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Commentary

Wildlife risk to aviation: a multi-scale issue requires a multi-scale solution

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Aircraft collisions with birds and other wildlife (wildlife strikes) pose increasing safety and financial concerns to the aviation industry worldwide. Recent events such as the ditching of US Airways Flight 1549 in the Hudson River have renewed public interest in risks to aircraft posed by wildlife (Marra et al. 2009). However, wildlife biologists and aviation personnel have been aware of these issues for decades (Solman 1973, Blokpoel 1976). Since the inception of the Federal Aviation Administration's (FAA) National Wildlife Strike Database in 1990, 99,411 reported wildlife strikes to airplanes have resulted in at least $1.2 billion annually in losses (direct and indirect) to civil aviation worldwide and >$625 million annually in the United States, as well as >200 human lives lost (Allan 2002, Dolbeer et al. 2010).

Wildlife-strike mitigation at airports involves reducing the likelihood that a strike occurs and reducing the level of damage if a strike does happen. Historically, wildlife management at airports has occurred at small spatial scales relative to overall animal space use. Wildlife damage management strategies (e.g., harassment and deterrents) usually occur within the confines of airport property. However, the effectiveness of these techniques depends in part on the surrounding landscape and ecology of species involved. For example, the Cessna Citation 1 crash in Oklahoma in 2008 that killed 5 people was caused by American white pelicans (*Pelecanus erythrorhynchos*) likely flying to or from a lake <2 km from the crash site (Dove et al. 2009, National Transportation Safety Board 2009). York et al. (2000) reported that site-specific return rates of Canada geese (*Branta canadensis*) to a U.S. Air Force base after harassment were contingent on the distance from the airport to their resting site. Further, typical habitat management techniques consider only 1 life-history trait. For example, Bernhardt et al. (2009) reported how the manipulation of a single food source within airport property reduced use by tree-swallows (*Tachycineta bicolor*). Although these insights are useful, they would be more meaningful in a spatially-explicit context (Dunning et al. 1995, Turner et al. 1995). Blackwell et al. (2008) demonstrated that including proximity metrics improved model performance in estimating bird use of stormwater ponds. Specifically, probability of pond use by birds was near zero when isolated (>8 km distance) from other ponds. Ideally, wildlife-strike risk mitigation should be an integrative process based on ecological principles and on scales that are not constrained by administrative boundaries or management resources. Unfortunately, the opposite has been status quo. Our point is not to diminish the work done by airport wildlife management programs, which has often been highly effective, but, rather, to acknowledge the difficulty implementing control efforts beyond airport boundaries.

Dolbeer (2006) noted that 66% of bird strikes resulting in substantial damage to aircraft occurred ≤152 m above ground level (AGL), effectively 3 km from the airfield (based on a 3° glideslope [Foundation 2000, Blackwell et al. 2009]). Additionally, about 95% of all bird strikes occur ≤1,067 m AGL (Dolbeer 2006). At that altitude, aircraft would be within 18.5 km of the airfield (Federal Aviation Administration [FAA] 2008). Dolbeer (2011) reported that bird-strike rates >152 m AGL have increased since 1990, whereas strike rates ≤152 m AGL have decreased during that time period. These empirical data suggest recent wildlife management on airports has reduced strike rates. However, the data also emphasize the importance of the area outside of direct airport control. Airport property is usually only a small portion of the landscape at spatial extents >3 km (Figure 1). Effective risk management is less likely without considering spatial extents beyond airport boundaries. Blackwell et al. (2009) outlined the need to incorporate consideration of wildlife collisions into land-use planning for airports. We agree with their assessment, but complement their conclusions with a reciprocal approach that incorporates land-use and land-cover management into wildlife-strike risk management at multi-spatial scales.

The airport landscape in this context can be considered a theoretical zone that influences strike risk and viewed as a hierarchical structure consisting of multiple spatial extents (Figure 1). This landscape is more than a theoretical construct; it is a realized area dependent on many ecological- and aviation-based factors. In practice, and as a starting point, these spatial extents could correspond to the distances described by Dolbeer (2006) and the FAA Advisory Circular 150/5200-33B (2007). This document outlines separation criteria for hazardous wildlife attractants on or near airports with the outward most extent being 5 miles (8 km). However, these guidelines are not necessarily based on the ecology of hazardous wildlife species. Ecologically and geospatially, airport landscapes intersect home ranges and migratory pathways of animals. For example, waterfowl may use the river as a migratory pathway within an 18-km buffer of the airport (see Figure 1). Further, Belant et al. (1993) observed that gull movements during nesting and chick-rearing range 4.6 to 14.7 km from the nesting colony to landfills to acquire food. This type of knowledge can be used to make land-use and habitat-management decisions on the airport not to provide food sources, terrestrial loafing grounds, and roosts for hazardous birds. Furthermore, information on animal space use at multiple scales (temporal and spatial) can inform air traffic control decisions to avoid high-risk airspace. For example, in the case of Figure 1, the river cannot be altered, but flight paths can be altered when bird-use is high. Similarly, critical habitat for some species may be within the buffer zone. In these cases, mitigating risk may be difficult, but collaborations with land-use planners will be invaluable (Blackwell et al. 2009).

The influential landscape, the surrounding land-use and spatial context that affects animal movements, may be much larger than the example 18-km buffer in some cases. For instance, VerCauteren and Marks (2004) demonstrated that resident urban geese are capable of seasonal movements up to 109 km. Also, Stolen and Taylor (2003) reported black vulture (*Corogyps atratus*) movements of 8 to 152 km in relation to roost sites. Additionally, DeVault et al. (2004) noted that annual home ranges of turkey vultures (*Cathartes aura*) can exceed 40,000 ha, and often they are centered on communal roosts. Both black and turkey vultures are hazardous to aircraft (Dolbeer et al. 2000, Dolbeer and Wright 2009). Seasonal and daily movements of high-risk species such as these should be considered in the context of land-use and habitat management (e.g., Blackwell and Wright 2006). Data on movements and landscape ecology will be lacking for some species, but taxonomically similar species can be used as surrogates in addition to expert opinion (Murray et al. 2009). Additionally, administrative boundaries, such as land ownership, should be considered to establish jurisdiction and allow representatives to rank management priorities collectively in the context of ecological scales and aviation airspace. It would benefit airport personnel and ecologists to work together to understand

Figure 1. An example of varying spatial extents surrounding an airport and the diversity of land use within the proximity of the airport. Upper panel depicts an airport with a 3-km (from center) buffer; note the majority of area is urban. The lower panel depicts an 18-km buffer; note the presence of a major river (upper right), which would likely influence wildlife movements.

underlying mechanisms in determining appropriate management scales, such that land-use planning and habitat management are most effective (Belant et al. 1997).

Wildlife management in the context of strike-risk reduction involves a combination of land-use planning and vegetation or other resource management (e.g., water and food) in conjunction with wildlife damage control methods, such as deterrents, harassment, and removal. As an example, land-use planning and habitat management at airports typically involves establishment of turf grasses maintained at short heights by frequent mowing. Mowing is costly, energy-intensive, and it may have the unintended consequence of producing vegetation structure that attracts some species that pose strike risk (e.g., Canada geese, ring-billed gulls [*Larus delawarensis*], and European starling [*Sturnus vulgaris*]). Habitat management in the context of strike-risk mitigation should strive to create areas that, if used by wildlife, would decrease individual fitness (e.g., reducing food resources, increasing vigilance, etc.) by managing vegetation structure and composition in such a way that does not trigger a settling response, alter space use, or create an aversive response (C. R. Ayers, Mississippi State University, unpublished data). Unfortunately, generalizations about vegetation height or other resource attributes may not be optimal under most situations; several authors have provided examples of contradictory outcomes (see Seamans et al. 1999, 2007; Deacon and Rochard 2000; Barras and Seamans 2002; Washburn and Seamans 2004). Consequently, region-specific management recommendations may be warranted based on maladaptive conditions for high-risk species of particular regions (Dolbeer et al. 2000).

An alternative to using turfgrasses on portions of airport properties or on surrounding lands may be to convert land-use to less-preferred habitat to reduce wildlife-strike risk. Potential alternatives to turf grass include row-crop agriculture, pasture, timber production, biofuel crops, hay fields, or conversion to hardscapes (e.g., paved or graveled areas; [(Lyster 2010)]). However, FAA and the International Civil Aviation Organization have historically taken a position against all types of agriculture on airport property (FAA 2007). These recommendations are not based on research, but mostly on the perceived risk associated with these land uses (Blackwell et al. 2009). An overriding principle of changing land use is that, regardless of vegetation or resource type, habitat will be created for a different wildlife community. However, the goal should be to transition toward less suitable environments for the most hazardous species (Dolbeer et al. 2000, Dolbeer and Wright 2009). Although habitat management could shift the wildlife community to less hazardous species, at least some use by more hazardous species will likely still occur. In these cases, wildlife damage techniques, such as deterrents, harassment, and lethal control, should be considered.

A primary goal of any habitat management or land-use change in the context of aviation is to reduce strike hazards. Management beyond the airport boundary is a very difficult task, but not impossible. Creative approaches to affecting land-use change beyond the airport boundary do exist and should be explored. For example, cost-share or other incentives could be provided to agricultural producers to convert to other crop types within a defined zone around airports. Economic incentives will alter land use, provided that just compensation is supplied to offset direct and opportunity costs. Numerous conservation programs provide incentives to induce adoption of practices that address specific resource concerns and produce broader societal benefits, including biofuel production, soil erosion reduction, water quality enhancement, and wildlife population restoration. In many cases, eligibility for these practices is geographically restricted to increase programmatic efficiency; proximity to airports could provide criteria for practice eligibility and ranking. Also, cooperative wildlife management between airports and surrounding land owners could reduce strike risk while concurrently reducing crop and property depredation. We as biologists, airport managers, planners, and others should continue to work together to explore possible solutions to manage the larger airport landscape effectively.

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