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Integrating mammalian hazards with management at U.S. civil airports: a case study

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Abstract: Wildlife incidents with U.S. civil aircraft cost an estimated $1.4 billion from 1990 to 2010, with mammals 5 times more likely to cause damage than other wildlife. We surveyed 2 general aviation (GA) airports and 6 Part-139 certificated (i.e., certified) airports to assess efficacy of management practices for mammalian species hazardous to aircraft. We obtained information on mammalian species present on airport grounds, types and estimated effectiveness of management techniques, and effort spent on wildlife management. We evaluated management techniques relative to aircraft–wildlife collisions (i.e., incident) frequencies taken from Federal Aviation Administration's (FAA) National Wildlife Strike Database and species hazard scores calculated by body mass. Certificated airports spent 5 times more effort and used twice as many techniques as GA airports. Species considered most hazardous by all airports included white-tailed deer (*Odocoileus virginianus*; hazard score = 94) and coyote (*Canis latrans*; 62). Generally, all airports surveyed are managing effectively for mammals; however, we recommend that airports with deer present install additional exclusion devices. By prioritizing species to manage and targeting management for them, airports can reduce mammalian risks to U.S. civil aircraft.

Keywords: airport, airport management, aviation hazard, human–wildlife conflicts, mammals, United States, wildlife–aircraft incident, wildlife strike

Globally, wildlife collisions with aircraft (hereafter, incidents) cost an estimated $2 billion annually (International Civil Aviation Organization 2009). Wildlife incidents with U.S civil aircraft alone cost an estimated $1.4 billion from 1990 to 2010 (Biondi et al. 2011). Though 97% of wildlife incidents with U.S. civil aircraft involve birds (Dolbeer et al. 2012), mammals are 5 times more likely to cause some kind of damage to aircraft than are other wildlife (Biondi et al., unpublished data). Most airports in the United States are categorized as Part-139 certificated (i.e., certified) or general aviation (GA; Federal Aviation Administration 2012). Certificated airports are those that receive regularly-scheduled passenger flights with >9 seats or unscheduled flights with >30 seats, or are otherwise required by the Federal Aviation Administrator to hold a certificate (Federal Aviation Administration 2012). Frequency of mammalian incidents, damaging incidents, and mammalian species involved in incidents vary by airport type (Biondi et al. 2011, Dolbeer et al. 2012). Therefore, airports may be vulnerable to different mammalian species, making a distinct management regimen necessary for each airport.

Numerous techniques are available to reduce mammalian risk to aircraft, including exclusion (Belant et al. 1998, Conover 2002, DeVault et al. 2008, Seamans and Helon 2008), removal (Ishmael and Rongstad 1984, Conover 2002, DeNicola and Williams 2008), habitat modification (Barras et al. 2000, Cleary and Dolbeer 2005, Cleary and Dickey 2010), and harassment (Craven and Hyngnstrom 1994, Belant et al. 1996, Conover 2002). Although fencing is considered the most effective exclusion technique for medium- and large-sized mammals (Conover 2002, Seamans and

VerCauteren 2006, DeVault et al. 2008), costs for constructing and maintaining fences limits their use at some airports (Cleary and Dickey 2010). For example, GA airports typically receive less federal funding than certificated airports; consequently, they are more likely to have no fencing or incomplete fencing (DeVault et al. 2008, Dolbeer et al. 2008, Cleary and Dickey 2010), leaving them more vulnerable to incidents involving mammals. Limited funding for some airports may also reduce the ability to hire and train personnel for wildlife management (Dolbeer et al. 2008), making removal and harassment techniques less likely to be implemented. Further, because damage to aircraft increases with increasing species body mass and decreasing aircraft mass (DeVault et al. 2011, Biondi et al. unpublished data), typically smaller aircraft at GA airports are at greater risk for damaging incidents.

The diversity of mammals involved in incidents is greater at certificated airports than at GA airports (Dolbeer and Wright 2009), which may require use of more techniques for effective management. However, certificated airports have a higher reporting rate of incidents and increased reporting of non-damaging incidents (Dolbeer et al. 2012), providing a more accurate depiction of species present. Because GA airports have a lower reporting rate (Dolbeer et al. 2012) and may underreport incidents that do not cause damage (Biondi et al., unpublished data), not all species involved in incidents at GA airports may be reported to the FAA National Wildlife Strike Database. Thus, increased knowledge of species present at airports, species involved in incidents, and a species hazard rank as provided by airport personnel will help ensure management emphasizes species most hazardous to aircraft.

We surveyed airports regarding current mammalian management practices, incidents with aircraft, and potential additional management. Although we did not survey a random sample of airports, our purpose was to use these airports as a case study to demonstrate application of mammalian hazard scores to potentially refine management to reduce aircraft risk. As airports across the nation vary by size, aircraft movements, aircraft size, surrounding habitat, and landcovers, each may have different hazard species or management techniques on their grounds. These methods provide a standardized process for airports to evaluate their vulnerability to mammalian incidents, prioritize hazardous species for management, and implement or improve management techniques.

Methods

We sent surveys to 2 GA airports and 6 certificated airports in the United States. Each airport was given a unique identification, with GA airports identified as GA1 and GA2, and certificated airports as Cert1 to Cert6. Because GA and certificated airports vary from each other by size, aircraft movements, federal funding, wildlife management techniques, and incident reporting rates (Dolbeer et al. 2012), we separated these airports by airport type.

We asked airport personnel questions regarding current mammalian management practices, estimated effectiveness of those techniques, number of personnel and time spent on all wildlife control management, mammalian species present on airport grounds, and whether additional mammalian management was needed. Because most airports had difficulty separating time and personnel and time spent on mammalian management from all wildlife management, we requested and used estimates of effort for all wildlife management. We asked airport personnel specifically if they used fencing, how much of the airport was enclosed by fencing, if the bottom of the fence was buried, how high the fence was, and if the fence was maintained. We also requested all other techniques used for mammalian management and that personnel categorize the effectiveness of each as highly effective, moderately effective, or not effective. We asked airports to create species hazard ranks for all mammalian species present on airport grounds by ranking each species as hazards to the airport.

We summarized and qualitatively compared responses among airports by wildlife management effort, mammalian management practices, and mammalian species present on airport grounds. We calculated the relative hazard score using log body mass (g) of each species present (Best et al. 1996, Felhammer et al. 2003) in the equation $y = -50/x^2 - 28.1$, where x = log body mass (Biondi et al., unpublished data). We gave any species that produced a score <0 a relative hazard score of zero. We also assessed frequency of mammalian incidents and species involved in incidents at each airport using the FAA National Wildlife Strike Database from 1990 to 2010. Because incidents are not always reported to the database, we wanted airport personnel to provide species hazard ranks to ensure that all species are accounted for. We assessed current mammalian management techniques at each airport relative to the species present, species relative hazards, total number of incidents, and number of incidents for each species. As applicable, we suggest additional mammalian management techniques or improvements to existing techniques to potentially further reduce mammalian incidents.

Figure 1. Coyotes (*Canis latrans*) are among the most hazardous mammalian species at U. S. airports. *(Photo S. Thompson, courtesy U.S. Fish and Wildlife Service)*

Results

Wildlife management activities at certificated airports ranged from 80 to 320 hours per week, whereas effort at GA airports ranged from 3 to 7 hours per week. Most (5) certificated airports had ≥2 full-time employees for wildlife management, whereas GA airports had no personnel designated exclusively for wildlife management. The most common management techniques used at all airports were fencing and shooting, followed by trapping, pyrotechnics, vehicles, and patrols

Table 1. Mammal management techniques used at 8 U.S. civil airports, 1990 to 2010.

Management technique	GA1[a]	GA2[a]	Cert1	Cert2	Cert3	Cert4	Cert5	Cert6
Exclusion								
Fencing	✓	✓	✓	✓	✓	✓	✓	✓
Lethal								
Shooting	✓	✓	✓	✓	✓	✓	✓	✓
Trapping			✓	✓	✓	✓	✓	
Snaring						✓		
Carbon monoxide gas								✓
Falconry			✓					
Nonlethal								
Bangers and noise makers	✓							
Immobilization gun								✓
Noose pole								✓
Pyrotechnics			✓	✓	✓	✓	✓	
Vehicles			✓	✓	✓	✓	✓	
People			✓	✓	✓	✓	✓	
Talon net gun								✓
Throw nets								✓
Dog							✓	

[a] Indicates general aviation airport, all others are certificated airports.

(Table 1). Overall, personnel at certificated airports used more management techniques than did GA airports. Personnel at certificated airports use ≥4 nonlethal techniques, whereas personnel at GA airports use ≤1 technique. Personnel at GA2 airports used exclusion and lethal removal for wild mammalian species but also performed live capture of domestic dogs (*Canis lupus familiaris*) and returned them to their owners. All airports had fencing and conducted routine maintenance; however, GA2 had only the runways enclosed, or 66% of the airport. Most (7) airports had a chain-link fence with a height of ≥2.4 m and an additional 0.3 to 0.9 m barbed wire. GA1 was the only airport with sections of chain-link fencing <2.4 m in height and that did not have barbed wire. Cert6 was the only airport with its fence buried 0.9 m underground. No airports used cattle guards or other exclusion devices at fence openings.

Generally, personnel considered exclusion and trapping to be more effective than either shooting or nonlethal techniques. However, habitat management was rated highly effective at GA2, moderately effective at 5 certificated airports, and not effective at GA1. All airport personnel indicated that fencing was highly effective in managing mammals. Although nonlethal techniques other than exclusion were not evaluated individually by certificated airport personnel, they were considered overall less effective than exclusion or lethal methods. Only personnel at GA1 used a technique that they consider not effective (habitat management); all other personnel used techniques considered highly or moderately effective.

The number of mammalian species reported present on airport grounds ranged from 2 to 9 at certificated airports and 2 to 3 at GA airports (Table 2). Overall, coyotes (*Canis latrans;* Figure 1) and muskrats (*Ondatra zibethicus*) were most frequently reported as present, followed by white-tailed deer (*Odocoileus virginianus*) and eastern cottontails (*Sylvilagus floridanus*). Of these species, white-tailed deer has the highest relative hazard score (94), followed by coyotes (62), eastern cottontails (21), and muskrats (19; Table 3). Cert1 personnel considered black-tailed jackrabbits (*Lepus californicus*) to be of greatest management concern, but it had a relatively low hazard score (31). Both GA airports and Cert6 personnel reported only species present on airport grounds with relatively high (≥62) hazard scores, whereas personnel at 3 certificated airports reported only species with relatively low (≤40) hazard scores.

All airport personnel stated that all wildlife incidents that were detected were reported to the FAA National Wildlife Strike Database. Incident frequency was low at GA1, Cert3, and Cert6; however, these incidents involved hazardous species present on airport grounds, including white-tailed deer at GA1 and Cert3 and coyotes at Cert6 and Cert3. No incidents occurred at GA2 or Cert2. All incidents with species reported present at Cert1 involved black-tailed jackrabbits. Few incidents with relatively low hazard species (e.g., eastern cottontail) occurred at Cert4. Of species present on airport grounds, those involved most frequently in incidents at Cert5 had relatively low hazard scores, including woodchucks (*Marmota monax*; 37) and Virginia opossums (*Didelphis virginiana*; 27).

Personnel at 4 airports wanted more mammalian management, including habitat modifications and exclusion. For example, removal or restriction of crops and planting less palatable plants or repellent plants was suggested for GA1. Cattle guards, higher fences, improved gates, and fence skirts would be installed at Cert3. Additional management of species including eastern cottontails and muskrats at Cert4 was recommended. Personnel at GA2 stated additional mammalian management was not needed, but if additional funding were available they would add a skirt to the fence.

Discussion

There was considerable variation in management and mammalian species present on airport grounds within and between airport types. Although certificated airport personnel employed more techniques and personnel hours for management than the GA airports, they also had a greater frequency of reported incidents. Despite limited funding for GA airports (Dolbeer et al. 2008), personnel at all airports have implemented multiple effective management techniques, particularly regarding fencing that encompassed the airport operations areas. However, this complete

Table 2. Species hazard ranking as reported by airport for species present on airport grounds at 8 U.S. civil airports, 1990 to 2010. GA= general aviation.

	GA airports		Certificated airports					
Species	GA1	GA2	Cert1	Cert2	Cert3	Cert4	Cert5	Cert6
White-tailed deer (*Odocoileus virginianus*)	1	1	0	0	1	0	1	0
Domestic dog (*Canis lupus familiaris*)	0	0	0	0	0	0	0	2
North American beaver (*Castor canadensis*)	0	3	0	0	0	0	0	0
Coyote (*Canis latrans*)	2	2	0	0	2	0	2	1
Red fox (*Vulpes vulpes*)	0	0	0	0	4	0	0	0
Domestic cat (*Felis catus*)	0	0	3	0	0	0	6	0
Woodchuck (*Marmota monax*)	0	0	0	0	3	0	3	0
Raccoon (*Procyon lotor*)	0	0	5	0	0	0	8	0
Striped skunk (*Mephitis mephitis*)	0	0	0	0	0	0	5	0
Black-tailed jackrabbit (*Lepus californicus*)	0	0	1	0	0	0	0	0
Virginia opossum (*Didelphis virginiana*)	0	0	6	0	0	0	9	0
Eastern cottontail (*Sylvilagus floridanus*)	0	0	2	0	0	1	7	0
Muskrat (*Ondatra zibethicus*)	0	0	4	1	0	2	4	0
Gray squirrel (*Sciurus carolinensis*)	0	0	7	0	0	0	0	0
Bats[a] (Chiroptera)	0	0	8	2	0	0	0	0
Indiana bat (*Myotis sodalis*)	0	0	0	0	5	0	0	0

[a] Greater western mastiff bat (*Eumops perotis*) was used to represent bats, as it is the largest bat in the United States and, therefore, denotes the maximum hazard score possible.

fencing was not typical of most GA airports (DeVault et al. 2008, Dolbeer et al. 2008, Cleary and Dickey 2010). GA1, however, had sections of chain link fence <2.4 m in height with no additional barbed wire, making the fence below the recommended height of ≥3.0 m (FAA 2004, Cleary and Dolbeer 2005) and more vulnerable to intrusions, particularly by white-tailed deer, which can jump fence heights up to 2.4 m (VerCauteren et al. 2006, 2010; Stull et al. 2011).

All airports surveyed appeared to manage effectively for mammals as they have either a low frequency of reported incidents or the incidents involve species with low hazard scores. Techniques and effort appeared particularly effective for hazardous species (e.g., white-tailed deer and coyotes) as few incidents occurred. The low frequency of incidents at GA1, Cert3, and Cert6 indicated effective management; however, these incidents involved high hazard species that may warrant additional management. Because no incidents occurred at GA2 or Cert2, mammalian management techniques appear highly effective, particularly at GA2, as the airport has high hazard species present on airport grounds. Although Cert1 and Cert5 had high incident frequencies, these incidents involved low hazard species, indicating that personnel at these airports are managing effectively for species most hazardous to aircraft. However, the high frequency of incidents with low hazard species at Cert1 and Cert5 indicates that additional management may be warranted. The low frequency of incidents at Cert4, all of which involved low hazard species, suggests effective mammalian management. As frequency of incidents and species involved in incidents vary among airports, each airport must examine the effectiveness of techniques used for each potentially hazardous species, and determine whether reprioritization of efforts is necessary.

We recommend a no-tolerance policy for white-tailed deer and coyotes at airports and encourage removal of all individuals from the premises. Small mammalian management

Table 3. Relative hazard score and number of incidents with U.S. civil aircraft reported in Federal Aviation Administration National Wildlife Strike Database for species present on airport grounds at 8 U.S. civil airports, 1990 to 2010. GA = general aviation.

		Number of incidents reported in database							
		GA airports		Certificated airports					
Species	Relative hazard score	GA1	GA2	Cert1	Cert2	Cert3	Cert4	Cert5	Cert6
All mammals		3	0	75	0	4	8	57	9
White-tailed deer	94	3	0	0	0	2	0	0	0
Domestic dog	78	0	0	0	0	0	0	0	0
North American beaver	68	0	0	0	0	0	0	0	0
Coyote	62	0	0	0	0	1	0	0	8
Red fox	40	0	0	0	0	0	0	0	0
Domestic cat	39	0	0	0	0	0	0	1	0
Woodchuck	37	0	0	0	0	1	0	16	0
Raccoon	34	0	0	0	0	0	0	2	0
Striped skunk	33	0	0	0	0	0	0	1	0
Black-tailed jackrabbit	31	0	0	58	0	0	0	0	0
Virginia opossum	27	0	0	0	0	0	0	14	0
Eastern cottontail	21	0	0	0	0	0	4	15	0
Muskrat	19	0	0	0	0	0	1	3	0
Gray squirrel	9	0	0	0	0	0	0	0	0
Bats[a] (Chiroptera)	0	0	0	0	0	0	0	0	0
Indiana bat	0	0	0	0	0	0	0	0	0

[a]Greater western mastiff bat (*Eumops perotis*) was used to represent bats, as it is the largest bat in the United States and, therefore, denotes the maximum hazard score possible.

should also be implemented to reduce mammalian carnivore use (e.g. coyotes and foxes [*Vulpes* spp.]), as well as potential use by raptors (Dolbeer et al. 2000). Perimeter fencing should meet the recommended height of ≥3.0 m, particularly if the airport contains or is near agricultural crops (FAA 2004, Cleary and Dolbeer 2005). At most (7) airports, fencing met the recommended height with the inclusion of barbed wire, so, additional fence height was not necessary. However, GA1 personnel should consider increasing the height of sections with low fence-height of ≥1.15 m, possibly with the addition of barbed wire to the top to achieve the recommended fence height and more effectively exclude white-tailed deer. Personnel at airports where white-tailed deer are present should install cattle guards (Belant et al. 1998, Cleary and Dolbeer 2005), or electrified mats (Seamans and Helon 2008) at gates to deter entry. Also, because many airports have species that dig or burrow (i.e., coyotes, eastern cottontails), fences should be buried 0.9 m underground (Cleary and Dolbeer 2005, DeVault et al. 2008).

Airport personnel should prioritize potential changes based on the hazard scores of mammalian species present and species most frequently involved in incidents. For instance, Cert3 personnel would like to install cattle guards, a fence skirt, increase fence height, and improve gates. Because incidents with white-tailed deer and coyotes have occurred at Cert3, and these species have high hazard scores, these exclusion techniques would be more valuable than others. Installing a fence skirt at Cert1 and Cert5 may further reduce incidents, particularly with black-tailed jackrabbits and eastern cottontails.

The efficiency of current mammalian management practices on airports can be estimated by examining management techniques with incident frequency and relative hazards of mammalian species involved in incidents with aircraft. Because airports across the United States can vary drastically, the process demonstrated in this case study allows an airport to be evaluated as to what mammalian hazards are present and management regime needed for its own unique circumstances. Additional or improved mammalian management techniques should be implemented when necessary and be tailored toward species most hazardous with greatest frequency of incidents. Prioritizing management using this approach will likely further reduce the risk of mammalian incidents with U.S. civil aircraft.

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