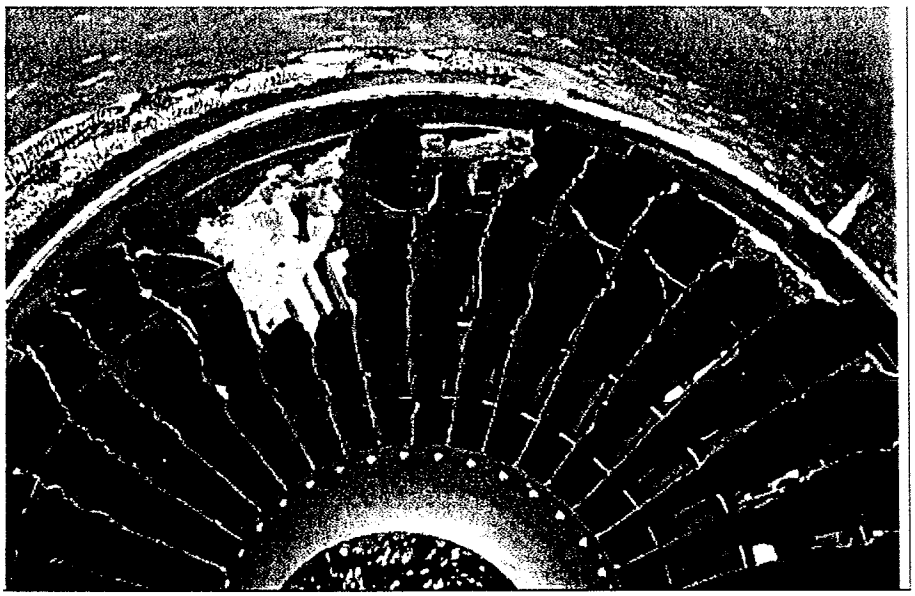
WILDLIFE STRIKES TO CIVIL AIRCRAFT IN THE UNITED STATES 1990-1998

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION



FEDERAL AVIATION ADMINISTRATION
WILDLIFE AIRCRAFT STRIKE DATABASE
SERIAL REPORT NUMBER 5

REPORT PREPARED BY
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Cover

This engine on a Boeing-737 sustained major damage when a female eider duck was ingested during landing at an airport in Maine, 1995. (Photo courtesy National Transportation Safety Board)

All future reports will feature one of more photographs of aircraft damage resulting from a wildlife strike. Anyone with quality photographs of wildlife-aircraft strike damage is encouraged to submit them to one of the authors for consideration. Full credit will be given for all photographs used.

LIST OF FIGURES

ACKNOWLEDGMENTS

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PREFACE

Wildlife strikes to civil aircraft are a serious economic and safety problem in the United States. The Federal Aviation Administration (FAA) has a standard form (FAA Form 5200-7) for the voluntary reporting of bird and other wildlife strikes with aircraft. Although FAA personnel have monitored these reports since 1965 to determine general patterns in wildlife strikes, no quantitative analyses of these data were conducted until 1995.

The FAA, through an interagency agreement with the United States Department of Agriculture's (USDA) National Wildlife Research Center, initiated a project to obtain more objective estimates of the magnitude and nature of the wildlife strike problem nationwide for civil aviation in April 1995. This project includes 1) editing all strike reports (FAA Form 5200-7) sent to the FAA since 1990 to ensure consistent, error-free data; 2) entering all edited strike reports since 1990 in a Wildlife Strike Database; 3) supplementing FAA-reported strikes with additional, non-duplicated strike reports from other sources; 4) providing FAA with an updated computer file each quarter containing all edited strike reports; and 5) assisting the FAA with the production of annual reports summarizing the results of the analyses. Such analyses are critical to determine the economic cost of wildlife strikes, the magnitude of safety issues, and most importantly, the nature of the problems (e.g., bird species, aircraft and engine types, airports, and seasonal patterns) so that corrective actions can be taken.

The first annual report on wildlife strikes to civil aircraft in the USA, covering 1994, was completed in November 1995 (Dolbeer et al. 1995). Subsequent reports covering the years 1993-1995, 1992-1996, and 1991-1997 were issued in 1996, 1997, and 1998, respectively (Cleary, et al. 1996, 1997, 1998). This is the fifth report in the series. It is the intention of the FAA to publish a detailed report covering the 10-year period, 1990-1999, in the year 2000. Subsequent detailed reports will be produced at 5-year intervals. In the interim years, annual reports summarizing data in tabular and graphic form for all available years will be produced.

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SYNOPSIS

This publication presents a synopsis of data on wildlife strikes to United States civil aircraft for 1990-1998. Unless noted, all numbers are totals for the 9-year period, and percentages are of the known total. For the 9-year period, 22,935 ($\bar{x}$ = 2,548/year) strikes were reported to the FAA. Between 1990 and 1998 there was a 107% increase in the number of strikes reported annually (Figure 1). Most reports were filed using FAA Form 5200-7 (Table 1). Pilots and tower personnel filed 28% and 17% of the reports, respectively (Table 2). About 81% of the reported strikes involved commercial aircraft; the remainder involved business, private, and miscellaneous aircraft (Table 3).

Reports were received from all 50 states, from some U.S. territories, and from foreign countries when U.S. registered aircraft were involved. Tables 4 shows the distribution of reported bird and mammal strikes for the various states and territories.

Most bird strikes (51%) occurred between July and October (Table 5 and Figure 2); 66% occurred during the day (Table 6 and Figure 3); 53% occurred when the aircraft was on approach or during the landing roll, and 39% occurred during takeoff and climb (Table 7). Fifty-five percent of the bird strikes occurred when the aircraft was at an altitude of less than 100 ft. above ground level (AGL), 78% occurred under 900 ft. AGL, and 87% occurred under 2,000 ft. AGL (Table 8 and Figure 5).

Most mammal strikes (42%) occurred between September and November (Table 5 and Figure 2); 62% occurred at night (Table 6 and Figure 4); 60% occurred when the aircraft was on approach or landing; and 34% occurred during takeoff. Eleven percent of the reported mammal strikes occurred while the aircraft was still in the air, when the aircraft struck deer with the landing gear or encountered bats (Table 7).

The fixed-wing aircraft types most often involved in strikes that had a negative effect-on-flight were Boeing-737, McDonnell-Douglas MD-80/DC-9, British Aerospace-31, and Cessna 172. The aircraft types most often involved in a strike that damaged one or more aircraft

components were Boeing-737, McDonnell-Douglas MD-80/DC-9, Boeing-727, and British Aerospace-31 (Table 9).

The aircraft components most commonly reported as struck by birds were windshield, engine, wing/rotor, and nose. Those components most often reported as damaged were engine, wing/rotor, radome, and windshield. Aircraft components most commonly reported as struck by mammals were landing gear, propeller, wing/rotor, other, and engine. These same components ranked highest for the parts most often reported as damaged (Table 10A).

Of the 22,935 strikes reported, 16,283 reports indicated the strike did not damage the aircraft; 2,086 reports indicated the aircraft suffered minor damage; 1,268 reports indicated the aircraft suffered substantial damage; and 19 reports indicated the aircraft was destroyed as a result of the strike (Table 10B).

Fifteen and 63% of the bird and mammal strike reports, respectively, indicated the strike had an adverse effect on the flight (Table 11).

Birds were involved in 97% of the reported strikes, mammals in 3%, and <1% involved reptiles. Gulls, waterfowl, doves, and raptors were the most commonly struck bird groups (Table 12A). The most commonly struck mammals were deer and coyotes (Table 12B). Gulls were involved in 2.6 times as many strikes as waterfowl, but both groups were involved in essentially the same number of damaging strikes (Table 13).

For the 9-year period, 3,773 reports indicated the strike damaged one or more aircraft components (Table 13); and 2,443 reports indicated the strike had a negative effect on the flight (Table 14).

For the 9-year period, reported losses from bird strikes totaled 97,813 hours of aircraft down time (Table 15) and $67.63 million in monetary losses (Table 16). Reported losses from mammal strikes totaled 65,854 hours of aircraft down time (Table 15) and $6.78 million in monetary losses (Table 16).

Of the 5,011 reports that indicated the strike had an adverse effect on the aircraft and/or flight, 988 provided an estimate of the aircraft down time (Σ = 163,667 hours, $\bar{x}$ = 166 hours/incident), and 759 provided an estimate of the direct and/or other cost (Σ = $74.4 million, $\bar{x}$ = $139,000 damage/incident). Of the 759 reports providing a damage cost estimate, 681 gave an estimate of direct aircraft damage (Σ = $61.89 million, $\bar{x}$ = $91,000 damage/incident), and 262 gave an estimate of other

monetary losses (Σ = $12.51 million $\bar{x}$ = $47,000 lost/incident) (Table 17).

Analysis of strike reports from three major U.S. airports showed that less than 20% of all strikes occurring at these airports were reported to the FAA (Cleary et al. 1996, 1997, 1998; Dolbeer et al. 1995). Additionally, many reports received by the FAA were filed before aircraft damage had been fully assessed. For these reasons, the information on the number of strikes and their associated costs compiled from the voluntary reporting program is believed to underestimate the magnitude of the problem.

Assuming all 5,011 reported wildlife-aircraft strikes that had an adverse effect on the aircraft and/or flight engendered similar amounts of down time and/or monetary losses, and that these reports are all of the damaging strikes that occurred, then at a minimum, wildlife-aircraft strikes cost the U.S. civil aviation industry 92,233 hours/year of aircraft down time, $50.60 million/year in direct monetary losses, and $26.59 million/year in associated costs.

Further, assuming a 20% reporting rate, the cost of wildlife-aircraft strikes to the U.S. civil aviation industry is estimated to be in excess of 461,165 hours/year of aircraft down time, $253.02 million/year in direct monetary losses and $132.96 million/year in associated costs (Table 17).

With the analysis of 9 years of strike data, the magnitude and severity of the wildlife-aircraft strike problem is becoming more obvious. Two important points need to be made. First, airport managers need to be aware of the wildlife hazards on their airports and take appropriate actions, under the guidance of professional biologists trained in wildlife damage management, to minimize the problems. Second, the focus of airport wildlife management needs to be widened to consider habitats and land-uses in proximity to the airport, such as wetlands, waste-disposal facilities, and wildlife refuges that can attract wildlife hazardous to aviation. Such land uses and activities are often incompatible with aviation safety and should be prohibited near airports or designed and operated in a manner that minimizes the attraction of hazardous wildlife.

Finally, there is a need for increased and more detailed reporting of wildlife strikes. For example, our previous analysis indicated <20% of all wildlife strikes involving U.S. civil aircraft are reported. Furthermore, 51% of all reported bird strikes, 1990-1998, provided no information on the species struck and only 15% of strike reports indicating an adverse effect provided an estimate of cost.

Strikes should be reported by pilots, airport operations and aircraft maintenance personnel, or anyone else who has knowledge of the strike. 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 being entered into the database. Reports of the same incident filed by different people are combined and provide a more complete documentation of the strike than would be possible if just one report had been filed.

The identification of the species of wildlife struck is particularly important. Bird strike remains that cannot be identified by airport personnel can often be identified by a local biologist or by sending feather remains in a sealed plastic bag (with FAA Form 5200-7) to:

Federal Aviation Administration
Office of Airport Safety and Standards, AAS-310
800 Independence Avenue, SW
Washington, DC 20591

Please send whole feathers whenever possible as diagnostic characteristics are often found in the downy barbules at the feather base. Beaks, feet, bones, and talons are also useful diagnostic materials.

Strikes can also be reported via the Internet (http://www.faa.gov.arp/birdstrike), in addition to the traditional means of filling out and mailing FAA Form 5200-7.

Literature Cited

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Table 1. Source of information for reported wildlife strikes to civil aircraft, USA, 1990-1998.

Source	Reported strikes		% of total
	9-year total	9-year avg.	
FAA Form 5200-7	17,308	1,923	75
Multiple[1]	1,920	213	8
Airport Report	1,354	150	6
Aircraft Incident Report	568	63	2
Other[2]	583	65	3
Engine Manufacturer	367	41	2
Preliminary Aircraft Incident Report	339	38	1
Airline Report	284	32	1
Aviation Safety Reporting System	104	12	<1
Aircraft Incident Preliminary Notice	47	5	<1
National Transportation Safety Board	45	5	<1
Daily Alert Bulletin	16	2	<1
Total	22,935	2,548	100

[1] More than one report is filed for the same strike.
[2] Various sources such as the media, Commercial Incident Reports, etc.

Table 2. Person filing report of wildlife strike to civil aircraft, USA, 1990-1998.

Person reporting	Reported strikes		% of total
	9-year total	9-year avg.	
Pilot	6,353	706	28
Tower	3,878	431	17
Unknown[1]	7,455	828	33
Carcass found[2]	1,686	187	7
Airport Operations	1,477	164	6
Airline Operations	1,323	147	6
Other[3]	763	85	3
Total	22,935	2,548	100

[1] Person filing report did not give their title or position.
[2] Airport operations found wildlife remains on or close to runway that appeared to have been struck by aircraft. No strike report was filed by pilot or other entity.
[3] Persons such as Aviation Safety Inspectors, engine manufacturer, etc.

Table 3. Number of reported wildlife strikes to civil aircraft by type of operator, USA, 1990-1998.

Operator	Reported strikes		% of total known
	9-year total	9-year avg.	
Commercial	16,611	1,846	81
Business	2,814	313	14
Private	961	107	5
Government /police	88	10	<1
Total known	20,474	2,275	100
Total unknown	2,461	273	
Total	22,935	2,548	

Table 4. Number of reported wildlife strikes to civil aircraft by U.S. state, including Puerto Rico (PR) and the U.S. Virgin Islands (VI), 1990-1998.

	Birds		Mammals	
	Reported strikes		Reported strikes	
State	9-year total	9-year avg.	9-year total	9-year avg.
AK	215	24	5	1
AL	282	31	4	<1
AR	125	14	11	1
AZ	167	19	17	2
CA	2,017	224	20	2
CO	261	29	7	1
CT	317	35	13	1
DC	571	63	18	2
DE	14	2	1	<1
FL	2,056	228	29	3
GA	454	50	9	1
HI	474	53	1	<1
IA	172	19	3	<1
ID	51	6	4	<1
IL	1,235	137	43	5
IN	232	26	5	1
KS	66	7	2	<1
KY	603	67	4	<1
LA	531	59	6	1
MA	326	36	7	1
MD	268	30	16	2
ME	100	11	4	<1
MI	409	45	26	3
MN	206	23	6	1
MO	400	44	13	1
MS	100	11	3	<1
MT	36	4	1	<1
NC	563	63	15	2
ND	45	5	0	0
NE	209	23	7	1
NH	78	9	4	<1
NJ	673	75	27	3
NM	49	5	1	<1
NV	116	13	2	<1
NY	1,445	161	36	4
OH	724	80	15	2
OK	233	26	14	2
OR	301	33	4	<1
PA	1,040	116	48	5
PR	39	4	0	0
RI	63	7	3	<1
SC	125	14	4	<1
SD	38	4	3	<1
TN	591	66	6	1
TX	1,775	197	30	3
UT	240	27	4	<1
VA	460	51	18	2
VI	32	4	0	0
VT	16	2	0	0
WA	382	42	8	1
WI	244	27	14	2
WV	75	8	31	3
WY	13	1	2	<1
U.S. Total	21,257	2,362	574	64
Foreign	1,063	118	6	1
Total	22,320	2,480	580	64

Table 5. Number of reported wildlife strikes to civil aircraft by month, USA, 1990–1998. See also Figure 2.

	Birds			Mammals		
	Reported strikes			Reported strikes		
Month	9-year total	9-year avg.	% of total	9-year total	9-year avg.	% of total
Jan.	872	97	4	29	3	5
Feb.	806	90	4	16	2	3
Mar.	1,244	138	6	38	4	7
Apr.	1,415	157	6	30	3	5
May	1,983	220	9	32	4	6
June	1,559	173	7	48	5	8
July	2,280	253	10	51	6	9
Aug.	3,024	336	14	49	5	8
Sep.	3,147	350	14	63	7	11
Oct.	2,975	331	13	81	9	14
Nov.	1,879	209	8	100	11	17
Dec.	1,136	126	5	43	5	7
Total	22,320	2,480	100	580	64	100

Table 6. Reported time of occurrence of wildlife strikes to civil aircraft, USA, 1990-1998. See also Figures 3 and 4.

	Birds			Mammals		
	Reported strikes			Reported strikes		
Time	9-year total	9-year avg.	% of total known	9-year total	9-year avg.	% of total known
Dawn	824	92	4	10	1	2
Day	13,551	1,506	66	132	15	26
Dusk	1,017	113	5	52	6	10
Night	5,186	576	25	307	34	62
Total known	20,578	2,287	100	501	56	100
Not reported	1,742	194		79	9	
Total	22,320	2,480		580	64	

Table 7. Reported phase of flight at time of wildlife strikes to civil aircraft, USA, 1990-1998.

	Birds			Mammals		
	Reported strikes			Reported strikes		
Phase of flight	9-year total	9-year avg.	% of total known	9-year total	9-year avg.	% of total known
Parked	13	1	<1	0	0	0
Taxi	87	10	<1	11	1	2
Take-off	3,899	433	20	170	19	34
Climb	3,697	411	19	11	1	2
En route	716	80	4	2	<1	<1
Descent	735	82	4	2	<1	<1
Approach	7,352	817	37	44	5	9
Landing roll	3,229	359	16	254	28	51
Total known	19,728	2,192	100	494	55	100
Total unknown	2,592	288		86	10	
Total	22,320	2,480		580	64	

Table 8. Number of reported bird strikes to civil aircraft by altitude (feet) above ground level (AGL), USA, 1990-1998. See also Figure 5.

Altitude of strike[1] (feet AGL)	Reported strikes		% of total known	Cumulative % of total known
	9-year total	9-year avg.		
0 -	7,177	797	40	39.8
1 - 99	2,786	310	15	55.3
100 - 199	1,226	136	7	62.1
200 - 299	813	90	5	66.6
300 - 399	571	63	3	69.8
400 - 499	328	36	2	71.6
500 - 599	607	67	3	75.0
600 - 699	189	21	1	76.0
700 - 799	137	15	1	76.8
800 - 899	259	29	1	78.2
900 - 999	111	12	1	78.8
1,000 - 1,499	887	99	5	83.8
1,500 - 1,999	579	64	3	87.0
2,000 - 2,999	720	80	4	91.0
3,000 - 3,999	520	58	3	93.9
4,000 - 4,999	332	37	2	95.7
5,000 - 9,999	614	68	3	99.1
10,000 - 19,999	145	16	1	99.9
20,000 - 29,999	8	1	<1	100.0
30,000 +	7	1	<1	100.0
Total known	18,016	2,002	100	
Total unknown	4,304	478		
Total	22,320	2,480		

[1] On 23 October 1991, a DC-8-62 struck a "blue bird with red feet" at 39,000 feet. This is the highest reported altitude for a bird strike in the USA.

Table 9. Number of reported strikes that had an adverse effect on the flight of the aircraft, or damaged an aircraft component, for the 25 most frequently reported aircraft types, USA, 1990-1998.

Negative effect-on-flight				Damaged aircraft component			
Aircraft		Reported strikes		Aircraft		Reported strikes	
Type	Engine[1]	9-year total	9-year avg.	Type	Engine[1]	9-year total	9-year avg.
B-737	TF/TJ	451	50	B-737	TF/TJ	763	85
MD-80/DC-9	TF	187	21	MD-80/DC-9	TF	304	33
BA-31	TP	102	11	B-727	TJ	156	17
C-172	PS	85	9	BA-31 Jetstrm	TP	153	17
Saab 340	TP	81	9	B-757	TF	146	16
B-727	TJ	77	9	PA-28	PS	109	12
B-757	TF	68	8	C-172	PS	108	12
PA-28	PS	64	7	B-747	TF	98	11
B-747	TF	52	6	BE-1900	TF	97	11
BE-1900	TF	50	6	B-767	TF	65	7
C-152	PS	49	5	Citation 2/3	TF	64	7
DHC8 Dash 8	TP	45	5	C-152	PS	55	6
EMB-120	TP	39	4	Saab-340	TP	49	5
Citation 2	TF	34	4	FK-100	TF	42	5
Bell 206	TS	32	4	DC-10	TF	40	4
Helicopter		28	3	A-320	TF	39	4
ATR-42	TP	26	3	EMB-120	TP	39	4
B-767	TF	26	3	C-182	PS	38	4
C-150	PS	24	3	PA-31	PS	37	4
Learjet-31/35	TF	24	3	A-300	TF	35	4
C-310	PS	23	3	C-310	PS	35	4
FK-100	TF	22	2	Bell-206	TS	34	4
Learjet-25	TJ	22	2	BE-58	PS	33	4
C-402	PS	21	2	Learjet-31/35	TF	33	4
Total known		1,632	181	Total known		2,572	286
Total unknown/other		802	89	Total unknown/other		1,201	133
Total		2,434	270	Total		3,773	419

[1] TF = Turbo-fan, TJ = Turbo-jet, TP = Turbo-prop, PS = Piston.

Table 10 A. Civil aircraft components reported as being struck and damaged by wildlife, USA, 1990-1998.

	Birds		Mammals	
	Reported strikes		Reported strikes	
Parts of aircraft	9-year total	9-year avg.	9-year total	9-year avg.
Radome				
Struck	2,149	239	6	1
Damaged	353	39	5	1
Windshield				
Struck	3,539	393	7	1
Damaged	308	34	4	<1
Nose				
Struck	2,538	282	27	3
Damaged	218	24	22	2
Engines				
Struck	3,201	356	51	6
Damaged	1,357	151	49	5
Propeller				
Struck	722	80	82	9
Damaged	86	10	72	8
Wing/rotor				
Struck	2,544	283	63	7
Damaged	873	97	65	7
Fuselage				
Struck	2,107	234	35	4
Damaged	136	15	33	4
Landing Gear				
Struck	1,049	117	187	21
Damaged	147	16	122	14
Tail				
Struck	298	33	21	2
Damaged	145	16	24	3
Lights				
Struck	184	20	6	1
Damaged	157	17	6	1
Other				
Struck	610	68	55	6
Damaged	298	33	55	6
Total struck	18,941	2,105	540	60
Total damaged	4,078	453	457	51
Total	23,019	2,558	997	111

Table 10 B. Reported damage[1] resulting from wildlife strikes to civil aircraft, USA, 1990-1998.

Damage	Reported strikes		% of total known
	9-year total	9-year avg.	
None	16,283	1,809	81
Minor[2]	2,086	232	10
Minor?[3]	400	44	2
Substantial[4]	1,268	141	6
Destroyed[5]	19	2	<1
Total known	20,056	2,228	100
Not reported	2,879	320	
Total	22,935	2,548	

[1] The damage codes and descriptions follow the *Manual on the International Civil Aviation Organization Bird Strike Information System*

[2] The aircraft can be rendered airworthy by simple repairs or replacements and an extensive inspection is not necessary.

[3] The aircraft was damaged, but details as to the extent of the damage are lacking.

[4] The aircraft incurs damage or structural failure which adversely affects the structure strength, performance or flight characteristics of the aircraft and which 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; engine blade damage not requiring blade replacement.

[5] The damage sustained makes it inadvisable to restore the aircraft to an airworthy condition.

Table 11. Reported effect-on-flight of wildlife strikes to civil aircraft, USA. 1990-1998.

	Birds			Mammals		
	Reported strikes			Reported strikes		
Effect-on-flight	9-year total	9-year avg.	% of total known	9-year total	9-year avg.	% of total known
None	13,290	1,477	86	135	15	37
Aborted takeoff	557	62	4	66	7	18
Precautionary landing	1,126	125	7	39	4	11
Engine shut down	128	14	1	8	1	2
Other	391	43	3	119	13	32
Total known	15,492	1,721	100	367	40	100
Not reported	6,828	759		213	24	
Total	22,320	2,480		580	64	

Table 12A. Identified bird groups involved in reported wildlife strikes to civil aircraft, USA, 1990-1998.

Bird groups	9-year total
Loons	2
Grebes	8
Grebes	4
Eared grebe	3
Western grebe	1
Tropicbirds	1
Albatrosses	1
Pelicans	20
Cormorants	27
Cormorants	8
Double-crested cormorant	7
Anhingas	8
Frigatebirds	4
Waterfowl	1,243
Ducks, geese, swans	73
Ducks	342
Blue-winged teal	2
American wigeon	2
European wigeon	1
Northern pintail	2
Mallard	142
Common eider	1
Ring-necked duck	1
American black duck	1
Common merganser	1
Canvasback	1
Ring-necked duck	1
Mottled duck	1
Wood duck	2
Gadwall	1
Geese	399
Snow goose	20
Canada goose	240
Brant	6
Greater white-fronted goose	1
Swans	2
Tundra swan	1
Cranes	40
Cranes	16
Sandhill crane	24
Rails/gallinules	6
American coot	4
Common moorhen	1
Purple gallinule	1

Bird groups	9-year total
Shorebirds	330
Shorebirds	7
Common snipe	2
Jacanas	1
Oystercatchers	2
Plovers	38
Lesser golden-plover	11
Black-bellied plover	4
Killdeer	185
Pacific golden-plover	5
Sandpipers	47
Upland sandpiper	17
Spotted sandpiper	1
Semipalmated sandpiper	1
Least sandpiper	1
American woodcock	2
Lesser yellowlegs	1
Dunlin	1
Short-billed dowitcher	1
Whimbrel	2
Avocets	1
Terns	30
Terns	20
Common tern	2
Gull-billed tern	1
Arctic tern	4
Forster's tern	2
Least tern	1
Gulls	3,222
Gulls	2,912
Herring gull	89
Mew gull	6
Ring-billed gull	114
Glaucous-winged gull	8
Greater black-backed gull	11
Franklin's gull	4
Laughing gull	65
Bonaparte's gull	6
Western gull	6
California gull	1
Woodpeckers	9
Woodpeckers	2
Northern flicker	5
Yellow-bellied sapsucker	2

Table 12A. Continued

Larks	32
Larks	8
Horned lark	24
Swallows	264
Swallows	145
Purple martin	24
Barn swallow	57
Cliff swallow	4
Tree swallow	34
Jays	9
Blue jay	2
Magpie	5
Yellow-billed magpie	2
Crows	190
Crows	152
American crow	33
Ravens	5
Chickadees	2
Wrens	17
Mockingbirds	24
Mockingbirds	20
Gray catbird	1
Brown thrasher	3
Raptors	1,150
Hawks, eagles	15
Vultures	128
Lappet-faced vulture	1
Black vulture	5
Turkey vulture	79
Osprey	28
Kites, eagles, hawks	5
Eagles	12
Bald eagle	20
Golden eagle	1
Hawks	395
Red-tailed hawk	170
Red-shouldered hawk	3
Rough-legged hawk	4
Swainson's hawk	1
Cooper's hawk	1
Sharp-shinned hawk	1
Northern harrier	8
Falcons	11
Peregrine falcon	19
Merlin	8
American kestrel	235
Gallinaceous birds	61
Grouse	5
Grouse, ptarmigans	3
Quails	6
Ring-necked pheasant	30
Hungarian partridge	3
Guineafowl	1
Turkeys	13
Herons	90
Herons	31
Great blue heron	57
Black-crowned night-heron	2
Egrets	202
Egrets	140
Cattle egret	43
Great egret	11
Snowy egret	1
Wood stork	2
White ibis	5
Doves	1,241
Pigeons, doves	12
Doves	523
Rock dove	473
Mourning dove	223
Barred ground-dove	8
Inca dove	1
Spotted dove	1
Owls	215
Owls	135
Barn-owl	36
Snowy owl	16
Eastern screech owl	1
Short-eared owl	12
Burrowing owl	2
Barred owl	2
Long-eared owl	2
Great horned owl	8
Northern saw-whet owl	1
Thrushes	98
Thrushes	4
Swainson's thrush	1
American robin	91
Hermit thrush	1
Eastern bluebird	1

Table 12A. Continued

Nighthawks	22	Meadowlarks	118
Common nighthawk	19	Bobolink	1
Whip-poor-will	2	Meadowlarks	28
Nightjars	1	Eastern meadowlark	76
Parrots	3	Western meadowlark	13
Kingfishers	4	Finches	52
Perching birds	44	Finches	12
Tyrant flycatchers	2	American goldfinch	5
Tyrant fly-catchers	1	House sparrow	5
Great-crested flycatcher	1	Rose-breasted grosbeak	1
Swifts	14	Red-created cardinal	1
Swifts	4	Snow bunting	27
Chimney swift	10	Rufous-sided towhee	1
Waxwings	1	Sparrows	788
Cedar waxwing	1	Sparrows	775
Starlings	544	Savannah sparrow	8
European starling	535	Golden crowned sparrow	1
Mynas	9	Field sparrow	1
Warblers	2	White-throated sparrow	2
Wood warblers	1	Fox sparrow	1
Canada warbler	1	Mannikins	25
Blackbirds	678	Mannikins	9
Blackbirds	618	Nutmeg mannikin	6
Red-winged blackbird	17	Chestnut mannikin	10
Brewer's blackbird	1		
Grackles	35		
Brown-headed cowbird	3		
Orioles	4		

Total known birds	10,830
Total unknown birds	11,490
Total birds	22,320

Table 12B. Identified mammal and reptile groups involved in reported wildlife strikes to civil aircraft, USA, 1990-1998.

Mammals	9-year total
Edentates (Armadillo)	11
Chiropteras (Bats)	27
Carnivores	112
Coyotes	61
Dog	12
Fox	18
Raccoon	7
Coatis	1
Striped skunk	8
House cat	3
River otter	2
Marsupial (Opossum)	14
Rodents	18
Woodchuck	15
Muskrat	2
Rodents	1
Lagomorphs (hares, rabbits)	6
Ungulates	385
Caribou	1
Cattle	5
Deer	79
Mule deer	1
White-tailed deer	284
Elk	6
Horse	3
Moose	2
Peccary	1
Pronghorn	3
Total known mammals	573
Total unknown mammals	7
Total mammals	580

Reptiles	
Turtles	25
Turtle	19
Florida soft shell turtle	3
Box turtle	3
Alligators	10
Total reptiles	35

Table 13. Number of reported wildlife strikes damaging one or more components of a civil aircraft by wildlife group, USA, 1990-1998.

Birds	9-year total	% of total known
Waterfowl	578	31.2
Gulls	576	31.1
Raptors	277	14.9
Doves	134	7.2
Blackbirds	49	2.6
Herons	44	2.4
Owls	30	1.6
Starlings	23	1.2
Shorebirds	21	1.1
Crows	20	1.1
Gallinaceous birds	19	1.0
Cranes	17	0.9
Sparrows	17	0.9
Pelicans	11	0.6
Cormorants	8	0.4
Thrushes	7	0.4
Larks	6	0.3
Swallows	3	0.2
Terns	2	0.1
Nighthawks	2	0.1
Perching birds	2	0.1
Finches	2	0.1
Loons	1	<0.1
Grebes	1	<0.1
Tropicbirds	1	<0.1
Albatrosses	1	<0.1
Rails	1	<0.1
Swifts	1	<0.1
Mockingbirds	1	<0.1
Total known	1,855	100.0
Total unknown	1,591	
Total birds	3,446	

Mammals	9-year total	% of total known
Ungulates	311	96.3
Carnivores	10	3.1
Chiropteras	2	0.6
Total known	323	100.0
Total unknown	3	
Total mammals	326	

Reptiles		
Alligators	1	100.0
Total reptiles	1	

Table 14. Number of wildlife strikes having a negative effect on the flight of a civil aircraft, USA, 1990-1998.

Birds	9-year total	% of total known
Grebes	1	0.1
Tropicbirds	1	0.1
Pelicans	6	0.5
Cormorants	3	0.2
Waterfowl	264	21.1
Raptors	168	13.4
Gallinaceous birds	13	1.0
Herons	16	1.3
Egrets	7	0.6
Cranes	9	0.7
Shorebirds	20	1.6
Gulls	424	33.8
Terns	2	0.2
Doves	136	10.9
Owls	20	1.6
Woodpeckers	2	0.2
Larks	8	0.6
Swallows	4	0.3
Starlings	37	3.0
Crows	15	1.2
Mockingbirds	2	0.2
Thrushes	3	0.2
Perching birds	1	0.1
Blackbirds	50	4.0
Finches	6	0.5
Snow bunting	4	0.3
Sparrows	30	2.4
Mannikins	1	0.1
Total known birds	1,253	100.0
Unknown birds	956	
Total birds	2,209	

Mammals	9-year total	% of total known
Carnivores	22	9.6
Lagomorphs	1	<1
Rodents	1	<1
Ungulates	204	89.5
Total known	228	100.0
Total unknown	4	
Total mammals	232	

Reptiles		
Alligators	1	50.0
Turtles	1	50.0
Total reptiles	2	100.0

Table 15. Reported aircraft down time (hours) resulting from wildlife strikes to civil aircraft, USA, 1990-1998.

	Reported down time (hours)		
Birds	9-year total	9-year avg.	% of total known
Loons	504	56	0.6
Tropicbirds	10	1	<0.1
Anhingas	16	2	<0.1
Frigatebirds	3	<1	<0.1
Pelicans	137	15	0.2
Herons	175	19	0.2
Egrets	1,413	157	1.7
Cranes	379	42	0.5
Waterfowl	29,837	3,315	36.8
Raptors	23,244	2,583	28.6
Gallinaceous birds	69	8	0.1
Shorebirds	150	17	0.2
Terns	4	<1	<0.1
Gulls	17,666	1,963	21.8
Doves	5,370	597	6.6
Owls	851	95	1.0
Swallows	16	2	<0.1
Perching birds	31	3	<0.1
Starlings	168	19	0.2
Crows	78	9	0.1
Blackbirds	976	108	1.2
Snow buntings	12	1	<0.1
Finches	2	<1	<0.1
Sparrows	19	2	<0.1
Mannikins	3	<1	<0.1
Total known birds	81,133	9,015	100.0
Total unknown birds	16,680	1,853	
Total birds	97,813	10,868	
Mammals			
Carnivores	7,950	883	12.1
Ungulates	57,904	6,434	87.9
Total mammals	65,854	7,317	100.0
Grand total	163,667	18,185	

Table 16. Reported monetary losses (cost of damage, lost revenue, and other monetary losses) in U.S. dollars, resulting from wildlife strikes to civil aircraft, USA, 1990-1998.

	Reported monetary losses ($)		
Birds	9-year total	9-year avg.	% of known
Loons	11,200	1,244	<0.1
Tropicbirds	5,200	578	<0.1
Anhingas	1,800	200	<0.1
Frigatebirds	4,900	544	<0.1
Pelicans	34,000	3,778	0.1
Herons	507,000	56,333	1.0
Egrets	135,540	15,060	0.3
Cranes	255,660	28,407	0.5
Waterfowl	27,854,250	3,094,917	53.5
Raptors	6,303,267	700,363	12.1
Gallinaceous birds	5,120	569	<0.1
Shorebirds	232,902	25,878	0.4
Gulls	10,102,777	1,122,531	19.4
Doves	4,456,164	495,129	8.6
Owls	900,408	100,045	1.7
Thrashers	120	13	<0.1
Starlings	31,550	3,506	0.1
Crows	7,905	878	<0.1
Perching birds	300,000	33,333	0.6
Blackbirds	864,250	96,028	1.7
Sparrows	2,950	328	<0.1
Mannikins	2,000	222	<0.1
Total known	52,018,963	5,779,885	100.0
Total unknown	15,612,047	1,734,672	
Total birds	67,631,010	7,514,557	
Mammals			
Carnivores	140,120	15,569	2.07
Ungulates	6,636,745	737,416	97.93
Total mammals	6,776,865	752,985	100.0
Grand total	74,407,875	8,267,542	

Table 17. Number of reported wildlife strikes and reported losses by category of effect and category of losses to civil aircraft, USA, 1990-1998.

	Number of reported strikes						Cost in millions of dollars (No. reports)		
Year	Total	With effect on flight (EOF)	With damage	Damage and EOF	% with damage and EOF	Lost time in hours (No. reports)	Direct	Other	Total
1990	1,720	125	315	359	21	3,248 (60)	3.798 (32)	0.529 (15)	4.327 (42)
1991	2,064	162	323	405	20	4,529 (60)	1.985 (50)	0.542 (23)	2.527 (54)
1992	2,275	214	319	446	20	8,849 (78)	2.902 (51)	0.083 (26)	2.985 (66)
1993	2,317	242	371	478	21	18,574 (66)	2.494 (56)	0.105 (20)	2.599 (61)
1994	2,380	284	420	540	23	40,218 (102)	3.439 (77)	1.604 (25)	5.033 (83)
1995	2,526	310	451	608	24	9,792 (95)	18.734 (64)	4.501 (29)	23.235 (74)
1996	2,696	350	472	647	24	20,111 (146)	4.385 (89)	0.623 (35)	5.009 (99)
1997	3,381	368	561	765	23	34,725 (182)	8.016 (133)	1.421 (38)	9.437 (145)
1998	3,576	381	536	763	21	23,621 (199)	16.140 (129)	3.104 (51)	19.244 (135)
9-year total	22,935	2,436	3,768	5,011		163,667 (988)	61.894 (681)	12.513 (262)	74.398 (759)
9-year avg.	2,548	271	419	557	22	18,185 (110)	6.877 (76)	1.390 (29)	8.226 (84)
Losses/incident						166	0.091	0.047	0.139
Estimated annual losses									
Minimum [1]						92, 233	50.604	26.592	77.196
Maximum [2]						461,165	253.018	132.96	385.978

[1] Minimum values are based on the assumption that all 5,011 reported strikes having an adverse effect on the flight and/or aircraft engendered similar amounts of damage and/or down time, and that these reports are all of the damaging strikes that occurred.
[2] Maximum values are based on the assumption that the 5,011 reported strikes having an adverse effect represent 20% of all strikes that that had an adverse effect.

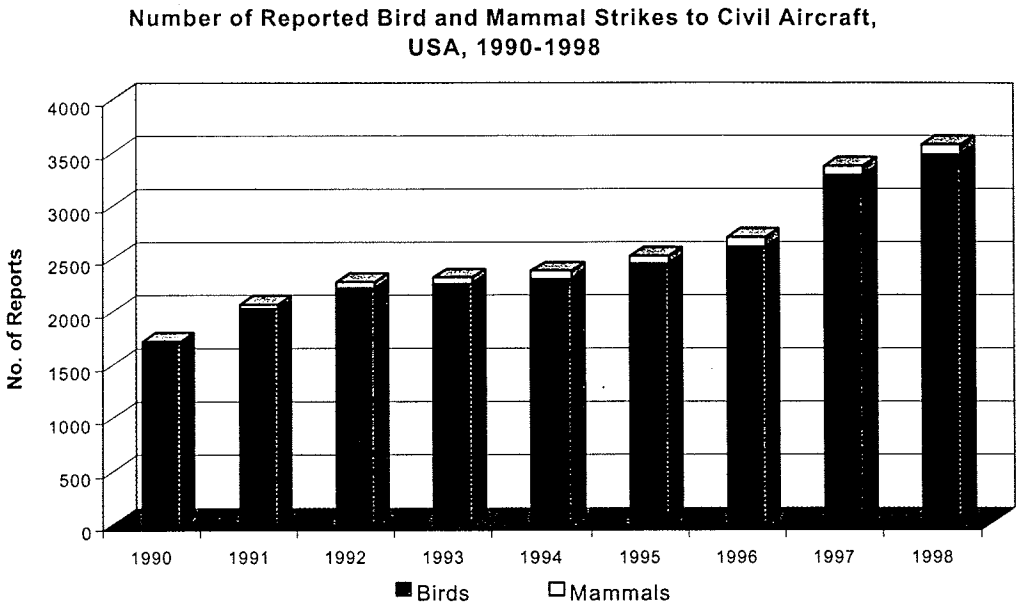

Figure 1. Total reported bird and mammal strikes to civil aircraft by year, USA, 1990-1998, n = 22,320 (birds), n = 580 (mammals).

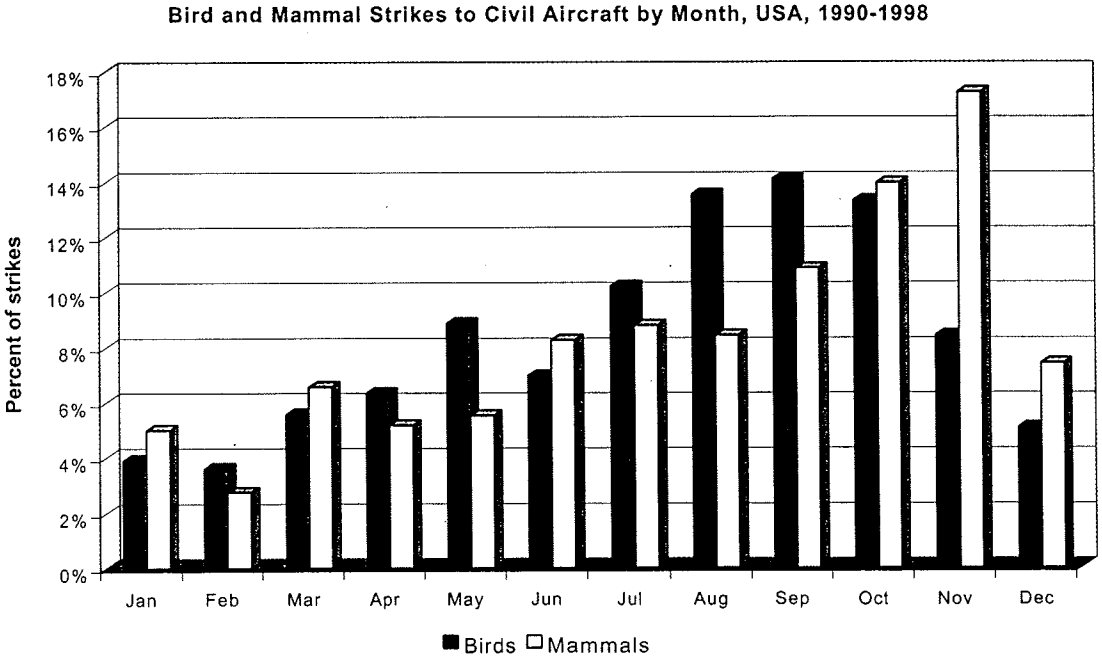

Figure 2. Percent of reported bird and mammal strikes to civil aircraft by month, USA, 1990-1998, n = 22,320 (birds), n = 580 (mammals). See also Table 5.

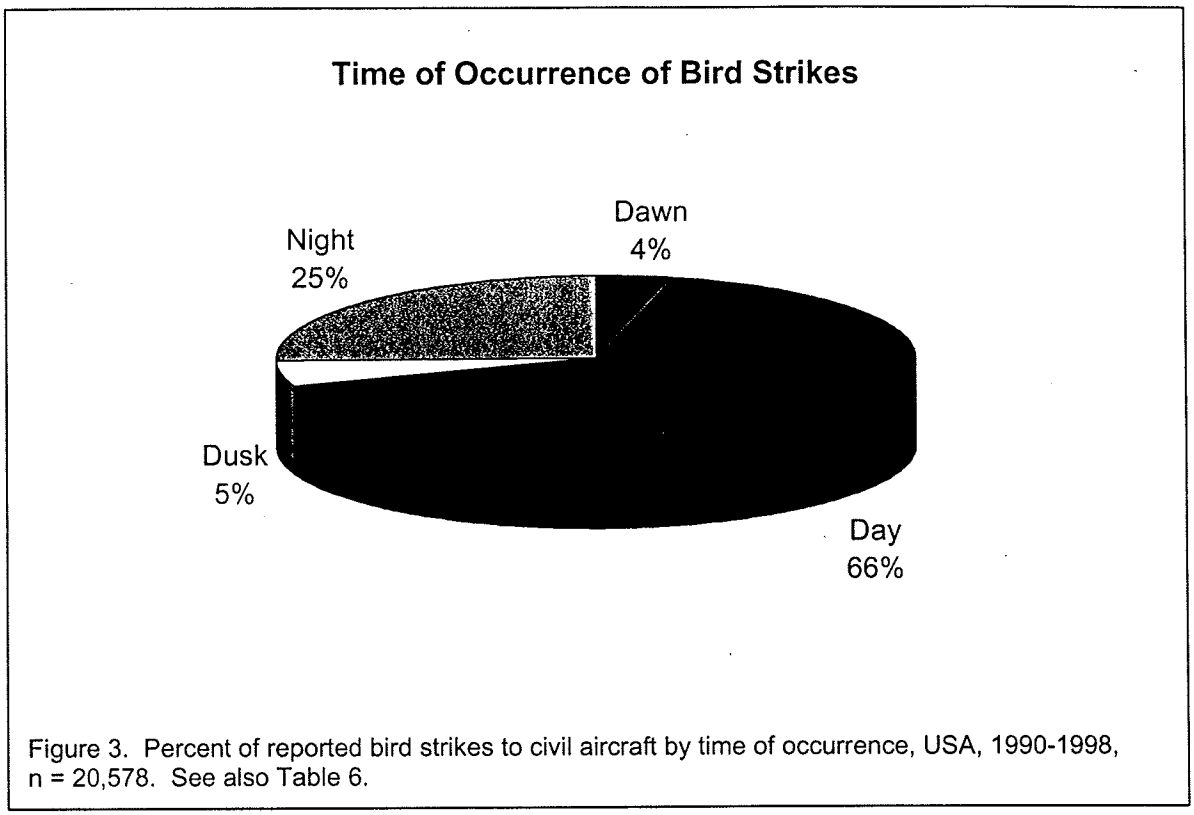

Figure 3. Percent of reported bird strikes to civil aircraft by time of occurrence, USA, 1990-1998, n = 20,578. See also Table 6.

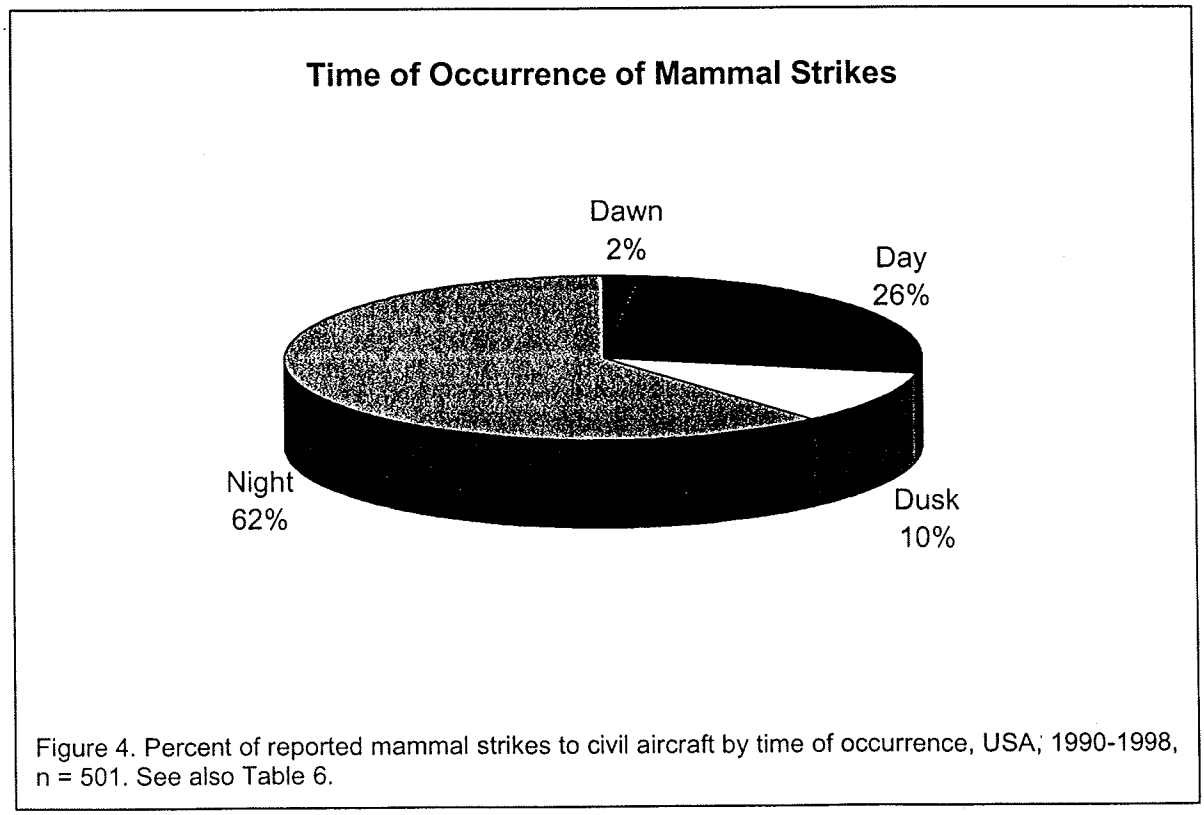

Figure 4. Percent of reported mammal strikes to civil aircraft by time of occurrence, USA, 1990-1998, n = 501. See also Table 6.

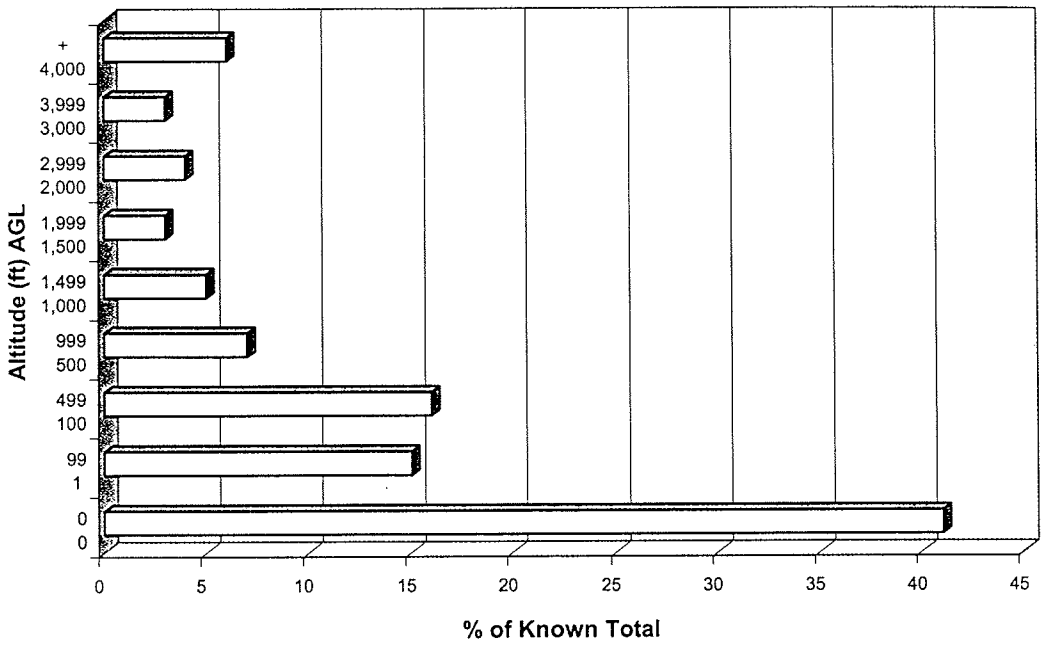

Figure 5. Percent of reported bird strikes to civil aircraft by altitude above ground level (AGL) of occurrence, USA, 1990-1998, n = 18,016. See also Table 8.