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Wildlife in Airport Environments: Chapter 8 Identification and Management of Wildlife Food Resources at Airports

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8 Identification and Management of Wildlife Food Resources at Airports

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Wildlife use airport habitats for a variety of reasons, including breeding, raising young, resting, taking refuge from predators, and locating sources of water. But the chief motivation for most individuals to encroach on airports is food. Depending on the specific habitat types present and habitat management strategies employed, airports can harbor large numbers of small mammals, insects, earthworms, and palatable vegetation that attract many species hazardous to aircraft. Often the best way to reduce populations of hazardous wildlife at airports is to determine which sources of food are being used, and then remove or modify those foods to make them less attractive (Washburn et al. 2011). Fortunately, the science of wildlife ecology and management has a long and productive history of research on wildlife food habits and foraging strategies, and the applied nature of most food habit studies conducted in airport environments facilitates straightforward specialization of investigational techniques. In this chapter we (1) discuss in more detail food resources as a primary motivation for wildlife use of airport properties, (2) consider some established principles of wildlife food habits and foraging strategies that affect airport wildlife management, (3) review techniques used to investigate wildlife food habits and identify those most useful for airports, (4) discuss methods for eliminating or modifying some preferred foods at airports, and (5) briefly consider future research needs.

Although we focus our discussion on birds (>97% of all wildlife–aircraft strikes involve birds), white-tailed deer (*Odocoileus virginianus*; Biondi et al. 2011) and other mammals (Dolbeer et al. 2010) present significant hazards at some airports. Even so, deer and many other mammals can be managed effectively with exclusion techniques (Chapter 5). For airports without adequate fencing, the food habits of deer, coyotes (*Canis latrans*), and other hazardous mammals should be considered when developing wildlife hazard management protocols. For example, even though few birds regularly feed on soybeans (Sterner et al. 1984, Krapu et al. 2004), deer are major consumers of soybean plants (Humberg et al. 2007), and thus soybean cultivation should be discouraged at and near airports without adequate fencing.

Food: A Primary Motivation for Wildlife Use of Airports

Why are so many wildlife species attracted to airports? There are many reasons. Although they can contain a variety of habitat types (Blackwell et al. 2009, DeVault et al. 2009), airports are usually characterized by wide-open spaces relatively free from human activity. DeVault et al. (2012) calculated that airports in the USA certificated by the Federal Aviation Administration (FAA; see Appendix) contain an average of 297 ha of grassland. Airports also have stormwater treatment facilities and other water bodies that can attract hazardous wildlife (Chapter 9).

If one considers the three basic needs of wildlife—food, water, and shelter—wildlife can readily obtain all three at an airport. On closer investigation, however, water and shelter may be less problematic overall and easier for airport biologists to manage than food resources. Water bodies certainly do attract waterfowl and other hazardous wildlife to airports, and at times offer considerable management challenges. Even so, water attractants are usually identified easily, and substantial progress has been made in recent years in the design and management of water bodies at airports to deter use by hazardous wildlife (Chapter 9). As for shelter, the overall homogeneity of airport lands relative to off-airport areas helps to limit refuge and loafing areas for some types of hazardous wildlife. Biologists can identify and remove mammal dens and raptor nests, and close hangars and other airport buildings to deny access to rock pigeons (*Columba livia*), European starlings (*Sturnus vulgaris*), and other birds closely associated with humans. But because wildlife food resources are so abundant and take so many different forms, it is difficult—if not impossible—to remove them completely. Even at airports employing full-time wildlife biologists, wildlife consistently forage on airport properties.

An examination of the FAA's National Wildlife Strike Database (Dolbeer et al. 2010) indicates that hazardous wildlife use airports primarily for foraging, as opposed to nesting, loafing, and other activities. Blackwell et al. (2013) reviewed database records from 1990 to 2008 and determined that of the nine grassland-associated bird species that caused the most damaging strikes to aircraft, only killdeer (*Charadrius vociferous*) commonly nest in airport grasslands. The remaining bird species—Canada goose (*Branta canadensis*) red-tailed hawk (*Buteo jamaicensis*), and European starling—use airport grasslands primarily for foraging on grasses, small mammals, and insects, respectively. These data suggest that proper management of food resources at airports could help reduce strike risk by reducing wildlife foraging in critical areas.

Other studies have indicated that food resources are primary determinants of bird movements and spatial ecology (i.e., where and how birds choose to spend their time). Rolando (2002:53) reviewed factors affecting home range characteristics and determined that "food availability is the primary determinant of home range ecology in birds and all other factors are secondary." Further evidence for the importance of food resources on bird movement behaviors is illustrated by black vultures (*Coragyps atratus*) and turkey vultures (*Cathartes aura*), common North American scavengers (Kirk and Mossman 1998, Buckley 1999) that are particularly hazardous to aircraft (Dolbeer et al. 2000, DeVault et al. 2011). Black and turkey vultures adjust their home range characteristics, movement patterns, and even flight behaviors based on the local nature of carrion resources. Coleman and Fraser (1987, 1989) studied black and turkey vultures in an agricultural region of Pennsylvania and Maryland, USA, and found that they relied heavily on carrion from domestic (farm) animals, a relatively predictable and constant source of food. Conversely, DeVault et al. (2004, 2005) and Kelly et al. (2007) investigated movement behaviors and food habits of both species in a heavily forested environment in South Carolina, USA, and found that those vultures relied almost exclusively on carrion from wild animals, a more ephemeral and unpredictable source of food. DeVault et al. (2004, 2005) also determined that vultures in their heavily forested study area had much larger home ranges (~100% larger) and spent a greater percentage of daylight hours in flight (approximately two to five times more) than their counterparts in Pennsylvania and Maryland (Coleman and Fraser 1989). DeVault and colleagues concluded that differences in habitat structure—and, by extension, food resources—presented a more challenging foraging environment to vultures in the heavily forested region in South Carolina, reflected by the substantial differences in their spatial ecology across the two environments. This plasticity in vulture behavior across their ranges underscores the importance of food resources on bird movements and demonstrates how the manipulation of food resources can potentially influence wildlife activity patterns at airports.

Principles of Wildlife Food Habits and Foraging Strategies

Research on wildlife food habits has a long history in wildlife research and management, and there is a well-developed literature on theory and application. In this section we consider a few of those topics that we believe are especially important for airport investigations. Readers interested in a general discussion of methods for investigating wildlife food habits and subsequent management strategies are encouraged to see Litvaitis (2000) and McDonald et al. (2005).

Use, Selection, and Preference

Although the terms "use," "selection," and "preference" are often used interchangeably, there are important differences among them (Johnson 1980, Litvaitis 2000, McDonald et al. 2005). Use is nothing more than the consumption of a particular food, whereas selection occurs when an animal chooses a certain food item when others are more readily available; that is, disproportionally to its availability. Preference for a food is independent from its availability; preference can be inferred only when foods are equally available. Questions of food preference are generally not addressed in the airport context, because necessary study designs to investigate such questions (e.g., cafeteria-style experiments or enclosures where resources are carefully controlled) are usually not practical. Therefore food selection is most often the variable of interest at airports. Mere use of a food does not necessarily imply that eliminating that food will influence behavior of the species consuming it, because that species might simply switch to an equally desirable food (Litvaitis et al. 1994) available at the airport. Identification of food resources that hazardous wildlife select, however, is an important component of effective management.

Abundance versus Availability

Many studies on wildlife food habits have measured and reported food abundance, rather than availability, because of the difficulty in measuring true availability (Litvaitis 2000, McDonald et al. 2005). However, it is availability—the proportion of a food resource that is accessible—that influences food selection by wildlife (Johnson 1980). Buckley and McCarthy (1994) studied laughing gulls (*Larus atricilla*) at John F. Kennedy International Airport (JFK), New York, New York, USA, and found that gulls fed on adult Oriental beetles (*Anomala orientalis*) only in shortgrass areas, even though the same beetles were equally abundant (but much more difficult to capture, and thus less available) in nearby tallgrass areas. Another example of abundance versus availability that is particularly applicable to airport wildlife management concerns the issue of small mammals as prey for raptors (i.e., hawks, eagles, and falcons), which present substantial hazards to aircraft (DeVault et al. 2011). Several researchers have investigated habitat use of a variety of raptor species as it relates to prey densities across habitat types; these authors consistently reported that prey availability (a function of both prey density and vulnerability to predation), rather than abundance, most strongly correlates with habitat use (e.g., Wakely 1978, Baker and Brooks 1981*a*,*b*, Bechard 1982, Preston 1990, Beier and Drennan 1997). To consider one example in particular, Baker and Brooks (1981*a*) studied the distribution of red-tailed hawks and rough-legged hawks (*B. lagopus*) at Toronto International Airport, Toronto, Ontario, Canada. In their study, both hawk species were more numerous in shortgrass areas than on straw fields or old fields (both of which had taller vegetation and less bare ground), despite lower densities of their most common prey, meadow voles (*Microtus pennsylvanicus*), in shortgrass areas. Baker and Brooks (1981*a*) concluded that meadow voles were more vulnerable to predation in shortgrass areas, which led to increased raptor use of those fields.

Dietary Breadth

In normal circumstances, many animals use fewer types of foods than they are physiologically capable of consuming. But during food shortages, animals often increase the diversity of their food habits (Litvaitis 2000), and some species regularly use a surprisingly wide variety of foods. We propose that, in general, wildlife have more diverse diets than is commonly believed (see also Polis 1991). For example, snakes are often thought of exclusively as predators of small animals, but wild snakes regularly consume carrion (including road-killed frogs that are peeled from the road surface; DeVault and Krochmal 2002) and have been known to consume cooked spareribs (Savidge 1988), slaughtered pig (Heinrich and Studenroth 1996), and canned dog food (Parker and McCallum 2010). Further evidence concerning the dietary breadth of wildlife comes from studies using remote cameras to study predation of bird nests. Such studies have demonstrated that various squirrel species (usually considered herbivores) can be major nest predators (Sieving and Willson 1998, Williams and Wood 2002, Grant et al. 2006), and have documented white-tailed deer (also herbivores) eating grassland bird nestlings (Pietz and Granfors 2000). Given the ability and occasional motivation of various species to consume "unusual" foods, managers must keep an open mind regarding wildlife food habits when investigating and managing food resources at airports. As an example, Bernhardt et al. (2009) found that tree swallows (*Tachycineta bicolor*), which generally feed on flying insects, fed almost exclusively on fruits from bayberry bushes (*Myrica pensylvanica*) at JFK. Removal of bayberry bushes resulted in a 75% reduction in tree swallow–aircraft strikes at the airport.

Constraints on Optimal Foraging

Theory suggests that animals forage in a way that maximizes energy intake and minimizes energy expenditure (e.g., prey capture and handling time; MacArthur and Pianka 1966, Shoener 1971). Decades of studies on optimal foraging theory (see Shoener 1986) have been helpful in developing our understanding of foraging behavior, including food selection. However, optimal foraging theory is a simplification (Litvaitis 2000). In reality, many other factors influence foraging behavior, including nutritional content, intra- and interspecific competition, body condition, sex and age class, environmental conditions, and (most notably in the current context) risk of predation (Lima and Dill 1990, Lima 1998). Such constraints on optimal foraging behavior are important to recognize, because it may be possible to use these constraints in the context of airport wildlife management. Blackwell et al. (2013) discuss how vegetation could potentially be managed to enhance the perceived risk of predation and thus reduce frequency of foraging on airport grasslands by some bird species.

Techniques for Investigating Wildlife Food Habits at Airports

Accurate determination of food selection by wildlife at airports usually requires collecting food samples from regurgitated pellets or gastrointestinal tracts, although direct observation of foraging behaviors and feeding site surveys is possible in some circumstances. We discuss techniques to investigate wildlife food habits, concentrating on those most useful for airports. More exhaustive treatment of food habit analysis techniques is available in Rosenberg and Cooper (1990), Litvaitis et al. (1994), and McDonald et al. (2005).

We emphasize that priority for study, as well as for subsequent management actions, should be placed on those species that are most hazardous to aircraft; that is, those most likely to cause damage or to have a negative effect on flight when struck (Dolbeer et al. 2000, Dolbeer and Wright 2009, DeVault et al. 2011). Such information is important because alteration of a food resource to decrease airport use by one species might inadvertently (and unavoidably) create an attractant for another. A priori knowledge of relative hazard level, as well as established wildlife–habitat relationships, helps to inform priorities for study and management.

Although choosing the specific techniques to study food habits generally depends on the question being addressed (see McDonald et al. 2005), in the airport context the questions are usually fairly consistent: what foods do hazardous wildlife at this airport select, and how can I subsequently remove or modify those foods so that they are no longer selected by that species? Airport investigations of food habits are somewhat unique in that the investigator is most interested in what the animal eats within certain administrative boundaries. Diet composition of focal individuals outside airport property (assuming that the airport does not constitute the entire home range) is somewhat less important, because management of food resources outside the airport boundary is often impractical or impossible. Even so, food selection for an individual can occur at scales larger than the airport property (especially for birds; Martin et al. 2011), and the portion of the home range occupied by the airport could contain anywhere from all to none of the food regularly consumed by that individual. Common examples include Canada geese feeding on airport turfgrass but nesting in an adjacent wetland, or gulls feeding in a nearby landfill but loafing on the airport pavement. When possible, one must understand the food selection of hazardous airport wildlife in a larger context. This knowledge can help discern the contribution to an animal's diet of food resources found in airport and off-airport habitats, as well as those specific to a particular airport.

The sample size necessary for accurate representation of food habits will vary depending on season, variability in diet across individuals, and dietary breadth, and for this reason it is difficult to determine before study initiation (Rosenberg and Cooper 1990, Litvaitis et al. 1994). Fortunately, when using individuals killed during control activities or birds struck by aircraft, sample size is generally not an issue—one simply uses all the birds available, or at a minimum continues analysis until no more unique information is added to the data set (Rosenberg and Cooper 1990). However, the location of collection can heavily influence study results. Washburn et al. (2011) compared stomach contents from European starlings collected at JFK on airport grasslands and near the shoreline to birds struck by aircraft, and found that only birds collected on grasslands had diets similar to those of struck birds. Because food habits of birds involved in actual strikes with aircraft provide the most relevant data to airport investigations, such samples should be used whenever possible. Because the availability of aircraft-struck birds is limited at most airports, however, it is often necessary to obtain diet samples by other means (see below). Care should be taken to ensure that samples are representative of individuals most vulnerable to aircraft strikes. Mangers must also consider the most appropriate temporal and demographic sampling scheme for collections. Within species, food needs often change seasonally (Williams and Jackson 1981, Fischl and Caccamise 1987, Bernhardt et al. 2010) and across age and sex classes (Litvaitis et al. 1994).

Several techniques can be used to obtain dietary samples or to observe foraging activities at airports, each with advantages and disadvantages (Table 8.1). The most common and preferred technique, as inferred above, is the use of gastrointestinal tracts from birds struck by aircraft or collected during wildlife control activities (Chapter 7). Stomach contents and bird crops can provide a multitude of diet information and can be analyzed by sex, age, and reproductive class (Fig. 8.1). The study of gastrointestinal tracts is also favored because the samples are readily provided—it is not necessary to collect animals specifically for study. Even though such samples are conveniently obtained, however, they might be limited in number and, in the case of samples collected during control activities, might not accurately reflect the diets of individuals actually struck by aircraft. The analysis of regurgitated pellets (birds) and feces (mammals) is also commonly employed. These techniques are inexpensive, minimally invasive, and can yield a great deal of information. Unfortunately, analysis of these samples often suffers from bias due to differential digestibility of various food types (Litvaitis et al. 1994), and usually does not provide information on sex, age, or reproductive class of the focal species.

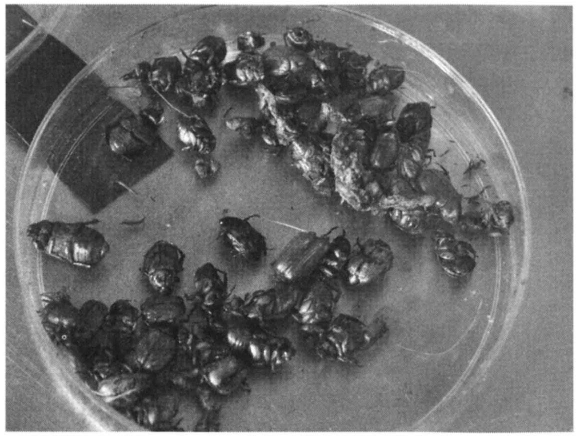

Fig. 8.1. Analysis of stomach contents can reveal important information about food resources used by wildlife hazardous to aviation, such as these June beetles (*Phyllophaga* spp.) consumed by a laughing gull at an eastern U.S. airport. Photo credit: Brian E. Washburn

After samples are obtained, initial analysis usually consists of sorting and identifying all food items, and then summarizing the results in terms of frequency of occurrence, number, and volumetric proportions in the diet (Rosenberg and Cooper 1990), resulting in a ranked list of foods consumed. When identifying dietary samples, it is helpful to have a reasonably complete inventory of vegetation, small mammals, insects, or other potential food items present at the airport. Many airports have wildlife hazard management plans in place; these serve as good starting points for such inventories.

For many airport applications, it is likely not necessary to conduct detailed statistical analyses of food selection (i.e., quantifying food availability and comparing it to diet composition; see McDonald et al. 2005 for an overview of analysis methods). In this way, most studies of airport food habits are greatly simplified compared to many other investigations (Washburn et al. 2011). Even so, as noted above, one must consider food availability as it relates to diet composition

Table 8.1. Techniques for investigating wildlife food habits at airports. Note that examining the gastrointestinal tracts from animals killed during control activities or from birds struck by aircraft presents both advantages and disadvantages. Modified from Rosenberg and Cooper (1990), Litvaitis et al. (1994), and Litvaitis (2000).

Method	Advantages	Disadvantages
Gastrointestinal tracts	Can examine sex, age, physical condition, reproductive status, and other traits; samples can be readily obtained from animals killed during control activities or from animals struck by aircraft.	Samples are usually limited to animals that are killed during control activities or struck by aircraft; heavily masticated or partially digested materials can be difficult to identify.
Pellet or feces analysis	Inexpensive; makes it possible to sample a large proportion of the population; can be done with minimal disturbance; identification guides and keys of hair, mammal skulls, and the like, are available.	Usually cannot determine sex or age class of focal species; differential digestibility can bias relative importance of various foods; samples can be greatly fragmented.
Direct observation	Inexpensive; sex and age classes can sometimes be determined; birds are not disturbed; can sample a large proportion of the population.	Dense vegetation can obscure observations; biased toward large and conspicuous prey; quantity of food consumed can be difficult to estimate; if control is necessary, there is often limited time available to observe focal animals.
Feeding site surveys	Can identify major foods consumed by species of interest; can roughly estimate quantity of food consumed.	Completely consumed foods cannot be surveyed; usually cannot determine sex or age class of focal species; usually only applicable to herbivores.

Fig. 8.2. A ring-billed gull (*Larus delawarensis*) feeds on earthworms on an active aircraft taxiway. Direct observation of wildlife foraging in airport environments can identify important food resources. Photo credit: U.S. Department of Agriculture, Wildlife Services

before initiating management of food resources. Furthermore, a more robust analysis of food selection may be warranted when contemplating management (e.g., removal) of a valuable or sensitive resource, such as expensive landscaping plants established at the airport for aesthetic reasons.

In some circumstances, wildlife foraging can be observed directly, and the use of dietary samples can be bypassed entirely (Table 8.1; Fig. 8.2). Direct observation is inexpensive and minimally invasive, and at times sex and age classes can be determined. But data from direct observations are generally biased toward large and conspicuous prey (small prey items are often missed entirely), and observations are usually limited to open environments. In addition, if the focal individual presents an immediate risk of collision with an aircraft, dispersal or removal obviously takes precedence over observation. Apparent feeding sites also can be investigated to determine the species responsible for food consumption and the amount of food consumed. This technique is limited to certain circumstances (e.g., foraging on agricultural crops; MacGowan et al. 2006) and is usually applicable only to herbivores. When conducting direct observations or feeding site surveys, it is still important to consider food availability in relation to foods consumed.

Managing Wildlife Food Resources at or near Airports

Once the most important food resources used by hazardous wildlife at a given airport have been identified, they should be eliminated or modified if possible. In some cases this task might seem relatively straightforward, but other situations are more challenging. Every portion of the airport must be "covered" by some form of land use, and airport wildlife managers must ensure that the chosen replacement for a wildlife food resource does not present an even greater attractant or, worse yet, attract a different but more hazardous wildlife species. Even bare pavement can be an attractant for some birds (e.g., gulls; Belant et al. 1995).

The most effective management of wildlife food resources is conducted during the planning process, before land covers are established at airports (Washburn and Seamans 2004, Blackwell et al. 2009). Even considering the caveat on dietary breadth explored above, general food habit preferences are reasonably well known for most bird species that are hazardous to aircraft (the *Birds of North America* series is an excellent resource for North American species; http://bna.birds.cornell.edu/bna/). Many landscaping plants, turfgrasses, trees, and other potential food resources that are best avoided at airports can be eliminated from consideration before they are established. For example, most airports maintain relatively large expanses of turfgrass adjacent to taxiways and runways. The species composition, seed production capacity, and height of these turfgrass areas should be managed to minimize use of this resource by wildlife hazardous to aviation, especially Canada geese (DeVault et al. 2011). Fortunately, Canada geese have clear preferences for some turfgrass species over others (Conover 1991, Washburn et al. 2007, Washburn and Seamans 2012). Unpalatable turfgrass species should be given high consideration for establishment at airports (Chapter 10). Regardless, all airport planning and construction projects should be done in consultation with a knowledgeable airport wildlife biologist.

We list wildlife food resources commonly found at airports and give recommendations for management of those resources in Table 8.2 (see also FAA 2007). We also provide examples from the scientific literature that provide additional details regarding management of specific food resources. Several of the food resources listed (i.e., carrion, agricultural crops, and municipal solid waste) warrant further discussion, because they are particularly attractive to hazardous wildlife or are difficult to remove or manage appropriately.

Carrion (e.g., animals struck and killed by cars or aircraft) should be removed from airport grounds and disposed of immediately upon discovery (Blackwell and Wright 2006). Although vultures are the best-known scavengers (and are extremely hazardous to aircraft), nearly all carnivorous vertebrates will eat carrion (DeVault et al. 2003). Hawks, eagles, owls, crows, gulls, and carnivorous mammals are all attracted to animal carcasses, and all are unwanted at airports (Fig. 8.3, see p. 87).

Recent and ongoing research has suggested that some agricultural crops might be compatible with safe airport operations (see below; Chapter 11). However, other crops like corn (*Zea mays*) and small grains like wheat (*Triticum* spp.) are known wildlife attractants (Cerkal et al. 2009) and should be avoided at and near airports when possible. Many wildlife species attracted to corn and small grains are especially hazardous to aircraft, such as Canada geese, snow geese (*Anser caerulescens*), sandhill cranes (*Grus canadensis*), and large flocks of blackbirds (e.g., red-winged blackbirds [*Agelaius phoeniceus*]; DeVault et al. 2011). Unfortunately, cultivation of corn and small grains is surprisingly common at airports (especially smaller facilities; DeVault et al. 2009). Further information on crop production that is safe for airport use is needed (Chapter 11).

Municipal solid waste management facilities, such as open landfills and trash-transfer stations, can attract birds hazardous to aviation and can increase the potential for strikes when these facilities are located near airports (Fig. 8.4, see p. 87). Gulls, vultures, European starlings, rock pigeons, and other birds forage on anthropogenic food waste at landfills and trash-transfer facilities (Patton 1988, Washburn 2012). Guidance and regulations regarding the siting of waste management facilities related to airports are available (FAA 2000, 2007). Considerable variation exists among solid waste management facilities with regard to their attractiveness to hazardous wildlife. Foraging birds heavily use some facilities, whereas wildlife use of other facilities is esentially nonexistent. Washburn (2012) found that several factors, including the geographic location, time of year, building design, and on-site facility management practices (e.g., cleanliness of outside areas), interact to influence the attractiveness of trash-transfer stations to hazardous wildlife. Integrated wildlife damage management practices that involve active wildlife control

Table 8.2. **Common wildlife food resources found at and near airports, the hazardous species they attract, and options for management.**

Food resource	Species or species group	Management options	References
Turfgrasses	Canada geese	Replace palatable turfgrasses with less desired species or types, alternative land covers, or artificial turf.	Conover (1991), Pochop et al. (1999), Washburn et al. (2007), Washburn and Seamans (2012); Chapter 10
Other terrestrial vegetation (seeds, fruit, etc.)	White-tailed deer, passerine birds, doves and pigeons, wild turkeys	Remove plants; erect netting or fencing.	Bernhardt et al. (2009), Biondi et al. (2011)
Aquatic vegetation	Ducks	Remove plants; erect netting; physically alter stormwater retention and detention ponds.	Blackwell et al. (2008); Chapter 9
Small grain and corn production	Geese, blackbirds, doves, sandhill cranes	Convert to alternative crops.	Williams and Jackson (1981), Humberg et al. (2007), Blackwell et al. (2009), Martin et al. (2011); Chapter 11
Small mammals	Raptors, owls, coyotes	Reduce population with rodenticides; manage or convert vegetation.	Stucker and Dunlap (2002), Witmer and Fantinato (2003), Witmer et al. (2007), Witmer (2011)
Carrion	Nearly all carnivorous vertebrates, but especially vultures, gulls, raptors, crows, coyotes, raccoons	Promptly remove and dispose of vertebrates struck by aircraft or ground vehicles.	DeVault et al. (2003), Blackwell and Wright (2006)
Fish and other aquatic animals	Ducks, osprey, eagles, pelicans, cormorants, herons	Remove fish in airport water bodies.	Werner and Dorr (2006)
Earthworms	Gulls, passerine birds	Modify runways and taxiways; use earthworm deterrents.	Dekker (2003)
Insects	Gulls, passerine birds, some raptors	Modify vegetation.	Buckley and McCarthy (1994), Caccamise et al. (1994), Bernhardt et al. (2010), Kutschbach-Brohl et al. (2010), Washburn et al. (2011)
Trash facilities (landfills, trash-transfer stations)	European starlings, gulls, pigeons	Properly manage trash facilities; employ frightening (dispersal) techniques.	Belant (1997), Patton (1988), Washburn (2012)
Human food waste (restaurants, etc.)	Geese, ducks, European starlings, pigeons, sparrows, and so on	Discourage feeding wildlife near airports.	International Civil Aviation Organization (2002)

(e.g., hazing with pyrotechnics) and alteration of facility operations (e.g., covering waste at night) can be effective in reducing the use of waste management facilities by hazardous birds.

Research Needs

The management of wildlife food resources at airports is inextricably linked to management of habitats (Caccamise et al. 1994, Barras and Seamans 2002, Kutschbach-Brohl et al. 2010, Washburn et al. 2011, Witmer 2011) and, unfortunately, the practice of habitat management at airports is often based on longstanding paradigms with scant scientific support (Blackwell et al. 2013; Chapter 11). For example, the FAA categorically denounces the presence of agriculture (including hay crops) on airport properties in the USA, because many types of agriculture provide food resources and thus attract hazardous wildlife species (FAA 2007; see also similar recommendations by the International Civil Aviation Organization 2002). However, field studies examining the importance of various types of agriculture in the diets of hazardous wildlife are lacking (Blackwell et al. 2009, Martin

Fig. 8.3. A peregrine falcon (*Falco peregrinus*) feeds on a gull carcass at a major airport in the eastern USA. Animal carcasses found on airfields should be removed immediately upon discovery so they do not attract hazardous wildlife. Photo credit: Jenny Mastantuono

Fig. 8.4. When not managed properly, solid waste management facilities like this trash-transfer station can attract wildlife hazardous to aviation. Photo credit: Brian E. Washburn

et al. 2011). Re-examination of habitat management paradigms (and wildlife food availability) will be needed to advance the science of wildlife management at airports. Given the immense scale of managed land at airports worldwide (e.g., airport grasslands in the continental USA encompass >3,300 km^2 [1,274 miles^2], and the USA contains about 15,000 of the world's 44,000 airports; U.S. Central Intelligence Agency 2010, DeVault et al. 2012), questions regarding the interplay among habitat types, food availability, and wildlife movements on and near airports are critical.

Summary

Food acquisition is often the chief motivation for wildlife to use airport habitats. Frequently, the most effective way to reduce populations of hazardous wildlife at airports is to determine which foods are being used and then remove or modify those foods to make them less attractive. Several techniques are available for determining food selection by wildlife at airports, and samples are often readily available (e.g., animals struck by aircraft or collected during control activities). Once important food resources have been identified, management actions can be employed to reduce or remove them. Given the variety and abundance of wildlife foods available at airports, such efforts can be difficult and require careful consideration of the proper management actions to implement, such as habitat manipulation. Integrated wildlife damage management practices can be effective in removing food attractants from airport environments and reduce the risk of damaging wildlife strikes.

LITERATURE CITED

Baker, J. A., and R. J. Brooks. 1981*a*. Distribution patterns of raptors in relation to density of meadow voles. Condor 83:42–47.

Baker, J. A., and R. J. Brooks. 1981*b*. Raptor and vole populations at an airport. Journal of Wildlife Management 45:390–396.

Barras, S. C., and T. W. Seamans. 2002. Habitat management approaches for reducing wildlife use of airfields. Proceedings of the Vertebrate Pest Conference 20:309–315.

Bechard, M. J. 1982. Effect of vegetative cover on foraging site selection by Swainson's hawk. Condor 84:153–159.

Beier, P., and J. E. Drennan. 1997. Forest structure and prey abundance in foraging areas of northern goshawks. Ecological Applications 7:564–571.

Belant, J. L. 1997. Gulls in urban environments: landscape-level management to reduce conflict. Landscape and Urban Planning 38:245–258.

Belant, J. L., S. W. Gabrey, R. A. Dolbeer, and T. W. Seamans. 1995. Methyl anthranilate formulations repel gulls and mallards from water. Crop Protection 14:171–175.

Bernhardt, G. E., L. Kutschbach-Brohl, B. E. Washburn, R. B. Chipman, and L. C. Francoeur. 2010. Temporal variation in terrestrial invertebrate consumption by laughing gulls in New York. American Midland Naturalist 163:442–454.

Bernhardt, G. E., Z. J. Patton, L. A. Kutschbach-Brohl, and R. A. Dolbeer. 2009. Management of bayberry in relation to tree-swallow strikes at John F. Kennedy International Airport, New York. Human–Wildlife Conflicts 3:237–241.

Biondi, K. M., J. L. Belant, J. A. Martin, T. L. DeVault, and G. Wang. 2011. White-tailed deer incidents with U.S. civil aircraft. Wildlife Society Bulletin 35:303–309.

Blackwell, B. F., T. L. DeVault, E. Fernández-Juricic, and R. A. Dolbeer. 2009. Wildlife collisions with aircraft: a missing component of land-use planning for airports. Landscape and Urban Planning 93:1–9.

Blackwell, B. F., L. M. Schafer, D. A. Helon, and M. A. Linnell. 2008. Bird use of stormwater-management ponds: decreasing avian attractants on airports. Landscape and Urban Planning 86:162–170.

Blackwell, B. F., T. W. Seamans, P. M. Schmidt, T. L. DeVault, J. L. Belant, M. J. Whittingham, J. A. Martin, and E. Fernández-Juricic. 2013. A framework for managing airport grasslands and birds amidst conflicting priorities. Ibis 155:199–203.

Blackwell, B. F., and S. E. Wright. 2006. Collisions of red-tailed hawks (*Buteo jamaicensis*), turkey (*Cathartes aura*), and black vultures (*Coragyps atratus*) with aircraft: implications for bird strike reduction. Journal of Raptor Research 40:76–80.

Buckley, N. J. 1999. Black vulture (*Coragyps atratus*). Number 411 in A. Poole and F. Gill, editors. The birds of North America. Academy of Natural Sciences, Philadelphia, Pennsylvania, and American Ornithologists' Union, Washington, D.C., USA.

Buckley, P. A., and M. G. McCarthy. 1994. Insects, vegetation, and the control of laughing gulls (*Larus atricilla*) at Kennedy International Airport, New York City. Journal of Applied Ecology 31:291–302.

Caccamise, D. F., J. J. Dosch, K. Benett, L. M. Reed, and L. DeLay. 1994. Management of bird strike hazards at airports: a habitat approach. Proceedings of the International Bird Strike Committee 22:285–306.

Cerkal, R., K. Vejražka, J. Kamler, and J. Dvořák. 2009. Game browse and its impact on selected grain crops. Plant, Soil, and Environment 55:181–186.

Coleman, J. S., and J. D. Fraser. 1987. Food habits of black and turkey vultures in Pennsylvania and Maryland. Journal of Wildlife Management 51:733–739.

Coleman, J. S., and J. D. Fraser. 1989. Habitat use and home ranges of black and turkey vultures. Journal of Wildlife Management 53:782–792.

Conover, M. R. 1991. Herbivory by Canada geese: diet selection and effects on lawns. Ecological Applications 1:231–236.

Dekker, A. 2003. Taking habitat management one step further. Proceedings of the International Bird Strike Committee 26:265–272.

DeVault, T. L., J. L. Belant, B. F. Blackwell, J. A. Martin, J. A. Schmidt, L. W. Burger Jr., and J. W. Patterson Jr. 2012. Airports offer unrealized potential for alternative energy production. Environmental Management 49:517–522.

DeVault, T. L., J. L. Belant, B. F. Blackwell, and T. W. Seamans. 2011. Interspecific variation in wildlife hazards to aircraft: implications for airport wildlife management. Wildlife Society Bulletin 35:394–402.

DeVault, T. L., and A. R. Krochmal. 2002. Scavenging by snakes: an examination of the literature. Herpetologica 58:429–436.

DeVault, T. L., J. E. Kubel, O. E. Rhodes Jr., and R. A. Dolbeer. 2009. Habitat and bird communities at small airports in the midwestern USA. Proceedings of the Wildlife Damage Management Conference 13:137–145.

DeVault, T. L., B. D. Reinhart, I. L. Brisbin Jr., and O. E. Rhodes Jr. 2004. Home ranges of sympatric black and turkey vultures in South Carolina. Condor 106:706–711.

DeVault, T. L., B. D. Reinhart, I. L. Brisbin Jr., and O. E. Rhodes Jr. 2005. Flight behavior of black and turkey vultures: implications for reducing bird–aircraft collisions. Journal of Wildlife Management 69:601–608.

DeVault, T. L., O. E. Rhodes Jr., and J. A. Shivik. 2003. Scavenging by vertebrates: behavioral, ecological, and evolutionary perspectives on an important energy transfer pathway in terrestrial ecosystems. Oikos 102:225–234.

Dolbeer, R. A., and S. E. Wright. 2009. Safety management systems: how useful will the FAA National Wildlife Strike Database be? Human–Wildlife Conflicts 3:167–178.

Dolbeer, R. A., S. E. Wright, and E. C. Cleary. 2000. Ranking the hazard level of wildlife species to aviation. Wildlife Society Bulletin 28:372–378.

Dolbeer, R. A., S. E. Wright, J. Weller, and M. J. Begier. 2010. Wildlife strikes to civil aircraft in the United States 1990–2009. Serial Report 16. U.S. Department of Transportation, Federal Aviation Administration, Office of Airport Safety and Standards, Washington, D.C., USA.

FAA. Federal Aviation Administration. 2000. Construction or establishment of landfills near public airports. Advisory Circular 150/5200-34. U.S. Department of Transportation, Washington, D.C., USA.

FAA. Federal Aviation Administration. 2007. Hazardous wildlife attractants on or near airports. Advisory Circular 150/5200-33B. U.S. Department of Transportation, Washington, D.C., USA.

Fischl, J., and D. F. Caccamise. 1987. Relationships of diet and roosting behavior in the European starling. American Midland Naturalist 117:395–404.

Grant, T. A., E. M. Madden, T. L. Shaffer, P. J. Pietz, G. B. Berkey, and N. J. Kadrmas. 2006. Nest survival of clay-colored and vesper sparrows in relation to woodland edge in mixed-grass prairies. Journal of Wildlife Management 70:691–701.

Heinrich, G., and K. R. Studenroth Jr. 1996. *Agkistrodon piscivorus conanti* (Florida cottonmouth): diet. Herpetological Review 27:22.

Humberg, L. A., T. L. DeVault, B. J. MacGowan, J. C. Beasley, and O. E. Rhodes Jr. 2007. Crop depredation by wildlife in northcentral Indiana. Proceedings of the National Wild Turkey Symposium 9:59–65.

International Civil Aviation Organization. 2002. Land use and environmental control. Airport Planning Manual, Document 9184 AN/902, Part 2. Montreal, Quebec, Canada.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65–71.

Kelly, N. E., D. W. Sparks, T. L. DeVault, and O. E. Rhodes Jr. 2007. Diet of black and turkey vultures in a forested landscape. Wilson Journal of Ornithology 119:267–270.

Kirk, D. A., and M. J. Mossman. 1998. Turkey vulture (*Cathartes aura*). Number 339 in A. Poole and F. Gill, editors. The birds of North America. Academy of Natural Sciences, Philadelphia, Pennsylvania, and American Ornithologists' Union, Washington, D.C., USA.

Krapu, G. L., D. A. Brandt, and R. R. Cox Jr. 2004. Less waste corn, more land in soybeans, and the switch to genetically modified crops: trends with important implications for wildlife management. Wildlife Society Bulletin 32:127–136.

Kutschbach-Brohl, L., B. E. Washburn, G. E. Bernhardt, R. B. Chipman, and L. C. Francoeur. 2010. Arthropods of a semi-natural grassland in an urban environment: the John F. Kennedy International Airport, New York. Journal of Insect Conservation 14:347–358.

Lima, S. L. 1998. Non-lethal effects in the ecology of predator–prey interactions. BioScience 48:25–34.

Lima, S. L., and L. M. Dill. 1990. Behavioural decisions made under the risk of predation: a review and prospectus. Canadian Journal of Zoology 68:619–640.

Litvaitis, J. A. 2000. Investigating food habits of terrestrial vertebrates. Pages 165–190 *in* L. Boitani and T. K. Fuller, editors. Research techniques in animal ecology. Columbia University Press, New York, New York, USA.

Litvaitis, J. A., K. Titus, and E. Anderson. 1994. Measuring vertebrate use of terrestrial habitats and food. Pages 254–274 *in* T. Bookhout, editor. Research and management techniques for wildlife and habitats. The Wildlife Society, Bethesda, Maryland, USA.

MacArthur, R. H., and E. R. Pianka. 1966. On the optimal use of a patchy environment. American Naturalist 100:603–609.

MacGowan, B. J., L. A. Humberg, J. C. Beasley, and O. E. Rhodes Jr. 2006. Identification of wildlife crop damage. Publication FNR-267-W. Purdue University Extension, West Lafayette, Indiana, USA.

Martin, J. A., J. L. Belant, T. L. DeVault, L. W. Burger Jr., B. F. Blackwell, S. K. Riffell, and G. Wang. 2011. Wildlife risk to aviation: a multi-scale issue requires a multi-scale solution. Human–Wildlife Interactions 5:198–203.

McDonald, L. L., J. R. Alldredge, M. S. Boyce, and W. P. Erickson. 2005. Measuring availability and vertebrate use of terrestrial habitats and foods. Pages 465–488 *in* C. E. Braun, editor. Techniques for wildlife investigations and management. The Wildlife Society, Bethesda, Maryland, USA.

Parker, K., and M. L. McCallum. 2010. *Pantherophis obsoletus* (Texas ratsnake): diet and feeding behavior. Herpetological Review 41:502.

Patton, S. R. 1988. Abundance of gulls at Tampa Bay landfills. Wilson Bulletin 100:431–442.

Pietz, P. J., and D. A. Granfors. 2000. Identifying predators and fates of grassland passerine nests using miniature video cameras. Journal of Wildlife Management 64:71–87.

Pochop, P. A., J. L. Cummings, K. L. Wedemeyer, R. M. Engeman, and J. E. Davis Jr. 1999. Vegetation preferences of captive Canada geese at Elmendorf Air Force Base, Alaska. Wildlife Society Bulletin 27:734–740.

Polis, G. A. 1991. Complex trophic interactions in deserts: an empirical critique of food-web theory. American Naturalist 138:123–155.

Preston, C. R. 1990. Distribution of raptor foraging in relation to prey biomass and habitat structure. Condor 92:107–112.

Rolando, A. 2002. On the ecology of home range in birds. Review d'Ecologie—La Terre et la Vie 57:53–73.

Rosenberg, K. V., and R. J. Cooper. 1990. Approaches to avian diet analysis. Studies in Avian Biology 13:80–90.

Savidge, J. A. 1988. Food habits of *Boiga irregularis*, an introduced predator on Guam. Journal of Herpetology 22:275–282.

Shoener, T. 1971. Theory of feeding strategies. Annual Review of Ecology and Systematics 2:369–404.

Shoener, T. 1986. A brief history of optimal foraging theory. Pages 5–68 *in* A. C. Kamil, J. R. Krebs, and H. R. Pulliam, editors. Foraging behavior. Plenum, New York, New York, USA.

Sieving, K. E., and M. F. Willson. 1998. Nest predation and avian species diversity in northwestern forest understory. Ecology 79:2391–2402.

Sterner, R. T., D. J. Elias, M. V. Garrison, B. E. Johns, and S. R. Kilburn. 1984. Birds and airport agriculture in the conterminous United States: a review of literature. Pages 319–329 *in* M. J. Harrison, S. A. Gauthreaux Jr., and L. A. Abron-Robinson, editors. Proceedings of the wildlife hazards to aircraft conference. DOT/FAA/AAS/84-1. U.S. Department of Transportation, Federal Aviation Administration, Office of Airport Standards. Washington, D.C., USA.

Stucker, K. P., and B. G. Dunlap. 2002. Food habits of raptors using airports in north-central Kentucky. Proceedings of the Vertebrate Pest Conference 20:170–174.

U.S. Central Intelligence Agency. 2010. The world factbook. https://www.cia.gov/library/publications/the-world-factbook/geos/us.html.

Wakely, J. S. 1978. Factors affecting the use of hunting sites by ferruginous hawks. Condor 80:316–326.

Washburn, B. E. 2012. Avian use of solid waste transfer stations. Landscape and Urban Planning 104:388–394.

Washburn, B. E., S. C. Barras, and T. W. Seamans. 2007. Foraging preferences of captive Canada geese related to turfgrass mixtures. Human–Wildlife Conflicts 1:214–223.

Washburn, B. E., G. E. Bernhardt, and L. A. Kutschbach-Brohl. 2011. Using dietary analyses to reduce the risk of wildlife–aircraft collisions. Human–Wildlife Interactions 5:204–209.

Washburn, B. E., and T. W. Seamans. 2004. Management of vegetation to reduce wildlife hazards at airports. Proceedings of the 2004 worldwide airport technology transfer conference. Federal Aviation Administration, April 2004, Atlantic City, New Jersey, USA.

Washburn, B. E., and T. W. Seamans. 2012. Foraging preferences of Canada geese among turfgrasses: implications for reducing human–goose conflicts. Journal of Wildlife Management 76:600–607.

Werner, S. J., and B. S. Dorr. 2006. Influence of fish stocking density on the foraging behavior of double-crested cormorants, *Phalacrocorax auritus*. Journal of the World Aquaculture Society 37:121–125.

Williams, G. E., and P. B. Wood. 2002. Are traditional methods of determining nest predators and nest fates reliable? An experiment with wood thrushes (*Hylocichla mustelina*) using miniature video cameras. Auk 119:1126–1132.

Williams, R. E., and W. B. Jackson. 1981. Dietary comparisons of red-winged blackbirds, brown-headed cowbirds, and European starlings in north-central Ohio. Ohio Journal of Science 81:217–225.

Witmer, G. W. 2011. Rodent population management at Kansas City International Airport. Human–Wildlife Interactions 5:269–275.

Witmer, G. W., and J. W. Fantinato. 2003. Management of rodent populations at airports. Proceedings of the Wildlife Damage Management Conference 10:350–357.

Witmer, G. W., R. Saylor, D. Huggins, and J. Capelli. 2007. Ecology and management of rodents in no-till agriculture in Washington, USA. Integrative Zoology 2:154–164.