mean of 94,358 lbs (13,876 gallons) of fuel jettisoned per incident (N = 24, range 300 – 270,000 lbs; 44 - 39,706 gallons).
Fuel burn	99	Aircraft: EMB-120/145/170/190 (19); B-737 (11); A-319 to A330 (19); CL-RJ 100/700/900 (7); Learjet 24/60 (5); MD-80/88/90 (4); CitationJet (3); B-727, B-747, DHC8-Dash 8 (3), and PA-28 (2); and 22 other aircraft types with 1 each.
Overweight landing	107	Aircraft: B-737 (31); A-319/330 (22); B-757 (15); MD-80/83 (12); B-767 (10); CRJ-100 to 700 (4); EMB-145/170 (3), MD-80 to 83 (12); A-300, MD-11, and C-500/600 (2 each); B-747: CL-RJ 900; DA-50 Falcon and Dornier 328 (1 each).
Total	**267**	**A mean of 8.9 (range 0 – 21) incidents (fuel jettison, fuel burn, or overweight landing) per year, 1990 – 2019.**

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

Table 17. Indicated airspeed (nautical miles/hour [knots])[1] at time pilot aborted take-off after striking or observing wildlife on runway, civil aircraft, USA[2], 1990–2019. See Figure 13 for trend in high-speed aborted take-offs at ≥100 knots caused by wildlife, 1990–2019.

	Commercial aircraft[3]		General aviation aircraft[4]		All aircraft[5, 6]	
Aircraft speed (knots)	30-year total	% of total known	30-year total	% of total known	30-year total	% of total known
1-49	27	3	99	16	128	9
50-99	431	49	376	62	812	54
≥100	424	48	136	22	564	37
Total known	**882**	**100**	**611**	**100**	**1,504**	**100**
Unknown	**671**		**439**		**1,126**	
Total	**1,553**		**1,050**		**2,630**	

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

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

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

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

[5] Included in totals are 27 aborted take-offs in which type of operator was unknown. For these 27 events, the speed was unreported (16), 1-49 knots (2), 50-99 knots (5), and ≥100 knots (4).

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

Table 18. Total reported strikes, strikes causing damage, strikes having a negative effect-on-flight (NEOF), strikes involving >1 animal, and reported aircraft downtime and costs by identified wildlife species, civil aircraft, USA[1], 1990–2019 (page 1 of 25).

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Birds						
Loons	**65**	**35**	**23**	**0**	**6,368**	**3,419,082**
Loons	2	1	1			
Common loon	47	26	15		5,837	3,258,453
Red-throated loon	14	7	7		339	159,209
Pacific loon	2	1			192	1,420
Grebes	**168**	**40**	**23**	**22**	**2,675**	**5,951,897**
Grebes	15	5	2	3	200	42,998
Eared grebe	24	4	2	3	490	254,042
Western grebe	51	17	10	11	1,647	3,866,888
Pied-billed grebe	49	6	3	1	119	45,872
Horned grebe	18	5	4	1	146	146,097
Red-necked grebe	4	2	2	1		
Clark's grebe	5	1		1	73	1,596,000
Great crested grebe	1					
White-tufted grebe	1			1		
Albatrosses/shearwaters	**87**	**9**	**5**	**5**	**197**	**85,137**
Laysan albatross	36	8	4	1	197	85,137
Black-footed albatross	5	1				
Bonin petrel	12			4		
Northern fulmar	1					
Shearwaters	1					
Wedge-tailed shearwater	17		1			
Newell’s shearwater	11					
Storm-petrels	1					
Fork-tailed storm-petrel	2					
Band-rumped storm-petrel	1					
Tropicbirds	**38**	**19**	**15**	**0**	**260**	**171,121**
Tropicbirds	11	8	5		152	73,995
White-tailed tropicbird	24	10	9		108	89,051
Red-tailed tropicbird	3	1	1			8,075
Pelicans	**113**	**50**	**38**	**20**	**5,038**	**11,566,712**
Pelicans	10	2			108	22,659
Australian pelican	1	1	1			
Brown pelican	79	32	24	11	569	495,571
American white pelican	23	15	13	9	4,361	11,048,481

Table 18. Continued (Page 2 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Red-footed booby	**3**					
Cormorants	**191**	**62**	**47**	**29**	**3,385**	**6,590,339**
Cormorants	3	1			12	16,185
Great cormorant	2	1		2		
Dbl-crested cormorant	183	59	46	27	3,349	6,574,154
Pelagic cormorant	2					
Brandt's cormorant	1	1	1		24	
Anhinga	**47**	**23**	**14**	**5**	**254**	**1,028,903**
Frigatebirds	**23**	**8**	**5**		**89**	**36,684**
Great frigatebird	15	4	3		69	30,102
Magnificent frigatebird	8	4	2		20	6,582
Herons, egrets, bitterns	**2,131**	**231**	**240**	**262**	**9,558**	**18,673,095**
Herons, egrets, bitterns	6		1			
Herons	58	12	10	2	99	4,513
Gray heron	1	1	1			
Great blue heron	487	93	73	15	4,176	8,935,589
Black-crowned night-heron	113	9	4	5	112	396,648
Little blue heron	18	1	2			324
Green heron	40	2	2	1		
Yellow-crowned night-heron	70	10	7	5	186	842,594
Tricolored heron	7		2			
Purple heron	2	1			36	
American bittern	17	5	2	1	647	57,219
Yellow bittern	166		2	14		
Least bittern	5					
Egrets	364	35	56	91	3,624	4,794,874
Cattle egret	604	42	65	112	402	999,351
Great egret	126	14	10	12	177	2,590,972
Intermediate egret	1					
Snowy egret	46	6	3	4	99	51,011
Storks	**22**	**7**	**4**	**4**	**39**	**23,822**
White stork	1	1				
Wood stork	21	6	4	4	39	23,822
Ibises, spoonbills	**64**	**18**	**16**	**12**	**1,990**	**1,203,262**
Ibises	7		1	1		
Glossy ibis	4	1	1	1		2,226
White ibis	25	3	6	2	134	63,656
White-faced ibis	23	13	6	8	1,844	1,124,444

Table 18. Continued (Page 3 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Roseate spoonbill	5	1	2		12	12,936
Waterfowl	**6,183**	**2,411**	**1,239**	**2,006**	**185,539**	**268,281,376**
Ducks, geese, swans	142	69	32	54	823	1,470,695
Ducks	925	304	149	279	10,785	9,217,193
American wigeon	98	40	14	26	5,061	2,054,613
Northern pintail	213	97	46	86	2,637	9,405,877
Green-winged teal	102	19	9	27	908	1,164,572
Blue-winged teal	80	27	10	15	756	1,315,140
Eurasian wigeon	3	1		1		
Mallard	1,146	232	139	248	15,227	22,498,970
Common eider	4	2	1	1		
Ring-necked duck	39	15	8	9	1,696	139,154
Greater scaup	18	4	3	5		
Wood duck	79	20	6	12	550	192,194
Muscovy duck	3	1	1	1	120	629,531
Common goldeneye	8	2	1			2,532
Red-breasted merganser	10	2	1	2	3	
Hooded merganser	15	5	1	2	58	284,998
Common merganser	10	2	3	2	120	3,918
Northern shoveler	115	46	15	36	2,982	4,346,135
Gadwall	105	38	14	30	812	10,357,837
Canvasback	28	15	5	10	944	2,733,721
American black duck	73	8	4	22	2,672	1,156,144
Mottled duck	31	5	5	6	25	
Lesser scaup	73	29	16	21	2,043	339,355
Ruddy duck	89	21	8	13	359	287,617
Redhead	15	8	3	5	101	241,630
Bufflehead	29	5	4	2	388	17,901
Long-tailed duck	7	4	3	1	20	51,232
Philippine duck	1	1	1	1	96	12,358,992
Black-bellied whistling-duck	17	6	3	3	120	
Cinnamon teal	9	4	1	2	42	35,689
White-winged scoter	4	3	2	2	1,410	733,360
Hawaiian duck	16			5		
Harlequin duck	1					
Barrow's goldeneye	3					
Surf scoter	3	1			10	
Geese	426	232	103	155	28,108	3,629,808

Table 18. Continued (Page 4 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Snow goose	188	136	68	90	14,584	36,487,308
Canada goose	1,854	901	511	748	89,657	137,807,847
Brant	50	15	6	14	141	600,169
Gr white-fronted goose	77	51	23	44	1,175	6,409,742
Emperor goose	2	1				10,569
Cackling goose	30	16	3	8	201	490,264
Hawaiian goose	3	1	1	2	9	
Egyptian goose	2			1		
Swans	2	1				
Mute swan	10	2	1	2		
Tundra swan	23	17	13	12	824	605,217
Trumpeter swan	2	2	2	1	72	1,201,450
Hawks, eagles, vultures	**7,964**	**1,855**	**1,193**	**268**	**159,809**	**149,909,175**
Unknown birds of prey	45	20	7	1	7,280	234,280
New World vultures	352	204	106	28	29,540	14,472,092
Black vulture	241	154	82	13	18,959	12,636,243
Turkey vulture	901	446	280	55	46,522	33,047,412
Osprey	471	107	65	6	3,809	1,519,699
Kites	1					
White-tailed kite	74	4	2	2	46	6,330,000
Black kite	3	2	1			
Mississippi kite	17		1			
Swallow-tailed kite	5		1		1	39
Eagles	8	3	2	1		
Bald eagle	325	119	90	28	9,095	28,029,079
White-bellied sea-eagle	1	1	1			
Golden eagle	27	6	6	2	3,816	1,033,167
Wedge-tailed eagle	1	1	1			
Greater spotted eagle	1	1				
Hawks	1,504	287	208	45	17,053	5,907,313
Northern goshawk	4					
Red-tailed hawk	3,148	420	294	70	19,035	34,597,570
Rough-legged hawk	115	12	4	2	70	89,066
Red-shouldered hawk	82	7	9		214	4,208
Swainson's hawk	181	23	14	5	1,235	675,604
Eurasian sparrowhawk	2					
Sharp-shinned hawk	37	2		1	1,048	430,540
Cooper's hawk	147	8	6	1	54	216,104

Table 18. Continued (Page 5 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Ferruginous hawk	52	5	1		88	3,929,018
Broad-winged hawk	35	15	6	3	1,655	192,814
Harris's hawk	5					
Hawaiian hawk	3	2	3		2	
White-tailed hawk	5					
Eurasian buzzard	4	1			26	
Northern harrier	164	3	2	4	21	296,929
Old World vultures	2	1		1		
Lappet-faced vulture	1	1	1		240	6,268,000
Falcons and Caracaras	**7,399**	**86**	**151**	**316**	**2,705**	**5,167,430**
Falcons and Caracaras	57	5	6	2	178	109,699
Falcons, kestrels	7	1	1	2	13	532
Peregrine falcon	461	27	21	20	343	938,472
Gyrfalcon	2					
Merlin	147	2	4	6	28	558,368
Prairie falcon	31	1	3	2		6,452
American kestrel	6,659	42	111	282	2,078	3,553,906
Eurasian kestrel	7	1	1			
Caracaras, forest falcons	1					
Crested caracara	26	7	4	2	65	
Yellow-headed caracara	1					
Gallinaceous birds	**359**	**76**	**58**	**65**	**3,586**	**7,376,408**
Grouse	2	1				
Greater sage-grouse	41	12	6	15	556	526,701
Sharp-tailed grouse	20	1	2	3	24	815
Ruffed grouse	3					
Spruce grouse	1					
Ptarmigans	3	1	1	2	18	74,150
Willow ptarmigan	6	3	1	4	207	144,944
Rock ptarmigan	2	1				
Quails, pheasants	2	1				18,935
New World quail	9		3	2		
Northern bobwhite	16	3	3	2	93	8,592
Scaled quail	5					
Gambel's quail	1			1		
Ring-necked pheasant	96	18	12	5	883	112,542
Partridges	2			1		
Red-legged partridge	1					

Table 18. Continued (Page 6 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Gray partridge	34	4	5	13	44	5,851,594
Chukar	4		1	1		
Gray francolin	5					
Black francolin	6					
Helmeted guineafowl	3	1		2		
Turkeys	2	1				
Wild turkey	95	29	24	14	1,761	638,135
Cranes	**169**	**65**	**40**	**48**	**2,487**	**445,482**
Cranes	1					
Sandhill crane	167	64	40	48	2,439	383,512
Whooping crane	1	1			48	61,970
Limpkin	**1**					
Rails, gallinules	**519**	**91**	**42**	**20**	**4,715**	**9,002,957**
Rails	15	1	1	1		
Sora	88	8	1	5	131	727,758
Common gallinule	9	1	1		24	1,337
American coot	354	80	37	13	4,477	8,242,507
Eurasian coot	1					
Purple gallinule	5	1	1		72	31,354
Virginia rail	32		1	1	11	
Clapper rail	11					
Yellow rail	2					
King rail	2					
Shorebirds	**11,142**	**197**	**232**	**1,343**	**6,874**	**7,540,719**
Shorebirds	38	1		8	5	
American oystercatcher	30			2		
Plovers, lapwings	4			1		
Plovers	95	3	4	13	24	
European golden-plover	5			1		
American golden-plover	217	6	6	52	86	121,902
Black-bellied plover	177	9	5	25	36	219,738
Snowy plover	3			1	1	
Killdeer	7,056	61	93	618	1,836	4,336,439
Pacific golden-plover	1,219	13	23	154	321	388,645
Semipalmated plover	117		1	32		
Piping plover	3	1		1	2	235
Wilson's plover	5					
Kentish plover	1					

Table 18. Continued (Page 7 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Northern lapwing	1	1	1	1	25	
Red-wattled lapwing	1					
Southern lapwing	7	2	1			11,104
Sandpipers, curlews	335	16	31	79	185	214,792
Upland sandpiper	333	8	8	36	31	3,212
Spotted sandpiper	42	2	2	7	1	
Willet	13			2		
Common snipe	10					
American woodcock	152	5	3	7	572	53,211
Dunlin	107	9	8	28	666	344,480
Baird's sandpiper	50	2	1	6	25	98,098
Western sandpiper	213	7	9	83	1,519	187,925
Pectoral sandpiper	48	5	3	13	111	335,686
Sanderling	38	1	4	9	6	
Buff-breasted sandpiper	60	1		9		
Surfbird	1	1		1		5,888
Ruddy turnstone	33			5		
Bar-tailed godwit	1					
Least sandpiper	221	2	6	41	20	6,252
Semipalmated sandpiper	119	1	2	39	1	10,719
Lesser yellowlegs	22	5		5	9	57,000
Short-billed dowitcher	18	5	1	5	19	11,130
Hudsonian godwit	6	1	1	1	96	36,018
Solitary sandpiper	14	1		2		
Greater yellowlegs	21	5	1	3	121	64,937
Long-billed dowitcher	13			5	2	
Red knot	4		1			
White-rumped sandpiper	11			1		
Black turnstone	2					
Marbled godwit	6	1	1	1	48	177,488
Wilson's snipe	164	9	5	9	136	39,050
Rock sandpiper	2			2		
South American snipe	1					
Stilt sandpiper	2			1		
Purple sandpiper	1					
Wood sandpiper	1					
Eurasian curlew	2	1				
Whimbrel	20	2	1	4	360	56,800

Table 18. Continued (Page 8 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Long-billed curlew	10	1	1	1	504	745,960
Red-necked phalarope	16	2	3	5	60	
Wilson's phalarope	24	6	5	15	46	14,010
Red phalarope	1					
American avocet	10	1	1	4		
Black-necked stilt	14			5		
Red-necked stint	1					
Double-striped thick-knee	1					
Jaegers	**9**					
Parasitic jaeger	3					
Long-tailed jaeger	6					
Gulls	**12,442**	**1,580**	**1,363**	**2,302**	**61,182**	**64,576,857**
Gulls	7,232	1,165	974	1,626	39,657	32,218,394
Herring gull	1,536	137	127	153	3,381	5,529,357
Mew gull	80	8	6	12	49	111,142
Ring-billed gull	1,880	137	133	298	9,255	5,136,908
Glaucous-winged gull	161	28	19	18	535	2,255,521
Great black-backed gull	129	12	9	11	223	2,102,654
Franklin's gull	204	15	20	50	410	232,400
Laughing gull	649	21	28	65	776	930,056
Bonaparte's gull	77	3	5	14	8	96,395
Lesser black-backed gull	6	2	1	1		
Western gull	172	19	10	13	713	2,206,059
California gull	258	25	25	32	5,140	772,740
Heermann's gull	2			1		
Black-headed gull	8					
Iceland gull	3					
Yellow-legged gull	3	3	3	2	456	12,204,254
Glaucous gull	41	4	3	6	561	767,798
Vega gull	1	1			18	13,180
Terns, kittiwakes	**287**	**12**	**11**	**48**	**266**	**1,016,866**
Terns, Noddies	58	3	2	17	1	249,410
White-winged tern	2			1		
Little tern	2			1		
Caspian tern	40	2	1	2	24	628,800
Common tern	28	1		2		83,518
Sandwich tern	2					
Gull-billed tern	6					

Table 18. Continued (Page 9 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Black tern	6			1	2	
White tern	18	2	3	3	154	37,666
Arctic tern	6	1		2		
Roseate tern	1					
Forster's tern	18		1	3	5	208
Least tern	29			4		
Royal tern	8	1	1	1	32	
Sooty tern	7	1	1		48	17,264
Elegant tern	3					
Noddies	2			1		
Black noddy	19		1	7		
Brown noddy	8		1	1		
Black-legged kittiwake	3					
Red-legged kittiwake	1					
Black skimmer	20	1		2		
Alcidae	**3**		**1**		**1**	**110**
Pigeon guillemot	1					
Common murre	1					
Puffins	1		1		1	110
Pigeons, doves	**16,819**	**583**	**765**	**2,661**	**37,510**	**25,587,007**
Pigeons, doves	37	4	6	12	1,638	995
Pigeons	17		1	8	6	
Common wood-pigeon	10	1		2		
Band-tailed pigeon	27	8	1	3	184	204,712
Rock pigeon	3,589	276	310	924	21,686	13,790,721
Picazuro pigeon	1					
White-crowned pigeon	1					
Bare-eyed pigeon	1					
Scaly-naped pigeon	1		1		1	
Doves	1,099	48	83	222	585	575,983
Eurasian collared dove	57	3	4	9	26	1,079
Mourning dove	11,190	231	334	1,420	11,898	10,623,449
Spotted dove	243	4	13	13	150	373,011
Zebra dove	367	4	11	36	1,200	14,617
Inca dove	17			1		
Sundra collared dove	8					
White-winged dove	110	3		10	104	2,439
Common ground-dove	25		1	1		

Table 18. Continued (Page 10 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Zenaida dove	14	1			32	
Ruddy ground-dove	1					
Eared dove	1					
Philippine collared dove	2					
African collared dove	1					
Parrots	**34**			**6**	**5**	**8,085**
Parrots	3			1		
Budgerigar	17			1		
Monk parakeet	4			1		
Olive-throated parakeet	1			1		
Lilac-crowned Parrot	1			1		
Nanday parakeet	4				5	8,085
Red-masked parakeet	3					
Yellow-chevroned parakeet	1			1		
Cuckoos, roadrunners	**133**	**18**	**4**	**11**	**777**	**546,442**
Cuckoos	31	5	1	4	686	394,320
Yellow-billed cuckoo	85	12	3	7	72	152,122
Common cuckoo	1					
Black-billed cuckoo	13	1			19	
Philippine drongo-cuckoo	1					
Greater roadrunner	2					
Owls	**3,661**	**184**	**115**	**52**	**3,962**	**11,208,435**
Owls	364	34	22	8	1,484	542,007
Barn owl	1,572	57	37	23	748	3,337,232
Snowy owl	323	27	18	5	914	2,786,350
Little owl	1					
Short-eared owl	662	14	15	6	137	1,619,862
Long-eared owl	19	3	1		24	55,650
Northern saw-whet owl	9	2			96	
Burrowing owl	324	4	5	8	9	871
Barred owl	41	1	1			176
Northern pygmy-owl	1					
Great gray owl	2					
Flammulated owl	1					
Eastern screech-owl	5	2			24	13,771
Western screech-owl	3					
Great horned owl	332	40	16	2	526	2,852,517
Northern hawk owl	2					

Table 18. Continued (Page 11 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Nightjars	**1,014**	**7**	**5**	**51**	**97**	**208**
Nightjars	22					
Eastern whip-poor-will	15			2		
Common poorwill	15			1		
Lesser nighthawk	26			2	12	
Chuck-will's-widow	18	1	1		1	
Common nighthawk	899	6	4	45	84	208
Common pauraque	14			1		
Nacunda nighthawk	2					
Antillean nighthawk	3					
Swifts	**1,296**	**17**	**18**	**89**	**1,336**	**180,354**
Swifts	24	1		1		300
Black swift	5			1		
Pallid swift	2					
Chimney swift	1,106	11	15	83	1,279	65,086
Common swift	21	2		2	2	15,000
Vaux's swift	61				24	
White-throated swift	76	3	3	2	31	99,968
Alpine swift	1					
Hummingbirds	**106**			**4**	**3**	
Hummingbirds	7					
Ruby-throated hummingbird	60			2	1	
Rufous hummingbird	20			1		
Anna's hummingbird	12			1	2	
Black-chinned hummingbird	3					
Allen's hummingbird	1					
Calliope hummingbird	2					
Broad-tailed hummingbird	1					
Belted kingfisher	**15**					
Woodpeckers	**330**	**27**	**8**	**13**	**645**	**299,785**
Woodpeckers	17	1	1		1	
Northern flicker	160	12	1	3	320	136,786
Yellow-bellied sapsucker	122	11	2	10	241	135,250
Hairy woodpecker	3					
Red-naped sapsucker	5	2	2			19,605
Downy woodpecker	11		1		1	
Red-bellied woodpecker	7				10	
Red-breasted sapsucker	3					

Table 18. Continued (Page 12 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Red-headed woodpecker	1					
Ladder-backed woodpecker	1	1	1		72	8,144
Unidentified passiformes	**1,197**	**37**	**26**	**82**	**271**	**205,448**
Old world flycatchers	**4**					
Spotted flycatcher	1					
Blue-and-white swallow	2					
Black redstart	1					
Tyrant flycatchers	**1,134**	**10**	**9**	**71**	**20**	**20,842**
Tyrant flycatchers	44			6	1	1,222
Eastern wood-pewee	27			4		
Gray kingbird	11					
Great crested flycatcher	28			1		
Eastern kingbird	77	1	1	5	1	14,975
Scissor-tailed flycatcher	257	1	4	15		701
Acadian flycatcher	15			2		
Say's phoebe	20					
Western kingbird	382	3	3	23	4	1,646
Ash-throated flycatcher	10					
Great kiskadee	2			1		
Western wood-pewee	7					
Sulphur-bellied flycatcher	3					
Eastern phoebe	48	1		3		
Yellow-bellied flycatcher	27	1		2		658
Least flycatcher	26	1		2	1	
Hammond's flycatcher	21				1	
Pacific-slope flycatcher	51			3	10	1,619
Gray flycatcher	3			1	1	22
White-crested elaenia	3	1				
Willow flycatcher	11			1		
Alder flycatcher	42	1		2		
Cordilleran flycatcher	2				1	
Dusky flycatcher	4		1			
Couch's kingbird	3					
Thick-billed kingbird	1					
Olive-sided flycatcher	1					
Loggerhead kingbird	1					
Black phoebe	4					
Tropical kingbird	2					

Table 18. Continued (Page 13 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Olivaceous elaenia	1					
Larks	**5,705**	**29**	**64**	**811**	**1,625**	**1,089,307**
Larks	5			1		
Eurasian skylark	115			5	1	
Horned lark	5,584	29	64	805	1,624	1,089,307
Hume's short-toed lark	1					
Swallows	**12,430**	**67**	**178**	**2,297**	**3,982**	**717,888**
Swallows	1,291	11	50	330	145	140,450
Purple martin	276	14	8	51	328	117,716
Bank swallow	622	2	8	199	49	12,635
Barn swallow	6,909	29	75	1,154	3,290	123,955
Cliff swallow	2,177	5	22	313	98	318,523
Tree swallow	962	1	11	225	44	4,303
Violet-green swallow	38	2	1	2	2	305
N rough-winged swallow	103	1	1	9	2	
Cave swallow	51	2	2	14	24	
Gray-breasted martin	1					
Black drongo	**19**			**3**		
Starlings, mynas	**5,249**	**146**	**217**	**1,389**	**3,750**	**8,132,087**
European starling	5,118	141	211	1,357	3,700	8,132,087
Mynas	1	1				
Common myna	130	4	6	32	50	
Crows, ravens	**851**	**79**	**69**	**103**	**10,521**	**3,042,005**
Crows, ravens	3	1		1		
Crows	216	21	14	35	26	130,251
American crow	555	42	45	61	7,265	2,119,774
Carrion crow	3	1			35	5,320
Hooded crow	1	1	1			
Northwestern crow	7			1		
Rook	1					
Fish crow	4					
Ravens	1					
Common raven	60	13	9	5	3,195	786,660
Jays, magpies	**69**	**3**	**2**	**7**	**3**	**1,262**
Blue jay	38			2	2	305
Gray jay	1					
Yellow-billed magpie	8			2		
Black-billed magpie	22	3	2	3	1	957

Table 18. Continued (Page 14 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Chickadees, nuthatches	**41**	**1**		**9**		
Chickadees	1					
Black-capped chickadee	25	1		6		
Mountain chickadee	3			1		
Gray-headed chickadee	1			1		
Carolina chickadee	2			1		
Bushtit	2					
Nuthatches and creepers	1					
White-breasted nuthatch	2					
Red-breasted nuthatch	5					
Yellow-browed warbler	**1**					
Red-vented bulbul	**5**			**1**		
Wrens	**235**	**3**	**5**	**23**	**38**	**33,660**
Wrens	67	1	3	10	2	
Marsh wren	42	1	2	3	33	33,112
House wren	67	1		6	1	549
Carolina wren	12			1		
Rock wren	3			1		
Cactus wren	5					
Winter wren	19				2	
Bewick's wren	3					
Sedge wren	13			2		
Pacific wren	4					
Mimics	**501**	**9**	**6**	**31**	**261**	**2,280,005**
Brown thrasher	33	2	2	1	175	2,268,179
Sage thrasher	6					
Curve-billed thrasher	2					
Long-billed thrasher	8			4		
Pearly-eyed thrasher	1					
Mockingbirds	12	1		1		
Northern mockingbird	141	2	2	4	1	
Tropical mockingbird	1					
Gray catbird	297	4	2	21	85	11,827
Thrushes	**2,732**	**180**	**70**	**187**	**5,436**	**6,604,672**
Thrushes	60	3	1	3	7	34,451
Western bluebird	11	1	1	1	21	1,240
Swainson's thrush	398	26	7	32	405	2,845,824
Redwing	1					

Table 18. Continued (Page 15 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
American robin	1,625	118	46	105	4,076	3,529,050
Song thrush	1			1		
Hermit thrush	314	9	5	17	749	36,739
Eastern bluebird	19			2		
Gray-cheeked thrush	50		2	3	3	
Varied thrush	80	13	2	8	48	37,754
Wood thrush	74	5	2	8	72	119,614
Mountain bluebird	43			5		
Veery	51	4	4	2	55	
Townsend's solitaire	3	1				
Bicknell's thrush	2					
Wrentits, gnatcatchers	**62**		**2**	**4**	**2**	
Garden warbler	1					
Wrentit	1					
Blue-gray gnatcatcher	60		2	4	2	
Kinglets	**265**		**2**	**12**	**16**	**574**
Golden-crowned kinglet	64			3		
Ruby-crowned kinglet	201		2	9	16	574
Pipits	**277**	**1**	**3**	**43**	**29**	
Meadow pipit	2					
American pipit	265	1	3	43	29	
Sprague's pipit	8					
Olive-backed pipit	1					
Tree pipit	1					
Waxwings	**408**	**9**	**7**	**75**	**334**	**380,026**
Bohemian waxwing	3			2		
Cedar waxwing	405	9	7	73	334	380,026
Shrikes	**55**		**3**	**2**	**1**	
Northern shrike	3					
Loggerhead shrike	52		3	2	1	
Vireos	**362**	**8**	**4**	**21**	**101**	**37,260**
Vireos	4					
White-eyed vireo	10			1	2	11
Blue-headed vireo	27	2		2	5	
Yellow-throated vireo	5					
Warbling vireo	53	1		2	8	9,285
Red-eyed vireo	245	5	4	16	86	27,965
Cassin's vireo	6					

Table 18. Continued (Page 16 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Philadelphia vireo	11					
Bell's vireo	1					
Japanese white-eye	**3**					
New World wood-warblers	**2,326**	**18**	**26**	**152**	**580**	**466,717**
N World wood-warblers	99	1		8		2,025
Canada warbler	27		2		2	111
Yellow-breasted chat	39	1	1	2	4	230
Pine warbler	32			3		
Black-and-white warbler	64	1		2		
Northern parula	48			3	28	2,502
Ovenbird	149	3	1	11	18	4,923
Wilson's warbler	134			3	4	6,201
Common yellowthroat	190	2	1	10	122	417,074
Yellow-rumped warbler	454	2	7	28	70	4,490
Blackpoll warbler	115	1	2	8	9	11,492
Mourning warbler	10					
American redstart	97	1	1	11	12	
Orange-crowned warbler	65		1	3	4	
Yellow warbler	129	2	1	9	177	
Cape May warbler	22			2		
Hooded warbler	7	1				
Prairie warbler	13					
Northern waterthrush	55	1		5	59	7,448
Nashville warbler	54		1	4	22	
Townsend's warbler	33		1	2		108
Louisiana waterthrush	3	1				
Palm warbler	102		3	6	6	8,091
Magnolia warbler	48		2	3	6	219
Black-throated blue warbler	58			3		
Prothonotary warbler	4		1		4	240
MacGillivray's warbler	18					
Yellow-throated warbler	33		1	4	2	
Black-throated gray warbler	5				2	
Black-throated green warbler	37			1		
Hermit warbler	7					
Tennessee warbler	57			6	2	
Chestnut-sided warbler	29			3	1	1,064
Blackburnian warbler	26			4		

Table 18. Continued (Page 17 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Bay-breasted warbler	30			4	24	500
Connecticut warbler	5			1		
Kentucky warbler	17			2	2	
Worm-eating warbler	6	1				
Blue-winged warbler	2					
Golden-winged warbler	1			1		
Lawrence's warbler	2					
Meadowlarks	**5,474**	**46**	**78**	**438**	**672**	**1,068,201**
Meadowlarks	701	3	13	59	17	876
Eastern meadowlark	2,963	19	35	208	277	680,579
Western meadowlark	1,810	24	30	171	378	386,746
Blackbirds	**2,883**	**124**	**139**	**563**	**1,868**	**1,923,129**
Blackbirds	1,313	84	90	348	733	1,550,181
Red-winged blackbird	538	6	18	55	95	28,190
Yellow-headed blackbird	25	5	2	2	7	26,950
Brewer's blackbird	76	1	1	9	1	
Brown-headed cowbird	345	3	5	71	36	6,351
Bobolink	45	1	1	4	2	
Rusty blackbird	12					
Tricolored blackbird	1					
Grackles	164	13	6	30	768	234,120
Common grackle	254	8	12	34	178	77,014
Boat-tailed grackle	47	2	3	3	48	
Great-tailed grackle	63	1	1	7		323
Orioles	**67**	**1**	**3**	**5**	**8**	**286**
Orioles	6					
Baltimore oriole	38	1	2	4	8	286
Orchard oriole	10			1		
Bullock's oriole	9		1			
Hooded oriole	4					
Tanagers	**135**	**6**	**1**	**7**	**90**	**3,729**
Scarlet tanager	56	3		2	84	
Western tanager	64	3	1	3	6	3,729
Summer tanager	11			2		
Morelet’s seedeater	2					
Saffron finch	2					
Finches	**1,639**	**20**	**53**	**314**	**2,500**	**44,238**
Finches	129	2	5	23	7	

Table 18. Continued (Page 18 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Lapland longspur	96	1	5	28	27	
Chestnut-collared longspur	3					
Dark-eyed junco	282	3	2	11	99	12,436
Rose-breasted grosbeak	43		1	4	4	880
Common chaffinch	4					
Common canary	1					
Pine siskin	30	2		8	3	
Common redpoll	7		1		3	1,078
Purple finch	10			1		
Red crossbill	4		1	1		
Evening grosbeak	1					
American goldfinch	123		2	6	3	
House finch	182	1	3	15	1,041	960
Smith's longspur	9			1		
Dickcissel	30	1		5		1,205
White-winged crossbill	5	1	1	2	4	
Red avadavat	8			3		
McCown's longspur	3					
Lesser goldfinch	9					
Black-headed grosbeak	21	2				
Cassin's finch	2					
Pine grosbeak	1					
Gray-crowned rosy-finch	1					
Blue grosbeak	14	1		1	4	230
Hoary redpoll	2			1		
Eurasian siskin	1					
Yellow-fronted canary	1			1		
Lawrence's goldfinch	1					
Red-crested cardinal	6			1	1	
Northern cardinal	14					
Snow bunting	366	4	28	174	160	26,570
Indigo bunting	64		3	7	1,118	878
Lazuli bunting	6					
Lark bunting	151	2		19	26	
McKay's bunting	1		1	1		
Painted bunting	7					
Black-faced bunting	1			1		

Table 18. Continued (Page 19 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Sparrows	**6,650**	**98**	**153**	**949**	**1,622**	**1,192,050**
Sparrows	3,739	57	128	785	716	96,714
Harris's sparrow	8			1		
Swamp sparrow	143	2		5	245	5,053
Savannah sparrow	1,016	9	8	52	74	23,679
Fox sparrow	100	5	5	6	47	63,957
White-throated sparrow	381	7	3	36	59	42,264
Golden-crowned sparrow	36			2	6	160
Field sparrow	69			6	1	
Lark sparrow	42	1	1	4		16,185
White-crowned sparrow	136	7	3	7	408	826,571
Grasshopper sparrow	127	2	1	4	19	35,373
Vesper sparrow	79	1		5	1	
Chipping sparrow	151	1		8	6	345
Lincoln's sparrow	133	3	3	4	18	17,552
Song sparrow	373	3		21	20	63,690
Bell's sparrow	7				1	
American tree sparrow	38			2		274
Nelson's sparrow	6				1	235
Black-throated sparrow	4					
Brewer's sparrow	28		1	1		
LeConte's sparrow	8					
Cassin's sparrow	5					
Clay-colored sparrow	16					
Baird's sparrow	3					
Olive sparrow	2					
Towhees	**50**	**2**		**1**	**9**	**15,663**
Eastern towhee	33	1		1	9	15,663
Green-tailed towhee	8	1				
California towhee	3					
Spotted towhee	6					
Waxbills, mannikins	**329**	**2**	**3**	**93**	**22**	**10,547**
Waxbills, mannikins	3					
Common waxbill	10		1	4		
African silverbill	1					

Table 18. Continued (Page 20 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Munias	**122**			**13**		
Scaly-breasted munia	115	1	1	44	19	7,289
Chestnut munia	72	1	1	28	3	3,258
White-throated munia	6			4		
House sparrow	**391**	**4**	**4**	**36**	**33**	**2,338**
Total known birds	**124,387**	**8,614**	**6,802**	**17,391**	**535,146**	**627,169,681**
Unidentified birds	**98,366**	**7,550**	**5,287**	**8,978**	**259,406**	**147,126,127**
Unknown bird- size (unk)	15,634	805	868	793	13,736	5,428,643
Unknown bird - large	3,366	1,250	612	341	55,190	55,783,683
Unknown bird - medium	36,931	4,325	2,253	2,871	122,663	64,092,064
Unknown bird - small	42,435	1,170	1,554	4,973	67,817	21,821,736
Total birds	**222,753**	**16,164**	**12,089**	**26,369**	**794,552**	**774,295,808**
Flying mammals (bats)						
Bats (mega or micro)	**1**	**1**				**10,141**
Megabats (fruit bats)	**15**	**3**	**2**	**4**	**99**	**4,678,299**
Megabats (unk species)	12	2	2	4	99	4,678,299
Flying foxes	1					
Little red flying fox	1					
Indian flying fox	1	1				
Microbats (echo locating)	**3,286**	**22**	**14**	**231**	**242**	**708,520**
Microbats (unk species)	1,180	6	7	107	75	4,668
Vesper bats	127			4	1	1,407
Eastern red bat	354	5	2	22	68	16,148
Hoary bat	145	6		5	24	215,857
E. small-footed myotis	1					
Little brown bat	235			11		
Big brown bat	190		2	12	1	
Silver-haired bat	83	1		4	19	981
Seminole bat	15			1		
Tri-colored bat	29					
Northern yellow bat	10			2		
Evening bat	46			2		
Indiana bat	3					
Yuma myotis	2					
Long-eared myotis	1					
Western yellow bat	1					

Table 18. Continued (Page 21 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Common pipistrelle	2					
Long-legged myotis	2					
W. small footed myotis	1					
Kuhl's pipistrelle	1					
Western red bat	1					
Indian pipistrelle	1					
African yellow bat	1					
Kelaart's pipistrelle	1					
Free-tailed bats	202			15	12	622
Brazilian free-tailed bat	629	2	3	44	14	2,456
Pocketed free-tailed bat	3					
Big free-tailed bat	1					
Western mastiff bat	6	1			20	359,490
Florida bonneted bat	1					
Pallas's mastiff bat	3			1		
Egyptian free-tailed bat	2					
Black mastiff bat	1	1			8	106,890
Gray sac-winged bat	1					
Naked-rumped tomb bat	1					
Jamaican fruit bat	3			1		
Antillean fruit-eating bat	1					
Total Megabats	**15**	**3**	**2**	**4**	**99**	**4,678,299**
Total Microbats	**3,286**	**22**	**14**	**231**	**242**	**708,520**
Unidentified bat	**1**	**1**				**10,141**
Total bats	**3,302**	**26**	**16**	**235**	**341**	**5,396,960**
Terrestrial mammals						
Marsupials (V. opossum)	**356**	**1**		**5**		
Xenarthyras (armadillo)	**50**	**1**	**4**		**11**	**1,351**
Lagomorphs	**866**	**11**	**12**	**10**	**37**	**134,486**
Lagomorphs	18	2				
Hares	6		1		1	
Black-tailed jackrabbit	452	6	4	2	28	35,738
White-tailed jackrabbit	82		1	2	1	
Antelope jackrabbit	1					
Snowshoe hare	1					
Rabbits	96		2	6	1	
Eastern cottontail	165	3	4		6	98,748

Table 18. Continued (Page 22 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs.)	Reported costs ($)
Desert cottontail	45					
Rodents	**354**	**3**	**10**	**7**	**6**	**7,647**
North American beaver	4					
Prairie dogs	9					
Black-tailed prairie dog	63		1	2		
White-tailed prairie dog	5					
Gunnison's prairie dog	17		1	3		
Woodchuck	183	3	8	2	6	7,647
Yellow-bellied marmot	1					
Tree Squirrels	4					
Fox squirrel	1					
American red squirrel	1					
Eastern gray squirrel	1					
Ground squirrels	4					
Piute ground squirrel	1					
California ground squirrel	1					
13-lined ground squirrel	1					
Muskrat	36					
N American porcupine	19					
Coypu (nutria)	3					
Carnivores	**1,848**	**93**	**204**	**132**	**19,894**	**4,602,067**
Canids	4	1	1	1		
Coyote	673	58	134	73	16,793	4,062,914
Domestic dog	51	16	26	19	559	413,615
Foxes	38	4	6	3	10	1,112
Red fox	244	6	23	17	364	62,950
Common gray fox	17	2	2		5	555
Kit fox	4					
Raccoon	156	4	5	6	2,160	60,921
White-nosed coati	1					
Skunks	29					
Striped skunk	566	1	3	9	3	
River otter	2	1				
Badger	7					
Mink	6					
Long-tailed weasel	1					
Domestic cat	40			1		
Small Indian mongoose	5					

Table 18. Continued (Page 23 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
American black bear	3		3	3		
Bearded seal	1		1			
Artiodactyls	**1,260**	**1,043**	**582**	**194**	**309,317**	**62,768,802**
Deer	18	16	9	1	2,136	297,817
White-tailed deer	1,109	914	505	168	256,411	52,153,278
Mule deer	84	71	40	9	21,409	1,529,331
Wapiti (elk)	12	12	6	3	11,660	7,894,621
Moose	6	5	5	3		
Caribou	3	2	2	1		
Cattle	11	11	8	5	9,215	521,793
Domestic sheep	1	1	1			
Pronghorn	9	8	5	3	5,298	310,889
Swine (pigs)	3	2			3,188	61,073
Collared peccary	4	1	1	1		
Perissodactyls	**5**	**5**	**4**	**1**	**1,008**	**37,968**
Horse	4	4	4	1	1,008	37,968
Burro	1	1				
Total known t. mammals	**4,739**	**1,155**	**816**	**349**	**330,273**	**67,552,322**
Total unknown t. mammal	**35**	**9**	**10**	**5**		
Total t. mammals	**4,774**	**1,164**	**826**	**354**	**330,273**	**67,552,322**
Reptiles						
Turtles	**361**	**1**	**5**	**4**		
Turtles (unk species)	120		3	1		
Florida soft shell turtle	12	1	1			
Eastern box turtle	24					
Common snapping turtle	45		1	1		
Diamondback terrapin	56			2		
Painted turtle	45					
Florida red-bellied cooter	3					
Gopher tortoise	38					
Alligator snapping turtle	4					
Coastal plain cooter	3					
Pond slider	8					
Eastern mud turtle	1					
Chicken turtle	1					
Striped mud turtle	1					
American alligator	**27**	**2**	**3**	**2**	**3**	

Table 18. Continued (Page 24 of 25)

Wildlife group or species	30-year totals (1990–2019)					
	Number of reported strikes				Reported economic losses[2]	
	Total	With dam-age	With NEOF	With multiple animals[3]	Aircraft down time (hrs)	Reported costs ($)
Spectacled caiman	**1**					
Green iguana	**24**		**4**	**4**		
Snakes	**78**					
Snakes (unk species)	24					
Gopher snake	43					
Northern water snake	3					
E. diamondback rattlesnake	3					
Water moccasin	1					
Eastern pine snake	1					
W diamondback rattlesnake	2					
Prairie rattlesnake	1					
Total reptiles	**491**	**3**	**12**	**10**	**3**	
Total known (all species)	**132,918**	**9,799**	**7,646**	**17,985**	**865,763**	**700,108,822**
Total (unknown species)	**98,402**	**7,560**	**5,297**	**8,983**	**259,406**	**147,136,268**
Grand total	**231,320**	**17,359**	**12,943**	**26,968**	**1,125,169**	**847,245,090**

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

[2] These reported economic losses by species and species groups should be considered as relative indices of losses and not as actual estimated losses. For commercial aviation, an estimated 20 percent of strikes were reported in the 1990s. More recent analyses estimated that strike reporting for all civil aircraft combined (commercial and general aviation) at Part 139 airports had improved to 39 percent in 2004-2008 and to 47 percent in 2009-2013 (Dolbeer 2009, 2015). Strike reporting for commercial aircraft only at Part 139 airports was an estimated 79 percent in 2004-2008 and 91 percent in 2009-2013; reporting of strikes with damage was estimated at 78 percent and 93 percent for these respective time periods. In addition, only about 56 percent of reported strikes identified the wildlife species or species group responsible, 1990–2019. Furthermore, of the 17,359 reports indicating damage to the aircraft, only 27 percent (4,610) also provided an estimate of repair costs, and only 37 percent (11,464) of the 30,498 strikes indicating an adverse effect estimated the downtime (see Tables 23, 24). Finally, even when cost estimates were provided, some reports were filed before aircraft damage had been fully assessed. See Tables 23 and 24 for a more detailed projection of actual economic losses.

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

[4] Of the 222,753 reported bird strikes, 101,834 (46 percent) identified the bird to exact species (a total of 591 species of birds of which 298 caused damage) and an additional 22,553 strikes (10 percent) identified the bird at least to species group (e.g., gull, hawk, duck). Exact species identification has improved from less than 20 percent in the early 1990s to about 60 percent in 2016 - 2019 (Figure 7).

Table 18. Continued (Page 25 of 25)

[5] Of the 3,302 reported bat strikes, 1,779 (54 percent) identified the bat to exact species (36 species total of which 7 caused damage) and 1,522 (46 percent) identified the bat to species group (13 megabats [old world fruit bats] and 1,509 microbats [echo-locating bats]) of which 1,180 were microbats of unknown species, 202 were free-tailed bats and 127 were vesper bats. One bat strike was classified as unknown bat (either megabat or microbat).

[6] Of the 4,774 reported terrestrial mammal strikes, 4,513 (95 percent) identified the mammal to exact species (a total of 51 species of which 24 caused damage), 226 (5 percent) identified the mammal at least to species group, and 35 (<1 percent) were unknown species group.

[7] All of the 491 reported reptile strikes were identified to species group and 347 (71 percent) were identified to exact species (23 species total of which 2 caused damage).

[8] Reported costs of $847,245,090 include $748,496,047 in direct repair costs and $98,749,043 in other costs.

Table 19. Number of reported strikes, strikes with damage, and strikes involving multiple animals for the five most commonly struck bird groups and three most commonly struck terrestrial mammal groups, civil aircraft, USA[1], 1990–2019.

	Reported strikes		Strikes with damage		Strikes with >1 animal	
Species group[2]	30-year total	% of total known	30-year total	% of total known	30-year total	% of total known
Birds						
Pigeons, doves	16,819	14	583	7	2,661	15
Raptors[3]	15,363	12	1,941	23	584	3
Gulls	12,442	10	1,580	18	2,302	13
Shorebirds	11,142	9	197	2	1,343	8
Waterfowl	6,183	5	2,411	28	2,006	12
All other known	62,438	50	1,902	22	8,495	49
Total known	**124,387**	**100**	**8,614**	**100**	**17,391**	**100**
Total unknown	**98,366**		**7,550**		**8,978**	
Total birds	**222,753**		**16,164**		**26,369**	
Terrestrial mammals						
Carnivores	1,848	39	93	8	132	38
Artiodactyls	1,260	27	1,043	90	194	56
Lagomorphs	866	18	9	1	10	3
All other known	765	16	10	1	13	4
Total known	**4,739**	**100**	**1,155**	**100**	**349**	**100**
Total unknown	**35**		**9**		**5**	
Total Terr. Mammals	**4,774**		**1,164**		**354**	

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

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

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

Table 20. The 33 species of birds identified most frequently as struck by civil aircraft in USA, 1990–2019 and 2019 only. See Figure 15 for relation between mean body mass and percent of strikes causing damage for top 20 species, 1990-2019.

	Strikes (1990–2019)[1]			Strikes (2019 only)[1]		
Rank	Bird species	Num-ber	% with damage	Bird species	Num-ber	% with damage
1	Mourning dove	11,190	2.1	Mourning dove	972	1.4
2	Killdeer	7,056	0.9	Barn swallow	870	0.3
3	Barn swallow	6,909	0.4	Killdeer	697	0.3
4	American kestrel	6,659	0.6	American kestrel	511	1.0
5	Horned lark	5,584	0.5	Horned lark	440	1.1
6	European starling	5,118	2.8	Eastern meadowlark	355	1.4
7	Rock pigeon	3,589	7.7	European starling	307	0.7
8	Red-tailed hawk	3,148	13.3	Western meadowlark	206	0.5
9	Eastern meadowlark	2,963	0.6	Red-tailed hawk	203	6.4
10	Cliff swallow	2,177	0.2	Cliff swallow	195	0.0
11	Ring-billed gull	1,880	7.3	American robin	187	6.4
12	Canada goose	1,854	48.6	Rock pigeon	182	5.5
13	Western meadowlark	1,810	1.3	Savannah sparrow	179	0.6
14	American robin	1,625	7.3	Chimney swift	165	1.8
15	Barn owl	1,572	3.6	Herring gull	99	5.1
16	Herring gull	1,536	8.9	Barn owl	98	4.1
17	Pacific golden-plover	1,219	1.1	Ring-billed gull	95	3.2
18	Mallard	1,146	20.2	Common nighthawk	95	1.1
19	Chimney swift	1,106	1.0	Tree swallow	91	0.0
20	Savannah sparrow	1,016	0.9	Pacific golden-plover	86	0.0
21	Tree swallow	962	0.1	Mallard	81	18.5
22	Turkey vulture	901	49.5	Swainson's thrush	76	6.6
23	Common nighthawk	899	0.7	Y.-rumped warbler	74	1.4
24	Short-eared owl	662	2.1	Turkey vulture	73	45.2
25	Laughing gull	649	3.2	Canada goose	71	45.1
26	Bank swallow	622	0.3	Bank swallow	70	0.0
27	Cattle egret	604	7.0	Laughing gull	65	0.0
28	American crow	555	7.6	Cedar waxwing	60	0.0
29	Red-winged blackbird	538	1.1	Cattle egret	55	0.0
30	Great blue heron	487	19.1	Hermit thrush	53	1.9
31	Osprey	471	22.7	Red-winged blackbird	51	0.0
32	Peregrine falcon	461	5.9	Gray catbird	49	0.0
33	Y-rumped warbler	454	0.4	Short-eared owl	48	2.1

[1] Actual number struck was higher for each species because only 46 percent and 59 percent of the bird strike reports from 1990–2019 and in 2019, respectively, identified the bird to species. For example, there were 7,232 gull strikes reported from 1990-2019 in which the species of gull was not determined (Table 18).

Table 21. Number of strikes to civil aircraft causing human fatality or injury and number of injuries and fatalities by wildlife species, USA[1], 1990–2019.

Strikes causing fatalities			Strikes causing injuries		
Species of wildlife	No. of strikes	No. of humans	Species of wildlife	No. of strikes	No. of humans
Unknown bird	6	8	Unknown bird	49	65
Red-tailed hawk	1	8	White-tailed deer	20	28
Amer. white pelican	1	5	Turkey vulture	18	22
Bald eagle	1	4	Ducks	17	20
Snow goose	1	3	Canada goose	15	18
Canada goose	1	2	Black vulture	9	14
Rock pigeon	1	2	Red-tailed hawk	9	11
White-tailed deer	1	1	Gulls	9	10
Brown pelican	1	1	New World vultures	9	9
Black vulture	1	1	Ring-billed gull	3	9
Turkey vulture	1	1	Bald eagle	5	8
Total fatalities	**16**	**36**	Mallard	6	7
			Geese	6	6
			Snow goose	6	6
			Double-crested cormorant	5	6
			American coot	5	5
			Hawks	3	5
			American kestrel	1	5
			Lesser scaup	4	4
			Anhinga	3	4
			Golden eagle	2	4
			Eurasian kestrel	1	4
			Spotted dove	1	4
			Osprey	3	3
			Herring gull	3	3
			Rock pigeon	3	3
			Cattle	2	3
			Western grebe	2	3
			Gr white-fronted goose	2	3
			28 species each causing 1-2 injuries	30	35
			Total injuries	**251**	**327**

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

Table 22. Number of civil aircraft lost (destroyed or damaged beyond repair) after striking wildlife by wildlife species and aircraft mass category, USA[1], 1990–2019. See Figure 16 for number of lost aircraft by year, 1990–2019.

Wildlife species or species group	Aircraft[2] mass category (Maximum take-off mass in kilograms) ≤2,250	2,251-5,700	5,701-27,000	>27,000	Total aircraft lost
White-tailed deer	15	6	2		23
Unknown bird	11	2	2		15
Canada goose	1	3		1	5
Bald eagle	3				3
Cattle	2	1			3
Turkey vulture	3				3
Hawks	2				2
Amer. white pelican		1			1
Black vulture	1				1
Brown pelican	1				1
Coyote			1		1
Domestic dog	1				1
D-crested cormorant	1				1
Ducks	1				1
Eastern cottontail	1				1
Eurasian kestrel				1	1
Herring gull		1			1
Mourning dove			1		1
Mule deer	1				1
New World vultures	1				1
Redhead			1		1
Red-tailed hawk		1			1
Ring-billed gull		1			1
Rock pigeon	1				1
Snow goose		1			1
Wapiti (elk)			1		1
Total	**46**	**17**	**8**	**2**	**73**

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

[2] Engine types on the 73 destroyed aircraft were piston (51), turbofan (9), turboprop (6), turbojet (3), and turboshaft (4). Aircraft operators were business (41), private (26), commercial transport (5), and government (1).

[3] Forty-one (56 percent) of the 73 wildlife strikes resulting in a destroyed aircraft occurred at general aviation airports, 19 occurred “en route”, 8 occurred at USA airports certificated for passenger service under 14 CFR Part 139, 3 occurred in miscellaneous situations (taking off from river, herding cattle, aerial application of pesticides) and 2 occurred at foreign airports.

Table 23. Number of reported wildlife strikes indicating damage, a negative effect-on-flight (NEOF), aircraft downtime, repair costs, and other costs; and the mean losses per report in hours of downtime and inflation-adjusted U.S. dollars, civil aircraft, USA[1], 1990–2019.

	Number of reports indicating:					Mean losses per report[2]		
Year	Dam-age	NEOF	Aircraft down time	Repair costs	Other costs	Down-time (hours)	Repair costs ($)	Other costs ($)
1990	372	148	60	33	16	56.4	225,269	64,666
1991	400	184	61	49	25	79.8	76,394	41,180
1992	365	218	81	51	28	111.9	109,298	5,500
1993	399	240	67	57	19	277.9	92,843	9,800
1994	460	272	103	73	29	388.4	79,931	95,450
1995	497	307	95	62	33	96.3	525,893	229,583
1996	502	355	144	86	39	137.3	88,180	26,388
1997	578	379	182	126	47	230.7	79,487	41,607
1998	584	400	205	135	54	119.5	209,403	29,857
1999	706	446	282	179	79	148.8	115,245	21,831
2000	764	477	351	205	93	195.2	102,479	119,330
2001	645	434	293	157	65	142.6	296,327	40,645
2002	670	497	383	165	63	135.6	158,315	66,891
2003	632	437	355	172	81	111.8	168,274	44,561
2004	628	429	324	213	92	166.9	109,658	23,672
2005	610	454	327	227	125	88.0	278,606	80,261
2006	599	429	333	172	102	116.8	223,454	13,896
2007	568	453	364	178	135	165.2	179,853	34,624
2008	526	408	371	156	141	116.2	122,987	14,609
2009	605	520	563	195	193	80.8	390,181	15,284
2010	595	467	526	174	164	66.5	135,626	14,410
2011	542	498	526	179	208	70.8	244,712	15,765
2012	613	540	689	228	263	75.4	114,845	8,809
2013	609	521	802	238	304	75.7	68,187	13,008
2014	586	573	717	210	277	63.2	145,495	11,120
2015	622	545	704	207	293	48.0	156,714	20,274
2016	588	522	586	155	221	87.2	69,524	13,130
2017	665	568	633	193	262	50.3	182,768	12,998
2018	709	618	636	169	294	66.1	61,152	8,161
2019	720	604	701	166	242	71.9	104,845	21,334
Total	**17,359**	**12,943**	**11,464**	**4,610**	**3,987**			
Mean	**579**	**431**	**382**	**154**	**133**	**98.1**	**162,364**	**24,768**

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

[2] See Table 18 for actual losses reported in total and by species of wildlife, 1990-2019.

Table 24. Projected annual losses in aircraft downtime (hours) and in repair and other costs (inflation-adjusted U.S. dollars) from wildlife strikes with civil aircraft, USA[1], 1990–2019. Losses are projected from mean reported losses per incident (Table 23). (Page 1 of 2).

Year	No. of adverse incidents[4]	Projected losses[2, 3]			
		Down-time (hours)	Repair costs (x $1 million)	Other costs (x $1 million)	Total costs (x $1 million)
1990	427	24,061	96	28	124
1991	484	38,601	37	20	57
1992	493	55,179	54	3	57
1993	509	141,456	47	5	52
1994	582	226,070	47	56	102
1995	656	63,149	345	151	496
1996	684	93,893	60	18	78
1997	783	180,606	62	33	95
1998	806	96,319	169	24	193
1999	981	145,946	113	21	134
2000	1,114	217,436	114	133	247
2001	977	139,314	290	40	329
2002	1,101	149,299	174	74	248
2003	997	111,490	168	44	212
2004	951	158,682	104	23	127
2005	979	86,161	273	79	351
2006	942	110,027	210	13	224
2007	978	161,606	176	34	210
2008	906	105,243	111	13	125
2009	1,186	95,857	463	18	481
2010	1,126	74,875	153	16	169
2011	1,146	81,107	280	18	299
2012	1,334	100,642	153	12	165
2013	1,447	109,550	99	19	117
2014	1,459	92,269	212	16	229
2015	1,455	69,877	228	30	258
2016	1,338	116,726	93	18	111
2017	1,446	72,800	264	19	283
2018	1,583	104,677	97	13	110
2019	1,628	116,984	171	35	205
Total	**30,498**	**3,339,902**	**4,864**	**1,022**	**5,886**
Mean	**1,017**	**111,330**	**162**	**34**	**196**

Table 24. Continued (Page 2 of 2)

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

[2] Values are based on the assumption that all 30,498 reported strikes (mean of 1,017/year) indicating an adverse effect (see footnote 3) incurred similar amounts of damage and/or downtime and that these reports are all of the adverse-effect strikes that occurred, 1990–2019.

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

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

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Figures

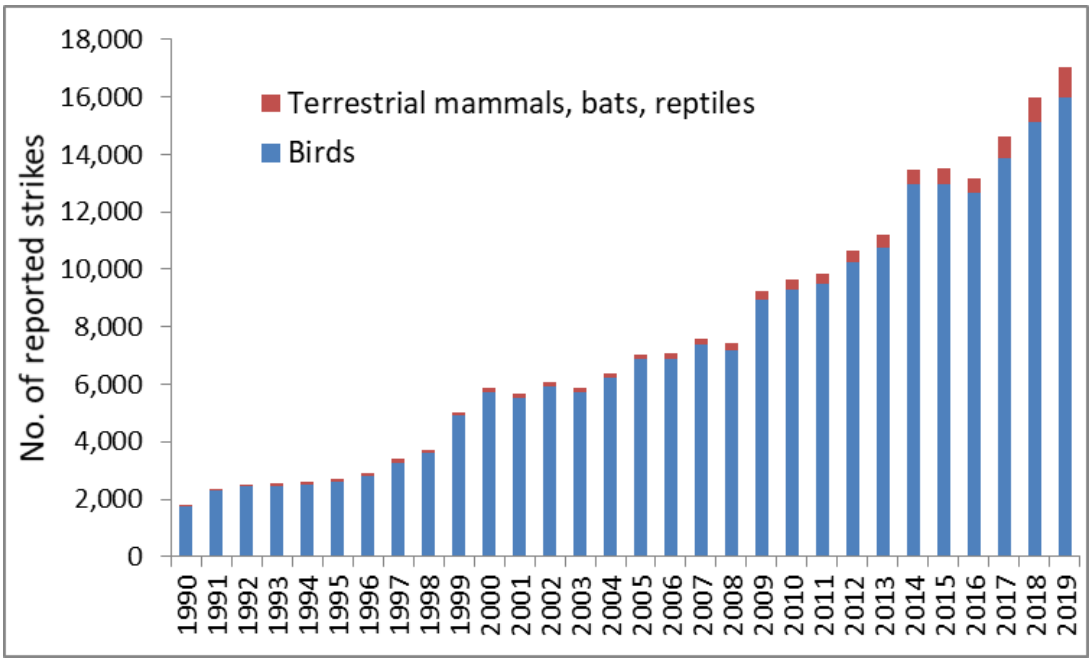


Figure 1. Number of reported wildlife strikes with civil aircraft, USA, 1990–2019. The 227,045 strikes involved birds (218,524), terrestrial mammals (4,761), bats (3,269), and reptiles (491). An additional 4,275 strikes were reported for U.S.-registered aircraft in foreign countries for a total of 231,320 strikes (see Tables 1, 2, and 18).

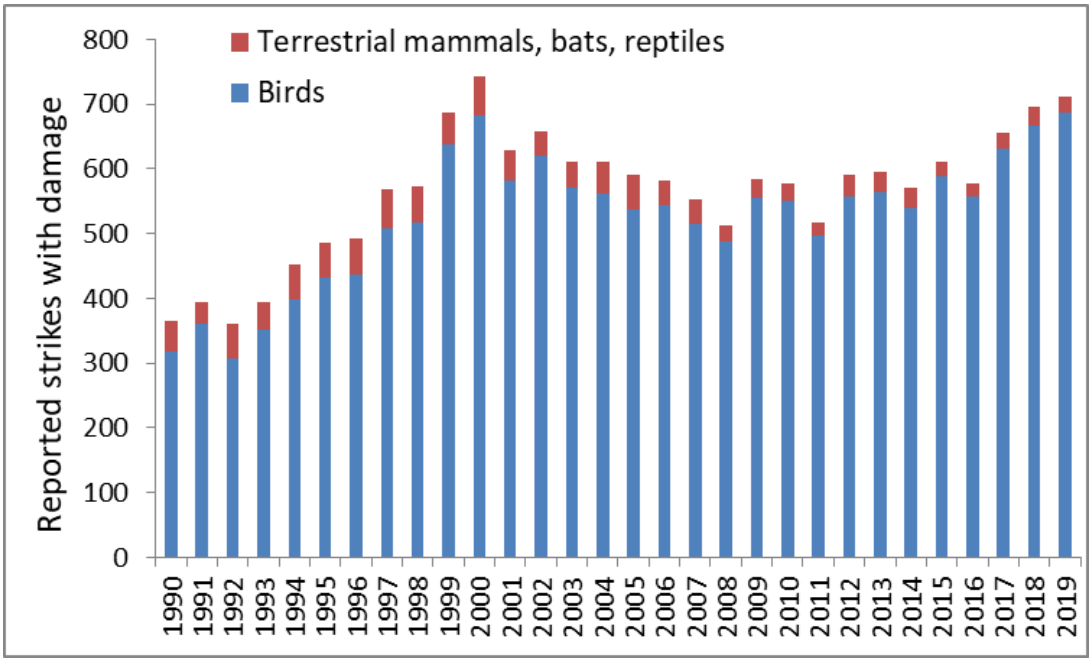


Figure 2. Number of reported wildlife strikes causing damage to civil aircraft, USA, 1990–2019. The 16,958 damaging strikes involved birds (15,768), terrestrial mammals (1,165), bats (22), and reptiles (3). An additional 401 damage strikes were reported for U.S.-registered aircraft in foreign countries (see Tables 1, 2 and 18).

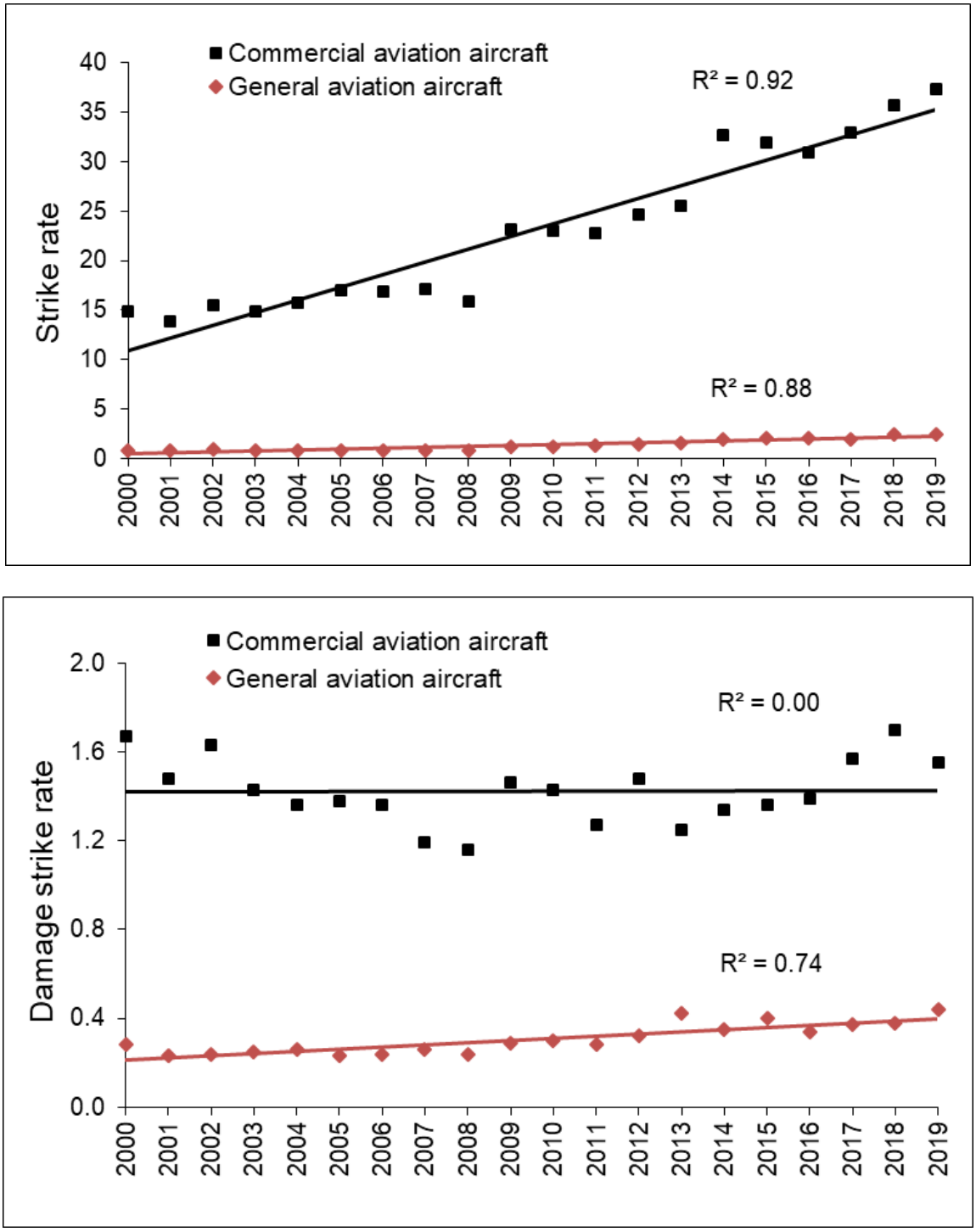
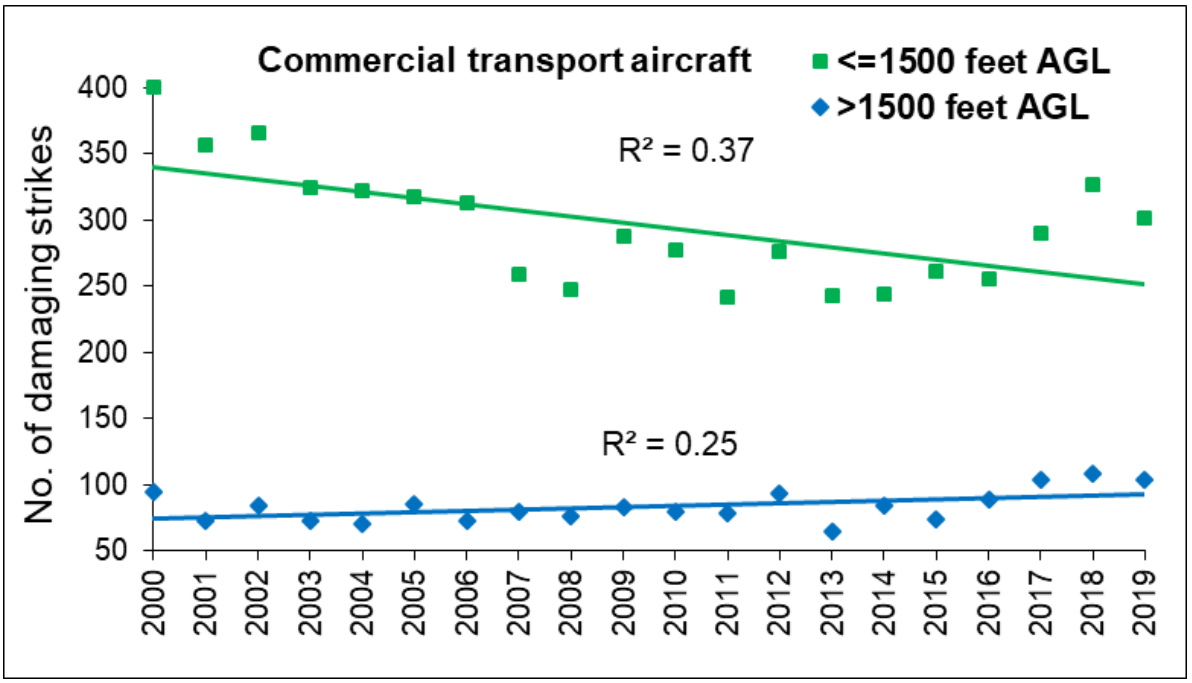


Figure 3. The strike rate and damaging strike rate (number of reported strikes and damaging strikes per 100,000 aircraft movements) for commercial (air carrier, commuter, and air taxi service) and general aviation aircraft, USA, 2000–2019. Strikes involving U.S.-registered aircraft in foreign countries are excluded. R^2 values greater than 0.20 and 0.31 indicate significant trends at the 0.05 and 0.01 levels of probability, respectively (Steel and Torrie 1960; see Tables 3 and 4 for complete data, 1990-2019).



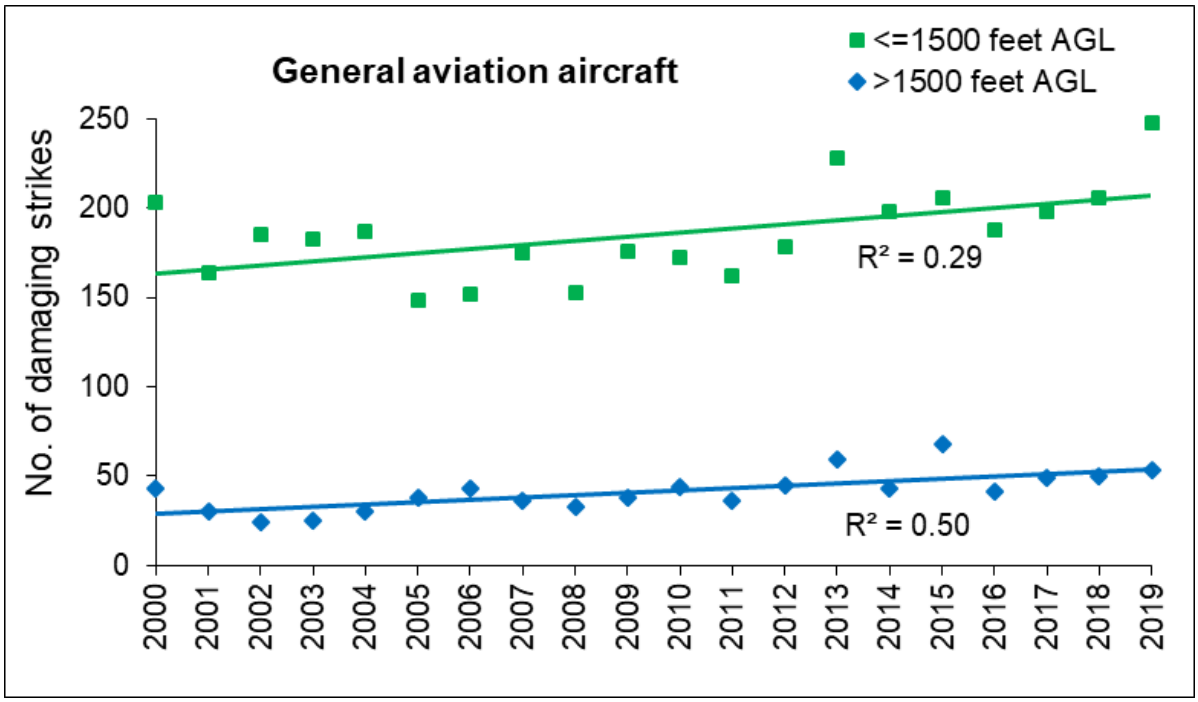


Figure 4. Number of damaging strikes with commercial (top graph) and general aviation (bottom graph) aircraft occurring at ≤ and >1500 feet above ground level (AGL) for all wildlife species, USA, 2000–2019. Strikes with unknown height AGL are included with strikes at ≤1500 feet AGL. Strikes involving U.S.-registered aircraft in foreign countries are excluded. R^2 values greater than 0.20 and 0.31 indicate significant trends at the 0.05 and 0.01 levels of probability, respectively (Steel and Torrie 1960).

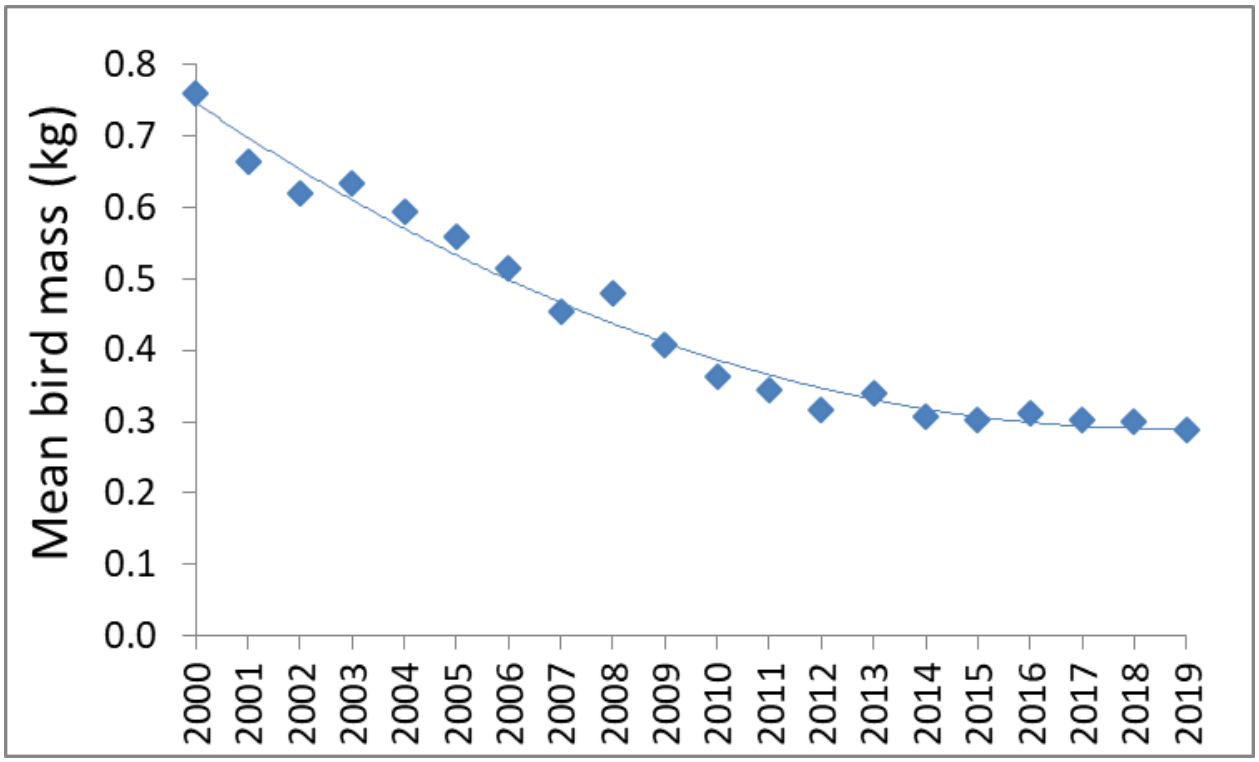


Figure 5. The mean body mass of birds reported as struck by civil aircraft in USA has declined by 62 percent from 2000 to 2019. This indicates that airports, pilots, and commercial aviation in general, are doing a better job of documenting all wildlife that are struck, many of which are small species that rarely cause damage. Means were calculated from all strikes in USA in which the bird was identified to species. See Figure 14 for number of identified bird species struck each year and Table 18 for a list of species struck.

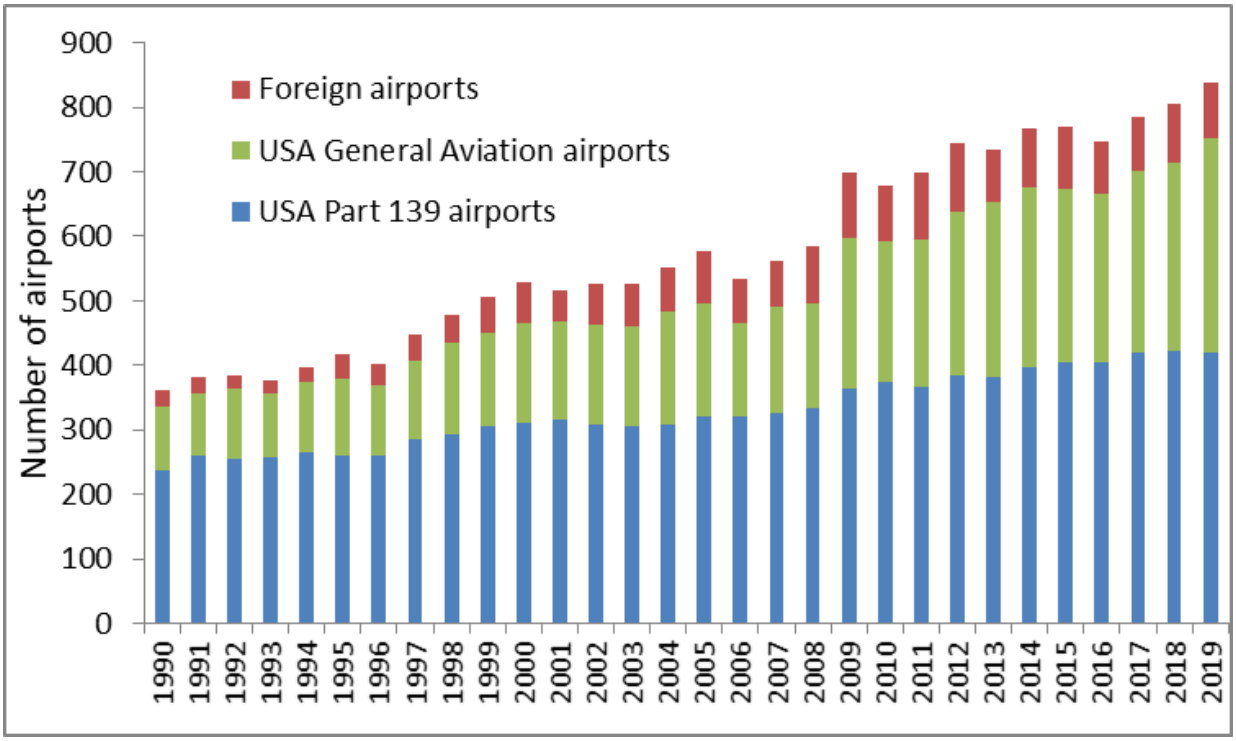
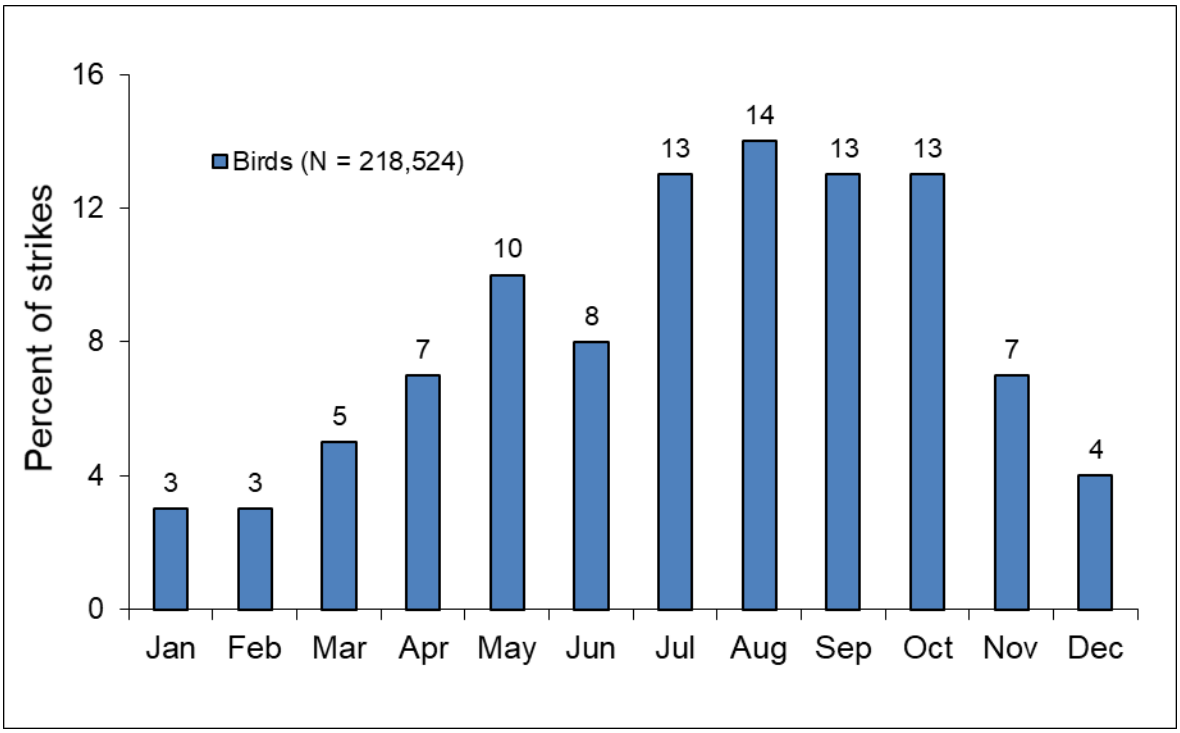


Figure 6. Number of Part 139-certificated airports and general aviation (GA) airports in USA with reported wildlife strikes and number of foreign airports at which strikes were reported for U.S.-registered civil aircraft, 1990–2019. Strikes were reported from 2,091 USA airports (522 Part 139-certificated, 1,569 GA) and 315 foreign airports in 108 countries, 1990-2019 (Table 8).



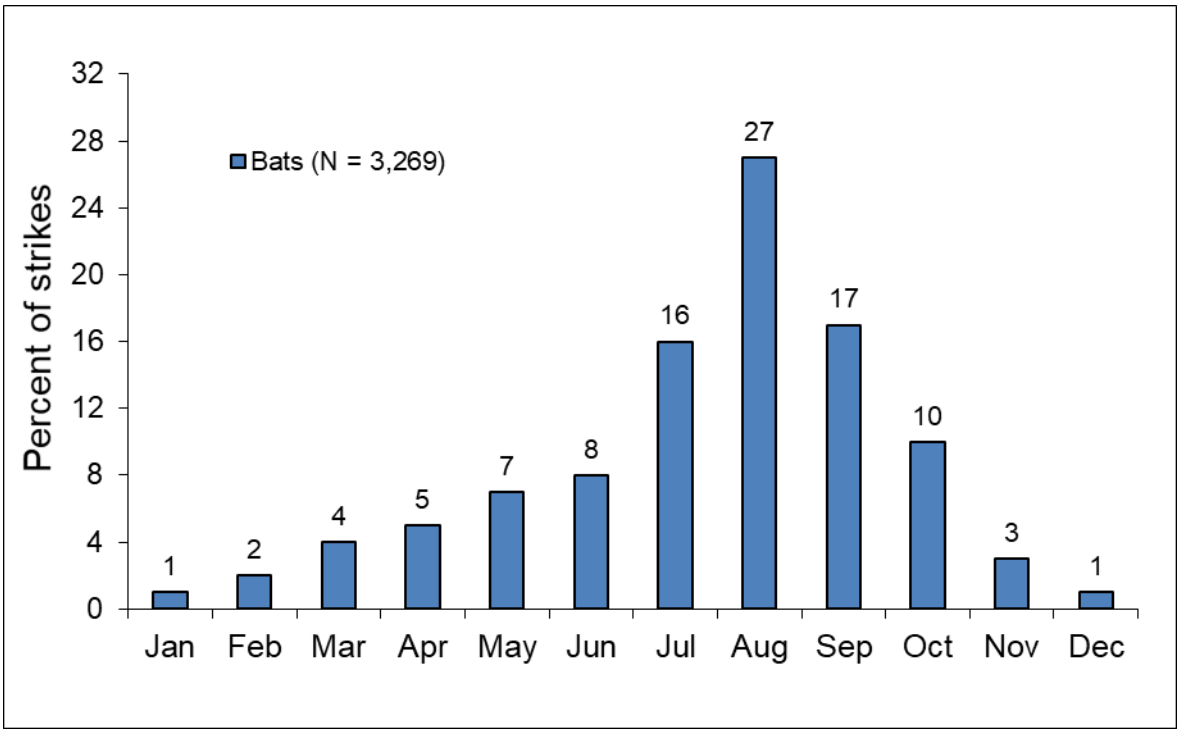
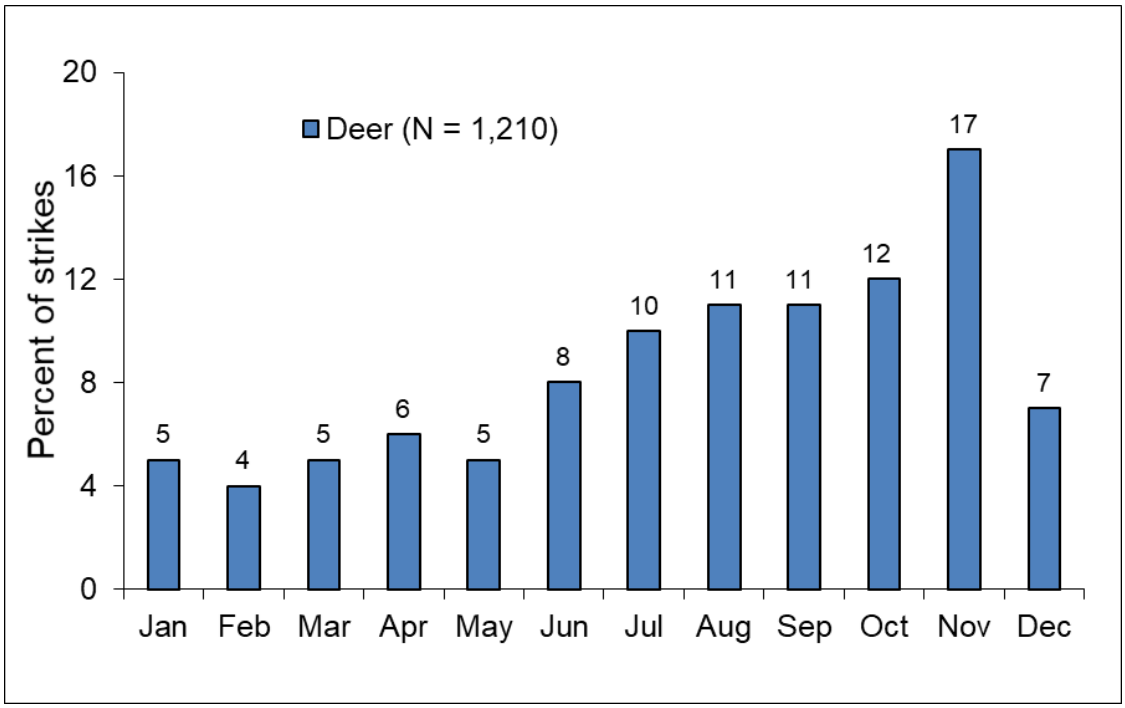


Figure 7. Percentage of reported bird (top graph) and bat (bottom graph) strikes with civil aircraft by month, USA, 1990–2019. In addition, 491 strikes with reptiles were reported of which 57 percent occurred in May – July. Strikes reported for U.S.-registered aircraft in foreign countries were excluded.



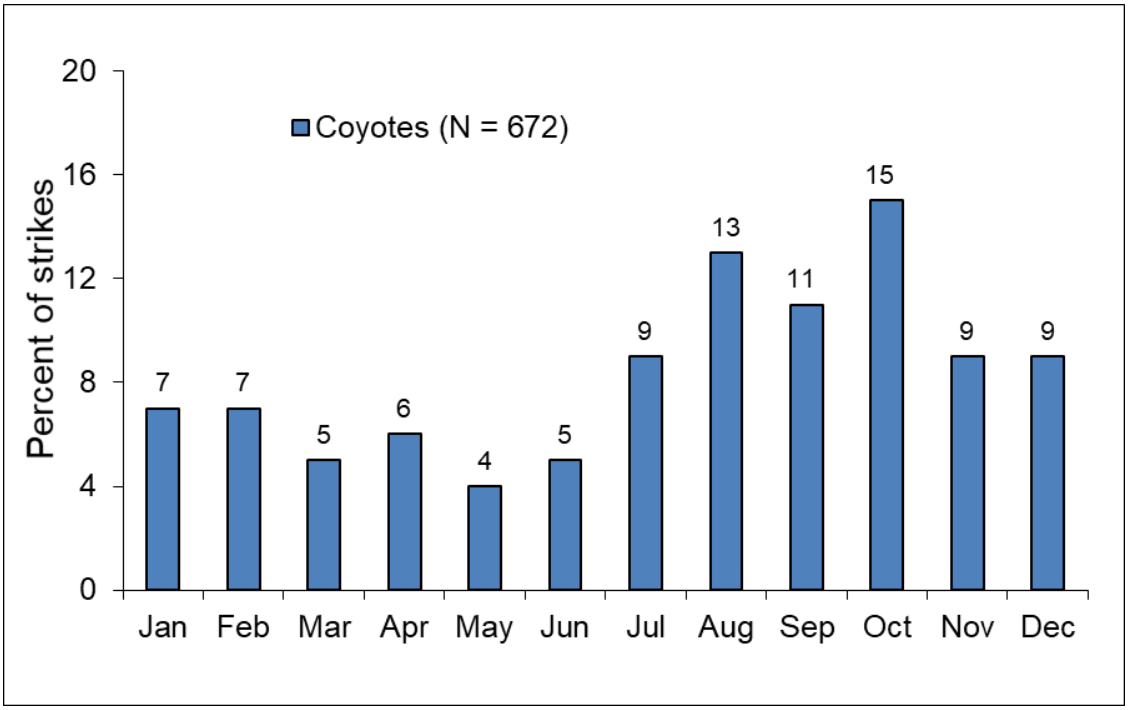
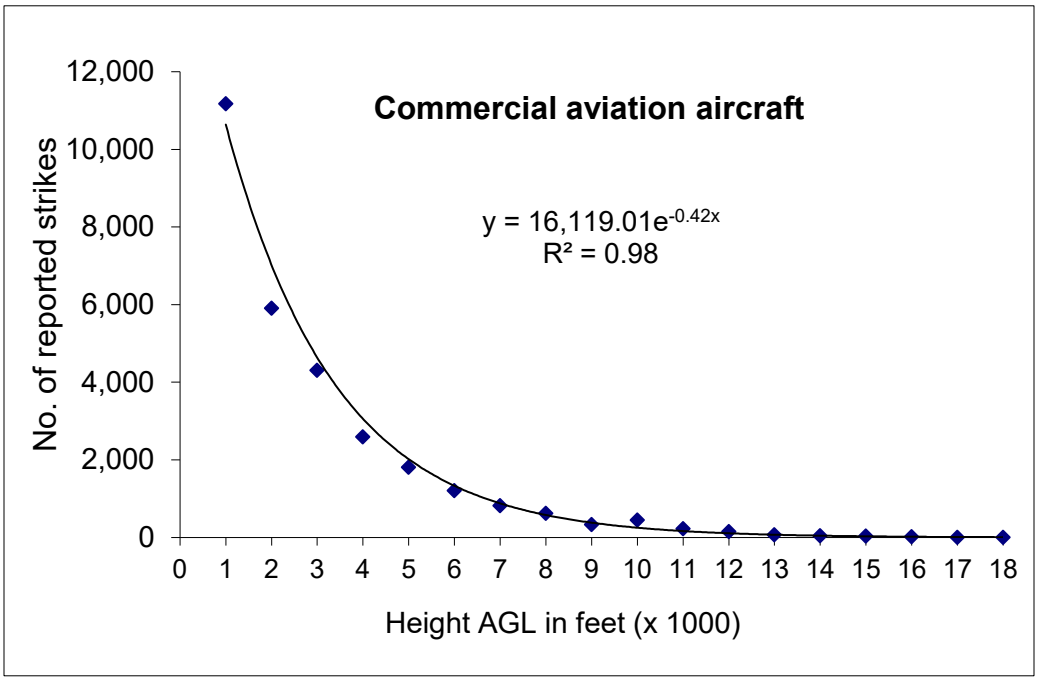


Figure 8. Percentage of reported deer (top graph) and coyote (bottom graph) strikes with civil aircraft by month, USA, 1990–2019. One deer and 1 coyote strike reported for U.S.-registered aircraft in foreign countries were excluded. Deer (1,108 white-tailed, 84 mule, 18 unidentified to species) and coyotes are the most commonly struck terrestrial mammals (Table 18). Biondi et al. (2011) provide a more detailed analysis of deer strikes with civil aircraft in the USA.



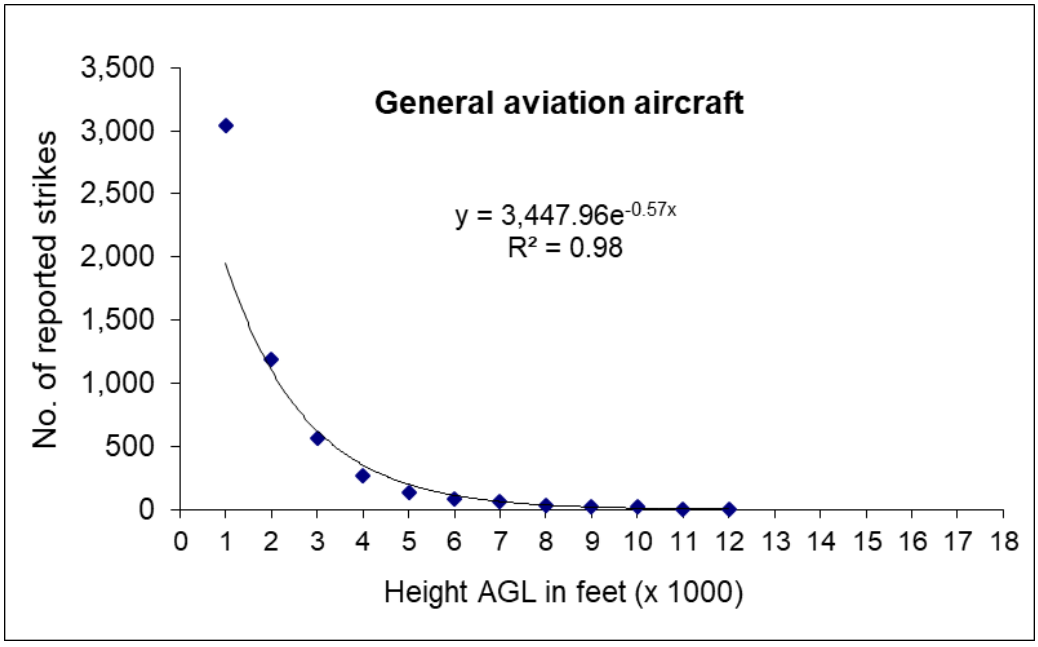


Figure 9. Number of reported bird strikes with commercial (top graph) and general aviation (GA) aircraft (bottom graph) in USA by 1,000-foot height intervals above ground level from 501—1,500 feet (interval 1) to 17,501—18,500 feet (interval 18) for commercial aircraft and to 11,501—12,500 feet (interval 12) for GA aircraft, 1990-2019. These graphs exclude strikes at ≤500 feet. Above 500 feet, the number of reported strikes declined consistently by 34 percent and 43 percent for each 1,000-foot gain in height for commercial and GA aircraft, respectively. The exponential equations explained 98 percent of the variation in number of strikes by 1,000-foot intervals from 501 to 18,500 feet for commercial aircraft and 501 to 12,500 feet for GA aircraft. See Tables 11 and 12 for sample sizes.

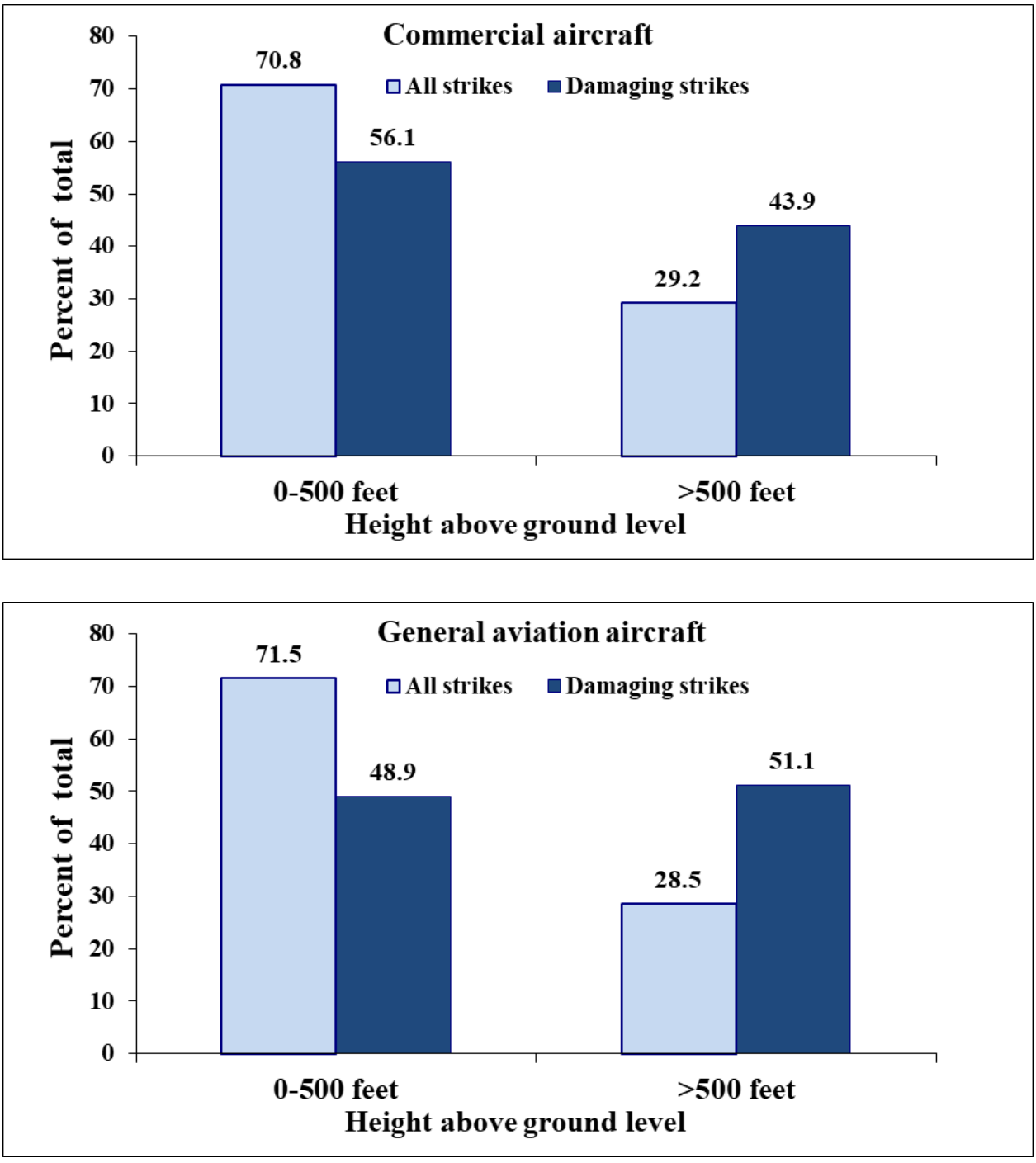


Figure 10. Percentages of total strikes and total damaging strikes occurring at 500 feet or less and above 500 feet for commercial (top graph) and general aviation (bottom graph) aircraft in USA, 1990–2019. See Tables 11 and 12 for sample sizes.

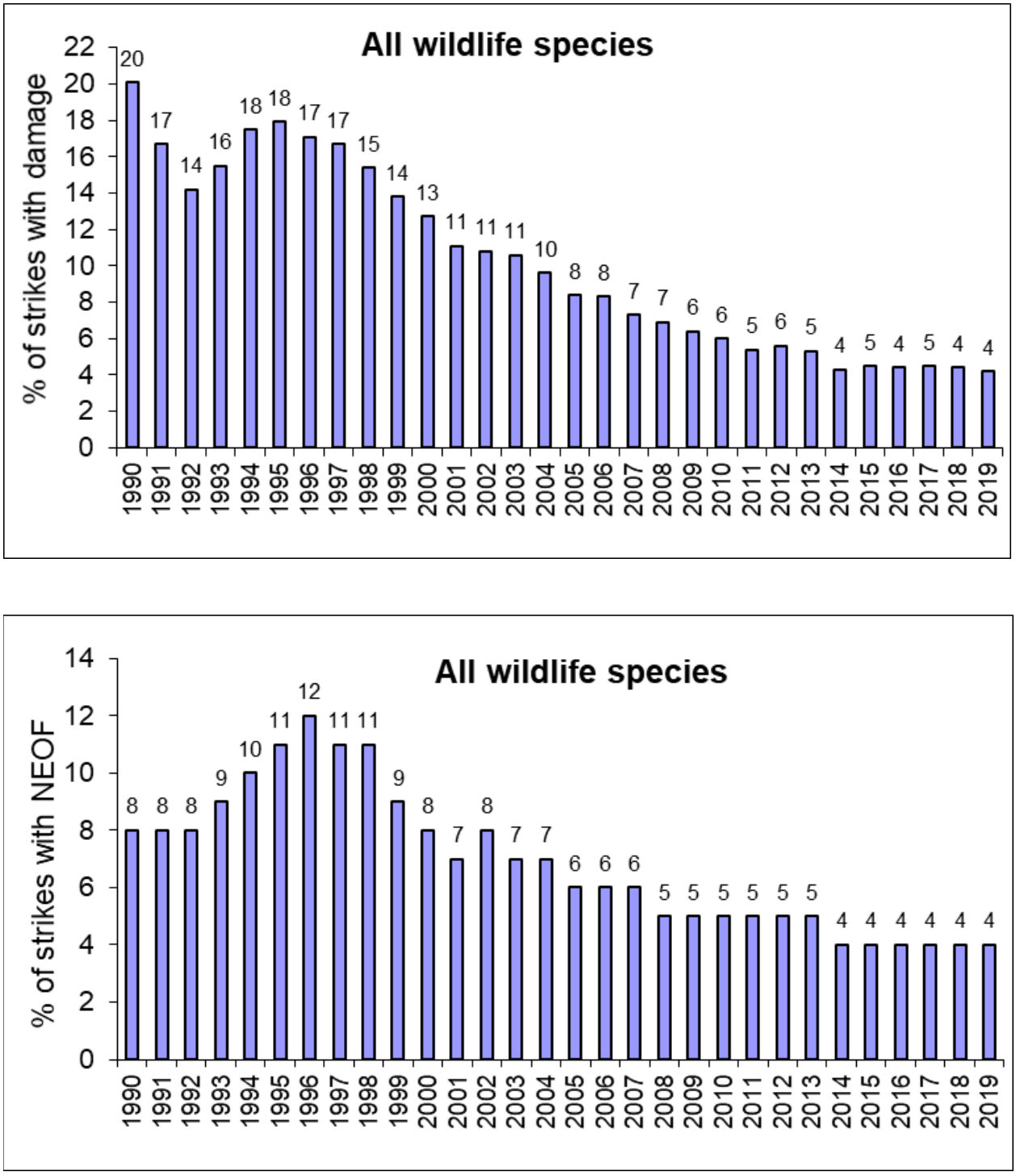


Figure 11. Percentage of reported strikes that indicated damage to the civil aircraft (top graph) or a negative effect-on-flight (NEOF, bottom graph), USA, 1990–2019. See Tables 1, 14, and 15 for sample sizes and classifications of damage and negative effects-on-flight.

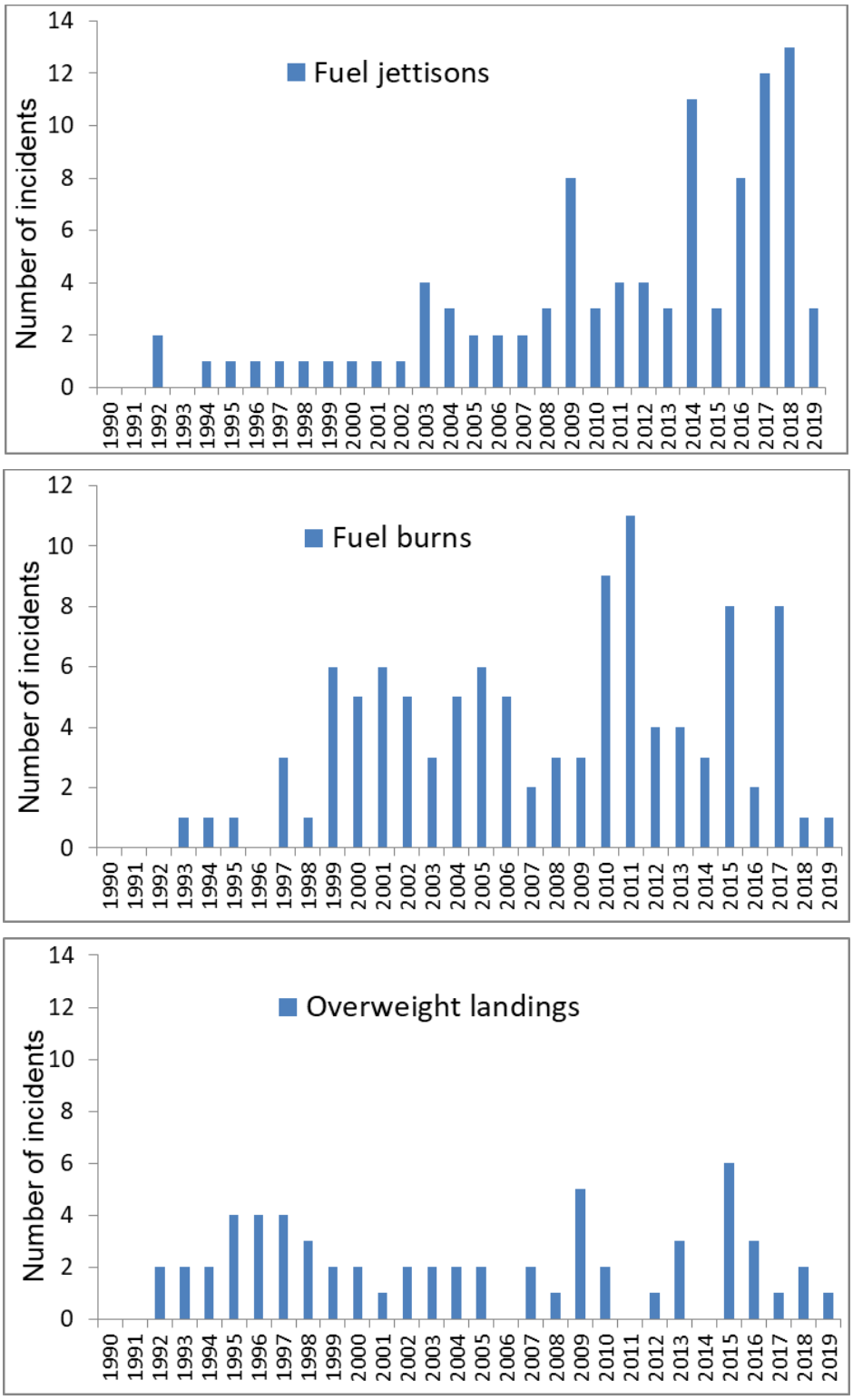


Figure 12. Number of reported incidents where pilot made an emergency or precautionary landing after striking wildlife during departure in which fuel was jettisoned or burned (circling pattern) to lighten aircraft weight or in which an overweight (greater than maximum landing weight) landing was made (no fuel jettison or burn), USA civil aircraft, 1990–2019. See Table 16 for details on aircraft involved and amount of fuel jettisoned.

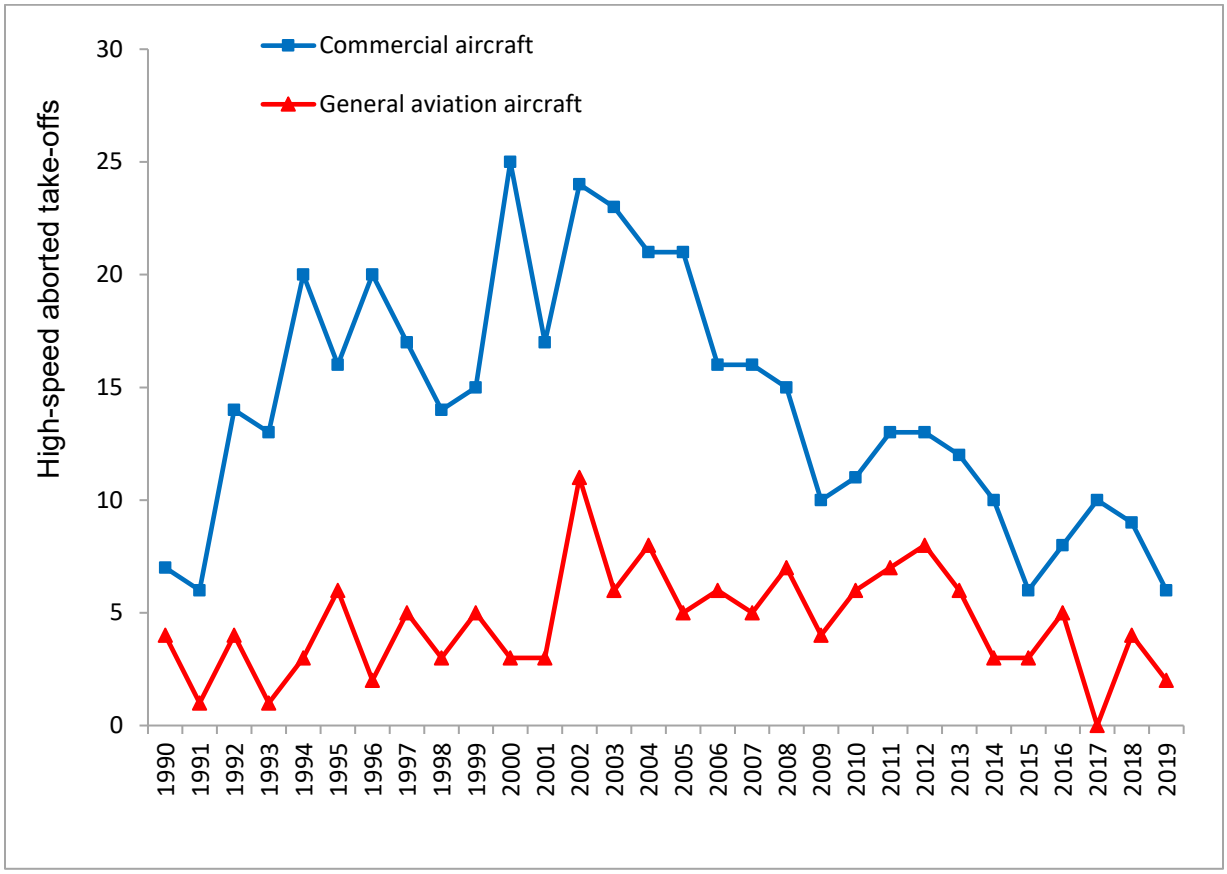


Figure 13. Number of reported incidents in which pilot made a high-speed aborted take-off (≥100 knots) after striking or observing wildlife during take-off run, USA civil aircraft, 1990–2019. See Table 17 for classification of aborted take-offs by indicated airspeed.

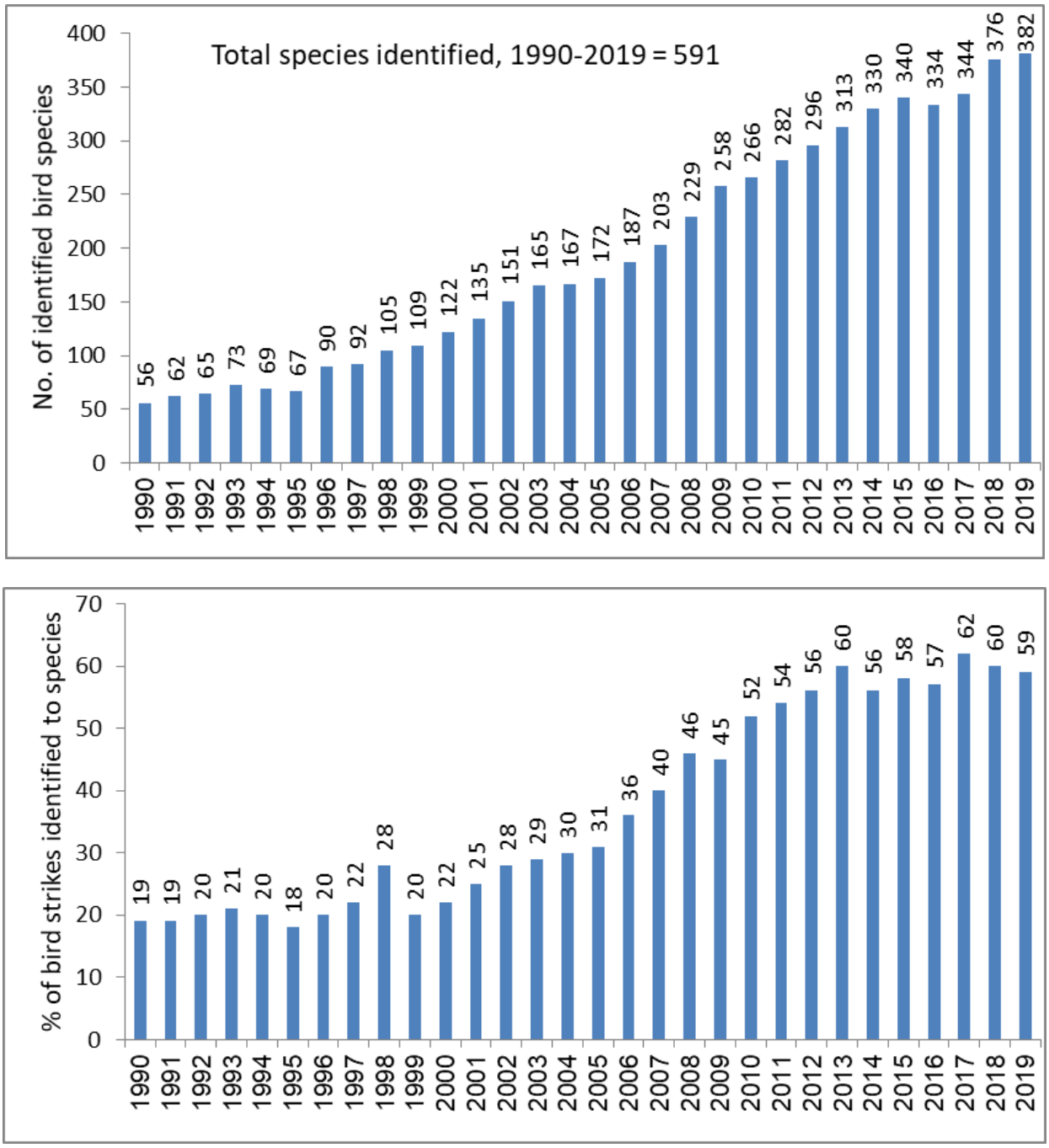


Figure 14. Number of identified bird species struck by civil aircraft each year (top graph) and the percentage of reported bird strikes in which the bird was identified to species (bottom graph), 1990–2019. From 1990 through 2019, 591 different species of birds have been identified. See Tables 1 and 18 for sample sizes and list of species.

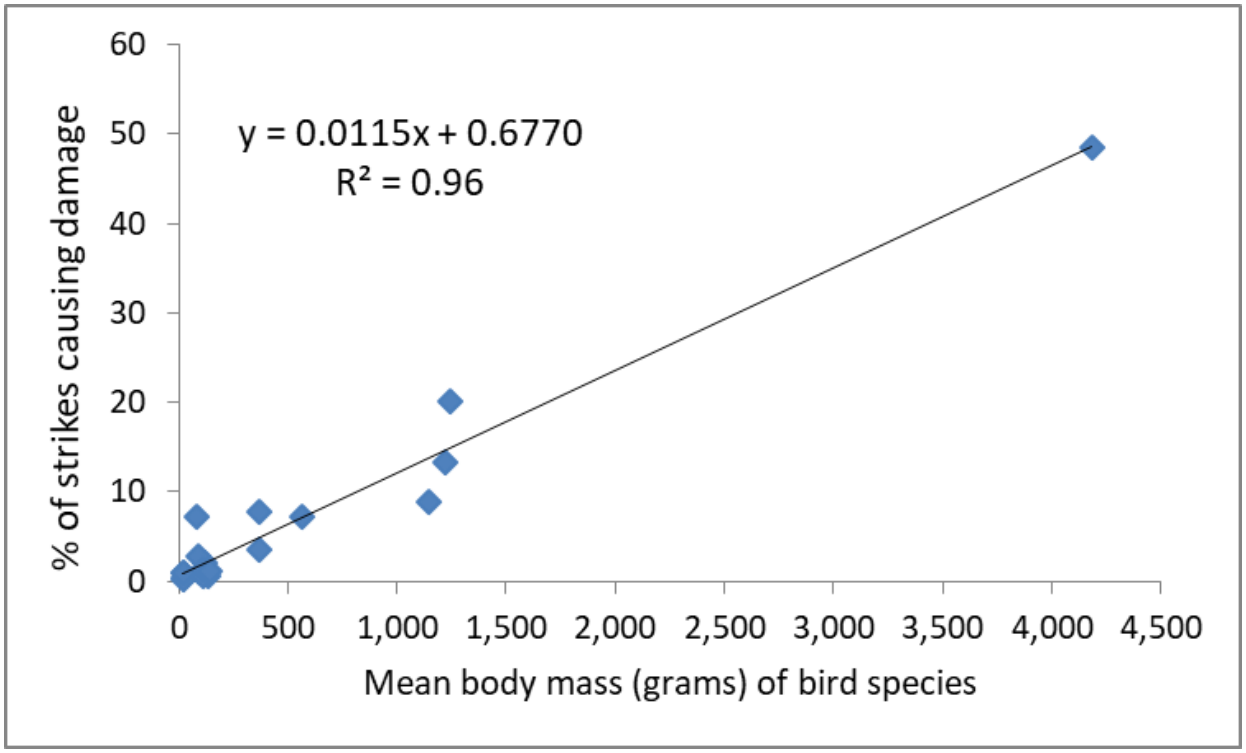


Figure 15. Relation between mean body mass (Dunning 2008) and likelihood of a strike causing damage to aircraft for the 20 species of birds most frequently identified as struck by civil aircraft in USA, 1990-2019 (Table 20). The linear regression equation explained 96 percent of the variation in the likelihood of damage among the 20 species. For every 100-gram increase in body mass, there was a 1.15 percent increase in the likelihood of damage.

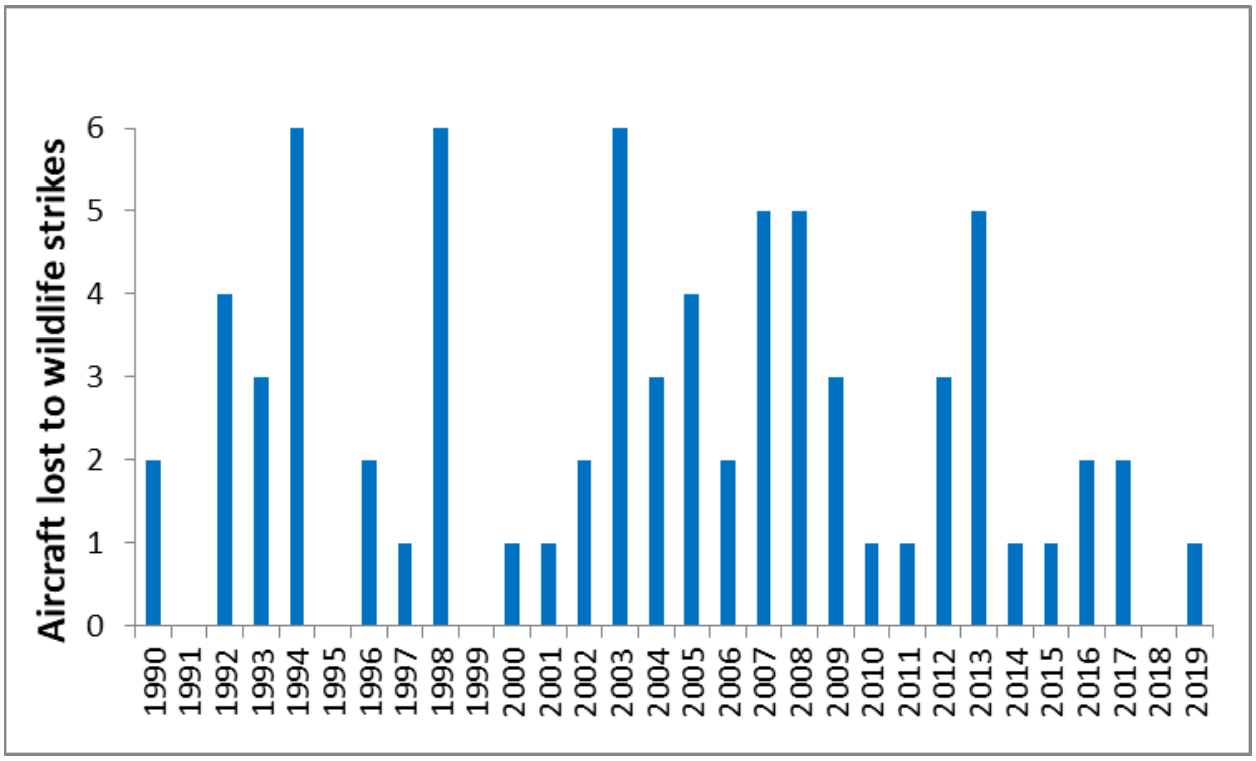


Figure 16. Number of civil aircraft destroyed or damaged beyond repair after striking wildlife, USA, 1990–2019. From 1990 - 2019, 73 aircraft have been lost (46 with maximum take-off mass ≤2,250 kg; 17, 2,251-5,700 kg; 8, 5,701-27,000 kg; 2, >27,000 kg). See Table 22 for wildlife species and types of aircraft and airports associated with these events.

APPENDIX A.

SELECTED SIGNIFICANT WILDLIFE STRIKES TO U.S. CIVIL AIRCRAFT, 2019

The U.S. Department of Agriculture, through an interagency agreement with the Federal Aviation Administration, compiles a database of all reported wildlife strikes to U.S. civil aircraft and to foreign carriers experiencing strikes in the USA. From 1990 through 2019, 231,320 strike reports from 2,091 USA airports and 315 foreign airports have been entered in the database (17,228 strikes from 753 USA and 85 foreign airports in 2019 alone, Tables 1, 8; Figure 6). The following 20 examples from the database in 2019 are presented to show the serious impact that strikes by birds or other wildlife can have on aircraft. These examples demonstrate the widespread and diverse nature of the problem. The examples are not intended to highlight or criticize individual airports because, as documented above, strikes have occurred on almost every airport in the USA. Some of the strike examples reported here occurred off airport property during approach, departure or en route. For more information on wildlife strikes or to report a strike, visit *www.birdstrike.org* and *http://wildlife.faa.gov*.

Date	Aircraft	Airport or location	Phase of flight	Effect on flight	Damage	Wildlife species	Comments from report
1/26/2019	PA-34-200	Delaware Airpark (DE)	Landing roll	None	Engine #2, propeller	White-tailed deer	The deer ran onto the runway from left to right about mid-field and was struck by propeller on the right engine. There was no visible damage to the airframe. Blood and fur was on the right main gear. The strike required a tear down of the right engine. Aircraft time out of service reported as 1,500 hours. Repairs reported as $20,000.
2/7/2019	G-V	Teterboro Arpt (NJ)	Approach (100 feet AGL)	None	Nose, fuselage	Canada geese	Short final struck approximately 10-15 birds. Aircraft landed runway 6 safely and taxied to ramp without incident. ID by Smithsonian Division of Birds.

Appendix A. (Page 2 of 6)

Date	Aircraft	Airport or location	Phase of flight	Effect on flight	Damage	Wildlife species	Comments from report
2/26/2019	B-737-800	Will Rogers World Arpt (OK)	Approach (3,000 feet AGL)	None	Wing	Unknown large bird	The leading-edge device metal was dented (approximately 8 inches horizontal dent). Time out of service reported as 24 hours. Repair costs reported as $25,000. Other costs reported as $210,000.
3/12/2019	EC-135	Near Monroe, LA	En route (1,500 feet AGL)	Precautionary landing	Windshield	Northern shoveler	Two ducks struck windshield with one penetrating the front windscreen. Time out of service reported as 72 hours. Repair costs reported as $30,000. Other costs reported as $90,000.
3/24/2019	B-767-300	Salt Lake City Intl Arpt (UT)	Approach (200 feet AGL)	None	Engine #2 cowling	Western/ Clark's Grebe species complex	Mechanics confirmed that the bird was ingested into the #2 engine. Borescope completed with no internal damage. Engine cowl was replaced. Time out of service reported as 36 hours. Repair costs reported as $959,000. ID by Smithsonian Division of Birds.
3/29/2019	B-737-700	Houston-Hobby (TX)	Descent (12,000 feet AGL)	None	Radome, fuselage	Wilson's Snipe	Dented radome with remains across the Captains side of the windscreen. Time out of service reported as 4 days. Repair costs reported as $20,000. ID by Smithsonian Division of Birds.

Appendix A. (Page 3 of 6)

Date	Aircraft	Airport or location	Phase of flight	Effect on flight	Damage	Wildlife species	Comments from report
3/31/2019	P-180 Avanti II	(CA)	En Route (5,000 feet AGL)	None	Wing	Unknown (Suspect Eagle or Osprey)	En Route at 5000' 30 miles NW of KVRB. Leading edge dented about the size of a quarter behind stall strips and top side of wing outside of rt. engine nacelle was scratched. Underneath wing looked like blood-stained slight scratching and hit the propeller. Estimated costs of repairs reported as $100,000. Other costs reported as $60,000.
4/12/2019	B-737-700	Sacramento Intl Airport (CA)	Climb (10 feet AGL)	Precautionary landing	Landing gear	Mallard	Damaged nose gear hydraulic system; nose gear would not retract. Hydraulic leak noted after returning to gate. Mallard carcass recovered on Runway 34R. ID by Smithsonian Division of Birds.
4/22/2019	Embraer Phenom 300	Naples Municipal Airport (FL)	Climb (1,600 feet AGL)	Precautionary landing	Wing	Black Vulture	The pilots observed the bird prior to the strike. They looked out the window and confirmed the strike by the visual damage seen to the right wing leading edge. Time out of service reported as 7 days. Repairs or replacement reported as $180,000. Other costs reported as $275,000. ID by Smithsonian Division of Birds.
5/22/2019	MD-83	Brownsville/ South Padre Island Intl Arpt (TX)	Take-off Run	Precautionary landing, loss of power to engine	Engine #2	Gull	Loss of power to right engine. Captain saw the birds before take-off. Stated that he ran up the engines to try to scare the birds. The birds flew away then returned while he was taking off on runway 13.

Appendix A. (Page 4 of 6)

Date	Aircraft	Airport or location	Phase of flight	Effect on flight	Damage	Wildlife species	Comments from report
5/27/2019	C-208 (Amphib-ious)	Francis S Gabreski Arpt (NY)	Approach (600 feet AGL)	None	Wing	Gull	Time out of service reported as 42 days. Repairs or replacement reported as $200,000.
6/2/2019	B-737-200	Addison Arpt (TX)	Take-off Run	Aborted takeoff	Engine #1	Unknown medium bird	Seventeen fan disk blades were damaged in the #1 engine. Time out of service reported as 3 days. Repairs or replacement reported as $75,000 and estimated other costs reported as $156,000.
7/2/2019	Cessna 680	Charlotte/ Douglas Intl Airport (NC)	Approach (4,000 AGL)	None	Wing	Black vulture	Leading edge damage to right wing. Dent the size of a football. ID by Smithsonian Division of Birds.
8/1/2019	Lear 40	Found KADS (TX)	Unknown	None	Engine #1 stator vane	Unknown medium bird	Upon arrival in Addison we discovered blood evidence of a bird strike on the #1 engine inlet. We did not notice any damage and reported to maintenance for inspection. Maintenance did a borescope inspection the following day and discovered a stator vane damaged beyond limits. They replaced the part, and returned it to service on 8/3/19. Time out of service reported as 40 hours. Repair costs reported as $14,350.

Appendix A. (Page 5 of 6)

Date	Aircraft	Airport or location	Phase of flight	Effect on flight	Damage	Wildlife species	Comments from report
9/4/2019	Hawker 900	Sheboygan County Memorial Airport (WI)	Take-off Run	None	Radome, Nose	Sandhill crane	Aircraft struck multiple sandhill cranes on takeoff from Sheboygan County Airport in Wisconsin. Aircraft went to Cessna Citation at KMKE for repairs. ID by wildlife biologist.
9/18/2019	HC-130	Richmond International Airport (VA)	Take-off Run	None	Engine #2	American kestrel	Bird struck nose of aircraft and was then ingested into the #2 engine. Borescope inspection revealed engine damage requiring engine replacement. Time out of service reported as 288 hours. Repair costs reported as $1.2 million. ID by Smithsonian Division of Birds.
10/12/2019	Robinson R44	(UT)	En Route (300 feet AGL)	None	Windshield, nose, forward vent, cockpit	Ducks	Bird came through the windscreen just above the landing light on the pilot's side leaving blood and organs along the pilot's legs and all throughout the cockpit.
11/3/2019	Mooney M20	Johnson County Airport (NC)	Climb (900 feet AGL)	Precautionary landing	Wing	Ruddy duck	Leading edge of left wing causing a 12x10 hole. Repair costs reported as $15,000. ID by Smithsonian Division of Birds.

Appendix A. (Page 6 of 6)

Date	Aircraft	Airport or location	Phase of flight	Effect on flight	Damage	Wildlife species	Comments from report
11/12/2019	RV-7 (Experi-mental)	Memorial Field (AR)	Landing roll	Fuel spill	Wing, fuselage, propeller, main fuel tank	White-tailed deer	Deer was crossing aircraft path left to right and struck propeller and impacted primarily the left-wing leading edge where the left main fuel tank is located. This resulted in a fuel spill from damaged tank. Damage was substantial and fatal to the deer (~7-point buck). Occurred after touchdown. Directional control was maintained, and aircraft was stopped on runway. Repair costs reported as $100,000.
12/30/2019	RV-10 (Experi-mental)	The Landings Airport (TX)	Approach (600 feet AGL)	Change in aerodynamics	Wing	Turkey vulture	90% left aileron to maintain level flight after the strike. Repair costs reported as $10,000.

APPENDIX B.

REPORTING A STRIKE AND IDENTIFYING SPECIES OF WILDLIFE STRUCK

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

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

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

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

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

The number of bird strike cases processed by the Smithsonian Feather Identification Lab for the FAA (civil aviation) in FY2019 was 4,682 with 5,167 separate identifications of

species (some cases involved remains from multiple impact points). This compares to 4,356 cases in 2018, 3,826 cases in FY2017, 3,670 cases in FY2016, and 3,118 cases in FY2015 (Dove et al. 2020). In addition, the Lab processed 3,739 cases involving 4,762 identifications for the U.S. Air Force and 890 cases involving 992 identifications for the U.S. Navy in FY2019 (not discussed in this report). DNA analysis (Dove et al. 2008) was used in 47 percent of civil aviation cases in FY2019 to identify the species and in an additional 21 percent to supplement or verify traditional identification methods.

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

Guidelines for Collecting Bird Strike Material

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

Feathers:

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

Tissue/blood ("Snarge"):

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

FTA® Micro Card and Sterile Applicators

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

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

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