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16. Abstract

A study was conducted in the mid-1990s to determine the level of participation of airports and other aviation safety stakeholders in the Federal Aviation Administration's (FAA) voluntary wildlife strike reporting system. A statistical analysis of reported strikes resulted in findings that only a certain percentage of wildlife strikes were actually being reported. According to data collected since 1990, the number of reported strikes has increased. Researchers are certain that several factors have contributed to that increase, including broader participation in the reporting process, increased numbers of hazardous species, a steady increase in air traffic, and a change in reporting statistics. The primary objective of this analysis was to examine the trends in strike reporting from 1990-2008 to determine if the percentage of strikes reported to the FAA for inclusion in the National Wildlife Strike Database is increasing. A second objective was to document trends in the percent of strikes reported to the FAA that can identify the species of the wildlife struck, which is the most critical piece of data in a strike report. Based on the findings of the first two objectives, a third objective was to assess if the data presently collected under a voluntary system are adequate for understanding the problem of wildlife strikes in the United States, or if additional measures, such as mandatory strike reporting, should be taken.

This report is the first of a two-part study focused on the subject of reporting wildlife strikes with civil aircraft in the U.S. Part 1 examines current strike reporting trends to determine if the current voluntary system is providing a sufficient quantity of data to support an accurate, statistical understanding of the national wildlife strike issue. Part 2 focuses on determining if changes are needed in the way wildlife strike data are collected by the FAA, and in particular if a mandatory reporting system needs to be implemented.

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LIST OF ACRONYMS

AC/AT	Air carrier/air taxi
CFR	Code of Federal Regulations
FAA	Federal Aviation Administration
EMD	Engine manufacturer's database
GA	General aviation
NPIAS	National Plan of Integrated Airport Systems
NWSD	National Wildlife Strike Database
SMS	Safety Management System
TAF	Terminal Area Forecast
U.S.	United States
USDA/WS	U.S. Department of Agriculture, Wildlife Services

EXECUTIVE SUMMARY

Reporting of wildlife strikes with civil aircraft in the United States (U.S.) is voluntary but strongly encouraged in Federal Aviation Administration (FAA) Advisory Circulars and other FAA publications. This report is the first of a two-part study focused on the subject of reporting wildlife strikes with civil aircraft in the U.S. The primary objective of this analysis was to examine the trends in strike reporting from 1990-2008 to determine if the percentage of strikes reported to the FAA for inclusion in the National Wildlife Strike Database is increasing. A second objective was to document trends in the percent of strikes reported to the FAA that provided a species identification, which is the most critical piece of data in a strike report. Based on the findings of the first two objectives, a third objective was to assess if the strike data presently collected under a voluntary system are adequate for understanding the problem of wildlife strikes in the U.S. or if additional measures, such as mandatory strike reporting, should be taken. Aircraft movement data for all Title 14 Code of Federal Regulations (CFR) Part 139-certificated airports and general aviation (GA) airports in the National Plan of Integrated Airport Systems (NPIAS) were used in the analysis. Additional data on aircraft movements by air carriers and bird ingestions into turbofan engines were provided by the aviation industry.

This analysis demonstrated that the total number of strikes reported (97.4% involving birds) and the number of airports reporting strikes has steadily and significantly increased from 1990 to 2008, for both 14 CFR Part 139 and NPIAS GA airports. Mean strike rates (strikes per 100,000 aircraft movements) have also increased steadily and significantly for both Part 139 and NPIAS GA airports from 1990-2008. The mean strike rate for Part 139 airports between 2004 and 2008 was about 3.2 times higher than the rate measured between 1990 and 1994. In contrast to the overall number of reported strikes, the number and mean rate of reported strikes indicating damage to the aircraft has not shown a significant increase from 1990-2008 for Part 139 airports.

Although overall reporting rates between 2004 and 2008 are much higher for strikes at Part 139 airports than at NPIAS GA airports, there is also a major disparity in reporting rates among Part 139 airports. Larger Part 139 airports, especially those that have well-established wildlife hazard management programs, have reporting rates about 4 times higher than other Part 139 airports. Based on the assumption that reported strike rates at 27 selected Part 139 airports is representative of the actual strike rates for all Part 139 airports nationwide, it is estimated that about 39% of the strikes at all Part 139 airports were reported between 2004 and 2008.

The current overall reporting rate of 39% is adequate to track national trends in wildlife strikes, to determine the hazard level of wildlife species that are being struck, and to provide a scientific foundation for FAA policies and guidance regarding the mitigation of risk from wildlife strikes. This conclusion is based on the following findings:

- There is a significant positive trend observed in overall strike reporting from 1990 to 2008.

- There has been a decline or stabilization in the reporting of damaging strikes since 2000.

- Professionally run wildlife hazard programs have been implemented at many Part 139 airports throughout the U.S. and are reporting all known strikes.

- There has been a significant improvement in species identification since 2000 exhibited in the fact that the database presently is capturing over 7500 strike events per year involving over 240 species of birds and other wildlife.

A major deficiency at this time is the lack of full participation in reporting strikes to the NWSD by some airports and air carriers. Increased reporting by these entities is needed to enable the airports where these strikes occur to define their local wildlife issues and to develop species-specific wildlife hazard management plans as part of their Safety Management Systems (SMS).

Given the positive trends in reporting rates and species identification coupled with the decline or stabilization in damaging strikes, mandatory reporting is not recommended at this time to achieve the objectives of the database. Based on the statistical trends measured in this study, the current collection of over 7500 strike reports annually involving over 240 identified species of wildlife, and the numerous database-generated reports and scientific papers published in recent years, the database appears to be adequate for defining the overall national problem, identifying the species posing the greatest and least hazards, and measuring national and regional trends in strikes. The focus of improved reporting needs to be directed at identifying any new sources of data on strike reports and in developing strategies for those specific airports and air carriers that may be not fully participating in the reporting program. The critical need is for those airports that are deficient in reporting to have a more complete record of their strikes so that they can develop more effective species-specific wildlife hazard management programs to mitigate the risk of wildlife strikes under a Safety Management System.

1. INTRODUCTION.

The miraculous ditching 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 [1 and 2] dramatically demonstrated that bird strikes are a serious aviation safety issue. However, the civil and military aviation communities have long recognized that the economic costs and threat to human safety from aircraft collisions with wildlife (wildlife strikes) are real and increasing [3 and 4]. Globally, wildlife strikes have killed more than 229 people and destroyed over 210 aircraft since 1988 [5, 6, and 7]. Three factors that contribute to the increasing threat are:

- Populations of certain wildlife species hazardous to aviation because of their size or flocking behavior have increased in the last few decades and have adapted to living in urban environments, including airports. For example, from 1980 to 2007, the resident (non-migratory) Canada goose (Branta canadensis) population in the United States (U.S.) and Canada increased at a mean rate of 7.3% per year [8]. Other species showing significant mean annual rates of increase included bald eagles (Haliaeetus leucocephalus, 4.6%), wild turkeys (Meleagris gallopavo, 12.1%), turkey vultures (Cathartes aura, 2.2%), American white pelicans (Pelecanus erythrorhy, 2.9%), double-crested cormorants (Phalacrocorax auritus, 4.0%), and sandhill cranes (Grus canadensis, 5.0%). Thirteen of the fourteen bird species in North America with mean body masses greater than 3.6 kg (8 lb) have shown significant population increases over the past 3 decades [9]. The white-tailed deer population (Odocoileus virginianus) increased from a low of about 350,000 in 1900 to over 17 million in the past decade [10 and 11].

- Concurrent with population increases of many large-bird species, air traffic has increased. From 1990 to 2008, passenger enplanements in the U.S. increased 52% from about 495 million to 750 million, and commercial air traffic increased 22% from about 23 million to 28 million aircraft movements [12]. U.S. commercial air traffic is predicted to continue growing at a rate of about 1.3% per year to 35 million movements by 2025.

- Commercial air carriers have replaced their older three- or four-engine aircraft fleets with more efficient and quieter, two-engine aircraft. In 1965, about 90% of the 2100 U.S. passenger aircraft had three or four engines. In 2005, the U.S. passenger fleet had grown to about 8200 aircraft, and only about 10% had three or four engines [13]. As demonstrated in the US Airways Flight 1549 incident, this reduction in engine redundancy increases the probability of life-threatening situations resulting from aircraft collisions with wildlife, especially with flocks of birds. In addition, previous research has indicated that birds are less able to detect and avoid modern jet aircraft with quieter turbofan engines [14, chapter 3] than older aircraft with noisier engines [14, chapter 2; 15; and 16].

The Federal Aviation Administration (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 U.S. Department of Agriculture, 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 to

- edit all strike reports (such as FAA Form 5200-7, Birds/Other Wildlife Strike Report) received by the FAA since 1990 to ensure consistent, error-free data.
- enter all edited strike reports in the FAA National Wildlife Strike Database (NWSD).
- supplement FAA-reported strikes with additional, nonduplicated strike reports from other sources.
- provide the FAA with an updated computer file each month containing all edited strike reports for inclusion in a web-based database accessible by the aviation industry and public [17].
- assist the FAA with the production of annual and special reports summarizing the results of analyses of the data from the NWSD.

Such analyses are critical to determining the economic cost of wildlife strikes, the magnitude of safety issues, and most important, the nature of the problems (e.g., wildlife species involved, types of damage, height and phase of flight during which strikes occur, and seasonal patterns). The information obtained from these analyses provides the foundation for FAA policies and guidance and for refinements in the development, implementation, and justification of integrated research and management efforts to reduce wildlife strikes.

The first annual report on wildlife strikes to civil aircraft in the U.S., covering 1994, was completed in November 1995 [18]. The FAA has published 14 subsequent reports covering the years 1993-1995, 1992-1996, 1991-1997, 1990-1998, 1990-1999, 1990-2000, 1990-2001, 1990-2002, 1990-2003, 1990-2004, 1990-2005, 1990-2006, 1990-2007, and 1990-2008 [19-32]. The current and historic annual reports are accessible at http://wildlife-mitigation.tc.faa.gov.

This report is the first of a two-part study focused on the subject of reporting wildlife strikes with civil aircraft in the U.S. Reporting wildlife strikes with civil aircraft is voluntary but strongly encouraged by the FAA Advisory Circular 150/5200-32A [33]. An initial analysis of independent strike data from one airport in New York and one airport in Hawaii in the mid-1990s suggested that less than 20% of known strikes were actually reported to the FAA for inclusion in the NWSD [18 and 34]. A subsequent analysis of 14 sets of wildlife strike data maintained by three airlines and three airports from 1991-2004 (11 of the 14 data sets were from 1991-1999) also indicated that about 20% of the known strikes were reported to the NWSD [35 and 28]. This report examines the previous strike reporting rate of 20% to determine if current data suggests a change in that rate. Part 2 of the study focuses on data sources to identify any gaps as well as potential areas for improvement in the way the FAA collects wildlife strike data.

2. OBJECTIVES AND PROCEDURES OF ANALYSES.

The primary objective of this analysis was to examine the trends in strike reporting from 1990-2008 to determine if the percentage of strikes reported to the FAA for inclusion in the NWSD is increasing. First, the overall number of strikes and damaging strikes reported to the FAA by wildlife type (bird, terrestrial mammal, bat (flying mammal), and reptile) by year was examined. Second, the overall strike reporting and trends in strike reporting was examined at the following three category airports:

- Certificated for passenger service under Title 14 Code of Federal Regulations (CFR) Part 139 (hereinafter referred to as Part 139) [36]

- Noncertificated general aviation (GA) airports in the National Plan of Integrated Airport System (NPIAS) [37]

- Other (non-NPIAS) GA airports

In addition, reporting rates for strikes involving commercial (air carrier) and GA aircraft, as well as strike reporting rates at selected Part 139 airports that have well-established wildlife hazard management programs with reporting rates at other Part 139 airports in the same states were compared. From this analysis, an estimate of the percentage of strikes being reported at Part 139 airports nationwide was derived. Strike reporting rates among commercial air carriers in the U.S. were also compared. The engine manufacturer's database and the NWSD were examined to determine the trend of the percentage of strikes that involved bird ingestion into turbofan engines that had been reported in both databases.

A second objective was to document trends in the percent of wildlife strikes reported to the FAA that identified either the species group (e.g., gull, Larus spp.) or the exact species (e.g., ring-billed gull, Larus delawarensis) of wildlife struck. There are over 700 species of birds in North America, ranging in body mass from about 2 to 12,000 grams [38]. Identifying the species responsible for a strike is critical for three reasons: (1) to analyze the impact force of the object striking the aircraft component; (2) to develop and evaluate species-focused wildlife hazard management plans under airport Safety Management Systems (SMS) to mitigate the risk of strikes [39]; and (3) to determine the legal (protective) status of the species involved in the strikes under federal regulations, such as the Migratory Bird Treaty Act and Endangered Species Act, as well as state and local laws [40]. Species identification is critical to obtain the necessary permits for management actions under an airport's SMS.

Based on the findings of the first two objectives, a third objective was to assess if the data presently collected under a voluntary system are adequate for understanding the problem of wildlife strikes in the U.S., or if additional measures, such as mandatory reporting, should be taken to collect sufficient information for regulatory and policy decisions.

3. DATA SOURCES.

Wildlife strike data for civil aircraft from 1990-2008 were obtained from the NWSD [32]. Military aircraft strikes at civil airports were excluded from the analyses. Aircraft movement data for all Part 139-certificated airports and NPIAS GA airports were obtained from the FAA Terminal Area Forecast (TAF) System [12]. Additional data on aircraft movements by air carriers and on bird ingestions into turbofan engines were provided by the Air Transport Association and by Pratt & Whitney.

Strike rates and damaging strike rates were calculated in terms of number of strikes and number of damaging strikes reported per 100,000 aircraft movements.

4. DATA ANALYSIS.

4.1 NUMBER AND TRENDS OF REPORTED STRIKES INVOLVING BIRDS, TERRESTRIAL MAMMALS, BATS, AND REPTILES.

For the 19-year period (1990-2008), 89,727 strikes were reported to the FAA. Birds were involved in 97.4% of the reported strikes, terrestrial mammals in 2.1%, bats in 0.3%, and reptiles in 0.1% (table A-1). The corresponding tables and figures for this study are provided in appendices A and B, respectively. The overall number of reported strikes has steadily increased from 1759 in 1990 to 7516 in 2008 (4.3-fold increase). In contrast, the number of strikes indicating damage to the aircraft increased from 340 in 1990 to a peak of 762 in 2000, but has subsequently declined by 33% to 512 in 2008 (figure B-1). The percent of reported strikes indicating damage ranged from 15% to 19% from 1990-1998, but has subsequently declined to 7% in 2008 (figure B-1).

4.2 REPORTED STRIKES AT PART 139 AIRPORTS, NPIAS GA AIRPORTS, AND NON-NPIAS GA AIRPORTS.

4.2.1 Number of Airports Reporting Strikes.

The number of Part 139 airports that had at least one wildlife strike reported in a given year increased steadily from 234 in 1990 to 333 in 2008 (table A-2 and figure B-2). On average, the Part 139 airports that had at least one strike reported increased by about five each year from 1990-2008. The percent of Part 139 airports (N=552) with at least one strike reported in a given year increased from 42% in 1990 to 61% in 2008 (figure B-3).

The number of NPIAS GA airports with at least one strike reported in a given year also increased, growing from 66 in 1990 to 152 in 2005, with a subsequent minor decline to 126-139 airports in 2006-2008 (table A-2 and figure B-2). Only 2.3% (1990) to 5.4% (2005) of the 2841 NPIAS GA airports had at least one strike reported in any year (1990-2008) (figure B-2). The number of non-NPIAS GA airports with at least one strike reported showed little trend from 1990-2008, ranging from 8 to 28. There are approximately 11,500 non-NPIAS GA airports (1,700 paved and 9,800 unpaved) in the U.S. [41 and 42]; thus, less than 0.25% of these airports had a wildlife strike reported in a given year.

The number of foreign airports with at least one strike reported (involving a U.S.-based aircraft) increased 3-fold from 27 in 1990 to 80 in 2008 (table A-2 and figure B-4). In all, the number of airports (all categories) where at least one strike was reported increased 1.7-fold from 335 in 1990 to 565 in 2008. Wildlife strikes were reported at 1668 airports between 1990 and 2008 (table A-2).

4.2.2 Number of Strikes Reported.

Trends in the total annual number of strikes reported for the different categories of airports from 1990 to 2008 were similar to those for the number of airports with at least one strike reported. Part 139 airports, NPIAS GA airports, and foreign airports all showed steady increases in the number of strikes reported from 1990 to 2008, whereas non-NPIAS GA airports showed no trend (table A-3). However, whereas Part 139 airports comprised only 31% of the 1668 airports reporting at least one strike (table A-2), these airports generated 92% of the total reported strikes (table A-3). NPIAS GA airports (42% of the airports with at least one strike reported) generated 5% of the total reported strikes. Foreign airports and non-NPIAS GA airports generated 2% and <1% of the strikes, respectively.

4.3 STRIKE RATES BY PART 139 AND NPIAS GA AIRPORTS.

4.3.1 Strike Rates by Year, 1990-2008.

For Part 139 airports, the mean strike rate (reported strikes per 100,000 movements) increased significantly and steadily (4.3-fold overall) from 2.41 in 1990 to 10.34 in 2008 (table A-4 and figure B-5). NPIAS GA airports also showed a significant, but not as pronounced, increase in the mean strike rate from 0.11 in 1990 to 0.22-0.38 in 2005-2008 (table A-4 and figure B-5).

Although both Part 139 and NPIAS GA airports showed increases in reported strike rates from 1990-2008, the actual strike rates were profoundly different for the two airport categories. In each of the 19 years, the reported mean strike rate was 17 to 47 times greater for Part 139 airports than for NPIAS GA airports (table A-4). For all 19 years combined, the mean reported strike rate for Part 139 airports (5.03 strikes per 100,000 movements) was 4.81 strikes per 100,000 movements greater (23 times higher) than the 0.22 strike per 100,000 movements recorded for NPIAS GA airports (table A-4).

4.3.2 Damaging Strike Rates by Year, 1990-2008.

Trends in the mean damaging strike rates (reported strikes with damage to aircraft per 100,000 movements) per year was dramatically different than for mean strike rates, especially for Part 139 airports (table A-5 and figure B-5). Whereas Part 139 airports showed a steady rise and an overall 4.3-fold increase in the reported strike rate from 1990 to 2008, the damaging strike rate showed no significant trend, ranging from 0.39 in 1992 to 0.94 in 2005. For damaging strikes at NPIAS GA airports, the rate increased significantly from 1990 to 2008, but the rise was much less pronounced and more erratic than the measured mean strike rates (figure B-5).

These comparisons of reported strike rates (strikes per 100,000 aircraft movements) are between Part 139 and NPIAS airports. Considering all strikes reported (both damaging and nondamaging) the comparisons clearly show a much higher reporting rate at Part 139 airports than at NPIAS airports. The reporting rate was 23 times higher at Part 139 airports for all years combined. The rates were 15 to 47 times higher at Part 139 airports for individual years over the 19-year period (see table A-4).

However, when reporting rates for damaging strikes only were compared between Part 139 airports and NPIAS airports, the differences were not as pronounced. Overall, the reporting rate of damaging strikes was 5 times higher at Part 139 airports than NPIAS airports. As explained in section 5.2, this indicates that there was a bias at NPIAS airports to report damaging strikes compared to reporting of nondamaging strikes. NPIAS airports still had an overall lower rate of reporting damaging strikes than Part 139, but the strikes that were reported were more likely to be damaging strikes. The NPIAS airports were much less likely to report nondamaging strikes than Part 139 airports.

4.3.3 Strike Rates by Air Carrier and GA Aircraft.

In this analysis, the mean strike rate and mean damaging strike rate were compared for reported strikes involving commercial aircraft (air carrier/air taxi (AC/AT)) at Part 139 airports with the respective rates for reported strikes involving GA aircraft (private, business, government) at NPIAS GA airports (1990-2008). In addition, the mean strike rate and mean damaging strike rate were compared for reported strikes involving AC/AT aircraft at Part 139 airports with the respective rates for reported strikes involving GA aircraft at the same Part 139 airports (table A-6 and figure B-6).

Overall, there was a profoundly (47-fold) higher mean strike rate for AC/AT aircraft at Part 139 airports (8.11 reported strikes per 100,000 AC/AT aircraft movements) compared to the mean strike rate of 0.17 reported strikes per 100,000 GA aircraft movements at NPIAS GA airports (table A-6 and figure B-6). The damaging strike rate was also higher for AC/AT aircraft at Part 139 airports (1.01) compared to GA aircraft at NPIAS GA airports (0.11), but the disparity was much less (10-fold difference) compared to the 47-fold difference in strike rates for the respective aircraft types at Part 139 and GA airports.

When strike rates and damaging strike rates for AC/AT aircraft and GA aircraft at the same Part 139 airports were compared, the disparities were much less than when strike rates between the two aircraft types were compared at Part 139 and NPIAS GA airports, as noted above. Overall, there was a 5.1-fold difference in the strike rate (8.11 for AC/AT aircraft and 1.60 for GA aircraft) and only a 3.4-fold difference in the damaging strike rate (1.10 and 0.31, respectively; table A-6 and figure B-6).

4.3.4 Strike Rate by Airport Size, 2004-2008.

In this analysis, the mean strike rate and mean damaging strike rate were compared for reported strikes involving all civil aircraft (AC/AT and GA) at different size Part 139 and NPIAS GA airports based on mean number of aircraft movements per year between 2004 and 2008. Because

the above analyses have shown that strike rates have substantially increased from 1990-2008, only strike data from the past 5 years were used in this analysis to determine what the influence of airport size has on reporting rates at the current time.

Airport size had a major influence on the reported strike rate for both Part 139 airports and NPIAS GA airports. For Part 139 airports, the strike rate increased about 4-fold from 4.43 reported strikes per 100,000 movements for airports averaging <50,000 movements per year to 16.10-17.65 for airports averaging >150,000 movements per year (table A-7 and figure B-7). For NPIAS GA airports, a 5-fold increase was measured; a mean strike rate of 0.26 was recorded for airports with <50,000 movements per year compared to 1.27 for airports with >200,000 movements per year. In contrast to the trend for all reported strikes, airport size had little influence on reported rates for strikes with damage for either Part 139 airports or NPIAS GA airports (table A-7 and figure B-7).

4.3.5 Frequency Distribution of Strike Rates, 2004-2008.

Part 139 airports and NPIAS GA airports had dramatically different distributions of strike rates between 2004 and 2008 (table A-8 and figure B-8). For the 5-year period, 16% (84) of the 522 Part 139 airports examined had a strike rate of 0 compared to 85% (2170) of the 2560 NPIAS GA airports examined. At the other extreme, 26% of the Part 139 airports had a reported rate of >10 strikes per 100,000 movements compared to only 0.4% for NPIAS GA airports.

The distribution of damaging strike rates was also different between Part 139 and NPIAS GA airports, but the differences were not as extreme (table A-9 and figure B-8). For the 5-year period, 42% (219) of the Part 139 airports had a damaging strike rate of 0 compared to 90% (2302) of the NPIAS GA airports. At the other extreme, 19% (99) of the Part 139 airports had a reported rate of >1 damaging strikes per 100,000 movements compared to 3.4% (86) of the NPIAS GA airports.

4.3.6 Strike Rates for Selected Part 139 Airports Compared to Other Part 139 Airports in the Same State.

In this analysis, the mean strike rate and mean damaging strike rate were compared for reported strikes involving all civil aircraft (AC/AT and GA) at 27 selected Part 139 airports in 19 states with strike rates at all other Part 139 airports in the same states, for the 5-year period. The 27 airports selected as a baseline have had well-established wildlife hazard management programs in place for at least 5 years, which are overseen by a wildlife biologist, either from USDA/WS [43], the private sector, in-house, or a combination thereof. These airports were selected based on their established programs and without an a priori examination of strike rates. The objective was to examine what influence these established wildlife hazard management programs had on the rate of strikes and damaging strikes reported by the airports. Selecting these 27 Part 139 airports as the baseline does not imply that the other Part 139 airports in these states, or in other states, have inadequate wildlife hazard management programs.

Major differences were found in the overall mean strike rates between the selected Part 139 airports and all other Part 139 airports in each of the 19 states where the comparisons were made.

Strike rates at the selected airports were 1.7 to 126.6 times higher than the mean strike rates at the other Part 139 airports in the same state (table A-10 and figure B-9). On average, the 27 selected Part 139 airports recorded a mean rate of 29.23 strikes per 100,000 movements compared to 6.50 for the other 214 Part 139 airports. This was a mean difference of 22.73 strikes reported per 100,000 movements (a 4.5-fold difference) for the selected Part 139 airports compared to the other Part 139 airports for the 5-year period.

These differences were also present but less pronounced in comparing damaging strike rates between the Part 139 airports and the other Part 139 airports in the same state. In three states, damaging strike rates at the selected airport(s) were less than the mean strike rate for the other Part 139 airports in the same state (table A-11 and figure B-9). On average, the 27 selected Part 139 airports recorded a mean rate of 1.77 damaging strikes per 100,000 movements compared to 0.49 for the 214 other Part 139 airports in the same states. This was a mean difference of 1.27 damaging strikes per 100,000 movements (a 3.6-fold difference) for the 5-year period.

4.3.7 Estimated Percent of Strikes Reported at Part 139 Airports.

An estimate of the percentage of strikes reported at Part 139 airports (between 2004 and 2008) can be obtained if the following assumptions are made:

- For the 27 selected Part 139 airports, the mean reported strike rate of 29.23 reflects the actual strike rates for these airports

- For the other 214 airports in those 19 states, as well as the 281 Part 139 airports from the 31 states not included in the comparison, the mean reported strike rates of 6.50 and 7.11, respectively, should actually be the same (i.e., 29.23) as that of the 27 selected Part 139 airports.

Of the 522 Part 139 airports analyzed between 2004 and 2008 (table A-10), the percentage of aircraft movements are broken down as follows: 20% for the 27 selected airports; 38% for the other 214 comparison airports in those same 19 states; and 42% for the 281 Part 139 airports in the other 31 states.

The proportion of actual strikes reported by each group of airports, i.e., the 27 selected Part 139, 214 comparison, and 281 other Part 139 airports, can be calculated by multiplying the fraction of total aircraft movements by the reported strike rate or 0.20 * 29.23 + 0.38 * 6.50 + 0.42 * 7.11 = 11.29. If all three groups of Part 139 airports had reported strikes at the same rate as the 27 selected Part 139 airports (29.23), the respective proportions would have been 0.20 * 29.23 + 0.38 * 29.23 + 0.42 * 29.23 = 29.23. Therefore based on the two assumptions above, it can be said that 39% (11.29/29.23) of the actual strikes were reported at the 522 Part 139 airports between 2004 and 2008.

4.4 COMPARISON OF STRIKE RATES AMONG AIR CARRIERS IN THE U.S., 2004-2008.

In this analysis, the strike rate and damaging strike rate were examined for reported strikes in the U.S. involving 48 commercial air carriers from 2004-2008. The air carriers were divided into two groups based on mean number of aircraft movements in the U.S. per year. Among the 13 largest air carriers (Group 1), all with >500,000 movements per year, there were major differences in the overall strike rates. Rates ranged from 6.31 to 59.82 strikes per 100,000 movements, a 9.5-fold difference among the carriers (table A-12). Reported damaging strike rates varied by a similar amount; these rates ranged from 0.27 to 2.54, which was a 9.4-fold difference.

For the 35 air carriers with fewer than 500,000 movements (Group 2) in the U.S. per year, reported strike rates varied even more widely. Overall rates ranged from 0 to 81.75 strikes per 100,000 movements. Damaging strike rates ranged from 0 to 6.00 (table A-13).

4.5 PERCENT OF STRIKES IN ENGINE MANUFACTURER'S DATABASE FOUND IN THE NWSD.

For this analysis, an aircraft engine manufacturer provided a database containing the reported incidents of bird ingestion. Only the entries for U.S. air carrier aircraft at any airport or foreign air carrier aircraft at any U.S. airport were selected from the engine manufacturer's database (EMD). These entries were compared with strikes reported to the FAA for inclusion in NWSD for two 5-year periods (1990-1994 and 2004-2008).

For the first 5-year period (1990-1994), 43% (128) of the 299 entries in the EMD were also found in the NWSD. This percentage of strikes in the EMD almost doubled to 83% (247 of the 297 EMD entries) for the second 5-year period, 2004-2008 (table A-14).

4.6 PERCENT OF REPORTED WILDLIFE STRIKES THAT IDENTIFY THE SPECIES STRUCK.

From 1990-2008, about 44% (38,484) of the reported strikes with birds (87,422) were identified to species or species group (table A-15) with about 28% identified to exact species. There has been a significant positive trend in species identification; only 17% of the birds involved in strikes were identified to species in 1990 compared to 40% in 2007 and 45% in 2008 (figure B-10). In 1990, only 49 different species of birds were identified as involved in strikes compared to 224 species during 2008 (table A-15 and figure B-10). From 1990-2008, 381 different species of birds involved in strikes were identified (about 50% of the total species of birds found in North America). Eight species of bats, thirty-three species of terrestrial mammals, and seven species of reptiles involved in strikes have been identified.

5. DISCUSSION.

5.1 NUMBER AND TRENDS OF REPORTED STRIKES.

This analysis demonstrated that the total number of strikes reported (97.4% involving birds, table A-1 and figure B-1) and the number of airports reporting strikes (tables A-2, A-3; figures B-2, B-3, and B-4) has steadily and significantly increased from 1990 to 2008 for both Part 139 and NPIAS GA airports. In contrast, the number of non-NPIAS GA airports reporting strikes and the number of strikes reported at these airports has been miniscule, which does not show a trend of increase (tables A-2 and A-3). Mean strike rates (strikes per 100,000 aircraft movements) also have shown a steady and significant increase for both Part 139 and NPIAS GA airports from 1990-2008. The mean strike rate for Part 139 airports during 2004-2008 was about 3.2 times higher than the rate measured in 1990-1994 (table A-4 and figure B-5).

An estimated 39% of all strikes at Part 139 airports were reported in 2004-2008 based on a comparison of reported strike rates among airports. This estimate is supportive of the overall trends of increased strike reporting shown in tables A-1 through A-5 and figures B-1 through B-5. Previous estimates based on strike data primarily from the 1990s showed that about 20% of strikes were reported [18, 34, 35, and 28].

In contrast to overall reported strikes, the number and mean rate of reported strikes indicating damage to the aircraft has not shown a significant increase from 1990-2008 for Part 139 airports (table A-5 and figure B-5). The mean damaging strike rate has increased slightly for NPIAS GA airports from 1990-2008; however, these airports generate only about 6% of the total strikes reported to the NWSD (table A-3). The total number of reported damaging strikes peaked in 2000 at 762 and has subsequently declined by 33% to 512 in 2008 (table A-1).

For Part 139 airports, the fact that the overall number of airports reporting strikes, the number of strikes reported, and mean strike rates have steadily increased since 1990 while the damaging strike rates have not increased, implies the interaction of several factors. First, management actions to reduce wildlife strikes by species of highest risk for damage [44] are being implemented at far more Part 139 airports now than in the 1990s [45-48]. For example, USDA/WS biologists provided assistance at 764 airports nationwide in 2008, including 387 Part 139 airports, to mitigate wildlife risks to aviation compared to only 42 airports in 1991 and 193 in 1998 [43]. A number of Part 139 airports have added a full-time biologist position to their operational program in recent years. This increase in various actions to mitigate the risk of damaging strikes at Part 139 airports has been precipitated by a combination of factors: revised regulations under 14 CFR Part 139.337 in 2004, new and updated Advisory Circulars regarding wildlife [49], and increased concerns by airport operators regarding liability in the aftermath of wildlife strikes [50]. One relevant change to 14 CFR Part 139 regulations in 2004 was that Part 139 airports now are required to provide 8 hours of recurrent training annually to airport staff involved in wildlife risk mitigation. This training specifically requires coverage of the importance of and methods for reporting strikes [51].

The implementation and enhancement of wildlife hazard management programs at many Part 139 airports nationwide has likely resulted in a reduction in strikes by species of highest risk to

cause damage. For example, the number and rate of reported strikes and damaging strikes by Canada geese have declined since 2000, even though the overall population has increased [52]. Of all bird species weighing over 1.8 kg (4 lb) recorded in the NWSD, Canada geese are by far the most common, amounting to 1181 strikes reported between 1990 and 2008 [32 and 9].

Implementation of these management plans has likely resulted in a reduction in damaging strikes, which is reflected in the reporting rates. These enhanced efforts have also resulted in increased reporting of all strikes at airports, an increasing percentage of which are nondamaging (figure B-1). Another indicator of this trend is that the number of species involved in reported strikes has increased dramatically, although the number of damaging strikes has declined. From 1990-1994, the number of different species of birds struck reported per year ranged from 49 to 66 (mean = 56). In comparison, 165-224 species of birds (mean = 190) were reported as struck per year from 2004-2008 (table A-15).

5.2 REPORTING OF STRIKES AT PART 139 AND NPIAS GA AIRPORTS.

There were major differences in reporting rates for Part 139 airports, NPIAS GA airports, and non-NPIAS GA airports. The number of Part 139 airports reporting at least one wildlife strike increased from 234 (42% of the 552 airports) in 1990 to 333 (60%) in 2008 (table A-2 and figure B-3). There also was an increase in the number of NPIAS GA airports reporting at least one wildlife strike from 1990-2008; however, the percent of these 2841 airports reporting a strike during a given year ranged from only 2% to 5%. Only 8 to 28 non-NPIAS GA airports (out of about 11,500) reported a strike during a given year. NPIAS GA airports generated only about 6% of the total reported strikes between 1990 and 2008.

The overall reported strike rates were 15 to 47 times higher at Part 139 airports compared to NPIAS GA airports each year (1990-2009) with a 23-fold difference for all years (table A-4). Although this may be explained by a different mix of aircraft using these two different categories of airports, the magnitude of the difference indicates actual reporting rates for NPIAS GA airports is much lower than for Part 139 airports. This was supported by an examination of reporting rates for damaging strikes where the magnitude of difference is much less (table A-5). Whereas Part 139 airports had a 23-fold higher reporting rate for all strikes compared to NPIAS GA airports, the reporting rate for damaging strikes was only 5-fold higher. Whereas about 11% of the strikes reported from Part 139 airports indicated damage to the aircraft (5.03 and 0.57, respectively, for all strikes and damaging strikes, tables A-4 and A-5), about 50% of the strikes reported from NPIAS GA airports indicated damage. Thus, even though fewer damaging strikes are reported (compared to Part 139 airports), there is more of a bias at NPIAS GA airports toward reporting damaging strikes compared to nondamaging strikes.

These same patterns were even more pronounced when specific strike rates for GA aircraft at NPIAS GA airports were compared to specific rates for commercial aircraft at Part 139 airports. There was a 47-fold difference in reporting rates of all strikes and a 9.7-fold difference in reporting rates for damaging strikes (table A-6 and figure B-6). The reported strike rate for GA aircraft at Part 139 airports was 9 times higher that the reported strike rate for GA aircraft at NPIAS GA airports. However, the damaging strike rate for GA aircraft at Part 139 airports was only 3 times higher than it was for GA aircraft at NPIAS GA airports. Thus, there is an

indication of a greater bias toward reporting damaging strikes than nondamaging strikes at NPIAS GA airports compared to Part 139 airports.

For Part 139 and NPIAS GA airports, the size of the airport (based on aircraft movements) had a definite influence on overall reporting rates from 2004-2008. Both airport categories showed a positive correlation between airport size and the mean strike rate (table A-7 and figure B-7). This relationship is explained by the assumption that larger airports are more likely to have well-developed wildlife hazard management programs in place than smaller airports.

When reporting rates of damaging strikes at smaller Part 139 airports and NPIAS GA airports are compared to the same damaging strikes reporting rates at larger Part 139 airports, the examination shows that damaging strikes are more likely to be reported than nondamaging strikes. Damaging strike rates varied little by airport size, whereas there was about a 5-fold difference between the reporting rate of all strikes at the smallest and largest airports.

Another finding that demonstrated the disparity in the reporting rates between Part 139 and NPIAS GA airports was the major differences in the frequency distribution of strike rates between 2004 and 2008. The strike rates for NPIAS GA airports were distributed much more toward low numbers than those for Part 139 airports, meaning the vast majority of NPIAS GA airports (85%) reported no strikes during the past 5 years compared to 16% of Part 139 airports not reporting a strike. For damaging strikes, the distribution of rates was also different between airport categories, but the differences were not as extreme (table A-9 and figure B-8). It is notable that of the 49 reported civil aircraft destroyed or damaged beyond repair because of wildlife strikes in the U.S. from 1990-2008, 33 (67%) occurred on GA airports [12].

The comparison of strike rates between 27 Part 139 airports in 19 states (selected because they have well-established wildlife hazard management programs) and all other Part 139 airports in those states also clearly demonstrated that strike reporting varied significantly among Part 139 airports. In each of the 19 states, the mean strike rate for the selected airports was higher than in the other Part 139 airports with an overall 4.5-fold difference of 22.73 strikes per 100,000 movements (table A-10 and figure B-9). This difference is even more pronounced, but consistent, in reporting strike rates among small- and large-sized Part 139 airports. The 27 selected airports are likely more diligent overall in reporting strikes because of the established management programs in place. The 27 selected airports, in general, had higher reporting rates for damaging strikes than did the other Part 139 airports, but the overall difference was less pronounced (3.6-fold) than for all strikes (4.5-fold difference). Thus, even though fewer of the damaging strikes were reported at the other Part 139 airports (compared to the 27 selected Part 139 airports), there was more of a bias at these other airports toward reporting damaging strikes compared to nondamaging strikes.

5.3 COMPARISON OF STRIKE RATES AMONG AIR CARRIERS IN THE U.S., 2004-2008.

The pattern of disparities in reporting rates at Part 139 airports compared to NPIAS GA airports was also demonstrated when the reported strike rates were calculated for air carriers. Strike rates varied 9.5-fold among the 13 largest carriers in the U.S. and damaging strike rates varied 4.1-fold. Even more extreme differences were noted among the 35 other air carriers. These

results clearly demonstrate differences among air carriers in reporting strikes to the NWSD. The reduced disparity among carriers in damaging strike rates compared to overall strike rates indicated a bias toward reporting damaging strikes more often than nondamaging strikes for some air carriers. This bias is consistent with biases noted above in section 5.3, which compared Part 139 airports with NPIAS GA airports and 27 selected Part 139 airports with other Part 139 airports.

5.4 PERCENT OF STRIKES IN ENGINE MANUFACTURER'S DATABASE THAT ARE ALSO IN THE NWSD.

The results of this analysis supported the trends of increased strike reporting at airports from 1990-2008. Overall, the percentage of strikes in the engine manufacturer's database that were also reported to the NWSD doubled from 43% in 1990-1994 to 83% in 2004-2008 (table A-14). The mean strike rate for Part 139 airports during 2004-2008 was about 3.2 times higher than the rate measured in 1990-1994 (table A-4 and figure B-3).

5.5 PERCENT OF REPORTED WILDLIFE STRIKES THAT IDENTIFY THE SPECIES STRUCK.

In 1999, the FAA funded a program at the Smithsonian Institution to identify bird strike remains for civil aviation [53 and 54]. This program has played a critical role in improving species identification. The annual 8-hour recurrent training sessions for airport personnel in which strike reporting is covered and the increased use of professionally trained biologists at airports in recent years (e.g., reference 43) also contributed to this positive trend.

6. CONCLUSIONS AND RECOMMENDATIONS.

Overall, the Federal Aviation Administration (FAA) National Wildlife Strike Database (NWSD) is providing very useful information regarding the characteristics and magnitude of the wildlife strike problem in the U.S. Numerous publications, reports, and documents have used data from the NWSD as supportive information for a wide range of analyses, assessments, management plans, policy developments, public education, and news media reports regarding wildlife strikes.

Based on the analyses presented in this report regarding trends and characteristics of strike reporting under the current voluntary system, the following conclusions were reached.

- Overall trends in the reporting of strikes are significantly positive; numbers and rates of strikes being reported for Title 14 Code of Federal Regulations (CFR) Part 139 airports are at least three times higher in 2004-2008 compared to 1990-1994. The quality of data being reported is also steadily improving as demonstrated by the fact that the percentage of reported bird strikes that include species identification has tripled.

- There is a wide disparity in overall reporting rates between 14 CFR Part 139 airports and National Plan of Integrated Airport Systems (NPIAS) general aviation (GA) airports. Less than 6% of total strike reports come from NPIAS GA airports and reporting rates

average less than 1/20 the rates at 14 CFR Part 139 airports. From 2004-2008, 2170 (85%) of the 2560 NPIAS GA airports did not have a single strike reported.

- Although overall reporting rates are much higher for strikes at Part 139 airports than at NPIAS GA airports, there is also a major disparity in reporting rates among Part 139 airports. Larger Part 139 airports, especially those that have well-established wildlife hazard management programs, have reporting rates about four times higher, on average, compared to other Part 139 airports from 2004-2008. There are 84 Part 139 airports that did not have a single strike report from 2004-2008. Based on the assumption that reported strike rates at 27 selected Part 139 airports is representative of the actual strike rates at Part 139 airports nationwide, it is estimated that about 39% of the strikes at all Part 139 airports were reported between 2004 and 2008.

- The pattern of disparity in reporting rates among Part 139 airports is also found in reporting rates for commercial air carriers. Reporting rates varied by a factor of 9 for the 13 largest carriers and by an even greater amount for 35 smaller carriers between 2004 and 2008.

- There is an overall bias toward the reporting of damaging strikes compared to nondamaging strikes, especially for NPIAS GA airports and certain Part 139 airports. At Part 139 airports, there is an overall continued increase in both the numbers and rates for all reported strikes. In contrast, there is a decline, or stabilization, in the numbers and rates for reported damaging strikes since 2000. These opposing trends indicate that the many wildlife hazard management programs implemented or enhanced at Part 139 airports in recent years are showing success in mitigating some of the risk caused by the more hazardous species (i.e., those species most likely to cause damage). The airports implementing these programs are also doing a better job of reporting all strikes, thus generating the overall increase in reporting rates.

- The current overall reporting rate of 39% is adequate to track national trends in wildlife strikes, to determine the hazard level of wildlife species that are being struck, and to provide a scientific foundation for FAA policies and guidance regarding the mitigation of risk from wildlife strikes. This is based on the following findings:

  - There is a significant positive trend observed in overall strike reporting from 1990 to 2008.

  - There has been a decline, or stabilization, in reporting of damaging strikes since 2000.

  - Professionally run wildlife hazard programs have been implemented at many Part 139 airports throughout the U.S. and are reporting all known strikes.

  - There has been a significant improvement in species identification since 2000 exhibited in the fact that the database, presently, is capturing over 7500 strike events per year involving over 240 species of birds and other wildlife.

- The major deficiency in the database at this time is the lack of full participation in reporting strikes to the NWSD by some airports and air carriers. Increased reporting by these entities is primarily needed to enable airports where these strikes are occurring to define their local wildlife issues and to develop species-specific wildlife hazard management plans as part of their Safety Management Systems.

The recommendations from this study are:

- Improve reporting rates for those Part 139 airports that do not fully participate in the strike reporting program. This may be accomplished by directed efforts through education, training, and leverage contained within existing Part 139 regulations and FAA Advisory Circulars. Reported strike data are essential for incorporating wildlife risk mitigation into an airport's Safety Management Systems.

- Emphasize the importance of reporting strikes to the NWSD for air carriers that do not fully participate in the reporting program. This will improve the ability of airports where these strikes occur to more effectively develop programs to mitigate the risk.
- Encourage air carriers to report off-airport strikes in departure and arrival paths to the NWSD. Such reports can be critical in helping airports work with local governments to minimize wildlife attractants near airports.

- Address the major deficiency in reporting rates for NPIAS GA and other GA airports.

- Maintain the reporting system as a voluntary program. Mandatory reporting is not recommended at this time to achieve the objectives of the database. The database appears to be adequate for defining the overall national problem, identifying the species posing the greatest and least hazards, and measuring national and regional trends in strikes.

- Identify new sources of strike data and methods for enhancing strike reporting.

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APPENDIX A—TABLES

Table A-1. Number of Reported Wildlife Strikes to Civil Aircraft by Wildlife Group (See figure B-1.)

Year	Birds	Bats	Terrestrial Mammals[b]	Reptiles[b]	Total	Strikes With Reported Damage
1990	1,738	4	17	0	1,759	340
1991	2,252	3	36	0	2,291	381
1992	2,351	2	56	1	2,410	353
1993	2,395	6	53	0	2,454	386
1994	2,459	2	73	1	2,535	453
1995	2,643	5	69	8	2,725	486
1996	2,840	1	91	3	2,935	504
1997	3,351	1	92	14	3,458	578
1998	3,656	3	105	7	3,771	586
1999	5,001	7	89	1	5,098	697
2000	5,873	16	120	3	6,012	762
2001	5,647	8	137	8	5,801	644
2002	6,047	19	116	15	6,197	668
2003	5,853	20	124	5	6,003	629
2004	6,399	27	118	6	6,550	613
2005	7,076	27	130	7	7,240	607
2006	7,042	49	140	9	7,240	593
2007	7,507	53	167	7	7,734	560
2008	7,286	46	179	5	7,516	512
Total	87,416	299	1912	100	89,727	10,352

[a] Wildlife strike data are from the FAA National Wildlife Strike Database (NWSD) [A-1].
[b] For terrestrial mammals and reptiles, species with body masses <1 kilogram (2.2 lb) are excluded from the NWSD [A-2].

Table A-2. Number of Airports, by Type, With at Least one Reported Wildlife Strike With Civil Aircraft (See figures B-2, B-3, and B-4.)

Year	Part 139 Certificated	General Aviation Airports			All U.S. Airports	Foreign Airports[b]	All Airports
		Airports in NPIAS	Airports not in NPIAS	Total GA Airports			
1990	234	66	8	74	308	27	335
1991	260	72	10	82	342	27	369
1992	256	77	17	94	350	20	370
1993	259	69	15	84	343	18	361
1994	273	76	16	92	365	22	387
1995	262	94	13	107	369	31	400
1996	266	82	22	104	370	33	403
1997	289	94	22	116	405	42	447
1998	293	116	23	139	432	43	475
1999	307	109	28	137	444	57	501
2000	318	120	23	143	461	64	525
2001	321	118	24	142	463	49	512
2002	312	127	18	145	457	64	521
2003	308	123	20	143	451	67	518
2004	312	146	14	160	472	66	538
2005	326	152	16	168	494	79	573
2006	322	126	11	137	459	69	528
2007	330	139	14	153	483	72	555
2008	333	131	21	152	485	80	565
Total	521[a]	699	233	932	1453	215	1668

[a] There are about 3393 airports in the NPIAS of which 552 are certificated under Part 139. Thus, there are 2841 non-Part 139-certificated GA airports in the NPIAS.
[b] Only foreign airports where a U.S.-based carrier was involved in the wildlife strike.

Table A-3. Number of Reported Wildlife Strikes With Civil Aircraft at Different Airport Types

Year	Part 139 Certificated	General Aviation Airports			All U.S. Airports	Foreign Airports	All Airports
		Airports in NPIAS[b]	Airports not in NPIAS	Total GA Airports			
1990	1,453	116	14	130	1,583	34	1,617
1991	1,940	134	12	146	2,086	37	2,123
1992	2,076	157	23	180	2,256	36	2,292
1993	2,145	154	19	173	2,318	33	2,351
1994	2,197	160	18	178	2,375	34	2,409
1995	2,307	177	16	193	2,500	44	2,544
1996	2,514	159	23	182	2,696	50	2,746
1997	2,922	156	31	187	3,109	69	3,178
1998	3,198	215	41	256	3,454	69	3,523
1999	3,820	201	43	244	4,064	97	4,161
2000	4,513	212	32	244	4,757	129	4,886
2001	4,427	247	31	278	4,705	124	4,829
2002	4,768	262	23	285	5,053	140	5,193
2003	4,677	288	22	310	4,987	142	5,129
2004	5,221	282	16	298	5,519	158	5,677
2005	5,515	299	19	318	5,833	181	6,014
2006	5,932	245	13	258	6,190	159	6,349
2007	6,559	289	15	304	6,863	142	7,005
2008	6,556	256	22	278	6,834	169	7,003
Total	72,740	4009	433	4442	77,182	1847	79,029[a]

[a] In addition, 10,687 strikes were reported in which the aircraft was en-route or the airport where the strike took place could not be determined with certainty and 11 strikes were reported at 8 private (no FAA identifier code) airfields.

[b] There are approximately 3393 airports in the NPIAS [A-3] of which 552 are certificated under Part 139. Thus, there are 2841 non-Part 139-certificated GA airports in the NPIAS.

Table A-4. Comparison of Mean (Standard Deviation) Reported Wildlife Strikes per 100,000 Aircraft Movements for Part 139 and NPIAS GA Airports[a] (See figure B-5.)

Year	Part 139 Airports[b]			General Aviation (NPIAS) Airports[b]			Strike Rate Ratio: Part 139/ GA Airports
	No. of Airports in Sample	No. (%) of Airports Reporting ≥1 Strike	Mean (SD) Reported Strike Rate	No. of Airports in Sample	No. (%) of Airports Reporting ≥1 Strike	Mean (SD) Reported Strike Rate	
1990	508	229	2.41 (7.10)	1847	59	0.11 (1.05)	21.9
1991	508	250	2.72 (7.10)	1847	62	0.10 (0.83)	28.1
1992	509	248	2.64 (4.52)	1847	68	0.12 (1.07)	22.0
1993	509	252	2.75 (5.50)	1827	60	0.12 (1.17)	23.0
1994	512	267	2.76 (4.43)	1834	70	0.13 (1.20)	20.5
1995	513	257	2.85 (5.66)	1855	85	0.19 (1.56)	14.9
1996	517	263	3.24 (6.69)	2186	74	0.10 (0.87)	31.9
1997	518	282	3.85 (9.17)	2193	85	0.22 (2.06)	17.3
1998	519	286	4.11 (8.03)	2322	105	0.20 (1.58)	20.6
1999	519	300	4.38 (7.09)	2329	106	0.17 (1.44)	25.6
2000	520	308	5.04 (10.16)	2432	118	0.22 (1.80)	23.2
2001	520	311	5.75 (15.47)	2506	117	0.16 (1.01)	36.0
2002	520	305	5.57 (9.42)	2513	122	0.30 (2.98)	18.5
2003	520	300	5.74 (10.64)	2512	121	0.26 (2.26)	21.8
2004	522	304	6.49 (10.83)	2518	144	0.36 (3.30)	17.8
2005	521	320	7.57 (16.45)	2531	150	0.38 (2.75)	19.8
2006	520	314	8.10 (14.67)	2538	125	0.28 (3.26)	29.3
2007	522	318	8.97 (14.54)	2543	137	0.32 (3.13)	28.0
2008	522	322	10.34 (23.83)	2542	129	0.22 (2.02)	46.7
Total	522	494	5.03 (11.44)	2599	657	0.22 (2.12)	23.1

[a] Wildlife strike data are from the FAA NWSD [A-1]. Strike rates are based on number of strikes reported for all civil aircraft per 100,000 movements for air carrier/air taxi (AC/AT) and general aviation (GA) aircraft combined. Strikes in which the type of aircraft (AC/AT or GA) were unknown (primarily carcasses found on runway that showed evidence of being struck but were not reported) were included in the analysis. Commercial and GA movement data are from the FAA TAF system [A-4].

[b] Of the 552 Part 139-certificated airports [A-3], 13 airports were inactive and 16 airports with <10,000 commercial movements were excluded from the analysis. Of the 2839 GA airports in FAA TAF system, 279 with <10,000 movements (1990-2008), were excluded from the analysis.

Table A-5. Comparison of Mean (Standard Deviation) Reported Damaging Wildlife Strikes per 100,000 Aircraft Movements for Part 139 and NPIAS GA Airports[a] (See figure B-5.)

Year	Part 139 Airports[b]			General Aviation (NPIAS) Airports[b]			Damaging Strike Rate Ratio: Part 139/GA Airports
	No. of Airports in Sample	No. of Airports Reporting ≥1 Damaging Strike	Mean (SD) Reported Damaging Strike Rate	No. of Airports in Sample	No. (%) of Airports Reporting ≥1 Damaging Strike	Mean (SD) Reported Damaging Strike Rate[c]	
1990	508	112	0.57 (6.00)	1847	32	0.06 (0.93)	9.3
1991	508	121	0.60 (6.01)	1847	36	0.05 (0.67)	11.7
1992	509	120	0.39 (1.43)	1847	40	0.07 (0.96)	5.3
1993	509	132	0.57 (3.52)	1827	36	0.06 (0.70)	9.6
1994	512	143	0.47 (1.13)	1834	42	0.09 (1.12)	5.2
1995	513	142	0.44 (1.11)	1855	48	0.13 (1.45)	3.5
1996	517	138	0.49 (1.78)	2186	45	0.06 (0.77)	7.8
1997	518	152	0.55 (1.51)	2193	43	0.14 (1.66)	3.9
1998	519	146	0.54 (1.33)	2322	60	0.13 (1.29)	4.2
1999	519	161	0.52 (1.18)	2329	62	0.10 (1.29)	5.0
2000	520	183	0.75 (1.99)	2432	67	0.14 (1.65)	5.5
2001	520	138	0.50 (1.26)	2506	61	0.07 (0.62)	7.3
2002	520	151	0.52 (1.24)	2513	56	0.15 (2.15)	3.4
2003	520	150	0.60 (1.41)	2512	64	0.11 (1.47)	5.4
2004	522	147	0.54 (1.48)	2518	72	0.13 (2.18)	4.2
2005	521	147	0.94 (6.35)	2531	79	0.23 (2.39)	4.0
2006	520	142	0.54 (1.47)	2538	57	0.10 (1.10)	5.4
2007	522	143	0.51 (1.08)	2543	70	0.18 (2.44)	2.7
2008	522	138	0.77 (5.98)	2542	58	0.10 (1.65)	8.0
Total	522	426	0.57 (3.14)	2599	517	0.11 (1.55)	5.0

[a] Wildlife strike data are from the FAA NWSD [A-1]. Strike rates are based on the number of strikes reported for all civil aircraft per 100,000 movements for AC/AT and GA aircraft combined. Strikes in which the type of aircraft (AC/AT or GA) were unknown (primarily, carcasses found on a runway that showed evidence of being struck but were not reported) were included in the analysis. Commercial and GA movement data are from the FAA TAF system [A-4].

[b] Of the 552 Part 139-certificated airports [A-3] 13 airports were inactive and 16 airports with <10,000 commercial movements were excluded from the analysis. Of the 2839 GA airports in the FAA TAF system, 279 with <10,000 movements were excluded from the analysis.

Table A-6. Comparison of Total Mean (Standard Deviation) Reported Wildlife Strikes per 100,000 Aircraft Movements for Part 139 and NPIAS GA Airports by AC/AT and GA Aircraft[a] (See figure B-6.)

Type of Airport[c]	Type of Aircraft	Number of Airports	Mean Number of Reported Strikes per 100,000 Movements[b]	
			All Strikes	Strikes With Damage
Part 139 certificated	AC/AT	522	8.11	1.10
NPIAS GA	GA	2560	0.17	0.11
Ratio of strike rates = AC/AT/GA			47.1	9.7
Part 139 certificated	AC/AT	522	8.12	1.10
Part 139 certificated	GA	522	1.60	0.31
Ratio of strike rates = AC/AT/GA			5.1	3.4

[a] Wildlife strike data are from the FAA NWSD [A-1]. Strikes in which the type of aircraft AC/AT or GA were unknown (primarily, carcasses found on a runway that showed evidence of being struck but were not reported) were excluded from analysis because the strike rates were calculated for AC/AT and GA aircraft separately. Commercial and GA movement data are from the FAA TAF system [A-4].

[b] Strike rates for AC/AT and GA aircraft are based on the number of strikes per 100,000 movements for AC/AT and GA aircraft, respectively.

[c] Of the 552 Part 139-certificated airports [A-3], 13 airports were inactive and 16 airports with <10,000 commercial movements (1990-2008) were excluded from the analysis. Of the 2839 GA airports in the FAA TAF system, 279 with <10,000 movements (1990-2008) were excluded from the analysis.

Table A-7. Comparison of Mean (Standard Deviation) Reported Wildlife Strikes per 100,000 Aircraft Movements for Part 139 and NPIAS GA Airports Between 2004 and 2008[a] (See figure B-7.)

Mean Aircraft Movements/Year (2004-2008)	Part 139 Airports[b]		General Aviation Airports[b]		Strike Rate Ratio: Part 139/GA Airports
	No. of Airports in Sample	Mean (SD) Reported Strike Rate	No. of Airports in Sample	Mean (SD) Reported Strike Rate	
<50,000	253	4.43 (9.23)	2254	0.26 (1.62)	16.9
50,001-100,000	133	8.41 (10.73)	212	0.47 (1.03)	17.8
100,001-150,000	58	11.26 (12.99)	60	0.79 (1.41)	14.3
150,001-200,000	19	17.65 (23.59)	20	0.86 (1.53)	20.6
>200,000	59	16.10 (10.92)	14	1.27 (1.38)	12.7
All airports	522	8.00 (11.81)	2560	0.30 (1.58)	26.4

Mean Aircraft Movements/Year (2004-2008)	Part 139 Airports[b]		General Aviation Airports[b]		Damaging Strike Rate Ratio: Part 139/GA Airports
	No. of Airports in Sample	Mean (SD) Reported Damaging Strike Rate	No. of Airports in Sample	Mean (SD) Reported Damaging Strike Rate	
<50,000	253	0.51 (1.67)	2254	0.14 (0.96)	3.6
50,001-100,000	133	0.52 (0.64)	212	0.14 (0.28)	3.6
100,001-150,000	58	0.65 (0.66)	60	0.18 (0.26)	3.6
150,001-200,000	19	1.20 (2.07)	20	0.20 (0.32)	6.0
>200,000	59	0.91 (0.69)	14	0.12 (0.11)	7.3
All airports	522	0.60 (1.32)	2560	0.14 (0.91)	4.2

[a] Wildlife strike data are from the FAA NWSD [A-1]. Strike rates are based on the number of strikes reported for all civil aircraft per 100,000 movements for AC/AT and GA aircraft combined. Strikes in which the type of aircraft (AC/AT or GA) were unknown (primarily, carcasses found on the runway that showed evidence of being struck but were not reported) were included in the analysis. Commercial and GA movement data are from the FAA TAF system [A-4].

[b] Of the 552 Part 139-certificated airports [A-3], 13 airports were inactive and 16 airports with <10,000 commercial movements were excluded from the analysis. Of the 2839 GA airports in FAA TAF system, 279 with <10,000 movements were excluded from the analysis.

Table A-8. Comparison of Frequency Distribution of Mean Reported Wildlife Strikes per 100,000 Aircraft Movements for Part 139 and NPIAS GA Airports[a] (See figure B-8.)

Mean Strike Rate Category (Strikes per 100,000 Movements)	Part 139 Airports[b]		General Aviation Airports[b]	
	No. of Airports in Category	Percent of Airports in Category	No. of Airports in Category	Percent of Airports in Category
0	84	16.1	2170	84.8
>0 to 1	75	14.4	204	8.0
>1 to 2	53	10.2	84	3.3
>2 to 3	43	8.2	37	1.4
>3 to 4	35	6.7	21	0.8
>4 to 5	30	5.7	10	0.4
>5 to 6	17	3.3	10	0.4
>6 to 7	14	2.7	5	0.2
>7 to 8	12	2.3	4	0.2
>8 to 9	10	1.9	3	0.1
>9 to 10	13	2.5	2	0.1
>10	136	26.1	10	0.4
All airports	522	100	2560	100

[a] Wildlife strike data are from the FAA NWSD [A-1]. Strike rates are based on the number of strikes reported for all civil aircraft per 100,000 movements for AC/AT and GA aircraft combined. Strikes in which the type of aircraft (AC/AT or GA) were unknown (primarily, carcasses found on runway that showed evidence of being struck but were not reported) were included in the analysis. Commercial and GA movement data are from the FAA TAF system [A-4].

[b] Of the 552 Part 139-certificated airports [A-3], 13 airports were inactive and 16 airports with <10,000 commercial movements were excluded from the analysis. Of the 2839 GA airports in FAA TAF system, 279 with <10,000 movements were excluded from the analysis.

Table A-9. Comparison of Frequency Distribution of Mean Reported Damaging Wildlife Strikes per 100,000 Aircraft Movements for Part 139 and NPIAS GA Airports[a] (See figure B-8.)

Mean Damaging Strike Rate Category (Strikes per 100,000 Movements)	Part 139 Airports[b]		General Aviation Airports[b]	
	No. of Airports in Category	Percent of Airports in Category	No. of Airports in Category	Percent of Airports in Category
0	219	42.0	2302	89.9
>0 to 1	204	39.1	172	6.7
>1 to 2	74	14.2	41	1.6
>2 to 3	13	2.5	17	0.7
>3	12	2.3	28	1.1
All airports	522	100	2560	100

[a] Wildlife strike data are from the FAA NWSD [A-1]. Strike rates are based on the number of strikes reported for all civil aircraft per 100,000 movements for AC/AT and GA aircraft combined. Strikes in which the type of aircraft (AC/AT or GA) were unknown (primarily, carcasses found on runway that showed evidence of being struck but were not reported) were included in the analysis. Commercial and GA movement data are from the FAA TAF system [A-4].

[b] Of the 552 Part 139-certificated airports [A-3], 13 airports were inactive and 16 airports with <10,000 commercial movements were excluded from the analysis. Of the 2839 GA airports in FAA TAF system, 279 with <10,000 movements were excluded from the analysis.

Table A-10. Comparison of Mean Reported Wildlife Strikes per 100,000 Aircraft Movements (AC/AT and GA Aircraft) Between 27 Part 139 Airports in 19 States That had Well-Established Wildlife Hazard Mitigation Programs and all Other Part 139 Airports in Those 19 States (See figure B-9.)

State[b]	Selected Part 139 Airports[a]		All Other Part 139 Airports[a]		Strike Rate Difference: Selected Airports/All Other Airports	Strike Rate Ratio: Selected Airports/All Other Airports
	Selected Airports	Mean Reported Strike Rate	Number of Airports	Mean Reported Strike Rate		
AZ	PHX	15.83	11	2.21	13.61	7.2
CA	LAX, SMF	42.68	31	5.53	37.15	7.7
CO	DEN	43.62	14	6.49	37.14	6.7
FL	MCO, RSW	27.79	23	5.65	22.14	4.9
IL	MDW, ORD	16.99	12	9.78	7.21	1.7
MA	BOS	17.25	5	2.53	14.72	6.8
MD	BWI	25.72	2	5.54	20.19	4.6
MN	MSP	14.28	8	1.73	12.55	8.2
MO	MCI, STL	37.14	7	6.44	30.70	5.8
NJ	ACY	36.32	3	18.59	17.73	2.0
NY	JFK, LGA	27.81	20	6.82	20.99	4.1
OH	BKL, CLE	46.76	8	10.06	36.71	4.7
OK	OKC, TUL	26.86	2	2.94	23.92	9.1
OR	PDX	38.52	9	5.80	32.72	6.6
TN	MEM	45.96	6	9.77	36.18	4.7
TX	DFW	25.69	29	8.85	16.84	2.9
UT	SLC	26.56	6	0.22	26.34	121.6
VA	DCA, IAD	16.63	7	8.69	7.95	1.9
WA	SEA	14.03	11	5.94	8.09	2.4
Totals	27	29.23	214	6.50[b]	22.73	4.5

[a] The 27 selected Part 139 airports from 19 states represented 20% of the total aircraft movements at the 522 Part 139 airports used in the analysis. The other 214 Part 139 airports in the same states represented 38% of the total movements; thus, the remaining 281 airports not used in the analysis represented 42% of the movements.

[b] The remaining 281 Part 139 airports from the 31 states not used in this comparison had a mean reported strike rate of 7.11.

Table A-11. Comparison of Mean Reported Damaging Wildlife Strikes per 100,000 Aircraft Movements (AC/AT and GA Aircraft) Between 27 Part 139 Airports in 19 States That had Well-Established Wildlife Hazard Mitigation Programs and all Other Part 139 Airports in Those 19 States (See figure B-9.)

State	Selected Part 139 Airports		All Other Part 139 Airports		Damaging Strike Rate Difference: Selected Airports/All Other Airports	Damaging Strike Rate Ratio: Selected Airports/All Other Airports
	Selected Airports	Mean Reported Damaging Strike Rate	Number of Airports	Mean Reported Damaging Strike Rate		
AZ	PHX	0.18	11	0.21	-0.03	0.9
CA	LAX, SMF	4.83	31	0.45	4.38	10.8
CO	DEN	1.38	14	0.29	1.09	4.7
FL	MCO, RSW	3.33	23	0.50	2.82	6.6
IL	MDW, ORD	0.81	12	0.83	-0.02	1.0
MA	BOS	1.27	5	0.26	1.02	4.9
MD	BWI	1.26	2	0.23	1.03	5.5
MN	MSP	0.90	8	0.17	0.72	5.2
MO	MCI, STL	1.95	7	0.26	1.69	7.5
NJ	ACY	0.84	3	1.07	-0.23	0.8
NY	JFK, LGA	2.30	20	0.88	1.42	2.6
OH	BKL, CLE	1.13	8	0.37	0.76	3.1
OK	OKC, TUL	1.24	2	0.00	1.24	---
OR	PDX	2.41	9	0.39	2.02	6.2
TN	MEM	2.10	6	0.25	1.85	8.6
TX	DFW	1.00	29	0.59	0.40	1.7
UT	SLC	2.38	6	0.12	2.26	19.5
VA	DCA, IAD	0.97	7	0.67	0.31	1.5
WA	SEA	0.80	11	0.66	0.14	1.2
Totals	27	1.77	214	0.49	1.27	3.6

Table A-12. Comparison of Reported Wildlife Strikes and Reported Damaging Wildlife Strikes per 100,000 Aircraft Movements for 13 Airlines With >500,000 Aircraft Movements in the U.S. per Year (The strike rates are based on reported strikes and aircraft movements in the U.S (2004-2008).)

Airlines Ranked by Strike Rate	Aircraft Movements per Year (2004-2008)[b]	All Strikes[a]		Damaging Strikes[a]	
		Total Reported	Strike Rate	Total Reported	Damaging Strike Rate
FDX	622,200	1,861	59.82	65	2.09
UAL	1,100,638	1,791	32.55	140	2.54
SWA	2,182,744	2,866	26.26	184	1.67
NWA	961,516	814	16.93	58	1.21
U.S.	854,424	710	16.62	60	1.40
SKW	1,097,124	882	16.08	54	0.98
DAL	1,233,800	874	14.17	89	1.44
EGF	1,053,655	690	13.10	56	1.06
AAL	1,576,487	1,006	12.76	77	0.98
COM	598,316	293	9.79	22	0.74
ASQ	590,476	221	7.49	8	0.27
COA	772,418	252	6.53	27	0.70
BTA	900,931	284	6.31	23	0.51
Totals	13,544,729	12,544	18.52	863	1.27

[a]Wildlife strike data are from the FAA NWSD [A-1].
[b]Aircraft movement data was provided by the Air Transport Association.

Table A-13. Comparison of Reported Wildlife Strikes and Reported Damaging Wildlife Strikes per 100,000 Aircraft Movements for 35 Airlines With <500,000 Aircraft Movements in the U.S. per Year (The strike rates are based on reported strikes and aircraft movements in the U.S (2004-2008))

Airlines Ranked by Strike Rate	Aircraft Movements per Year (2004-2008)[b]	All Strikes[a]		Damaging Strikes[a]	
		Total Reported	Strike Rate	Total Reported	Damaging Strike Rate
UPS	256,627	1049	81.75	77	6.00
ABX	117,891	298	50.56	21	3.56
JAL	23,406	54	46.14	4	3.42
FFT	180,579	358	39.65	29	3.21
DHL	43,252	85	39.31	3	1.39
EIA	2,625	5	38.10	1	7.62
JBU	305,160	523	34.28	51	3.34
HAL	109,729	163	29.71	5	0.91
ACA	149,802	198	26.44	12	1.60
NKS	96,568	98	20.30	12	2.49
ASA	359,663	362	20.13	28	1.56
AWE	408,752	202	16.47	16	1.31
UCA	84,547	69	16.32	7	1.66
TRS	446,390	341	15.28	31	1.39
WOA	6,125	4	13.06	0	0.00
MEP	95,471	53	11.10	3	0.63
PAC	9,394	5	10.65	3	6.39
VIR	22,937	12	10.46	1	0.87
GLA	136,142	66	9.70	8	1.18
AWI	335,392	148	8.83	15	0.89
BAW	56,879	24	8.44	2	0.70
MES	347,332	144	8.29	8	0.46
JIA	229,458	95	8.28	8	0.70
CKS	7,375	3	8.14	1	2.71
CHQ	418,124	155	7.41	13	0.62
AMT	67,975	23	6.77	2	0.59
AJM	21,540	7	6.50	0	0.00
ELY	6,253	2	6.40	0	0.00
PDT	285,402	90	6.31	3	0.21
DLH	42,937	12	5.59	2	0.93
CJC	196,676	54	5.49	8	0.81
GFT	134,706	35	5.20	7	1.04
LOF	233,849	52	4.45	5	0.43
AMW	110,428	14	2.54	4	0.72
KLM	13,191	0	0.00	0	0.00
Totals	5,362,577	4803	18.48	390	1.50

[a]Wildlife strike data are from the FAA NWSD [A-1].
[b]Aircraft movement data was provided by the Air Transport Association.

Table A-14. Number of Strikes Involving Ingestion of Birds Into One or More Turbofan Engines of U.S. Air Carrier Aircraft at any Airport or Foreign Air Carrier Aircraft at U.S. Airport Reported to the Engine Manufacturer That Were Also Reported to the FAA for Inclusion in NWSD, 1990-1994 and 2004-2005

Year	No. of Strikes in Engine Manufacturer's Database	No. of Strikes in Engine Manufacturer's Database Found in FAA NWSD	Percent of Strikes in FAA NWSD
1990	63	43	68.3
1991	81	31	38.3
1992	72	18	25.0
1993	51	25	49.0
1994	32	11	34.4
1990-1994	299	128	42.8
2004	43	20	46.5
2005	60	50	83.3
2006	83	75	90.4
2007	61	57	93.4
2008	50	45	90.0
2004-2008	297	247	83.2

Table A-15. Number of Strikes Involving Birds and Civil Aircraft in Which the Birds Were Unidentified, Identified to Species Group Only (e.g., Gull, Hawk), or to Exact Species (e.g., Ring-Billed Gull, Red-Tailed Hawk) Between 1990 and 2008

Year	Total Bird Strikes Reported	Bird(s) Involved in Strike Identified to			Percent of Strikes Identified to Exact Species	No. of Different Bird Species Identified
		Unknown Species Group or Species	Species or Species Group	Exact Species Within Species Group		
1990	1,738	850	888	292	16.8	49
1991	2,252	1,167	1,085	348	15.5	53
1992	2,351	1,239	1,112	377	16.0	56
1993	2,395	1,208	1,187	439	18.3	66
1994	2,459	1,270	1,189	441	17.9	58
1995	2,643	1,473	1,170	449	17.0	64
1996	2,850	1,578	1,272	538	18.9	85
1997	3,351	1,882	1,469	731	21.8	88
1998	3,656	1,919	1,737	970	26.5	103
1999	5,001	3,308	1,693	961	19.2	108
2000	5,873	3,733	2,140	1,297	22.1	122
2001	5,647	3,468	2,179	1,406	24.9	132
2002	6,047	3,652	2,395	1,644	27.2	152
2003	5,853	3,464	2,389	1,684	28.8	165
2004	6,399	3,743	2,656	1,883	29.4	165
2005	7,076	4,169	2,907	2,186	30.9	173
2006	7,042	3,856	3,186	2,481	35.2	186
2007	7,504	3,712	3,792	2,981	39.7	201
2008	7,285	3,247	4,038	3,290	45.2	224
Total	87,422	48,938	38,484	24,398	27.9	381[a]

[a] From 1990 to 2008, 381 different species of birds were identified in strikes with civil aircraft. In addition, 8 species of bats (299 strikes), 33 species of terrestrial mammals (1912 strikes), and 7 species of reptiles (100 strikes) were identified [A-1].

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A-1. Dolbeer, R.A., Wright, S.E., and Weller, J., "Wildlife Strikes to Civil Aircraft in the United States, 1990–2008," U.S. Department of Transportation, Federal Aviation Administration, Serial Report Number 15 DOT/FAA/AS/00-6 (AAS-310), Washington, DC, 2009 (in press).

A-2. Dolbeer, R.A., Wright, S.E., and Eschenfelder, P., "Animal Ambush at the Airport: The Need to Broaden ICAO Standards for Bird Strikes to Include Terrestrial Wildlife," 27*th International Bird Strike Committee Conference*, Athens, Greece, May 2005.

A-3. FAA, "Title 14, Code of Federal Regulations (CFR), Part 139—Certification of Airports," available at http://www.faa.gov/airports/airport_safety/part 139_cert/, last visited 11/3/09.

A-4. FAA, "Terminal Area Forecast (TAF) System," available at http://aspm.faa.gov /main/taf.asp, last visited 11/30/09.

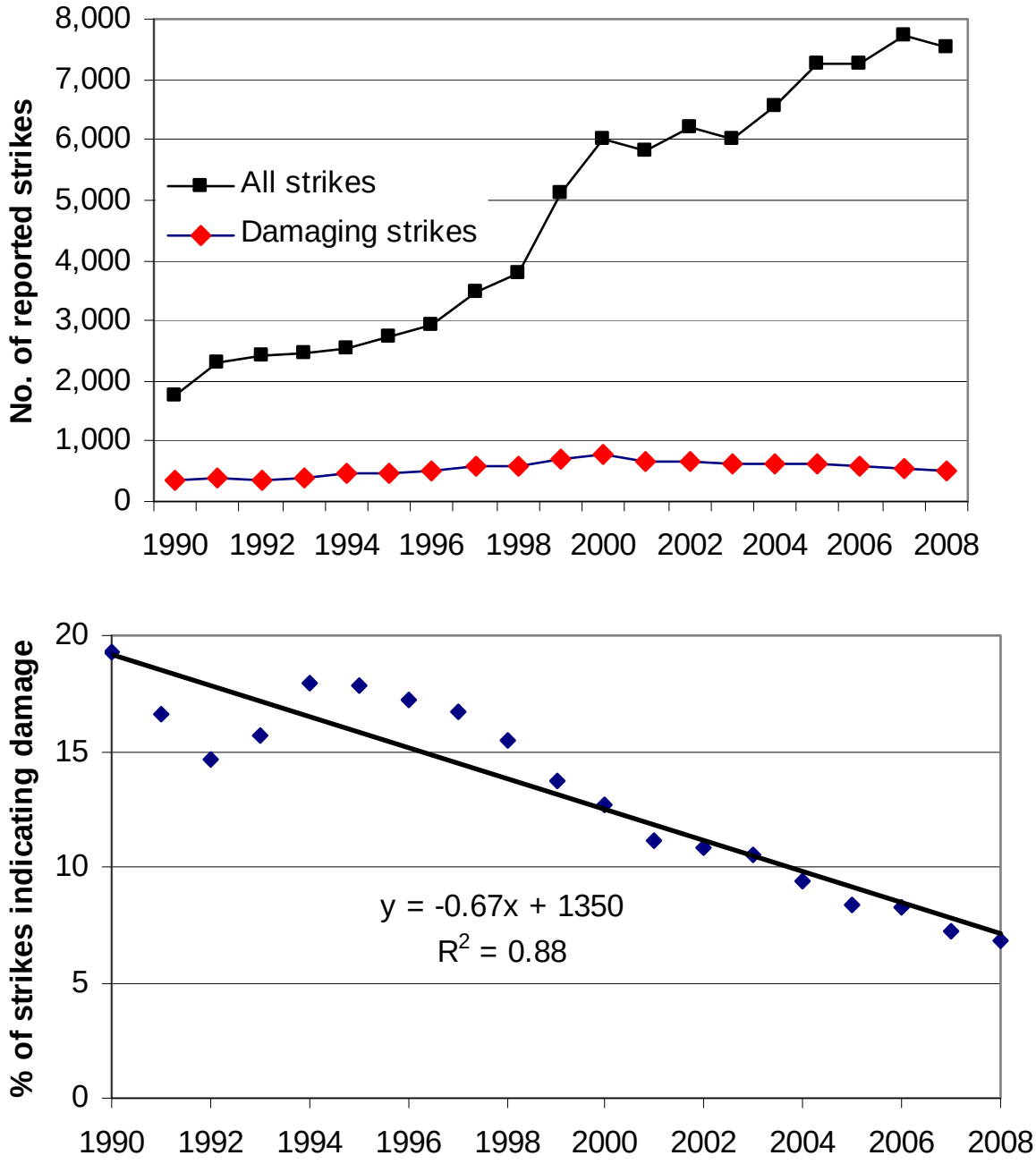


Figure B-1. Number of Reported Wildlife Strikes in the U.S. to Civil Aircraft and the Number of Strikes With Reported Damage (top) and Percent of Reported Strikes Indicating Damage (bottom) (R^2 values greater than 0.21 are significant at the 0.05 level of probability with 17 degrees of freedom [B-1].)

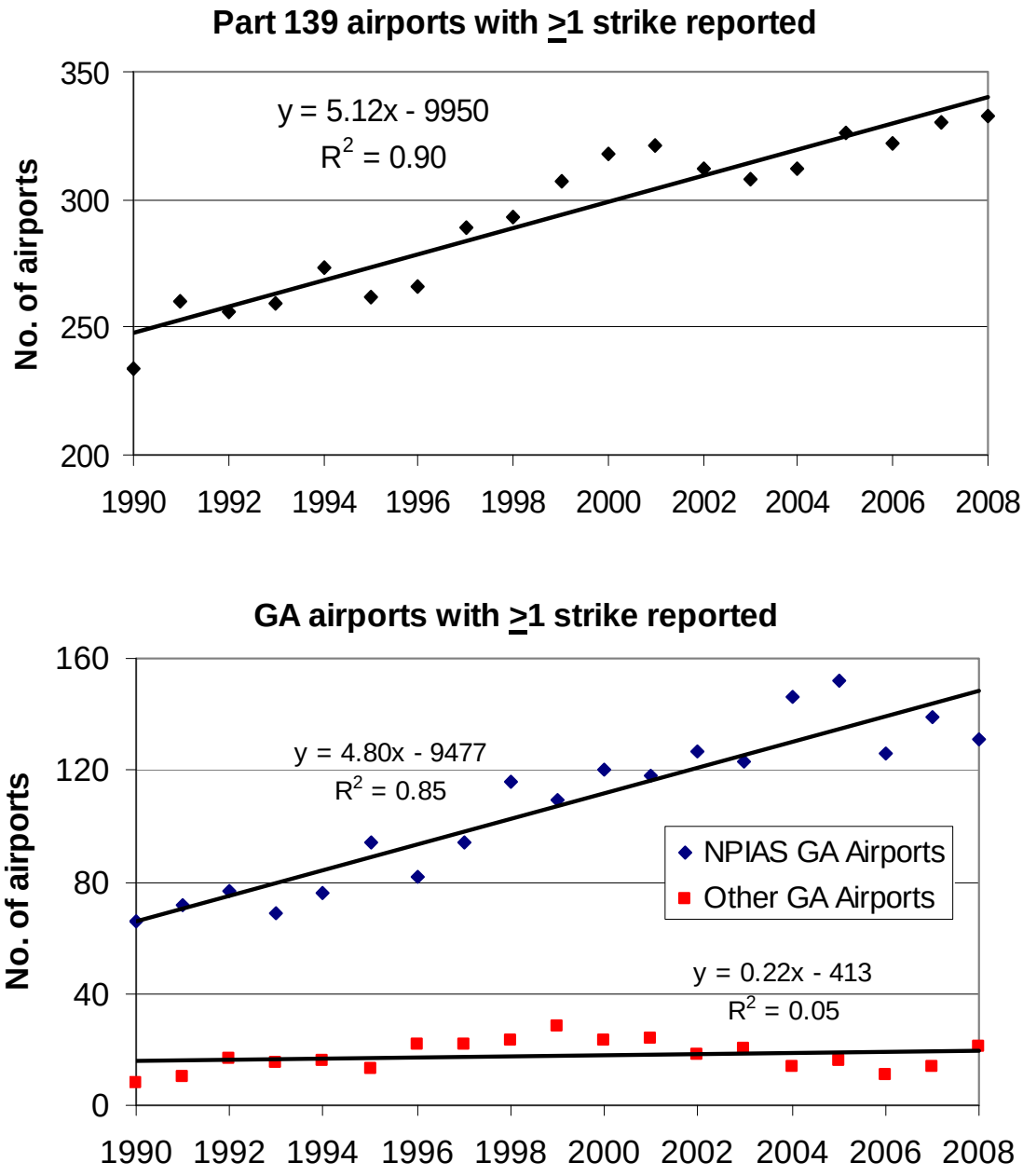


Figure B-2. Number of Airports With at Least One Reported Wildlife Strike for Part 139-Certificated Airports, National Plan of Integrated Airport Systems (NPIAS) General Aviation (GA) Airports and Non-NPIAS GA Airports (See table A-2. R^2 values greater than 0.21 are significant at the 0.05 level of probability with 17 degrees of freedom [B-1].)

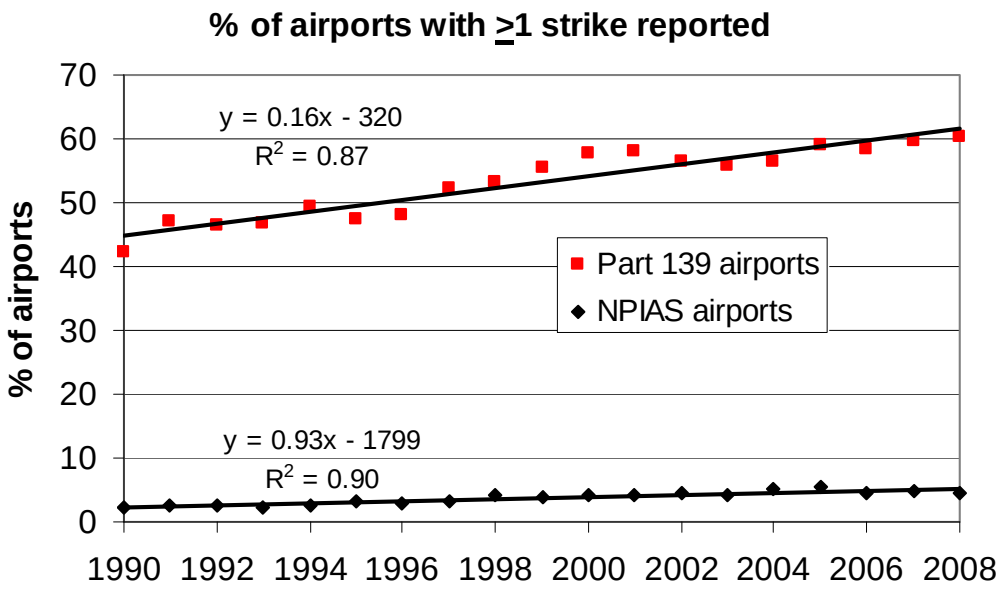


Figure B-3. Percent of Airports With at Least One Reported Wildlife Strike for the 552 Part 139-Certificated Airports and 2841 Non-Certificated NPIAS GA Airports (See table A-2. R^2 values greater than 0.21 are significant at the 0.05 level of probability with 17 degrees of freedom [B-1].)

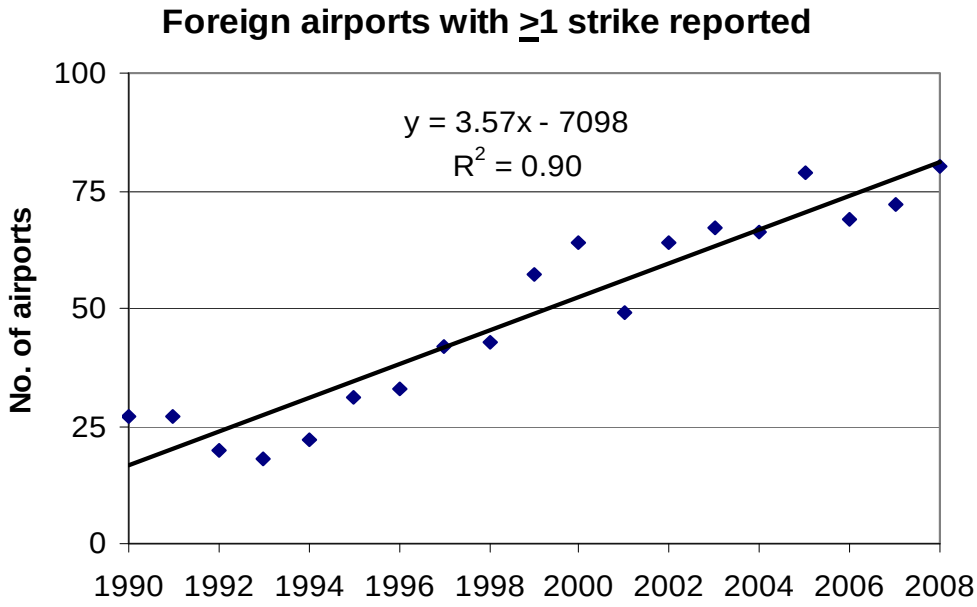


Figure B-4. Number of Foreign Airports With at Least One Reported Wildlife Strike Where U.S.-Based Carriers Were Involved in the Strike (See table A-4.)

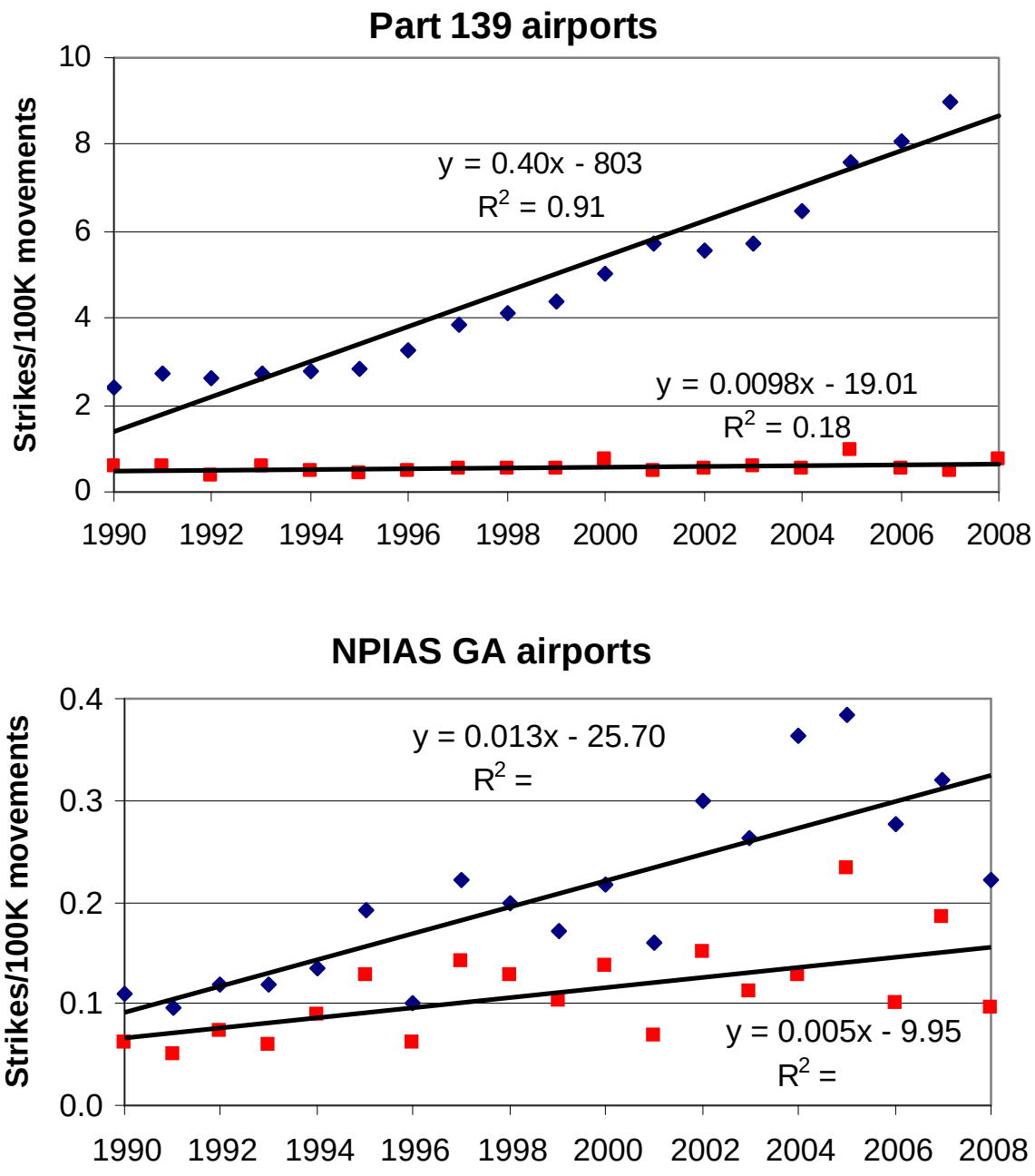


Figure B-5. Mean Strike Rates per Year (All Reported Strikes (black triangles) and Reported Damaging Strikes (red squares) per 100,000 Movements of all Air Carrier/Air Taxi (AC/AT) and GA Aircraft) for Part 139 Airports (508 to 522 per year) and NPIAS GA Airports (1848 to 2544 per year) (See tables A-4 and A-5. Note the 25-fold difference in the y-axis scale for the two graphs. R^2 values greater than 0.21 are significant at the 0.05 level of probability with 17 degrees of freedom [B-1].)

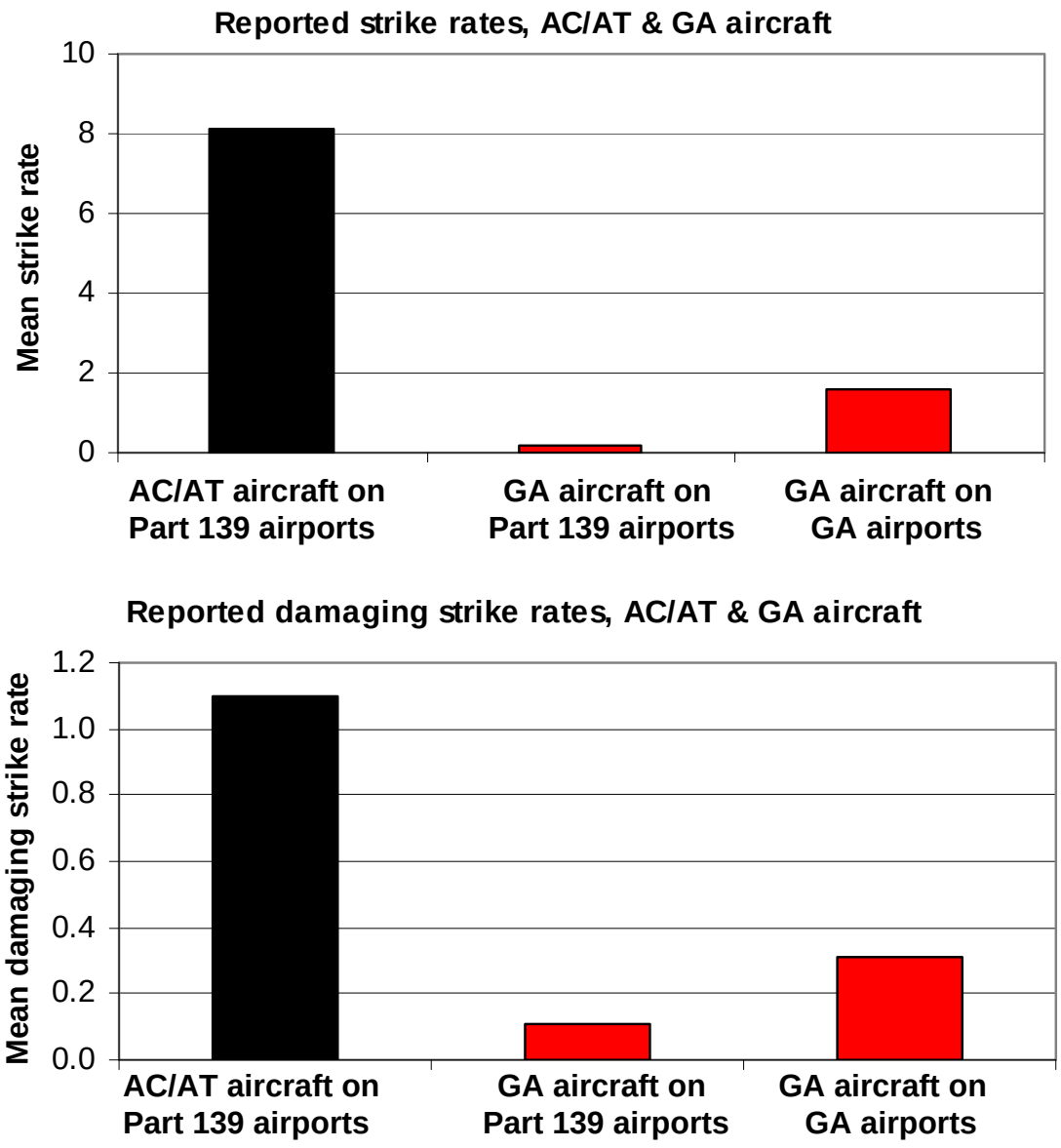


Figure B-6. Comparison of Mean Wildlife Strike Rates and Damaging Strike Rates (total number of reported strikes and damaging strikes per 100,000 aircraft movements) for Part 139-Certificated and NPIAS GA Airports in by AC/AT and GA Aircraft. (Strike rates for AC/AT and GA aircraft are based on the number of strikes per 100,000 movements for AC/AT and GA aircraft, respectively. Note 10-fold difference in the y-axis scale for the two graphs. See table A-6 for details.)

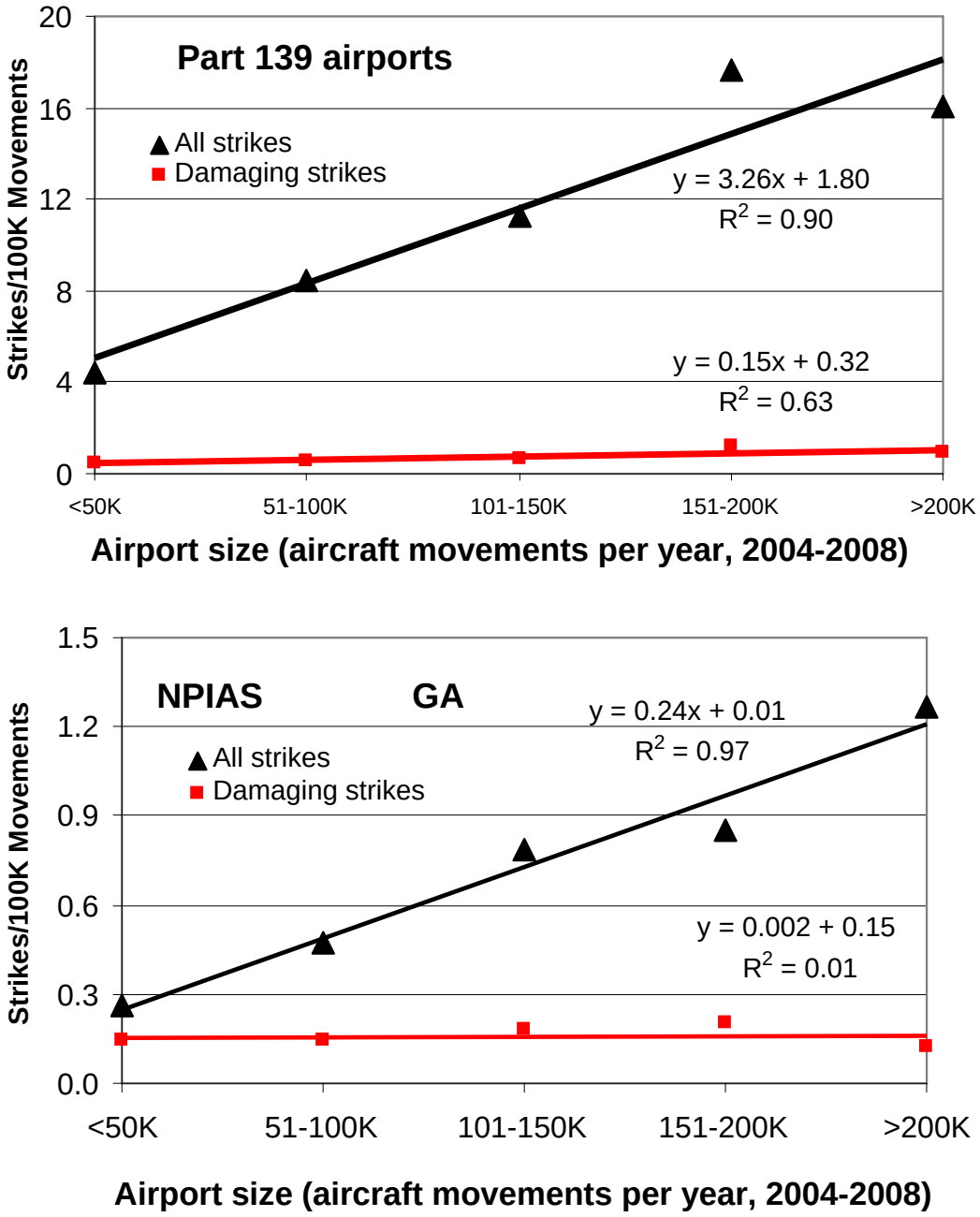
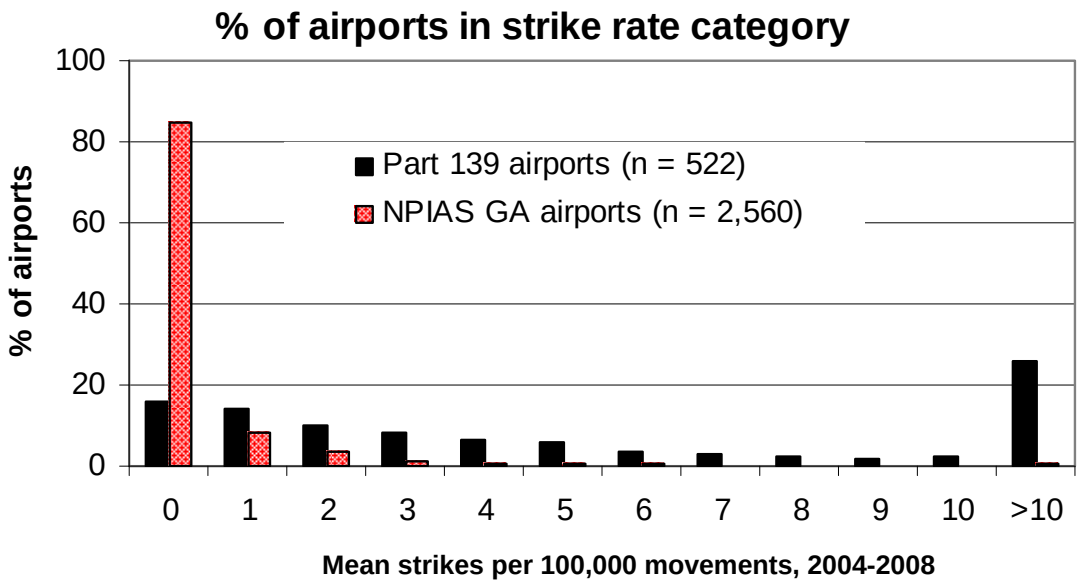


Figure B-7. Comparison of Mean Wildlife Strike Rates for AC/AT and GA Aircraft at Part 139 (top) and NPIAS GA Airports (bottom), Between 2004 and 2008. (Note the 13-fold difference in the scale between the two graphs. R^2 values greater than 0.77 are significant at the 0.05 level of probability with 3 degrees of freedom [B-1].)



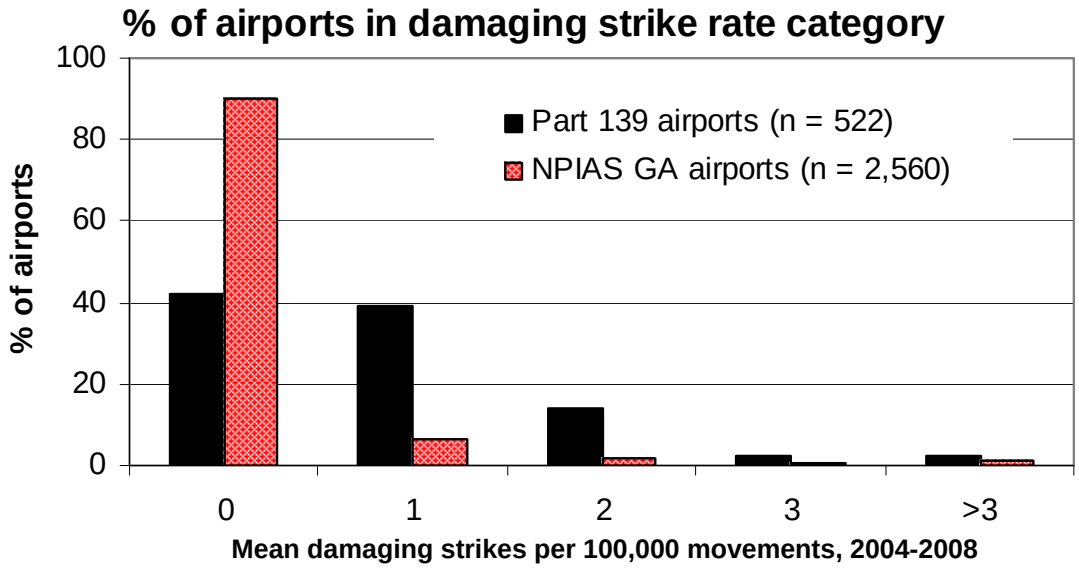


Figure B-8. Comparison of Frequency Distribution of Mean Reported Wildlife Strikes and Mean Reported Damaging Wildlife Strikes per 100,000 Aircraft Movements, Between 2004 and 2008 for Part 139 and NPIAS GA Airports (See tables A-8 and A-9 for details.)

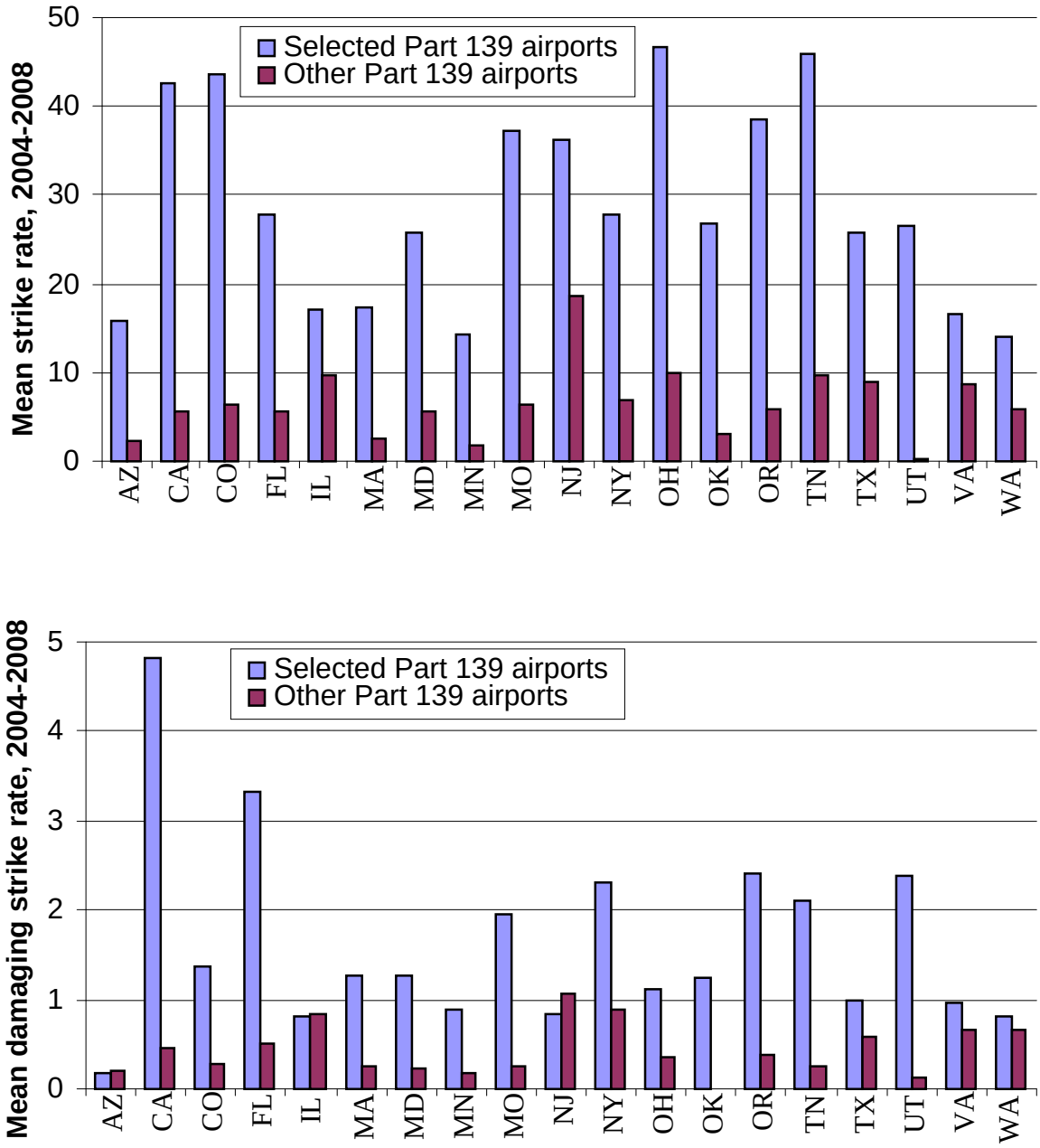


Figure B-9. Comparison of Mean Reported Wildlife Strikes and Mean Reported Damaging Wildlife Strikes per 100,000 Aircraft Movements, Between 2004 and 2008 for 27 Part 139 Airports in 19 States That had Well-Established Wildlife Hazard Mitigation Programs and all Other Part 139 Airports in Those 19 States (See tables A-10 and A-11 for details.)

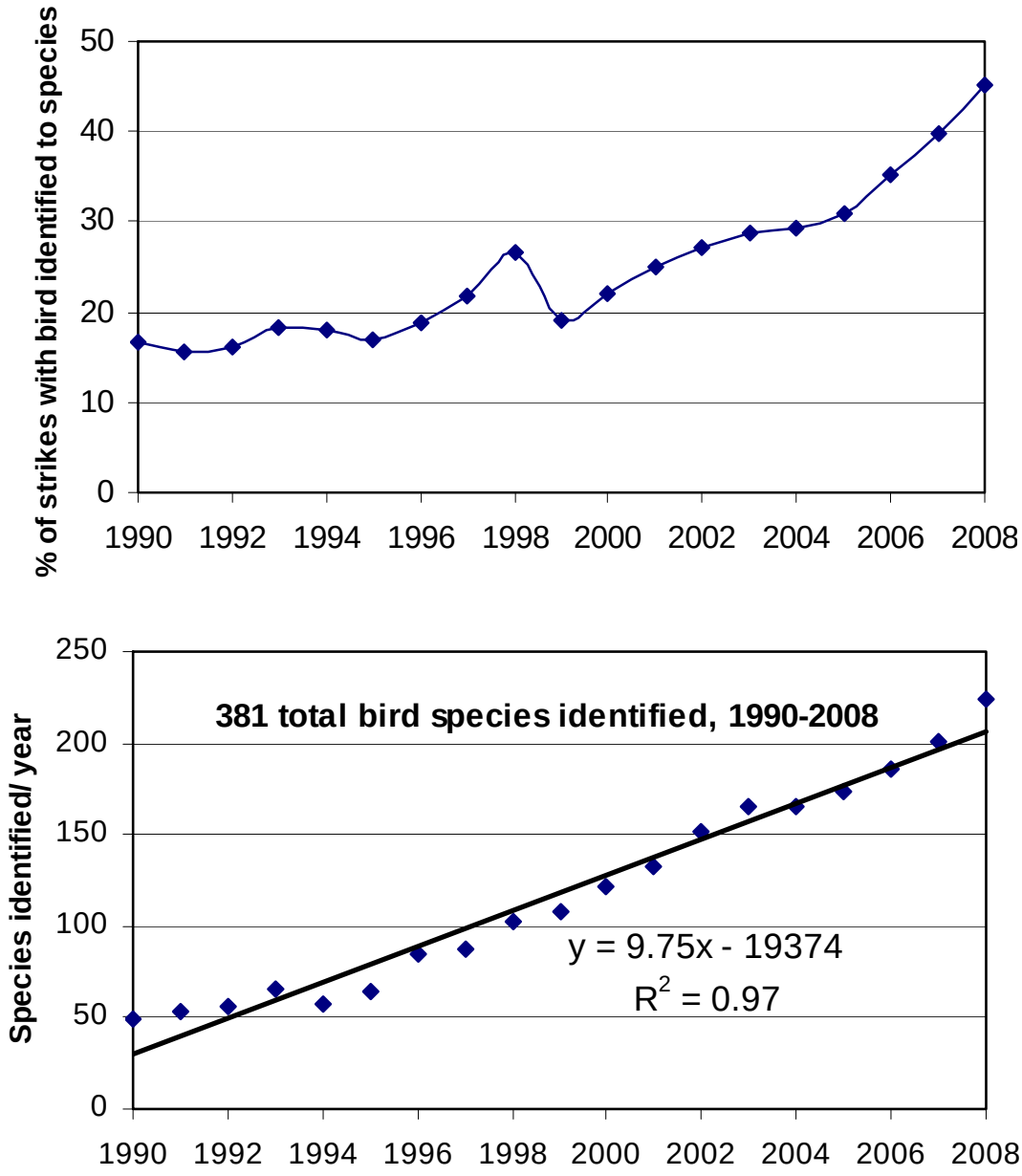


Figure B-10. Percent of Wildlife Strikes in Which the Birds Were Identified to Exact Species (N = 87,422 total strikes) and Number of Identified Bird Species Involved in Strikes Each Year (See table A-2. R^2 values greater than 0.21 are significant at the 0.05 level of probability with 17 degrees of freedom [B-1].)

REFERENCE.

B-1. Steele, R.G.D. and Torre, J.H., *Principles and Procedures of Statistics*, McGraw-Hill, New York, 1960.