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Wildlife Strikes to Civil Aircraft in the United States 1990–2016

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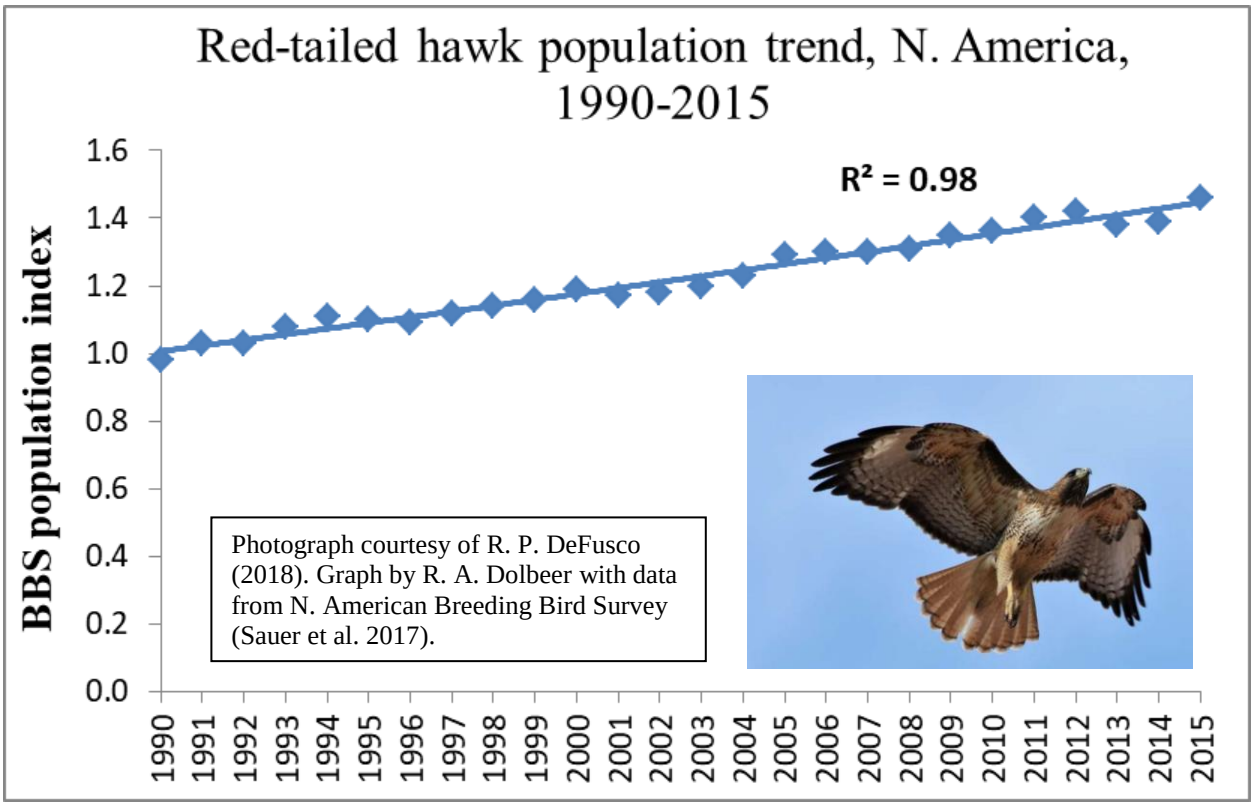
COVER PHOTOGRAPHS

The left wing of this Beechcraft 35 Bonanza struck a red-tailed hawk (inset photograph of banded leg) on touchdown at Charles B. Wheeler Downtown Airport (MKC), Kansas City, Missouri, December 30, 2016. The bird had been captured and banded at MKC as a hatch-year bird in November 2012, and then released at a location about 50 miles from MCI and MKC airports. Thus, the bird was 4.5 years old when struck at the same airport where it had been banded 4 years earlier. (Photographs courtesy of Jeremy Ritter, Airport Operations Agent).

The North American red-tailed hawk population has increased by about 50% from 1990-2015 (Sauer et al 2017) with an estimated breeding population that is now over 2.6 million birds (Rosenberg et al. 2016). From 1990-2016, 2,458 red-tailed hawks were reported as struck by civil aircraft in USA, including 348 (14%) which caused damage to the aircraft. In 2016 there were 213 reported red-tail hawk strikes of which 25 (12%) caused damage.



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EXECUTIVE SUMMARY - WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES, 1990–2016

The year 2016 marked the seventh anniversary of the emergency forced landing of US Airways Flight 1549 in the Hudson River on 15 January 2009 after Canada geese were ingested in both engines on the Airbus 320. The incident resulted in increased media attention to wildlife strikes and demonstrated to the public that wildlife strikes are a serious but manageable aviation safety issue. The civil and military aviation communities continue to understand that the threat from aircraft collisions with wildlife is real and increasing. Globally, wildlife strikes have killed more than 282 people and destroyed over 262 aircraft since 1988. Factors that contribute to this increasing threat are increasing populations of large birds and increased air traffic by quieter, turbofan-powered aircraft.

This report presents a summary analysis of data from the National Wildlife Strike Database for the 27-year period 1990 through 2016. A sample of 21 significant wildlife strikes to civil aircraft in the USA during 2016 is also included as Appendix I. Appendix II provides the rationale and instructions for reporting strikes and identifying the species of wildlife.

The number of strikes annually reported to the FAA has increased over 7-fold from 1,850 in 1990 to 13,408 in 2016. The 2016 total was a decrease of 401 strikes (3 percent) compared to the 13,809 strikes reported in 2015. For 1990–2016, 183,296 strikes were reported (179,542 in USA and 3,754 strikes by U.S.-registered aircraft in foreign countries). In 2016, birds were involved in 96.2 percent of the reported strikes in the USA, terrestrial mammals in 1.7 percent, bats in 1.9 percent and reptiles in 0.3 percent. Although the number of reported strikes in USA has dramatically increased, the number of reported damaging strikes has actually declined since 2000. Whereas the number of reported strikes increased 125 percent from 5,871 in 2000 to 13,234 in 2016, the number of damaging strikes declined 23 percent from 742 to 575. 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 nor for commercial aircraft at >1500 feet AGL.

The number of airports in the United States with strikes reported increased from 335 in 1990 to 662 in 2016. The 662 airports with strikes reported in 2016 were comprised of 403 airports certificated for passenger service under 14 CFR Part 139 and 259 GA aviation airports. From 1990 - 2016, strikes have been reported from 1,962 USA airports and 302 foreign airports (involving USA-registered aircraft).

The percentage of bird and terrestrial mammal strikes with reported damage has averaged 8 and 29 percent, respectively, for the 27-year period, 1990-2016. The overall percentage of strikes causing damage for all wildlife species has declined from 20 percent in 1990 to 4 percent in 2016. This decline is a reflection of a higher reporting rate for non-damaging strikes in recent years combined with an actual reduction in damaging strikes at Part 139-certificated airports.

A negative effect-on-flight was reported in 6 percent and 20 percent of the bird and terrestrial mammal strike reports, respectively. Precautionary/emergency landing after striking wildlife was the most commonly reported negative effect (5,854 incidents). Aborted take-off was the second most commonly reported negative effect (2,339 incidents). 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 2016.

Sixty-nine strikes have resulted in a destroyed aircraft from 1990-2016; 41 (59 percent) of these occurred at GA airports and 45 (65 percent) involved small aircraft (≤2,500 kg maximum take-off mass).

This analysis of 27 years of strike data documents the progress being made in reducing damaging strikes for commercial aircraft which primarily use Part 139-certificated airports. Management actions to mitigate the risk have been implemented at many airports since the 1990s; these efforts are likely responsible for the general decline in reported strikes with damage and a negative effect-on-flight from 2000-2016 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 their 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 automated avian-detection technologies (e.g. avian radar) and bird migration forecasting into airspace management and the development of aircraft lighting systems to enhance detection and avoidance by birds. Finally, there continues to be a need for increased and more detailed strike reporting, especially for general aviation aircraft. When reports are filed, it is important that relevant information be provided whenever possible regarding species identification, number of wildlife struck, time and height of strike, phase of flight, distance from airport, and damage to aircraft components.

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WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES, 1990–2016

INTRODUCTION

Bird strikes continue to be a serious aviation safety issue as demonstrated by the emergency forced landing of an Airbus 320 with 155 passengers and crew in the Hudson River in January 2009 after Canada geese were ingested in both engines (National Transportation Safety Board 2010, Marra et al. 2009) and the 19-fatality crash of a Dornier 228-200 in Nepal in September 2012 after a black kite was struck on take-off (Thorpe 2012). Globally, bird and other wildlife strikes killed more than 282 people and destroyed over 262 aircraft from 1988 – June 2018 (Richardson and West 2000; Thorpe 2012, Shaw and Dolbeer 2018).

As documented by Dolbeer et al. (2016), there are 3 important factors that contribute to this threat. First, populations of many large bird and mammal species commonly involved in strikes have increased markedly in the last few decades and adapted to living in urban environments, including airports. Second, concurrent with population increases of many large bird and mammal species, commercial air traffic in the USA increased from about 23.3 million movements in 1990 to 28.6 million movements in 2016 and passenger enplanements increased from about 495 million in 1990 to 823 million in 2016 (Federal Aviation Administration 2018*a*). Third, commercial air carriers have replaced their older three or four-engine aircraft fleets with more efficient and quieter, two-engine aircraft.

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

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

of flight during which strikes occur, and seasonal patterns). The information obtained from these analyses provides the foundation for FAA national policies and guidance and for refinements in the development and implementation of integrated research and management efforts to reduce wildlife strikes. Data on the number of strikes causing damage to aircraft or other adverse effects (e.g., aborted take-off) also provide a benchmark for individual airports to evaluate and improve their Wildlife Hazard Management Plans in the context of a Safety Management System (Dolbeer and Begier 2012). 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.

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 23rd report in the series and covers the 27-year period, 1990–2016[1]. 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 21 significant wildlife strikes to civil aircraft in the USA during 2016 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, 1990–2016, is available at http://www.faa.gov/airports/airport_safety/wildlife/.

RESULTS

NUMBER OF REPORTED STRIKES AND STRIKES WITH DAMAGE

The number of strikes annually reported to the FAA has increased over 7-fold from 1,850 in 1990 to 13,408 in 2016. The 2016 total was a decrease of 401 strikes (3 percent) compared to the 13,809 strikes reported in 2015 (Table 1, Figure 1). For the 27-year period (1990–2016), 183,296 strikes were reported of which 179,542 (98 percent) occurred in the USA and 3,754 occurred at foreign airports[2]. In 2016, birds were involved in 96.2 percent of the reported strikes in the USA, terrestrial mammals in 1.7 percent, bats in 1.9 percent and reptiles in 0.3 percent (Table 2).

Although the number of reported strikes has steadily increased, it is important to note that the overall number of reported damaging strikes in USA has actually declined since 2000 (Table 2, Figure 2). Whereas the number of reported strikes increased 125 percent from

[1] From 1996 to 2015, a detailed report was produced by August of each year covering the period 1990 to the most recent year (e.g., Dolbeer et al. 2016). In 2017, the database was being transitioned to a new computer system and problems were encountered entering reported strikes into the database. No submitted reports were lost and these problems have been resolved; but this situation caused a delay in the 2016 report until July 2018. Because the 2016 report has been delayed by 1 year, it does not include some of the detail presented in previous reports.

[2] The database contains strikes involving USA-registered or foreign-registered aircraft occurring in the USA and USA-registered aircraft in foreign countries.

5,871 in 2000 to 13,234 in 2016, the number of damaging strikes declined 23 percent from 742 to 575. From 2015 to 2016, the number of damaging strikes decreased 5 percent from 607 to 575.

This overall decline in damaging strikes since 2000 has occurred primarily in the commercial aviation sector. While the number and rate (per 100,000 movements) of all strikes with commercial aircraft has increased 75 and 108 percent, respectively, from 2000 to 2016, the number and rate of damaging strikes has declined 28 and 15 percent, respectively (Table 3, Figure 3).

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

As with commercial aircraft, there has been a steady increase in the strike rate for general aviation (GA) aircraft, from 0.77 in 2000 to 2.02 in 2016 (Table 4). However, in contrast to commercial aviation, the rate of damaging strikes with GA aircraft has not declined since 2000 but has fluctuated between 0.23 (in 2001 and 2005) and 0.42 (in 2013, Table 4, Figure 3). For GA aircraft, there has not been a decline in damaging strikes in the airport environment (at ≤1,500 feet AGL), and there has been an increase in damaging strikes at >1,500 feet AGL (Figure 4).

NUMBER OF AIRPORTS REPORTING STRIKES

The number of airports in the United States with strikes reported has increased steadily from 335 in 1990 to 662 in 2016 (Table 5, Figure 5). The 662 airports with strikes reported in 2016 were comprised of 403 airports certificated for passenger service under 14 CFR Part 139 and 259 general aviation airports. From 1990 - 2016, 158,557 strikes have been reported from 1,962 USA airports. In addition, 3,754 strikes involving USA-registered civil aircraft were reported at 302 foreign airports in 109 countries, 1990 – 2016 (174 strikes at 81 foreign airports in 45 countries in 2016).

REPORTED DAMAGE

For the 177,367 strike reports involving birds from 1990–2016, 14,133 (8 percent) indicated damage to the aircraft (Table 6). When classified by level of damage, 7,412 (4 percent) indicated the aircraft suffered minor damage; 3,521 (2 percent) indicated the aircraft suffered substantial damage; 3,162 (2 percent) reported an uncertain level of

damage; and 38 reports (less than 1 percent) indicated the aircraft was destroyed as a result of the bird strike (Table 6).

For the 3,804 terrestrial mammal strikes reported, 1,099 (29 percent) indicated damage to the aircraft. When classified by level of damage; 558 (15 percent) indicated the aircraft suffered minor damage; 422 (11 percent) indicated the aircraft suffered substantial damage; 88 (2 percent) reported an uncertain level of damage; and 31 (1 percent) indicated the aircraft was destroyed as a result of the strike (Table 6). Not surprisingly, a much higher percentage of terrestrial mammal strikes (29 percent) resulted in aircraft damage than did bird strikes (8 percent). Deer (1,138 strikes, of which 953 caused damage) were involved in 30 percent of the strikes and 87 percent of the damaging strikes involving terrestrial mammals.

Although the percentage of wildlife strikes (all species) with reported damage has averaged 8 percent for the 27-year period (Table 6), this number has declined from 20 percent in 1990 to 4 percent in 2016 (Figure 6). This decline is a reflection of a higher reporting rate for non-damaging strikes in recent years combined with an actual reduction in damaging strikes at Part 139-certificated airports (Table 1).

REPORTED NEGATIVE EFFECT-ON-FLIGHT

A negative effect-on-flight was reported in 6 percent and 20 percent of the bird and terrestrial mammal strike reports, respectively, (Table 7). Precautionary/ emergency landing after striking wildlife was the most commonly reported negative effect (5,854 incidents, 3 percent of strike reports). Aborted take-off after striking wildlife was the second most commonly reported negative effect (2,339 incidents, 1 percent of strike reports).

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 2016 (Figure 6).

AIRCRAFT DESTROYED DUE TO WILDLIFE STRIKES

For the 27-year period, reports were received of 69 aircraft destroyed or damaged beyond repair due to wildlife strikes (range of 0 to 6 per year, Table 8, Figure 7). The majority (45; 65 percent) were small ($\leq$2,250 kg maximum take-off mass) general aviation (GA) aircraft. Terrestrial mammals (primarily white-tailed deer) were responsible for 31 (45 percent) of the incidents. Canada geese (5 incidents) and vultures (4 incidents) were responsible for 39 percent of the 23 incidents involving birds in which the species or species group was identified.

Forty-one (59 percent) of the 69 wildlife strikes resulting in a destroyed aircraft occurred at GA airports, 16 occurred “en-route”, 7 occurred at USA airports certificated for passenger service under 14 CFR Part 139, and 3 occurred in miscellaneous situations (taking off from river, herding cattle, and aerial application of pesticides). Two occurred at

a foreign airport. GA airports, often located in rural areas with inadequate fencing to exclude large mammals, face unique challenges in mitigating wildlife risks to aviation (DeVault et al. 2008; Dolbeer et al. 2008).

CONCLUSIONS

The analysis of 27 years of strike data reveals the magnitude and nature of wildlife strikes with civil aircraft in the USA, and documents that progress is being made in reducing damaging strikes. Although wildlife strikes continue to pose an economic and safety risk for civil aviation in the USA, management actions to mitigate these risks have been implemented at many airports, especially beginning in 2000 when the FAA's manual Wildlife Hazard Management at Airports was initially available to airports nationwide (Cleary and Dolbeer 1999, second edition 2005). These efforts (examples of which are documented in Wenning et al. 2004, DeFusco et al. 2005, Dolbeer 2006a, Human Wildlife Conflicts Journal 2009, Human-Wildlife Interactions Journal 2011, Dolbeer 2011, DeVault et al. 2013, Dolbeer et al. 2014) are likely responsible for the general decline in reported strikes with damage and negative effects-on-flight from 2000-2016 for commercial aircraft (Table 1, Figures 2, 3, 4, 6, 7) in spite of continued increases in populations of many large bird species. As another measure of the increase in wildlife management activities, USDA Wildlife Services biologists provided assistance at 853 civil and military airports nationwide in 2016 to mitigate wildlife risks to aviation compared to only 42 airports in 1991 and 193 in 1998 (Begier et al. 2017). 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 150/5200-36A, Qualifications for Wildlife Biologist Conducting Wildlife Hazard Assessments and Training Curriculums for Airport Personnel Involved in Controlling Wildlife Hazards on Airports). They then must take appropriate actions, under the guidance of these biologists, to minimize risks posed by wildlife. Management actions should be prioritized based on the hazard level of species (Dolbeer et al. 2000, DeVault et al. 2011) observed in the aircraft operating area. The manual *Wildlife Hazard Management at Airports* (Cleary and Dolbeer 2005), available online in English, Spanish, and French at http://wildlife.faa.gov, provides guidance for conducting wildlife hazard assessments and in developing and implementing wildlife hazard management plans

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

To mitigate the risk for strikes beyond the airport fence, the general public and aviation community must first widen its view of wildlife management to consider habitats and land

uses within 5 miles of airports (DeVault et al. 2016). Wetlands, dredge-spoil containment areas, municipal solid waste landfills, and wildlife refuges can attract hazardous wildlife. Such land uses, as discussed in FAA Advisory Circular 150/5200-33B, Hazardous Wildlife Attractants on or Near Airports, are often incompatible with aviation safety and should either be prohibited near airports or designed and operated in a manner that minimize the attraction of hazardous wildlife (e.g., Washburn et al. 2010).

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

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

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TABLES

Table 1. Number of reported wildlife strikes to civil aircraft in USA and to U.S.-registered civil aircraft in foreign countries, 1990–2016.

	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	2,529	360	38	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	3,731	574	68	10	3,799	584
1999	5,014	685	98	18	5,112	704
2000	5,871	741	129	21	6,000	763
2001	5,695	630	125	15	5,820	645
2002	6,083	661	143	11	6,226	672
2003	5,863	612	138	20	6,001	632
2004	6,402	610	159	16	6,561	626
2005	7,046	585	181	20	7,227	605
2006	7,079	579	162	18	7,241	598
2007	7,603	553	142	16	7,745	569
2008	7,444	511	188	14	7,632	525
2009	9,256	585	253	20	9,509	605
2010	9,674	579	231	18	9,905	597
2011	9,851	519	266	23	10,117	542
2012	10,639	591	267	21	10,906	612
2013	11,209	596	200	13	11,409	609
2014	13,463	569	230	15	13,693	584
2015	13,559	607	250	12	13,809	619
2016	13,234	575	174	11	13,408	586
Total	**179,542**	**14,878**	**3,754**	**369**	**183,296**	**15,250**

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

Table 2. Number of reported wildlife strikes to civil aircraft in USA by wildlife group, 1990–2016.

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	2,453	2	73	1	2,529	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	3,610	3	111	7	3,731	574
1999	4,912	6	95	1	5,014	686
2000	5,730	15	123	3	5,871	742
2001	5,542	8	137	8	5,695	630
2002	5,930	19	119	15	6,083	661
2003	5,715	20	123	5	5,863	612
2004	6,243	27	126	6	6,402	610
2005	6,881	27	131	7	7,046	585
2006	6,884	46	139	10	7,079	580
2007	7,375	52	169	7	7,603	553
2008	7,213	44	182	5	7,444	511
2009	8,950	67	229	10	9,256	585
2010	9,305	112	246	11	9,674	579
2011	9,500	138	198	15	9,851	519
2012	10,255	161	204	19	10,639	591
2013	10,748	224	204	33	11,209	596
2014	12,952	254	222	35	13,463	569
2015	12,995	317	211	36	13,559	607
2016	12,728	248	222	36	13,234	575
Total	**173,643**	**1810**	**3793**	**296**	**179,542**	**14,881**

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

Table 3. Number and rate of reported wildlife strikes and strikes with damage for commercial air carrier aircraft, USA, 1990–2016 (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	23.23	5.80	0.94
1991	1,779	249	24.75	7.19	1.01
1992	1,797	207	25.14	7.15	0.82
1993	1,781	232	25.54	6.97	0.91
1994	1,893	279	26.55	7.13	1.05
1995	1,983	311	27.01	7.34	1.15
1996	2,057	310	27.55	7.47	1.13
1997	2,431	368	27.73	8.77	1.33
1998	2,482	361	27.97	8.87	1.29
1999	3,779	461	28.73	13.15	1.60
2000	4,378	492	29.51	14.83	1.67
2001	4,049	430	29.13	13.90	1.48
2002	4,276	452	27.60	15.49	1.64
2003	4,152	398	27.88	14.89	1.43
2004	4,551	390	28.85	15.77	1.35
2005	4,982	398	29.22	17.05	1.36
2006	4,759	385	28.28	16.83	1.36
2007	4,861	338	28.44	17.09	1.19
2008	4,444	323	27.94	15.90	1.16
2009	5,882	371	25.45	23.11	1.46
2010	5,793	360	25.10	23.08	1.43
2011	5,724	321	25.11	22.79	1.28
2012	6,143	368	24.89	24.68	1.48
2013	6,272	308	24.59	25.50	1.25
2014	7,968	326	24.42	32.63	1.34
2015	7,852	333	24.57	31.95	1.36
2016	7,678	353	24.83	30.92	1.42
Total	**115,093**	**9,343**	**720.04**	**15.98**	**1.30**

[1] Strikes involving an unknown operator (44,641 of which 43,474 were “Carcass Found” reports) 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 2018*a*).

Table 4. Number and rate of reported wildlife strikes and strikes with damage for general aviation aircraft, USA, 1990–2016 (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	77.45	0.43	0.17
1991	406	131	83.44	0.49	0.16
1992	432	142	82.23	0.53	0.17
1993	447	159	80.31	0.56	0.20
1994	475	172	79.11	0.60	0.22
1995	481	171	77.13	0.62	0.22
1996	505	179	78.88	0.64	0.23
1997	505	189	79.86	0.63	0.24
1998	566	204	84.16	0.67	0.24
1999	620	212	85.26	0.73	0.25
2000	673	246	87.00	0.77	0.28
2001	695	194	85.82	0.81	0.23
2002	782	209	85.72	0.91	0.24
2003	683	208	83.39	0.82	0.25
2004	695	217	82.63	0.84	0.26
2005	667	186	81.09	0.82	0.23
2006	687	194	80.11	0.86	0.24
2007	670	212	80.15	0.84	0.26
2008	627	186	77.96	0.80	0.24
2009	861	214	73.54	1.17	0.29
2010	845	216	71.17	1.19	0.30
2011	918	198	69.85	1.31	0.28
2012	1,028	223	69.52	1.48	0.32
2013	1,106	287	68.77	1.61	0.42
2014	1,339	241	68.15	1.96	0.35
2015	1,403	273	68.28	2.05	0.40
2016	1,369	219	67.87	2.02	0.32
Total	**19,819**	**5,416**	**2108.84**	**0.94**	**0.26**

[1] Strikes involving an unknown operator (44,641 of which 43,474 were “Carcass Found” reports) 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 2018*a*).

Table 5. Number of Part 139-certificated airports[1] and general aviation (GA) airports with reported wildlife strikes and number of strikes reported for these airports, civil aircraft, 1990–2016 (see Figure 5)[2].

	Part 139 airports		GA airports		All USA airports	
Year	Airports	Strikes	Airports	Strikes	Airports	Strikes
1990	235	1,503	100	168	335	1,671
1991	259	1,987	97	200	356	2,187
1992	254	2,171	108	229	362	2,400
1993	256	2,219	101	220	357	2,439
1994	264	2,220	111	247	375	2,467
1995	260	2,325	121	211	381	2,536
1996	260	2,496	108	193	368	2,689
1997	284	2,907	124	202	408	3,109
1998	292	3,215	144	268	436	3,483
1999	302	3,800	147	259	449	4,059
2000	312	4,465	152	278	464	4,743
2001	317	4,432	150	293	467	4,725
2002	307	4,771	154	308	461	5,079
2003	305	4,649	154	331	459	4,980
2004	308	5,211	176	321	484	5,532
2005	322	5,498	174	330	496	5,828
2006	323	5,924	143	271	466	6,195
2007	328	6,564	163	326	491	6,890
2008	331	6,625	162	309	493	6,934
2009	362	8,008	236	456	598	8,464
2010	374	8,296	216	463	590	8,759
2011	365	8,445	229	499	594	8,944
2012	384	8,905	254	576	638	9,481
2013	379	9,128	272	617	651	9,745
2014	395	11,023	279	699	674	11,722
2015	403	11,118	266	693	669	11,811
2016	403	10,903	259	782	662	11,685
Total	**521**	**148,808**	**1,441**	**9,749**	**1,962**	**158,557**

[1] There are about 530 airports in USA certificated for passenger service under CFR Part 139 Regulations (Federal Aviation Administration 2018*b*).

[2] In addition, 3,754 strikes involving USA-registered aircraft were reported from 302 foreign airports in 109 countries. Furthermore, 3,292 strikes (3,280 bird and 12 bat strikes) were reported in which aircraft was en-route. An additional 17,674 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 6. Number of civil aircraft with reported damage resulting from wildlife strikes, USA[1], 1990–2016 (see Tables 1 - 4 and Figures 2 – 4 and 6 for trends in damaging strikes, 1990–2016).

	REPORTED STRIKES					
	BIRDS		TERRESTRIAL MAMMALS		Total (all species)[2]	
Damage category[3]	27-year total	% of total[4]	27-year total	% of total[4]	27-year total	% of total[4]
None	**111,777**	**63**	**999**	**26**	**113,583**	**62**
Unknown	**51,457**	**29**	**1,706**	**45**	**54,467**	**30**
Damage	**14,133**	**8**	**1,099**	**29**	**15,247**	**8**
Minor	7,412	4	558	15	7,978	4
Uncertain	3,162	2	88	2	3,253	2
Substantial	3,521	2	422	11	3,947	2
Destroyed	38	<1	31	1	69	<1
Total	**177,367**	**100**	**3,804**	**100**	**183,297**	**100**

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

[2] Included in totals are 1,830 and 296 strikes involving bats and reptiles, respectively. For bats, 760 reports indicated no damage, 1,057 failed to indicate if damage occurred, and 13 indicated damage (7 minor, 3 uncertain level, 3 substantial [all substantial damage strikes were caused by megabats at foreign airports]). For reptiles, 47 reports indicated no damage, 247 failed to indicate if damage occurred, and 2 indicated damage (1 minor, 1 substantial [alligator]).

[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 54,467 reports that did not indicate if damage occurred or not (Unknown). We assume these strikes did not cause damage. “Carcass found” reports comprised 43,476 (80 percent) of these 54,467 reports. If the Unknown reports are excluded from the calculations, then 11, 52, and 12 percent of the strikes caused damage for birds, terrestrial mammals, and all species, respectively.

Table 7. Reported effect-on-flight of wildlife strikes to civil aircraft, USA[1], 1990–2016 (see Figure 6 for trends in strikes with negative effects on flight, 1990–2016).

	Reported strikes					
	Birds		Terrestrial mammals		Total[2]	
Effect-on-flight[3]	27-year total	% of total[3]	27-year total	% of total[4]	27-year total	% of total[4]
None	**94,887**	**53**	**929**	**24**	**96,486**	**53**
Unknown	**72,091**	**41**	**2,127**	**56**	**75,653**	**41**
Negative effect	**10,389**	**6**	**748**	**20**	**11,158**	**6**
Precautionary landing	5,734	3	111	3	5,854	3
Aborted take-off	2,098	1	240	6	2,339	1
Engine shutdown[5]	420	<1	32	1	452	<1
Other	2,137	1	365	10	2,513	1
Total	**177,367**	**100**	**3,804**	**100**	**183,297**	**100**

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

[2] Included in totals are 1,830 and 296 strikes involving bats and reptiles, respectively. For bats, 628 reports indicated no effect-on-flight, 1,191 failed to indicate if an effect-on-flight occurred, and 11 indicated a negative effect (8 precautionary landings, 3 “Other”). For reptiles, 42 reports indicated no effect-on-flight, 244 failed to indicate if an effect-on-flight occurred, and 10 indicated a negative effect (1 precautionary landing, 1 aborted take-off, 8 “Other”).

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

[4] The percentage of strikes causing negative effect-on-flight is calculated using the total strikes reported as the divisor, including the 75.653 reports that did not indicate if a negative effect occurred or not (Unknown). We assume these strikes did not have a negative effect. “Carcass found” reports comprised 43,306 (57 percent) of these 75,653 reports. If the Unknown reports are excluded from the calculations, then 10, 45, and 10 percent of the strikes caused a negative effect-on-flight for birds, terrestrial mammals, and all species, respectively.

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

Table 8. Number of civil USA-registered aircraft lost (destroyed or damaged beyond repair) after striking wildlife by wildlife species and aircraft mass category, 1990–2016 (see Figure 7 for number of lost aircraft by year and take-off mass, 1990–2016).

Wildlife species or species group	Aircraft mass category (Maximum take-off mass in kilograms) ≤2,250	2,251-5,700	5,701-27,000	>27,000	Total aircraft lost[1, 2]
White-tailed deer	15	6	2		23
Unknown bird	12	2	1	0	15
Canada goose	1	3		1	5
Bald eagle	3				3
Cattle	2	1			3
Turkey vulture	3				3
Hawks	2				2
A. white pelican		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
Red-tailed hawk		1			1
Ring-billed gull		1			1
Wapiti (elk)			1		1
Total	**45**	**16**	**6**	**2**	**69**

[1] Engine types on the 69 destroyed aircraft were piston (50), turbofan (8), turboprop (5), turbojet (3), and turboshaft (3). Aircraft operators were business (38), private (25), commercial transport (5), and government (1).

[2] Forty-one (59 percent) of the 69 wildlife strikes resulting in a destroyed aircraft occurred at general aviation airports, 16 occurred “en route”, 7 occurred at USA airports certificated for passenger service under 14 CFR Part 139, 3 occurred in miscellaneous situations (taking off from river, herding cattle, aerial application of pesticides) and 2 occurred at foreign airports.

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FIGURES

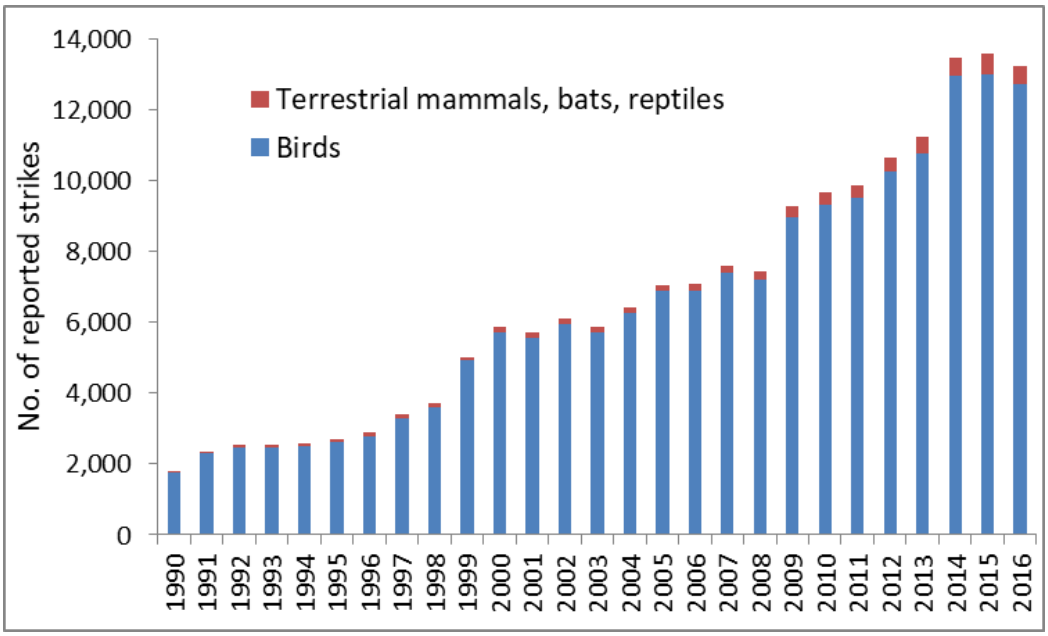

Figure 1. Number of reported wildlife strikes with civil aircraft, USA, 1990–2016. The 179,542 strikes involved birds (173,643), terrestrial mammals (3,793), bats (1,810), and reptiles (296). An additional 3,754 strikes were reported for U.S.-registered aircraft in foreign countries (see Table 1).

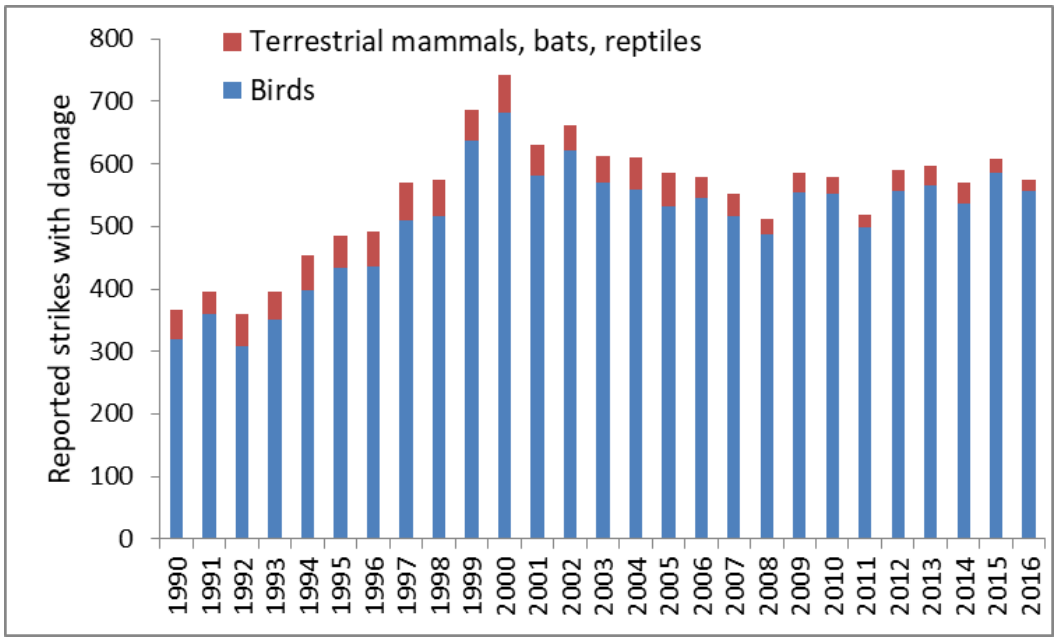

Figure 2. Number of reported wildlife strikes causing damage to civil aircraft, USA, 1990–2016. The 14,881 damaging strikes involved birds (13,768), terrestrial mammals (1,098), bats (13), and reptiles (2). An additional 369 strikes causing damage were reported for U.S.-registered aircraft in foreign countries (see Table 1).

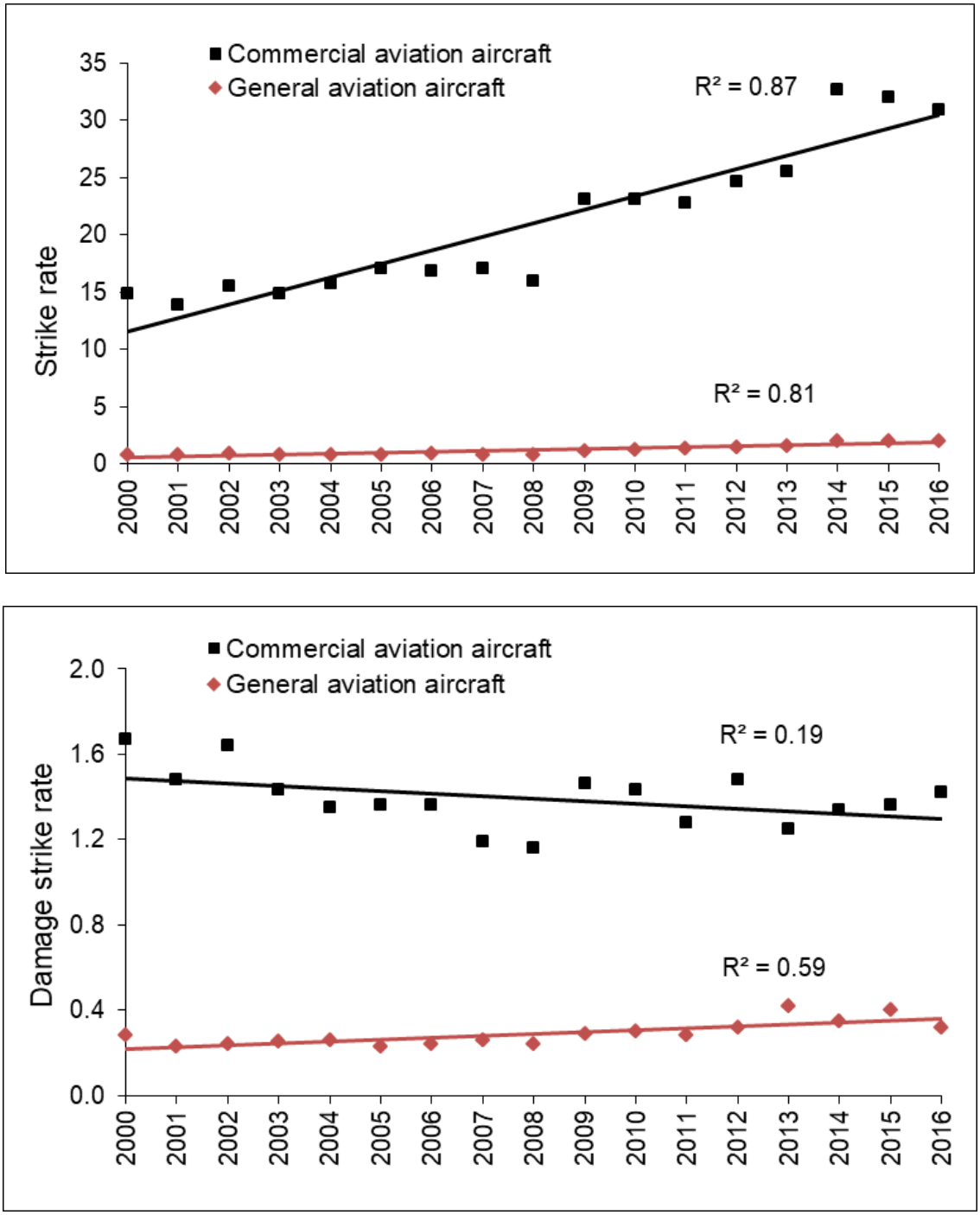

Figure 3. The strike rate and damaging strike rate (number of reported strikes and damaging strikes per 100,000 aircraft movements) for commercial (air carrier, commuter, and air taxi service) and general aviation aircraft, USA, 2000–2016. Strikes involving U.S.-registered aircraft in foreign countries are excluded. R^2 values greater than 0.23 and 0.36 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, 1990-2016).

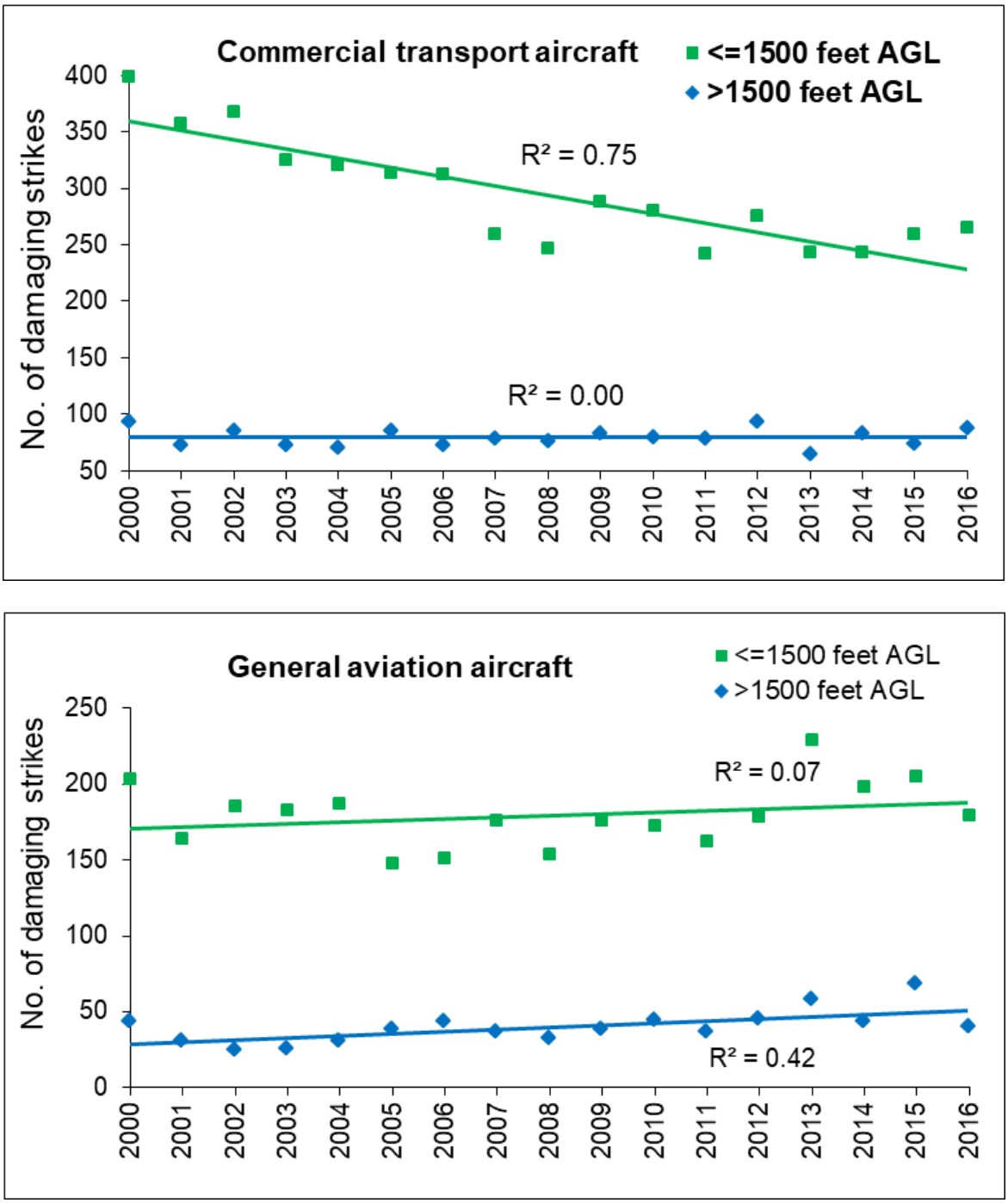

Figure 4. Number of damaging strikes with commercial (top graph) and general aviation (bottom graph) aircraft occurring at ≤ and >1500 feet above ground level (AGL) for all wildlife species, USA, 2000–2016. Strikes with unknown height AGL are included with strikes at ≤1500 feet AGL. Strikes involving U.S.-registered aircraft in foreign countries are excluded. R^2 values greater than 0.23 and 0.36 indicate significant trends at the 0.05 and 0.01 levels of probability, respectively (Steel and Torrie 1960).

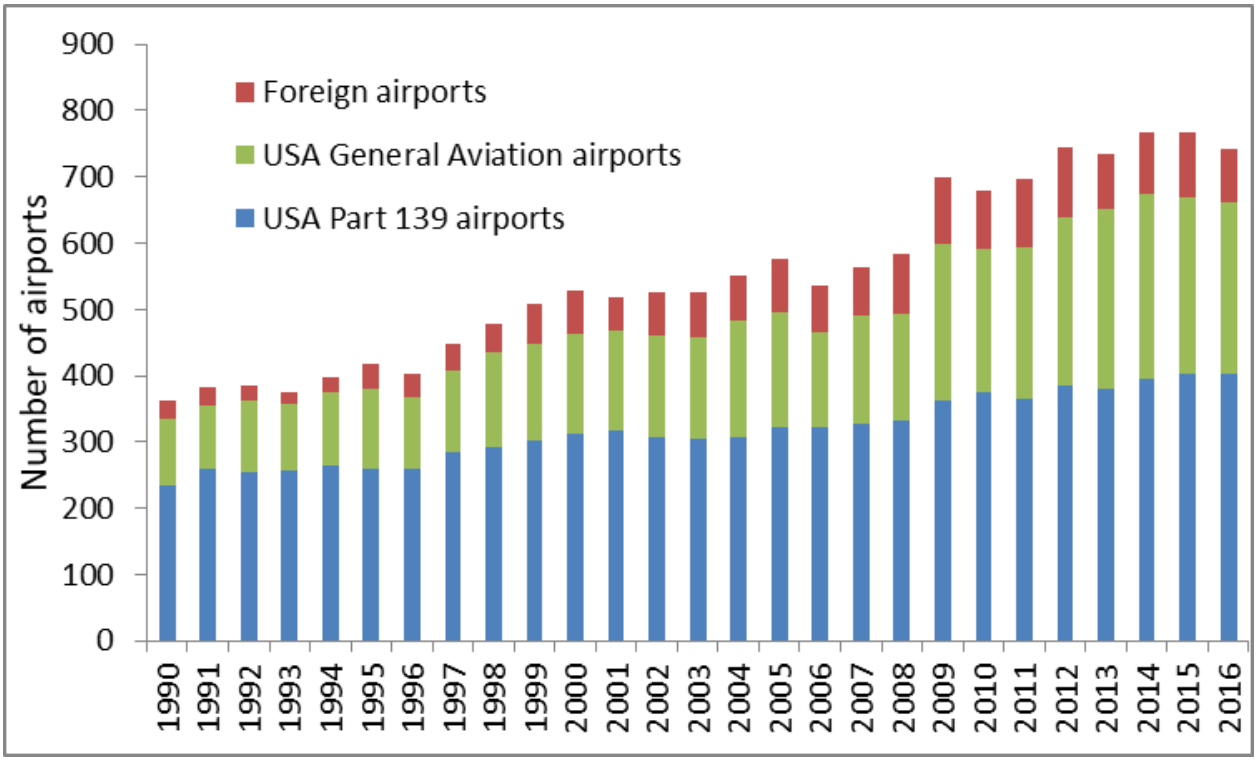

Figure 5. Number of Part 139-certificated airports and general aviation (GA) airports in USA with reported wildlife strikes and number of foreign airports at which strikes were reported for U.S.-registered civil aircraft, 1990–2016. Strikes were reported from 1,962 USA airports (521 Part 139-certificated, 1,441 GA) and 302 foreign airports in 109 countries, 1990-2016 (Table 5).

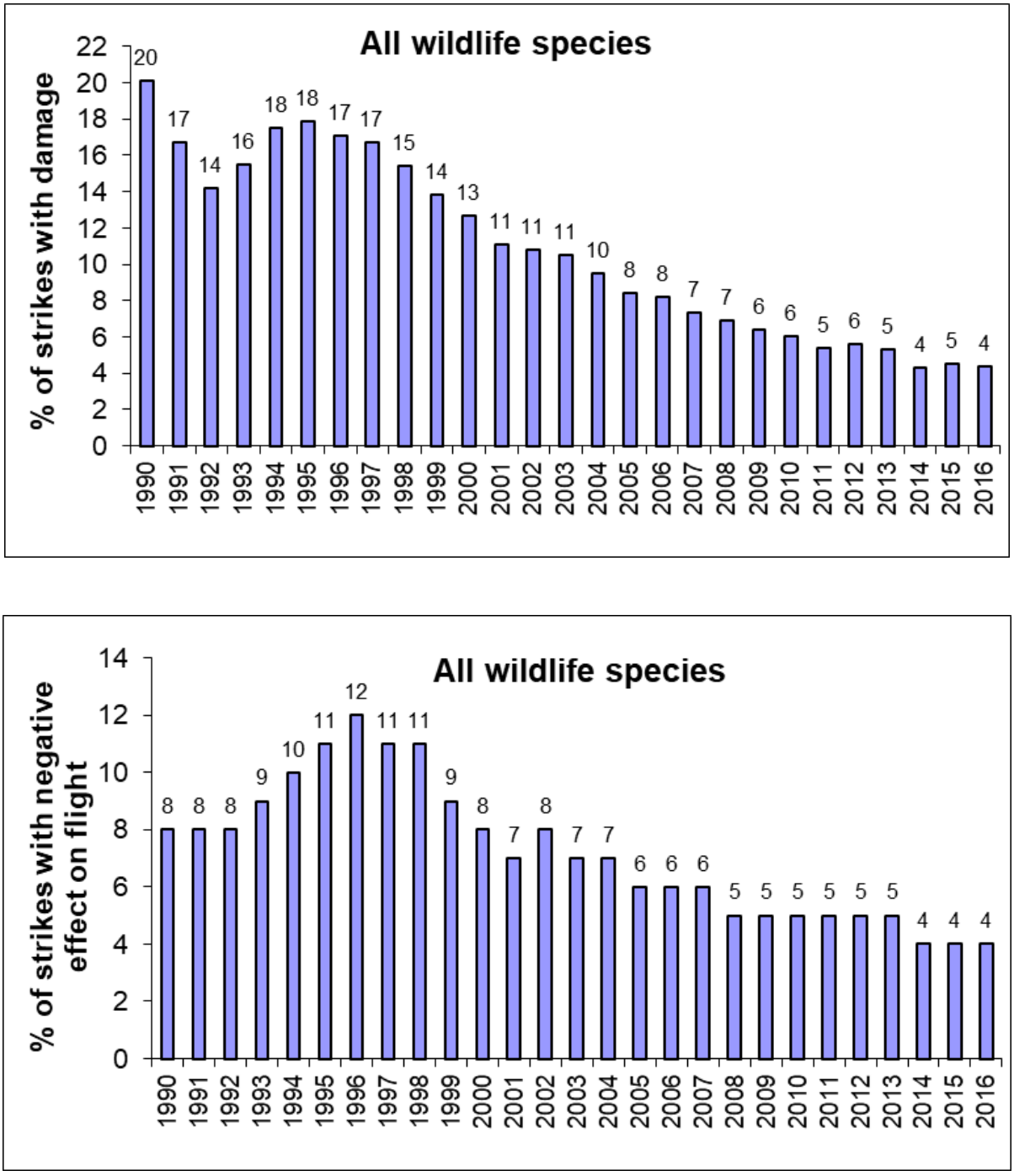

Figure 6. Percentage of reported strikes that indicated damage to the civil aircraft (top graph) or a negative effect-on-flight (bottom graph), USA, 1990–2016 (see Tables 1, 6, and 7 for sample sizes and classifications of damage and negative effects-on-flight).

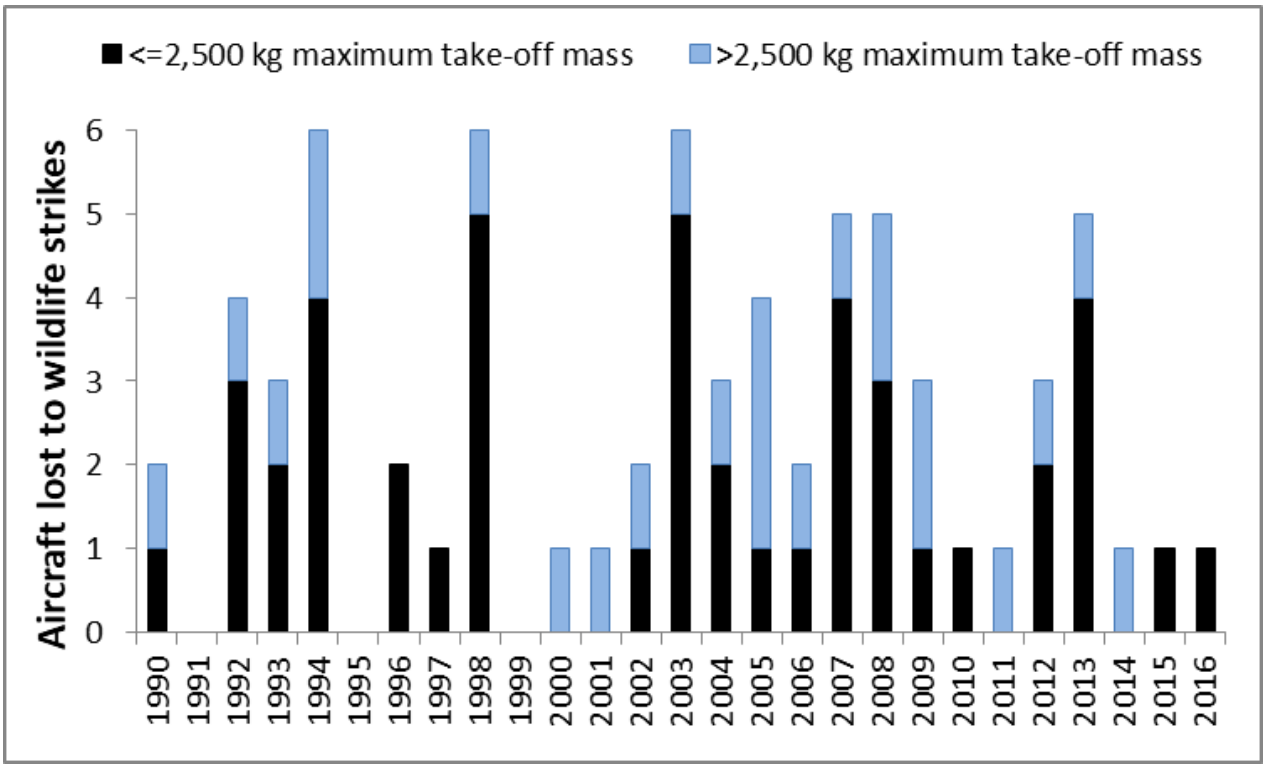

Figure 7. Number of civil aircraft destroyed or damaged beyond repair after striking wildlife, USA, 1990–2016. From 1990 - 2016, 69 aircraft were lost (45 with maximum take-off mass ≤2,250 kg; 16, 2,251-5,700 kg; 6, 5,701-27,000 kg; 2, >27,000 kg) (see Table 8 for wildlife species and types of aircraft and airports associated with these events).

APPENDIX A. SELECTED SIGNIFICANT WILDLIFE STRIKES TO U.S. CIVIL AIRCRAFT, 2016

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 2016, 183,296 strike reports from 1,962 USA airports and 302 foreign airports have been entered in the database (13,408 strikes from 662 USA and 97 foreign airports in 2016 alone, Tables 1, 5; Figure 5). The following 21 examples from the database in 2016 are presented to show the serious impact that strikes by birds or other wildlife can have on aircraft. These examples demonstrate the widespread and diverse nature of the problem. The examples are not intended to highlight or criticize individual airports because, as documented above, strikes have occurred on almost every airport in the USA. Some of the strike examples reported here occurred off airport property during approach or departure. For more information on wildlife strikes or to report a strike, visit *www.birdstrike.org* and *http://wildlife.faa.gov*.

Date:	8 January 2016
Aircraft:	A-320
Airport:	Sacramento International (CA)
Phase of Flight:	Approach (3000 feet AGL)
Effect on Flight:	None
Damage:	Engine #2 cowling, wing, pitot tube
Wildlife Species:	Greater white-fronted goose
Comments from Report: Multiple bird strikes on downwind approach. Aircraft taken out of service for repairs. ID by Smithsonian, Division of Birds.	

Date:	18 February 2016
Aircraft:	C-172
Airport:	Dexter Municipal Airport (MO)
Phase of Flight:	Climb (2900 feet AGL)
Effect on Flight:	None
Damage:	Wing
Wildlife Species:	Canada goose
Comments from Report: Four miles SE KDXE. Large dent and tear in the skin of right wing leading edge. Damage was found post-flight. Aircraft time out of service estimated at 3900 hours.	

Date:	6 March 2016
Aircraft:	Bell 407
Airport:	(FL)
Phase of Flight:	En Route (400 feet AGL)
Effect on Flight:	Precautionary landing
Damage:	Windshield
Wildlife Species:	Herring gull
Comments from Report: Bird entered cockpit and struck the pilot who was wearing a helmet with the sun visor down. Aircraft time out of service approximately 1025 hours.	

Date:	28 March 2016
Aircraft:	Gulfstream 150
Airport:	Wilmington International Airport (NC)
Phase of Flight:	Climb (1000 feet AGL)
Effect on Flight:	None
Damage:	Wing
Wildlife Species:	Herring gull
Comments from Report: Damage to right wing leading edge. Total aircraft time out of service approximately 240 hours. Estimated cost of repairs $110,000. ID by Smithsonian, Division of Birds.	

Date:	4 April 2016
Aircraft:	C-525
Airport:	Smith Reynolds Airport (NC)
Phase of Flight:	Landing roll
Effect on Flight:	None
Damage:	Nose cone, avionics
Wildlife Species:	White-tailed deer
Comments from Report: Pilot advised he applied the brakes when he saw four deer crossing the runway. At the point of impact with one deer, the aircraft was traveling at approximately 40 knots. The deer hit the nose cone and the aircraft suffered damage to the avionics behind the nose cone. No other areas of the aircraft seemed to be damaged. Estimated costs of repair $100,000.	

Date:	10 April 2016
Aircraft:	EMB-170
Airport:	Key West International Airport (FL)
Phase of Flight:	Climb (50 feet AGL)
Effect on Flight:	Engine shutdown, emergency landing
Damage:	Engine #1
Wildlife Species:	Turkey vulture
Comments from Report: During takeoff roll after V1 was called by non-flying pilot, a large black/dark bird was noticed by the flying pilot sitting on the runway centerline approximately 100 feet in front of the aircraft. The nose was raised for standard takeoff profile and the bird started to leave the center line of the runway to the aircraft left. Loud nose heard and the engine failed. Aircraft control was maintained and the takeoff was continued. An emergency was declared, emergency landing conducted with no injuries reported. Total aircraft time out of service approximately 100 hours. Estimated costs of repairs $1 million. Estimated other costs $500,000. ID by Smithsonian, Division of Birds.	

Date:	26 April 2016
Aircraft:	A-319
Airport:	Dallas Love Field Airport (TX)
Phase of Flight:	Take-off run
Effect on Flight:	Precautionary landing
Damage:	Engine #2
Wildlife Species:	Rock pigeon
Comments from Report: Pilot stated he saw 3-4 birds flying left to right on take-off roll. After rotation heard a continuous loud noise from engine #2 and decided to make a precautionary landing. All engine instruments indicated normal operation. Less than 2 miles from the airport. Distortion to three fan blades. Total aircraft time out of service 24 hours. Estimated costs of repairs $430,000 and $10,000 other costs.	

Date:	6 May 2016
Aircraft:	EMB-145
Airport:	(MD-DC)
Phase of Flight:	En Route (11000 feet AGL)
Effect on Flight:	None
Damage:	Windshield
Wildlife Species:	Unknown large bird
Comments from Report: Pilots heard loud noise and noticed outer layer of co-pilots windshield was shattered. Entire window shattered into 500 pieces. IMC conditions. Location reported as 30 miles NE KBWI at approximately 11,000 feet MSL.	

Date:	24 May 2016
Aircraft:	EMB-170
Airport:	Ronald Reagan Washington Intl Airport (DC)
Phase of Flight:	Climb (3500 feet AGL)
Effect on Flight:	Engine shutdown, precautionary landing
Damage:	Engine #1
Wildlife Species:	Great blue heron
Comments from Report: Lost Engine #1 and declared an emergency. Severe damage to engine. Crew ran the emergency checklists, left engine at idle and returned to KDCA for an uneventful landing. Engine fan blade damage requiring engine replacement. Total aircraft time out of service 48 hours. Estimated costs of repairs $1 million. Other costs $100,000.	

Date:	7 June 2016
Aircraft:	Boeing 737-700
Airport:	Boise Air Terminal/Gowen Field (ID)
Phase of Flight:	Take-off
Effect on Flight:	Aborted take-off
Damage:	Engine #2
Wildlife Species:	Mallard
Comments from Report: Flight crew heard a loud bang and aborted the take-off. On post flight inspection, Captain noticed bent fan blades on engine #2. Maintenance removed and replaced engine #2 fan blade set. ID by Smithsonian, Division of Birds.	

Date:	9 June 2016
Aircraft:	PA-32-300
Airport:	Lincoln Park Airport (NJ)
Phase of Flight:	Landing roll
Effect on Flight:	Aircraft controls effected
Damage:	Landing gear
Wildlife Species:	White-tailed deer
Comments from Report: Struck a deer after landing runway 1. Right landing gear was torn off the aircraft.	

Date:	29 June 2016
Aircraft:	C-172
Airport:	(TX)
Phase of Flight:	En Route
Effect on Flight:	Emergency landing
Damage:	Windshield
Wildlife Species:	Turkey vulture
Comments from Report: Training flight approximately 13 miles from KDWH. On their way back to KDWH both pilots noticed a flock of birds in the distance to the right and below the aircraft. One bird shattered the windshield with debris on both pilots. The bird struck the pilot, exited through the right window and then struck the wing. Minor injury to both pilots. Time out of service, 72 hours; cost of repairs, $4500.	

Date:	3 July 2016
Aircraft:	Lear 45
Airport:	Mason County Airport (MI)
Phase of Flight:	Climb (40 feet AGL)
Effect on Flight:	Diverted to KMKG
Damage:	Engine #1
Wildlife Species:	American crow
Comments from Report: Damage to 15 fan blades. Engine ran fine. Did not know the extent of the damage until post flight at alternate airport. Total aircraft time out of service 720 hours. Estimated costs of repairs $200,000. Other costs $10,000.	

Date:	10 July 2016
Aircraft:	C-310
Airport:	Graham Municipal Airport (TX)
Phase of Flight:	Take-off
Effect on Flight:	Aborted take-off
Damage:	Windshield
Wildlife Species:	Red-tailed hawk
Comments from Report: Broken windshield. Plane will be out of service approximately 504 hours. May also need paint work. Estimated cost of repairs $7,000. Other costs $750.	

Date:	7 August 2016
Aircraft:	BE-90
Airport:	(CO)
Phase of Flight:	Climb
Effect on Flight:	Engine fire, emergency landing
Damage:	Engine
Wildlife Species:	Unknown bird(s)
Comments from Report: Pilot reported flying into a flock of birds. Lost function from one of the engines due to engine ingestion while ascending during sky diving operation. All thirteen sky divers exited several thousand feet short of the normal jump altitude. All divers landed and were recovered safely despite being scattered in the surrounding area. Pilot returned to airport and landed without incident.	

Date:	22 August 2016
Aircraft:	Bell 407
Airport:	(TX)
Phase of Flight:	En Route (700 feet AGL)
Effect on Flight:	Precautionary landing
Damage:	Windshield
Wildlife Species:	Red-tailed hawk
Comments from Report: Pilots windscreen penetrated and facial injury to the pilot. Estimated aircraft time out of service 12 hours. Estimated cost of repairs $2,000.	

Date:	19 September 2016
Aircraft:	Boeing 737-800
Airport:	Portland Intl Airport (OR)
Phase of Flight:	Approach (5000 feet AGL)
Effect on Flight:	Smoke in cabin, pilot called an alert
Damage:	Engine #2, leading edge rt wing, rt horizontal stabilizer, fuselage
Wildlife Species:	Greater white-fronted goose
Comments from Report: Struck multiple geese at 5000’ AGL. Pilot called an alert, smoke in the cabin and damage to #2 engine. Flight landed safely. At least nine impact points found on aircraft. Two dents on the leading edge of the right wing, three impacts on the outside of #2 engine. Multiple geese believed to have gone into the #2 engine but exact number not known. Damage impact to the right horizontal stabilizer, snarge and bent metal on the bottom of the fuselage between the engines. At least one goose ingested in the #1 engine. ID by Smithsonian, Division of Birds.	

Date:	18 October 2016
Aircraft:	Boeing 737-300
Airport:	Indianapolis Intl Airport (IN)
Phase of Flight:	Approach
Effect on Flight:	None
Damage:	Wing
Wildlife Species:	American Coot
Comments from Report: Large hole in right wing next to engine. Pilot was unaware of the birdstrike. The damage was found during a preflight inspection. The following fight was cancelled. Clean up crews figured he was 4-6 miles out for the flap to be in that position when the strike occurred. ID by Smithsonian, Division of Birds.	

Date:	18 November 2016
Aircraft:	BE-36
Airport:	Southwest Florida Intl Airport (FL)
Phase of Flight:	Approach (1000 feet AGL)
Effect on Flight:	Utilized nearest runway
Damage:	Windshield
Wildlife Species:	Turkey vulture
Comments from report: The aircraft was crossing the KRSW Class C airspace when they struck a large bird approximately 3 miles west of KRSW. The windshield was completely damaged and the pilot decided to land the aircraft on runway 6 as it was the nearest runway. Airport Ops inspected the runway with negative results. Snarge was collected. ID by Smithsonian, Division of Birds.	

Date:	5 December 2016
Aircraft:	EMB-170
Airport:	Newark Liberty Intl Airport (NJ)
Phase of Flight:	Approach (7000 feet AGL)
Effect on Flight:	Precautionary landing, unreliable airspeed and altitude
Damage:	Nose
Wildlife Species:	Tundra swan
Comments from Report: Pilot reported seeing a flock of 8-10 large white birds before striking one bird resulting in damage to the nose of the aircraft beneath the first officer’s window. Airline maintenance advised the strike was to the RVSM area including the angle of attack sensor and pitot tube. The flight crew reported no depressurization, however received unreliable airspeed and altitude on the first officer’s side (250 knots indicated to landing, resulting in high speed warnings.) Ferry flight from KSTL with no passengers onboard. ID by Smithsonian, Division of Birds.	

Date:	5 December 2016
Aircraft:	MD-88
Airport:	Memphis Intl Airport (TN)
Phase of Flight:	Climb (900 feet AGL)
Effect on Flight:	Emergency landing
Damage:	Engine #1
Wildlife Species:	Common loon
Comments from Report: Bird ingested into engine #1, all fan blades damaged with one fan blade broken off. Contained engine failure. Returned to KMEM as an emergency. ID by Smithsonian, Division of Birds.	

APPENDIX B. REPORTING A STRIKE AND IDENTIFYING SPECIES OF WILDLIFE STRUCK

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

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

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

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

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

The number of bird strike cases processed by the Smithsonian Feather Identification Lab for the FAA (civil aviation) in 2016 was 3,670 with 4,006 separate identifications of species (some cases involved remains from multiple impact points). This compares to 3,118

cases in 2015, 3,209 cases in 2014, 2,474 cases in 2013, 2,072 cases in 2012, 1,580 cases in 2011 and 1,268 cases in 2010 (Dove et al. 2017). In addition, the Lab processed 3,732 cases involving 4,445 identifications for the U.S. Air Force and 864 cases involving 954 identifications for the U.S. Navy (not discussed in this report). DNA analysis (Dove et al. 2008) was used in 6,453 of all identifications for civil and military aviation to identify, supplement, or verify traditional identification methods.

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

Guidelines for Collecting Bird Strike Material

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

Feathers:

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

Tissue/blood ("Snarge"):

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

FTA® Micro Card and Sterile Applicators

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

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

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