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Title

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Journal

Proceedings of the Vertebrate Pest Conference, 19(19)

ISSN

0507-6773

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Publication Date

2000

DOI

10.5070/V419110122

BIRDS AND AIRCRAFT: FIGHTING FOR AIRSPACE IN CROWDED SKIES

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ABSTRACT: Birds and other wildlife such as deer (*Odocoileus* spp.) pose increasing economic and safety concerns to aviation interests in the USA. Civil aircraft collisions with wildlife (wildlife strikes) annually reported to the Federal Aviation Administration (FAA) increased from about 1,700 in 1990 to 4,500 in 1999. Waterfowl (Anatidae), gulls (*Larus* spp.), raptors (Accipitridae, Pandionidae, Cathartidae, Falconidae) and deer were involved in 80% of the reported strikes in which aircraft were damaged. Wildlife strikes caused annual losses of \$300 million to civil aviation, 1990 to 1998. The known number of civil aircraft destroyed as a result of wildlife strikes in the USA increased from four in the 1960s to 22 in the 1990s. The number of airports requesting assistance from the U.S. Department of Agriculture's Wildlife Services program increased from about 42 in 1990 to 363 in 1999. Attendance at annual Bird Strike Committee USA meetings increased from 10 people in 1990 to over 300 in 1998-1999. Four factors have synergistically interacted to increase the problem of, and interest in wildlife strikes in the past 20 years. First, populations of many species hazardous to aviation have increased and adapted to urban environments such as airports. Second, passenger enplanements and commercial air traffic (landings and takeoffs) have increased at annual rates of about 4.2% and 2.6%, respectively, from 1980 to 1998. Third, modern two-engine turbojet and turbofan aircraft are generally less apparent to birds because these aircraft are faster and quieter than older aircraft. Finally, liability issues related to wildlife strikes are increasing for airport operators and others. The National Transportation Safety Board issued nine recommendations to the FAA in November 1999 that, if implemented, should reduce the threat of wildlife strikes. These recommendations included more research in methods of repelling birds from airports, use of radar to warn pilots of bird concentrations, development of wildlife hazard management plans for airports, mandatory bird strike reporting with better identification of species which are struck, and improved interagency cooperation in issues involving aviation and wildlife.

KEY WORDS: aircraft, airport, bird strike, goose, deer, red-tailed hawk, ring-billed gull, turkey vulture

(March 6-9, 2000, San Diego, California)

Proc. 19th Vertebr. Pest Conf. (T.P. Salmon & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. 2000.

INTRODUCTION

Aircraft collisions with birds (bird strikes) have been a problem since the beginnings of powered flight in the early 1900s. Orville Wright reported striking a bird while flying near Dayton, Ohio in 1908, five years after the Wright brothers' historic first flight. In 1912, Cal Rogers, the first person to fly across the USA, became the first fatality as a result of a bird strike (Thorpe 1996). Although the problem is not new, bird and other wildlife strikes currently present unique challenges to airport operators, aeronautical engineers, and wildlife biologists because of major changes in aviation, land uses, and wildlife populations. The objectives of this paper are to: 1) provide an overview of the wildlife strike problem; 2) present data documenting why the strike problem is an increasing concern; and 3) discuss actions needed to reduce the economic and human safety impacts of strikes. The paper focuses on wildlife strike issues with civil aviation in the USA, but the conclusions are generally applicable to civil and military aviation worldwide.

WILDLIFE STRIKES: AN INCREASING PROBLEM IN USA

Increase in Reported Strikes to Civil Aircraft

The U.S. 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 U.S. Department of Agriculture's (USDA) National Wildlife Research Center, initiated a project in April 1995 to obtain more objective estimates of the magnitude and nature of the wildlife strike problem nationwide for civil aviation. This project included: 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; and 4) assisting the FAA with the production of annual reports summarizing the results of the analyses (e.g., Cleary et al. 1999). 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 justified, implemented, and defended.

The number of reported wildlife strikes to civil aircraft in the USA increased 2.6 fold from 1,729 in 1990 to about 4,500 (tentative figure) in 1999 (Figure 1). This increase was likely due to a combination of an actual increase in the number of strikes and to an increase in the reporting rate. Birds and mammals were involved in 97% and 3% of the strikes, respectively. Cleary et al. (1999) estimated that wildlife strikes cost civil aviation over \$300 million/year in the USA, 1990 to 1998.

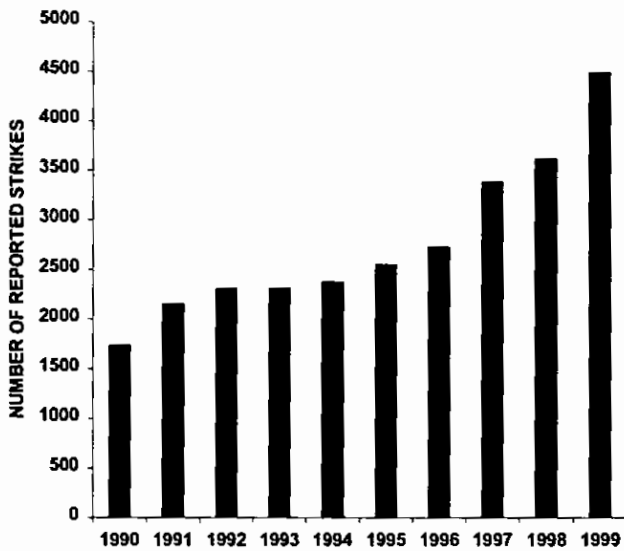


Figure 1. Number of reported bird (97%) and other wildlife (3%) strikes to civil aircraft in USA, 1990 to 1999 [from Cleary et al. 1999 (1990 to 1998) and S. E. Wright, U.S. Department of Agriculture, unpublished data (1999)].

The known number of civil aircraft destroyed as a result of wildlife strikes in the USA has increased over the past four decades, from 4 in the 1960s to 22 in the 1990s (Figure 2). The USA accounted for 67% of all known civil aircraft destroyed by wildlife strikes since 1960. Fortunately, the number of human fatalities resulting from wildlife strikes with civil aircraft has declined from the 1960s to the 1990s. In contrast, wildlife strikes with military aircraft have shown an opposite pattern from 1960 to 1999: the number of aircraft destroyed per decade has shown no trend, but the number of human deaths has increased (Figure 3).

Increase in Wildlife Biologists Working on Airports

There has been a major increase over the past decade in requests by airports for services of professional biologists trained in wildlife damage control. For example, in 1990 biologists from the USDA's Wildlife Services (WS) program provided assistance to about 42 airports nationwide in assessing wildlife hazards, developing wildlife hazard management plans, or conducting operational control programs (R. D. Owens and T. R. Hoffman, USDA, pers. commun.). In 1998 and 1999, requests for WS assistance had grown to 192 and 363 airports, respectively (Animal and Plant Health Inspection Service FY 1998 and FY 1999 Annual Program Performance Reports, Riverdale, Maryland).

Increased Attendance at Bird Strike Committee-USA Meetings

Bird Strike Committee-USA (BSC-USA) was founded in 1991 to serve as a forum for communication among the disparate groups concerned with wildlife strike issues (e.g., airport and landfill operators, pilots, aeronautical engineers, wildlife biologists, military personnel, environmentalists) in the USA. Attendance at annual

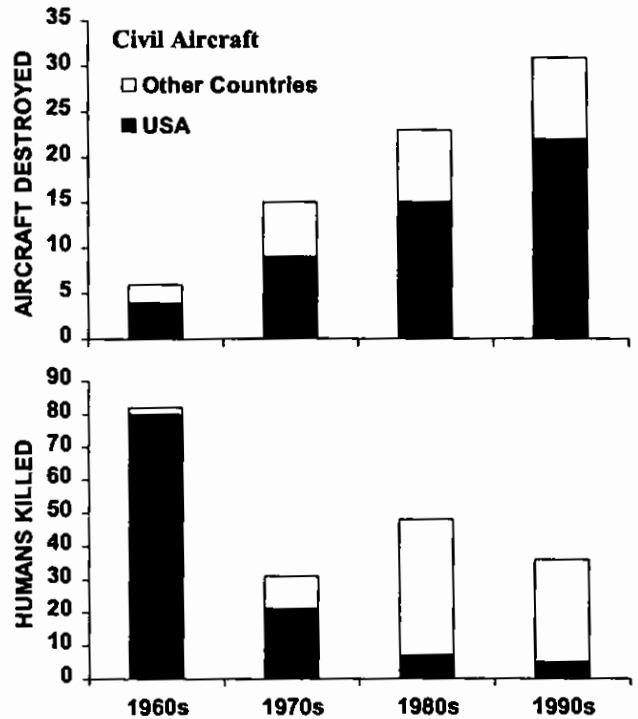


Figure 2. Minimum number of aircraft destroyed and humans killed as a result of civil aircraft collisions with birds and other wildlife, 1960 to 1999 [from Thorpe (1996, 1998), MacKinnon (1998), and S. E. Wright (U.S. Department of Agriculture, unpublished data)].

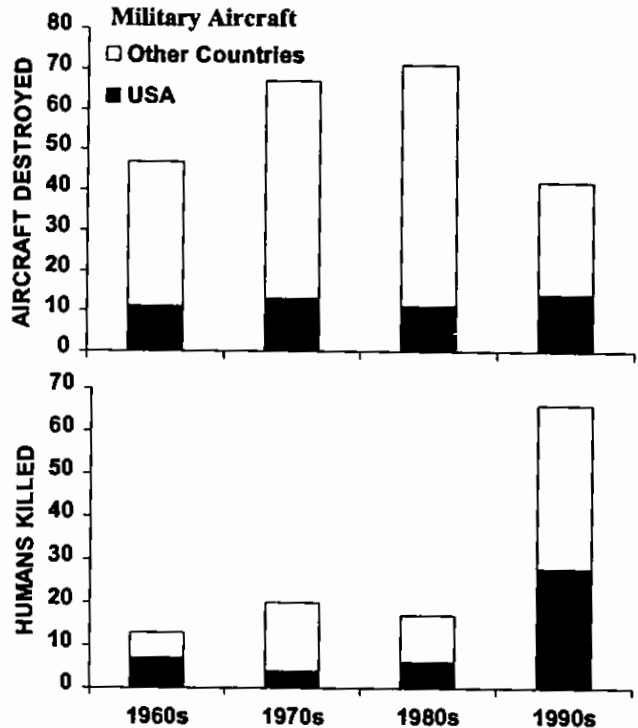


Figure 3. Minimum number of aircraft destroyed and humans killed as a result of military aircraft collisions with birds and other wildlife, 1960 to 1999 [from Richardson (1994, 1996), Satheseen (1994), and MacKinnon (1998)].

BSC-USA meetings steadily increased from 10 people in 1991 to over 300 in 1998 and 1999 (Figure 4), indicating an increased interest in the wildlife strike problem. BSC-USA and Bird Strike Committee Canada began holding a joint annual meeting in 1999.

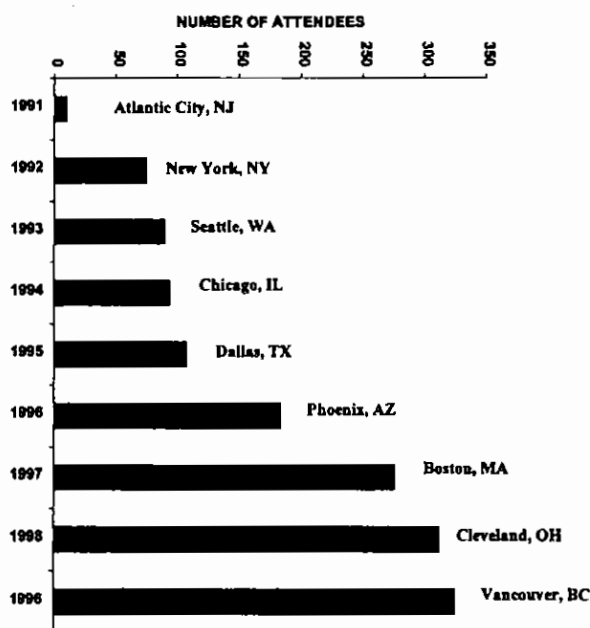


Figure 4. Number of attendees and locations for Bird Strike Committee USA Meetings, 1991 to 1999 (R. A. Dolbeer, U.S. Department of Agriculture, Unpublished Data). The 1999 meeting was held jointly with Bird Strike Committee Canada.

WHY IS THE WILDLIFE STRIKE PROBLEM INCREASING?

Four major factors have contributed to the increase in the problem of, and interest in wildlife strikes in the USA and elsewhere.

Increase in Populations of Certain Wildlife Species Hazardous to Aviation

For 1990 to 1998, waterfowl, gulls, and raptors were involved in 77% of the 1,855 identified bird strikes in which one or more aircraft components were reported damaged (Table 1). An additional 1,591 bird strikes were reported in which damage occurred, but the bird species group responsible was not identified. For mammals, ungulates (primarily deer) were involved in 96% of the strikes causing damage.

Aggressive programs by natural resource and environmental agencies and organizations during the past 50 years (e.g., pesticide regulation, expansion of wildlife refuge system), coupled with land-use changes, have resulted in dramatic increases in populations of many wildlife species in North America, especially species that are a threat to aviation (Table 1). In addition, many wildlife species such as gulls, Canada geese (*Branta canadensis*), and deer have adapted to urban and suburban environments (Dwyer et al 1996; Smith et al. 1999; Warren 1997), making the risk of wildlife strikes at airports much greater. The following examples are

presented to document increases in populations of species that are a major threat to aviation (Table 1).

Canada geese. About 90% of the 666 goose strikes reported for civil aviation in the USA, 1990 to 1998, were by Canada geese (Cleary et al. 1999). Resident or non-migratory populations of Canada geese increased ($P < 0.01$) at a mean annual rate of 13.1% in the USA, 1966 to 1998 (Figure 5). In the central USA alone, the breeding population increased from a few thousand geese in 1965 to 1.1 million in 1996 (Wood et al. 1996).

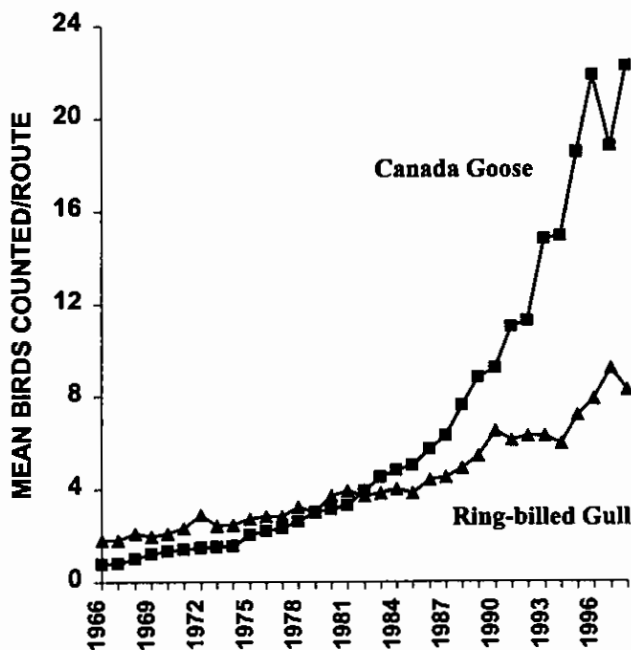


Figure 5. Mean numbers of ring-billed gulls and Canada geese recorded per North American Breeding Bird Survey route in the USA, 1966 to 1998. Ring-billed gulls and Canada geese were recorded on 350 and 894 routes, respectively (Sauer et al. 1999).

Gulls. Ring-billed gulls (*L. delawarensis*) were the most commonly struck gull species, 1990 to 1998, comprising 37% of the gull strikes for civil aviation in the USA where the species was identified (Cleary et al. 1999). The ring-billed gull population increased ($P < 0.01$) at a mean annual rate of 5.9% in the USA, 1966 to 1998 (Figure 5).

Raptors. Red-tailed hawks (*Buteo jamaicensis*) comprised 90% of the 188 identified hawks (Buteoninae and Accipitrinae) struck by civil aircraft, 1990 to 1998 (Cleary et al. 1999). An additional 395 hawks were reported struck, but not identified to species. The red-tailed hawk population increased ($P < 0.01$) at a mean annual rate of 3.1% in the USA, 1966 to 1998 (Figure 6). Turkey vultures (*Cathartes aura*) represented 93% of the 85 identified vulture strikes. An additional 128 unidentified vultures were reported struck. The turkey vulture population increased ($P < 0.01$) at a mean annual rate of 1.0% in the USA, 1966 to 1998 (Figure 6).

Table 1. Number of reported wildlife strikes and number of strikes reporting damage by various wildlife groups for civil aircraft in USA, 1990 to 1998 (from Cleary et al. 1999).

Wildlife Group	No. of Reported Strikes	No. of Strikes with Damage	% of Strikes Causing Damage
Birds			
Waterfowl	1,243	578	47
Gulls	3,222	576	18
Raptors	1,150	277	24
All other identified birds	5,215	424	8
Total identified birds	10,830	1,855	17
Total unidentified birds	11,490	1,591	14
Total birds	22,320	3,446	15
Mammals			
Ungulates	385	311	81
Carnivores	112	10	9
All other identified mammals	76	2	3
Total identified mammals	573	323	56
Total unidentified mammals	7	3	43
Total mammals	580	326	56
Reptiles	35	1	3
Grand total	22,935	3,773	16

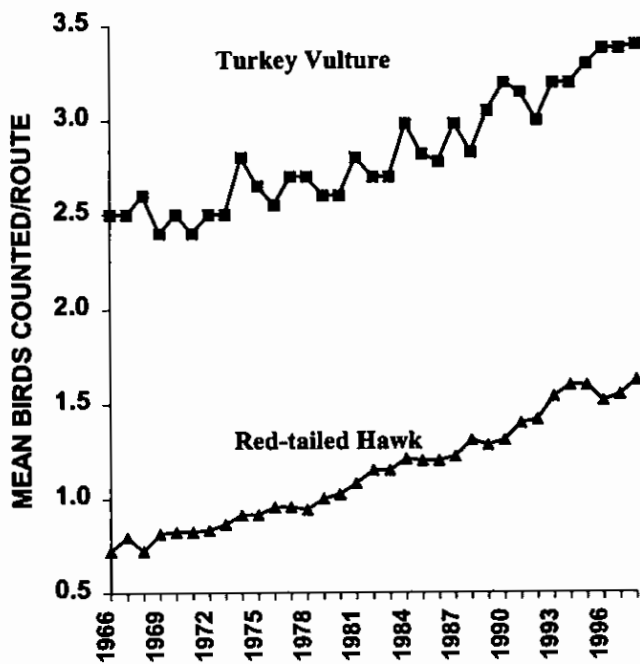


Figure 6. Mean numbers of red-tailed hawks and turkey vultures recorded per North American Breeding Bird Survey route in the USA, 1966 to 1998. Red-tailed hawks and turkey vultures were recorded on 2,371 and 1,760 routes, respectively (Sauer et al. 1999).

Deer. White-tailed deer (*O. virginianus*) comprised 93% of the 306 identified ungulates struck by civil aircraft, 1990 to 1998 (Cleary et al. 1999). An additional 79 deer were reported struck, but not identified to species. The white-tailed deer population has increased dramatically in the USA. The population, estimated at only about 350,000 in 1900, increased to perhaps 26 million in the 1990s (Jacobson and Kroll 1994). Much of this increase has occurred since 1970. For example, the white-tailed deer population in Ohio, virtually extirpated in 1940, increased slowly to about 50,000 in 1970 and to 550,000 in 1996 (Iverson and Iverson 1999).

Increase in Air Traffic

Air passenger and cargo traffic have increased dramatically since 1980 in the USA. Passenger enplanements on commercial aircraft increased 110% from about 305 million passengers in 1980 to 680 million in 1998, a mean annual increase of 4.2% (Figure 7). Commercial air traffic increased 58% from 17.8 million movements in 1980 to 28 million movements in 1998, a mean annual increase of 2.6% (Figure 7). Continued increases at current levels of growth are projected for both passenger enplanements and commercial aircraft movements through 2005.

Changes in Types of Aircraft

In addition to the rapid growth of air traffic, changes in the types of commercial aircraft are influencing the frequency of wildlife strikes and the potential consequences of those strikes. Modern turbojet- and

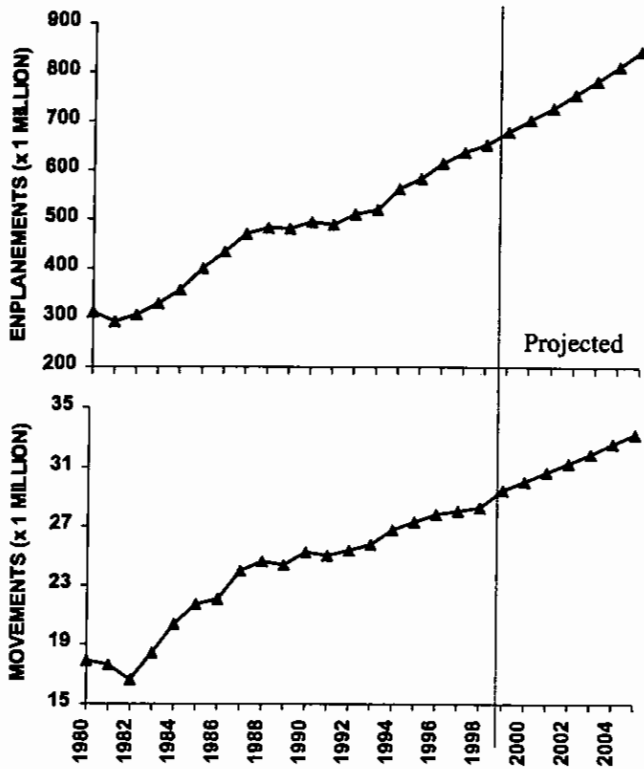


Figure 7. Commercial air traffic activity (movement=arrival or departure) and number of passenger enplanements in the USA, 1980 to 1998, and projected numbers for 1999 to 2005. The number of movements increased by 58% (10.4 million) from 1980 to 1998 or 2.6%/year. During the same time, the number of enplanements increased by 110% (342 million) or 4.2%/year (from FAA 1999).

turbofan-powered aircraft are quieter (in front of the aircraft) and faster than older propeller- and turboprop-powered aircraft. Thus, birds and other wildlife in an airport environment are less likely to detect modern aircraft in time to avoid collisions, and the higher speed of the aircraft makes the probability of damage greater (Buurma and Dekker 1996), compared to older aircraft. Furthermore, multiple-engine damage from the ingestion of flocks of birds is of particular concern as two-engine passenger and cargo aircraft replace older three- and four-engine aircraft in the USA fleet. In 1969, 75% of the 2,100 large commercial aircraft in the USA had three or four engines and 25% had two engines. This ratio had reversed in 2000, with about 72% of the fleet of 5,300 aircraft having only two engines. Over 81% of the USA fleet of 7,200 aircraft in 2010 are forecast to have two-engines (Figure 8). Curtis (1999), in a statistical analysis of past wildlife strike events and projected air traffic growth, concluded there was a 25% probability for the loss of a large commercial jetliner to a bird strike in North America over the next ten years.

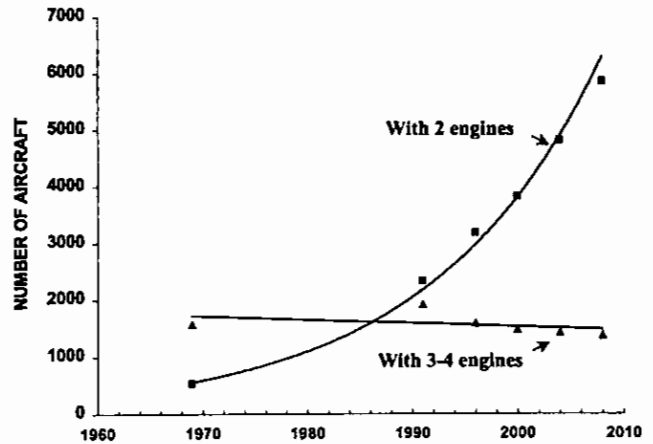


Figure 8. Number of USA-registered commercial aircraft with two engines and three to four engines, 1969 to 1998 and projected numbers, 1999 to 2010 [From J. Goglia (National Transportation Safety Board, Personnel Communication) and Lampi (1998)].

Liability Issues

A final factor that has increased interest in reducing wildlife strikes is the growing concern by airport operators and others (e.g., landfill operators near airports) over liability in the aftermath of damaging wildlife strikes (Robinson 1996). As a recent example, the Port Authority of New York and New Jersey paid Air France \$5.1 million in an out-of-court settlement in 1998 regarding damage to two engines on a Concorde that struck Canada geese during landing at John F. Kennedy International Airport in 1995 (Frank 1998). Airports with known wildlife hazards or habitats nearby that attract wildlife need to have comprehensive and professionally implemented wildlife hazard management plans in place to minimize liability exposure in the aftermath of wildlife strikes.

ACTIONS NEEDED TO REDUCE THE WILDLIFE STRIKE PROBLEM

The National Transportation Safety Board (NTSB), recognizing that wildlife strikes were an increasing concern, held accident investigation hearings in 1999 to examine the problem and make recommendations for actions to reduce damaging strikes. This investigation was precipitated by two strike incidents in February and March 1999 in which two-engine commercial jetliners encountered flocks of birds [starlings (*Sturnus vulgaris*) and snow geese (*Chen caerulescens*)] that damaged both engines on each aircraft.

The NTSB, in their final report issued 19 November 1999, made nine recommendations to the FAA (NTSB 1999). The nine recommendations were not prioritized, but presented as an integrated approach to increase aviation safety. These recommendations, summarized below, provide an excellent outline for actions needed to reduce the number and economic impact of wildlife strikes and to minimize the likelihood of the loss of a

commercial jetliner. The NTSB recommended that the FAA:

1. Evaluate the potential for using radar to provide civil Air Traffic Control personnel and flight crews with near real time warnings of bird migration and movement activity [Avian Hazard Advisory System (AHAS)] and if found feasible, implement AHAS in high-risk areas such as major hub airports and along migratory routes.
2. Coordinate with USDA to conduct research to determine the effectiveness and limitations of existing and potential bird hazard reduction techniques.
3. In consultation with USDA, require that wildlife hazard assessments be conducted at all airports certified for commercial traffic (14 Code of Federal Regulations, Part 139) where such assessments have not been done.
4. Require the development of a wildlife hazard management program for all airports determined to need one as a result of the wildlife hazard assessment proposed in recommendation #3 above.
5. Ensure that the wildlife hazard management programs are incorporated into the airport certification manuals and periodically inspect the progress of the programs.
6. Require all airplane operators to report wildlife strikes to the FAA (reports are now voluntary).
7. Contract with an appropriate agency to provide proper identification of bird strike remains [presently, about 50% of reported bird strikes do not provide any information on species struck (Cleary et al. 1999)]. Develop timely procedures for proper bird species identification and ensure that airport and aircraft maintenance employees are familiar with the procedures.
8. Before allowing high-speed, low-level aircraft operations, evaluate the potential risk of increased bird strike hazards to air carrier turbojet and turbofan aircraft.
9. With representatives from USDA, U.S. Departments of the Interior and of Defense, and the U.S. Army Corps of Engineers, convene a task force to establish a permanent bird strike working group to facilitate conflict resolution and improve communication between aviation safety agencies and wildlife conservation interests.

CONCLUSIONS

As documented above, the problem of wildlife strikes increased in the 1990s through the synergism of: 1) expanding, urban-adapted populations of wildlife hazardous to aviation; 2) increases in commercial air traffic by a growing fleet of quieter, two-engine aircraft; and 3) liability concerns by airport operators and others. The NTSB responded to this growing problem by making nine recommendations to the FAA in 1999 that, if enacted, should reduce the economic and safety risks of wildlife strikes. In addition to these recommendations, I make a final point to emphasize that wildlife hazard management on airports is a complex, public-sensitive, endeavor involving many species of wildlife governed by various federal and state regulations. As discussed by

Cleary and Dolbeer (1999), airports need to employ professional biologists trained in wildlife damage control to assist in the development, implementation, and evaluation of wildlife hazard management programs.

ACKNOWLEDGMENTS

This research was supported by the FAA, William Hughes Technical Center, Atlantic City, New Jersey under agreement DTFA03-99-X-90001. Opinions expressed in this study do not necessarily reflect current FAA policy decisions regarding the control of wildlife on or near airports. I appreciate the support and advice of FAA employees S. Agrawal, E. C. Cleary, and M. Hoven. S. C. Barras, J. L. Seubert, and S. E. Wright reviewed the manuscript and provided advice on analysis of data.

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