DEER ON AIRPORTS: AN ACCIDENT WAITING TO HAPPEN

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ABSTRACT: The authors analyzed data on civil aircraft strikes with wild ungulates (deer [*Odocoileus* spp.], elk [*Cervus canadensis*] and moose [*Alces alces*]) in the U.S. from the Federal Aviation Administration (FAA) Wildlife Strike Database and the National Transportation Safety Board (NTSB) Aviation Accident Database for 1983 to 1997. Prior to 1991, the FAA Form 5200-7 for reporting strikes was designated solely for bird strike data, thus, strike reports for non-avian species prior to 1991 are underrepresented. A total of 343 ungulate strikes was reported, 48 from 1983 to 1990 and 295 from 1991 to 1997. Forty-four states reported ungulate strikes with 77% of the reports from states east of the Mississippi River. November had more ($P < 0.01$) strikes (23%) than any other month. The strike rate (number/hr) was four to nine times greater ($P < 0.01$) at dusk than at night or dawn. Almost two-thirds of strikes ($P < 0.01$) occurred during landing, making landing at dusk in November the most likely time for deer strikes. About 79% of strikes had an effect on flight. Aircraft were damaged in 83% of strikes. Only 14% of reports indicating damage provided estimates of cost of repairs. The mean cost for these reports was $74,537. Reported human injuries have been few, but the potential exists for a major disaster. Aircraft with capacity of 101 to 380 passengers were involved in 45 (14%) of the reported strikes. Airports should adopt a "zero tolerance" for deer within the operations area. Deer removal by professional shooters, in conjunction with permanent exclusion with 3 m high fencing, is the preferred management action.

KEY WORDS: airplane, airport, collision, deer, *Odocoileus virginianus,* strike, vertebrate pest, wildlife damage

Proc. 18th Vertebr. Pest Conf. (R.O. Baker & A.C. Crabb, Eds.) Published at Univ. of Calif., Davis. 1998.

INTRODUCTION

There has been a dramatic increase in the white-tailed deer (*Odocoileus virginianus*) population in the United States in recent years. In 1900, white-tailed deer had been hunted to near extinction with only about 100,000 remaining, but they now number over 26 million (Jacobson and Kroll 1994). In addition to white-tailed deer, other ungulates whose populations have recovered include mule deer (*O. hemionus*), elk, and moose. In this paper, all wild ungulates are referred to as deer unless specifically noted otherwise.

Deer-automobile collisions are becoming more common in the U.S., increasing from an estimated 200,000 incidents in 1980 to 538,000 in 1991 (Romin and Bissonette 1996). However, most people are unaware that deer collisions with aircraft are also a serious problem. Airports often are situated in outlying areas surrounded by woods, agricultural fields, and early successional habitats. Landing fields, planted with grasses and forbs, provide prime locations for grazing.

The authors' objectives were to document the extent and characteristics of deer/aircraft collisions in the U.S. and to discuss methods to reduce these collisions. Their goal is to make airport managers, pilots, and the public more aware of the seriousness of deer/aircraft collisions so that more effective management programs can be put in place at airports.

METHODS

The data for this study were taken from two sources, the FAA Wildlife Strike Database and the NTSB Aviation Accident Database. The former relies on voluntary reporting of strikes to the FAA by pilots and other aviation personnel (primarily on FAA Form 5200-7). The latter comprises information collected by the NTSB during investigations of accidents or incidents involving civil aircraft. This study did not include incidents with military aircraft.

Form 5200-7 has been available since the 1960s; however, no quantitative analyses of strikes were done until 1995 (Dolbeer et al. 1995). In April 1995, the U.S. Department of Agriculture's National Wildlife Research Center, through an interagency agreement with the FAA, initiated a project 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 (Form 5200-7) sent to the FAA to ensure consistent error-free data; 2) entering all edited strike reports into a wildlife strike database; and 3) supplementing FAA-reported strikes with additional non-duplicating strike reports from other sources (e.g., NTSB, Aviation Safety Reporting System, engine manufacturers and others [Cleary et al. 1997]). In addition, phone calls were sometimes made to obtain additional details about strikes where incomplete data were submitted. Using this approach, the authors have presently (February 1998) compiled data on all reported wildlife strikes for 1991 to 1997. In addition, data were obtained for some deer strikes going back to 1983 (Form 5200-7 did not request data on wildlife other than birds until 1991).

RESULTS

Characteristics of Strikes

A total of 343 ungulate strikes was reported from 1983 to 1997, 48 from 1983 to 1990 when strikes were inconsistently reported, and 295 from 1991 to 1997 when records were more complete (Figure 1). From 1991 to 1997, there was a mean of 42.1 strikes/year: the most and fewest strikes reported in a year were 58 (1996) and 26 (1991). Species reported struck included 222 unidentified deer, 113 white-tailed deer, 5 elk, 2 moose, and 1 mule deer. Of the 121 ungulates identified to species, 93% were white-tailed deer.

Of the 44 states reporting deer strikes, 26 states east of the Mississippi River reported 77% of the strikes. States having the most deer strikes were West Virginia, Pennsylvania, New Jersey, Michigan and New York (Table 1). Most states (38) averaged <1 deer strike report/year.

Deer strikes were not evenly distributed throughout the year (X^2 = 151.6, 11 df, P < 0.01). November had 23% of the reported strikes, more than in any other month (Figure 2). For October to November, which represents 17% of the year, 40% of all deer strikes were reported. The fewest number of strikes was reported for the January to May period (21%).

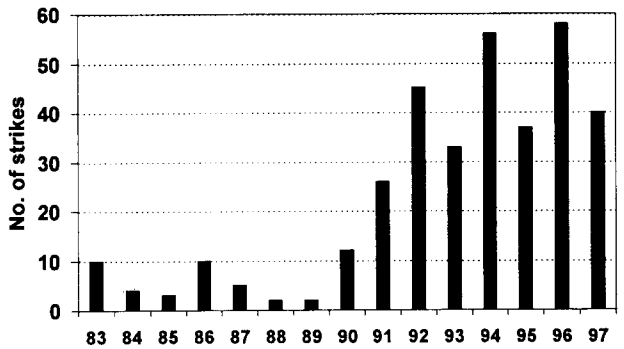

Figure 1. Number of reported ungulate strikes by year to civil aircraft, U.S., 1983 to 1997. Data were inconsistently collected before 1991.

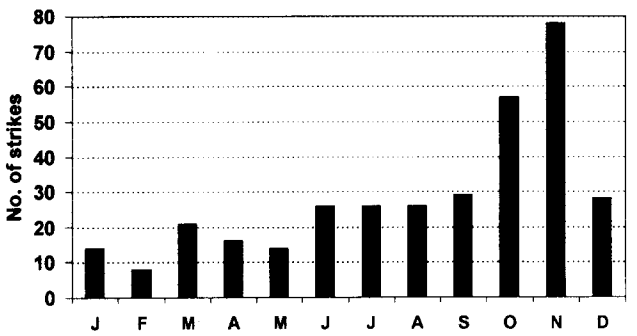

Figure 2. Number of reported ungulate strikes by month to civil aircraft, U.S., 1983 to 1997.

Table 1. States having 10 or more reported ungulate strikes to civil aircraft, 1983 to 1997.

	Strikes	
State	Number	Percent
West Virginia	33	10
Pennsylvania	31	9
New Jersey	25	7
Michigan	24	7
New York	21	6
Virginia	17	5
Maryland, Ohio, Texas, Wisconsin	11 each	13
Connecticut, Illinois, North Carolina, Missouri	10 each	12
All others	108	31
Total	343	100

Given that dusk and dawn average 0.75 hours each; and day and night average 11.25 hours each, deer strikes with aircraft occurred most often ($P < 0.01$) at dusk (69 strikes/hr) followed by night (17 strikes/hr) (Table 2). Almost nine times more strikes occurred at dusk than at dawn ($X^2 = 36.48$, 1 df, $P < 0.01$).

More strikes happened during approach/landing (63%) than during take-off/climb (36%) [$X^2 = 23.78$, 1 df, $P < 0.01$]. Less than 1% of strikes occurred during taxiing (Figure 3).

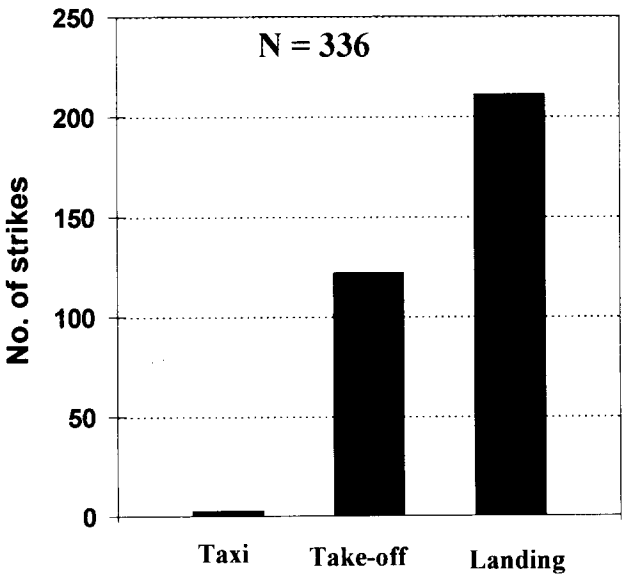

Figure 3. Number of reported ungulate strikes by phase of flight to civil aircraft, U.S., 1983 to 1997.

Most strike reports (41%) were from businesses followed by private owners (33%) and commercial airlines (26%). Aircraft with the capacity for 1 to 10 passengers were involved in the majority (65%) of reported strikes. Aircraft which carry 101 to 380 passengers were involved in 14% of the strikes (Table 3).

Effect of Strikes

Strikes had an effect on flight in 79% of the reports where effect was recorded. Effects included: aborted take-off (20%), precautionary landing (10%), engine shut down (2%), and other negative effect (47%) (Table 4).

The aircraft was damaged in 87% of the reported deer strikes (Table 4). The aircraft part most commonly struck was the landing gear (116) followed by the propeller (59) and the wing (53). The part most often damaged was the landing gear (106) followed by other (i.e., any part not listed on Form 5200-7) (56) and wing (55). Damage was substantial in 42% of the reports (Table 4). Twelve aircraft were destroyed.

Reports rarely showed the cost of deer-related damage; only 14% of the reports indicating damage provided estimates of cost of repairs. Based on data from strike reports which provided damage costs, the mean cost per deer strike was $74,537, or $21.2 million for the 285 reported damaging strikes. However, the authors believe this figure considerably underestimates the true cost. For example, none of the strike reports obtained from the NTSB database (53, 15% of total), which were all classified as substantial damage, had cost estimates. The most expensive strike reported ($1.4 million) was to a Hawker-Siddeley in which an engine was torn loose from the aircraft after hitting a deer at 160 kph on take-off.

Table 2. Reported time of day for ungulate strikes to civil aircraft, U.S., 1983 to 1997.

	Strikes		
Time of Day	Number	Percent	Number/hour[a]
Dawn	6	2	8.0
Day	72	23	6.4
Dusk	52	16	69.3
Night	190	59	16.8
Total Reported	320	100	
Not Reported	23		
Grand Total	343		

[a]Assumes 0.75 hour for dusk and dawn, and 11.25 hours for day and night. The strike rate/hour differed among time periods ($X^2=242.4$, 3 df, $P < 0.01$).

Table 3. Reported operator type and capacity of civil aircraft involved in ungulate strikes, U.S., 1983 to 1997.

Type of Operator	Strikes Number	Strikes Percent	Passenger Capacity	Strikes Number	Strikes Percent
Commercial passenger	87	26	101-380	45	14
Business	138	41	51-100	6	2
Private	109	33	11-50	63	20
Total	334	100	≤10	209	65
Unknown	9		Total	323	100
Grand Total	343		Unknown	20	
			Grand Total	343	

Table 4. Effect of flight and amount of damage to civil aircraft by ungulate strikes, U.S., 1983 to 1997.

Effect on Flight	Strikes Number	Strikes Percent	Amount of Damage	Strikes Number	Strikes Percent
Engine shut down	4	2	None	43	13
Precautionary landing	26	10	Unknown extent	4	1
Aborted take-off	50	20	Minor	132	40
Other negative effect	117	47	Substantial[a]	137	42
None	52	21	Destroyed	12	4
Total reported	249	100	Total reported	328	100
Not reported	94		Not reported	15	
Grand total	343		Grand total	343	

[a]Damage which adversely affects the structure strength, performance, or flight characteristics of the aircraft, and which would normally require major repair or replacement of the affected component (ICAO 1989).

Reported human injuries from deer strikes have been few, perhaps because injury reports are not specifically required on the 5200-7 Form. The only serious injury reported was in 1992 in Minnesota. The pilot in a Piper Cherokee hit a deer at rotation. When he attempted to turn back to the airport the airplane crashed 0.5 km south of the airport into trees. The pilot was seriously injured and the aircraft was destroyed.

DISCUSSION

Characteristics and Effects of Strikes

Although deer/car collisions have dramatically risen (Bellis and Graves 1971), there is no significant trend of increasing deer/aircraft strikes since 1991. The apparent increase from the 1980s to the 1990s is probably due to increased reporting of deer strikes which were not regularly reported before 1991. Even with the increased reporting of strikes from 1991 to 1997, many strikes go unreported for various reasons. Cleary et al. (1997) estimated that 80% of wildlife strikes to civil aircraft are unreported.

There are presently about twice as many white-tailed deer east as there are west of the Mississippi River (Jacobson and Kroll 1994). The fact that 77% of the reported deer/aircraft collisions were in the eastern U.S. is likely related to the higher population of white-tailed deer compared to the west. About 93% of identified ungulate strikes were caused by white-tailed deer.

The seasonal pattern of most aircraft/ungulate strikes occurring in October to November follows the same trend as with automobile/ungulate strikes (Bellis and Graves 1971). Deer are on the move at this time of year because of the rut (Hawkins et al. 1971). Young bucks are being chased off by adult bucks who are also busy courting does. As expected, most strikes occurred at night or during crepuscular periods when deer are most active (Carbaugh et al. 1975) and difficult to see.

Approximately twice as many strikes occurred during landing as opposed to take-off. This may be due to engine power reduction on landing which diminishes engine noise, allowing the aircraft to surprise the deer. In addition, deer may be more visible to pilots at take-off than at landing, unless it is dark. These findings point to the fact that both pilots and airport managers need to be especially aware of the increased likelihood of deer strikes during evening landings in the autumn.

The data indicated that 87% of the deer strikes from 1983 to 1997 caused damage to the aircraft and 45% of the aircraft struck had substantial damage or were destroyed. In contrast, only 16% of the 11,253 bird strikes reported from 1992 to 1996 caused damage (Cleary et al. 1997). Thus, although ungulate strikes comprise only about 1.9% of the total reported wildlife strikes (Cleary et al. 1997), they are over five times more likely to cause damage than birds. Deer strikes must be taken seriously.

One final point regarding strike characteristics is that since 1983 there have been 45 strikes with aircraft which carry 101 to 380 passengers. If one of these large carriers had ingested a deer into an engine during take-off, the result likely would have been devastating. More aggressive management is needed to prevent such a catastrophe from happening. In addition to aircraft damage and potential loss of human lives from deer/aircraft collisions, airport operators may be held liable for such collisions if adequate wildlife management plans are not in place (Hoff 1995).

Management Actions to Reduce Strikes

Because of the potential consequences of deer strikes, airport mangers should establish a "zero tolerance" policy for deer within aircraft operating areas (AOA). However, deer management can be complex and each airport has unique features. Therefore, airport managers with deer problems should request help from professional wildlife biologists trained in wildlife damage control to assess hazards and provide recommendations.

There are four basic management practices available to minimize deer numbers in an AOA: 1) exclusion; 2) population removal; 3) habitat management; and 4) harassment. The most secure protection against deer hazards is total exclusion with fencing (Craven and Hygnstrom 1994) done in conjunction with population removal. Deer can jump 2.4 m high fences (Sauer 1984); therefore, 3 m fencing with an additional three strands of barbed wire on top is recommended. Fences must be maintained so there are no gaps along the ground or at entry gates. Cattle guards ($\geq$4.6 m length) are effective in keeping deer from entering through gates that must be left open at times (Belant et al. 1998a).

Population removal requires close cooperation with state wildlife agencies for permits and approved methods. The safest and most humane removal technique is to have experienced sharpshooters work in conjunction with airport operations and safety personnel (Ishmael and Rongstad 1984; Montoney 1994). Capture and relocation is generally not recommended due to the elevated mortality rate of relocated deer, the high costs involved in relocation, and the scarcity of suitable release sites (Jones and Witham 1990). The authors emphasize that population removal without exclusion provides only temporary relief because deer will repopulate the AOA.

Habitat management includes removing wooded and brushy areas adjacent to runways. Although more research is needed, planting grasses that are less palatable to ungulates, such as tall fescue (*Festuca arundinacea*) associated with a symbiotic fungus (Aldrich et al. 1993), may be a new approach to make runway areas less attractive to deer. Chemical odor and taste repellents may be suitable for small garden plots and ornamental trees (Conover 1987) but are impractical for airports (Belant et al. 1998b).

Harassment techniques can include pyrotechnics (fireworks), sirens, propane exploders, flashing lights, and vehicles. Deer typically habituate to these devices within a few days (e.g., Belant et al. 1996, 1998c). Harassment can be effective if selectively used immediately prior to aircraft take-offs and landings. Increased diligence in harassment is needed especially during aircraft landings at dusk in October to November when the probability of deer strikes is highest.

In conclusion, although exclusion and population removal are the most effective strategies for minimizing deer hazards, no single technique will be 100% effective or appropriate at all times. Deer are adaptable and their populations are dynamic. In addition, costs may limit

options such as complete fencing on smaller airports. The best approach will be to integrate several methods into a comprehensive wildlife management plan that is periodically evaluated and updated. The important point, as the strike statistics from 1983 to 1997 indicate, is that deer constitute a serious safety hazard on airports that must not be ignored.

ACKNOWLEDGMENTS

The authors thank the following people for their assistance in providing support for this paper: E. C. Cleary, FAA Office of Airport Safety & Standards, Washington, DC.; S. K. Agrawal and T. H. Hupf, FAA Technical Center, Atlantic City, NJ.

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