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Grass management regimes affect grasshopper availability and subsequently American crow activity at airports

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Abstract: With large expanses of open vegetation, airports serve as major attractants for numerous bird species, such as the American crow (*Corvus brachyrhynchos*), which can lead to high risk of bird–aircraft collision. Previous observations of large influxes of crows at the Prince George Airport (British Columbia, Canada) in July and August suggested that crows were opportunistically foraging on grasshopper (*Melanoplus* sp.) population eruptions in mown grass during those months. We tested whether grasshoppers were more visible (i.e., easier for crows to detect) under different grass lengths, and whether crows were preferentially attracted to these same grass lengths. Employing line transects during July to August 2010 and 2011, we detected >6 times as many grasshoppers in short-cut grass (0 to 15 cm) than in uncut grass (>30 cm). Data from 2011 also revealed that grasshopper detections by crows was significantly higher in short-cut grass than in grass left at intermediate lengths (long-cut grass [15 to 30 cm]). Crow densities also varied with grass length, with significantly more crows foraging in short-cut than long-cut or uncut grass lengths. Our results indicate that allowing the grass to grow to >15 cm could reduce the attraction of crows to the airfield and may reduce bird–aircraft collisions.

Key words: aircraft damage, bird management, bird reduction, human–wildlife conflicts, prey availability, strike risk

Open fields with ample access to food items, clear views of predators, and fresh water make airports ideal locations for many bird species to congregate for foraging or resting (Brown et al. 2001, Oduntan et al. 2012, DeVault and Washburn 2013). Bird species that habitually frequent airports include hawks, falcons, sparrows, geese, ducks, gulls, corvids, and wading birds (DeVault et al. 2011). Given that most bird–aircraft collisions occur during aircraft take-off and landing (Cleary and Dolbeer 2005, Dolbeer 2006), birds on and around airport runways create both passenger safety issues and economic problems, such as flight delays. Globally, >231 people have been killed as a result of bird–aircraft collisions (Thorpe 2003), with estimated costs in the United States alone, conservatively ranging from $1 billion to $1.3 billion per year (Allan 2000). Due to increasing amounts of air traffic, the construction of quieter, larger bodied aircraft that may be more difficult for birds to hear, and with increasing populations of large-bodied birds (Sodhi 2002, Dolbeer and Eschenfelder 2003, Dolbeer 2006), it is becoming more critical to find practical solutions to avoid bird–aircraft collisions. As the ability to manoeuver aircraft during take-off and landing is limited (Soldatini et al. 2011), it is more practical to focus solutions on management of bird presence and behavior at airports.

Periods of fall and spring migration are particularly hazardous for bird–aircraft collisions (Sodhi 2002). Not only is there a large influx of birds navigating the skies, but many birds are seeking temporary foraging sites, and, fatigued from their migration, they may be more susceptible to aircraft collisions (Sodhi 2002). Additionally, the start of the fall migration period in northern latitudes corresponds to the fledgling dispersal period of many species (Dolbeer 2006), and these young, naïve birds may be particularly vulnerable to collisions with aircraft. Previous observations at our study airport in northern British Columbia, Canada (Prince George Regional Airport), concur that fall migration and dispersal periods constitute the most hazardous period annually;

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the greatest number of bird strikes occurred during August to October (M. L. Anderson and K. A. Otter, University of Northern British Columbia, unpublished report). Anecdotal observations at the Prince George airport over a number of years also suggested that American crow (*Corvus brachyrhynchos*) densities increased during these months, with flocks involving hundreds of individuals foraging within the infield areas of the airport. From 1990 to 2009, airports across the United States reported 141 strikes involving crows, 10% of which caused damage to the aircraft (DeVault et al. 2011). Though crows seemed to acclimatize to aircraft traffic by avoiding engaged runways, they were the most frequently observed species during May to July surveys at the Prince George Regional Airport (M. L. Anderson and K. A. Otter, 2007, unpublished report). Between 2000 and 2006, 57 confirmed air strikes were reported at the airport, and of the 39 cases where bird remains were recovered, five were identified as corvids, including at least 1 confirmed American crow (M. L. Anderson and K. A. Otter, 2007 unpublished report). Birdstrikes during this reporting period also peaked during July to August, when crow densities on the infield of the airport peak. Crows, therefore, constitute a particular local risk at the study airport. Further, managing for crow densities on airfields is relevant, given the frequency of birdstrikes involving crows across the United States, and the commonality of the species. Additionally, their medium-body size poses a significant risk for damage to aircraft during collisions.

The attraction of foraging birds to airfields due to prey availability can be exacerbated by airfield grass cutting policies for aesthetics and emergency response access; grass cutting can inadvertently increase availability of prey, resulting in the attraction of birds (Washburn and Seamans 2004, DeVault and Washburn 2013, Washburn and Seamans 2013). Mown lawns can increase bird access to ground-based insect prey (Buckley and McCarthy 1994), as well as provide birds with unobstructed sight lines for predator detection while foraging (Blackwell et al. 2013). Inspection of the primary foraging areas frequented by crows at the Prince George Regional Airport during months of peak bird presence (July and August) revealed large populations of grasshoppers (*Melanoplus* sp.) inhabiting the airport infields (M. L. Anderson and K. A. Otter 2007, unpublished report). The grasshoppers appeared to be exposed by grass-cutting regimes in these areas, given that groups of crows and magpies congregated on airport infields during and immediately following mowing (personal observation by the authors). Grasshoppers form a major component of samples of crow guts, particularly during the nestling and post-fledging periods of June to September (Hering 1934, Kalmbach 1939, Verbeek and Caffrey 2002) when grasshopper abundance also peaks. The aim of the current research is, therefore, to establish the potential link between prey availability and bird abundance, and to determine if grass habitat management can influence prey accessibility and be manipulated to decrease the attraction of insects to birds on airfields.

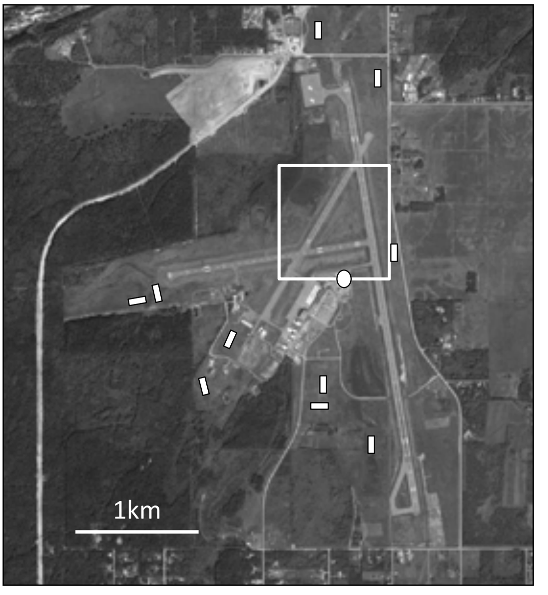

Figure 1. Aerial map of the Prince George Airport, British Columbia, Canada, showing the location of the elevated rooftop where crow observation surveys were taken (white mark on square), and the approximate area of the infield surveyed (open white square). The locations of the grass-length test plots are shown as white rectangles.

Methods

Study site

Prince George Regional Airport (Latitude 53.885422° N, Longitude -122.671854° E; Figure 1) has approximately 34 scheduled commercial flight arrivals and departures per operational day (0600 to 2300 hours), and is the regional center for numerous unscheduled flights each day (e.g., private and charter aircraft, forest fire service, and helicopter operations). Passenger aircraft range in size from 18-seat Beech 1900D twin engine turboprops to 120- to 140-seat Boeing 737 jets, with half of commercial flights being operated with jets that can hold >100 passengers. The airport has both national and international flights, and major runway extensions completed in 2009 have increased freight airline traffic for refueling and transport of goods, operations that are set to expand in the future. Combined, these result in multiple flights per hour, ranging from small private aircraft to commercial passenger and freight jets.

Study 1: grass length and foraging crow densities

From August 2 to 17, 2010, we observed crows from a central rooftop of one of the airport buildings. This vantage point provided a 360° view over most of the airport grounds, and was elevated 6.7 m above ground level (Figure 1). There was clear visibility for approximately 1.5 km in all directions. The airfield consisted of patches of grass maintained at different lengths, which allowed us to test for a difference in crow abundance and grasshopper visibility in grass lengths. Observations were conducted over 11 days (as weather permitted) from August 2 to 17, 2010, between 0600 and 1500 hours for 1 to 4 hours per day (average 2.4 ± 0.2SE hours/day). We tallied the number of crows that had landed and foraged within sections of 3 discrete lengths of grass over the course of each hour of observation: short-cut (0 to 15 cm), long-cut (15 to 30 cm) or uncut (>30 cm) grass. We used satellite images of the Prince George Regional Airport and surrounding grasslands to demark the boundaries of sections with different grass lengths, so that total area of each grass-length category could be later calculated to derive standardized crow densities. We measured the length of grasses twice weekly by randomly selecting 3 point locations within each observation section and averaging their grass lengths to the nearest 0.5 cm. As grass grew or new areas were mown, we recalculated the areas and boundary locations of different grass-length categories weekly. Using these adjusted areas, we calculated the densities of foraging crows/km^2 in each grass-length category each week of the study.

To compare the relative usage of areas of different grass length by foraging crows, we first calculated the cumulative areas of each grass length using polygons (adjusted over each sampling period as grass grew or new areas were cut) in ArcGIS software version 9.3 (ESRI, Redlands, Calif., 2008) superimposed on a digitized satellite map of the airport. The total number of crows detected on surveys within each area was used to calculate the average crows/km^2 within each grass-length category during each sampling period. We used Friedman ANOVAs to compare differences in crow density between grass-length categories across the sampling periods; post-hoc analyses comparing differences between each pair-wise combination of grass-height categories within sampling periods were conducted with Wilcoxon matched-pairs tests.

Study 2: grasshopper availability in subplots of different grass lengths

In 2010, we utilized 10 50-m × 200-m plots in the airport's grassland property established by a separate project, which was investigating the use of different grass mixtures and lengths in airport revegetation. Each plot had 4, 50-m × 50-m subplots within it, one of which was short-cut local grass (mown on a regular basis to maintain grass length to between 0 and 15 cm), and one was uncut local grass (>30 cm). The other 2 subplots contained experimental grass mixtures, but were not used in this study. As four of these study plots occurred within the airport security areas, consistent access to sample some subplots was not always possible. To supplement sampling in 2010, we also conducted random transects (50 m in length) through the mown grass next to the airport runways (short-cut) and through unmown grass on the airport's periphery (uncut) when access issues prevented sampling targeted subplots within the security area.

During July and August 2011, we utilized six of these same plots occurring outside the airport's security area to ensure consistent access. This also allowed us to introduce the

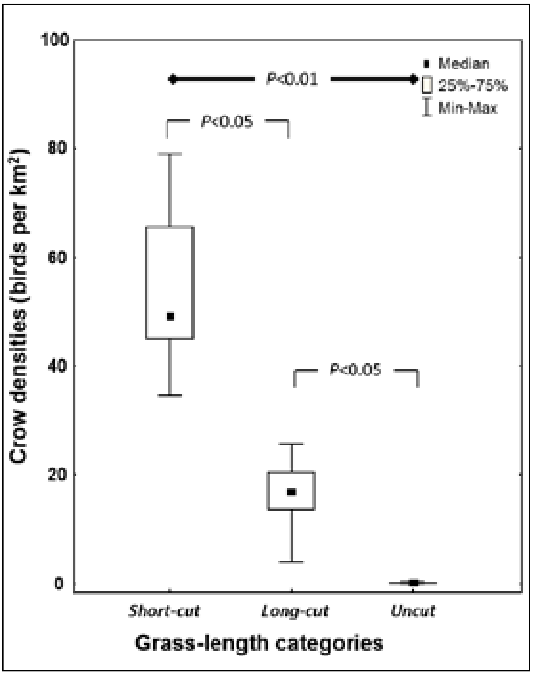

Figure 2. The density of foraging crows differed among 3 grass-length categories across the sampling period at the Prince George Airport, 2010. The greatest densities of crows were seen using short-cut grass (0 to 15cm), followed by long-cut grass (15 to 30 cm), and were lowest in uncut (>30 cm). The bar at the top of the figure represents the Friedman ANOVA effect comparing all 3 groups. The brackets show significance levels of individual pair-wise comparisons from post-hoc analyses.

third grass-length category to the experimental regime—long-cut grass length (15 to 30 cm)—in addition to the short-cut grass length (0 to 15 cm) and the uncut (>30 cm) subplots. We maintained cut subplots at their assigned lengths by mowing them every 2 weeks, allowing us to test for differences in grasshopper availability (and crow utilization) among all 3 grass-length categories in year 2.

Sampling was conducted 2 to 5 days per week over a 4-week period in 2010 (July 27 to August 17 [total 13 days sampling] and 3 to 4 days per week over a 6-week period in 2011 (July 4 to August 10 [21 days sampling]). We completed a 50-m transect across the middle of the short-cut and uncut subplots during 2010, or all 3 subplot types (short-cut, long-cut, and uncut for 1 to 3 plots per day during 2011. Each plot was sampled once during the 6-week sampling period in 2010, but sampling was intensified in 2011 when all plots were sampled 3 times over the study period. Plots sampled on a given day were chosen randomly in 2010, and in block random design in 2011. Transects were completed between 1000 and 1700 hours daily. We counted the number of grasshoppers that were displaced (i.e., those that jumped as we passed within 1 m when walking with even steps and taking 1 minute to traverse each subplot). This methodology simulated the typical foraging behavior of crows that we observed; crows walked through the fields and gleaned insects that they flushed; this method gave an index of relative prey availability (Onsager and Henry 1977). For each transect, we measured grass length at 3 randomly chosen points within the subplot to get an estimate of average grass length. We reversed the order (day of week and time during the day sampled) in which the plots were studied to control for time of day, seasonality, and temperature. We did not conduct transects on rainy days.

We calculated the average number of grasshoppers in short-cut versus uncut (2010) and short-cut, long-cut, and uncut (2011) grasses per week. As grasshopper densities varied among plots, we calculated the proportion of grasshoppers detected that had occurred within each grass-length plot. This allowed comparisons among plots that contained many grasshoppers and plots with few grasshoppers each week. This technique also helped control for unequal samples in some plots due to rain. We determined the proportion of grasshoppers in each plot type and performed Wilcoxon signed-rank tests or Friedman ANOVAs to compare the proportions of grasshoppers in the different grass-length categories across the 4-week sampling period in 2010 and 6-week sampling period in 2011.

Results

Study 1: grass length and crow densities

The average density of crows differed among the 3 sampled grass-length categories (Friedman ANOVA: $\chi^2 = 10$, $df = 2$, $P = 0.007$). Post-hoc analysis with pair-wise Wilcoxon signed-rank tests revealed significant differences between all pair-wise comparisons; crow density was higher in the short-cut grass compared to both long-cut ($P = 0.043$) and the uncut grass ($P = 0.04$); and the crow density also was greater in long-cut than uncut grasses ($P = 0.043$; Figure 2).

Study 2: grasshopper availability in subplots of different grass lengths

There was a greater proportion of the detected grasshoppers in short-cut grass compared to the uncut grass during each week of 2010 (Wilcoxon signed-rank: T = 0, n = 4, P = 0.07). This pattern also was observed during 2011. There was a consistent and significant difference among the proportion of grasshoppers found in each of the 3 plots across the 6 sampling periods (Friedman ANOVA: χ^2 = 12, df = 2, P = 0.003; Figure 3). In post-hoc analyses, grasshopper densities decreased as grass length increased (Figure 3). Short-cut grass plots had a significantly greater percentage of grasshoppers across the sampling period than both long-cut grass (P = 0.03) and uncut grass (P = 0.03), and long-cut grass had significantly greater percentage of grasshoppers than uncut grass (P = 0.03). This pattern appeared to be consistent across sampling periods, regardless of variation in total grasshopper abundance (Figure 4). Despite the availability of grasshoppers in the short-cut grass subplots on the airport's periphery, we observed no crows using these small subplots during the study in 2011.

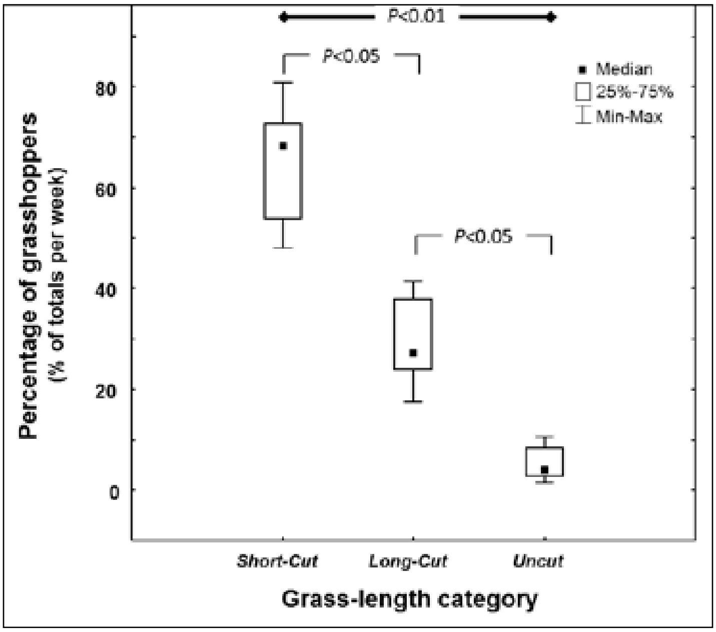

Figure 3. Proportions of grasshoppers detected in 3 grass-length categories across 6 time periods in the Prince George Airport, 2011. The bar at the top of the figure represents the Friedman ANOVA effect comparing all 3 groups. The brackets show significance levels of individual pair-wise comparisons from post-hoc analyses.

Discussion

From July to August 2010, we observed crows foraging on mowed grass in airfields at the Prince George Regional Airport, with a greater use of the short-cut grasses versus long-cut and uncut grass. Individuals within the group would space themselves as they traversed the field, visually scanning the grass ahead and to the sides, and occasionally pecking at flushed prey as they walked. Crows were never seen exhibiting this behavior in uncut grass. Therefore, we are confident that the elevated detection of crows in 2010 in short-cut grass areas was likely due to attraction of the birds to shorter grass, rather than biases in detection. To determine what was attracting crows, we simulated the crow foraging techniques (prey flushing) by completing transects in crow-populated grass in 2010 and 2011. We found that grasshoppers were the most abundant prey item flushed, with fewer grasshoppers detected in uncut (2010) and long-cut and uncut (2011) grasses compared to short-cut grass areas. This suggests that the primary attractant for crows was the increased availability of grasshoppers.

Shorter grass lengths provide birds with an unimpeded view of the landscape, as they lower their heads to catch prey items (Brough and Bridgman 1980); a clear view of a bird's surroundings will increase its ability to detect and avoid predators. This may apply particularly to birds, such as crows, where the eye height of a standing bird is <13 cm. Secondly, longer grasses hinder birds' abilities to catch or see invertebrates in the soil (Onsager and Henry 1977, Brough and Bridgman 1980, Buckley and McCarthy 1994, DeVault and Washburn 2013). Our analysis of the grasshoppers transects from both studies in 2010 and 2011 supported this hypothesis, as the number of accessible grasshoppers detected decreased with increasing grass length. We

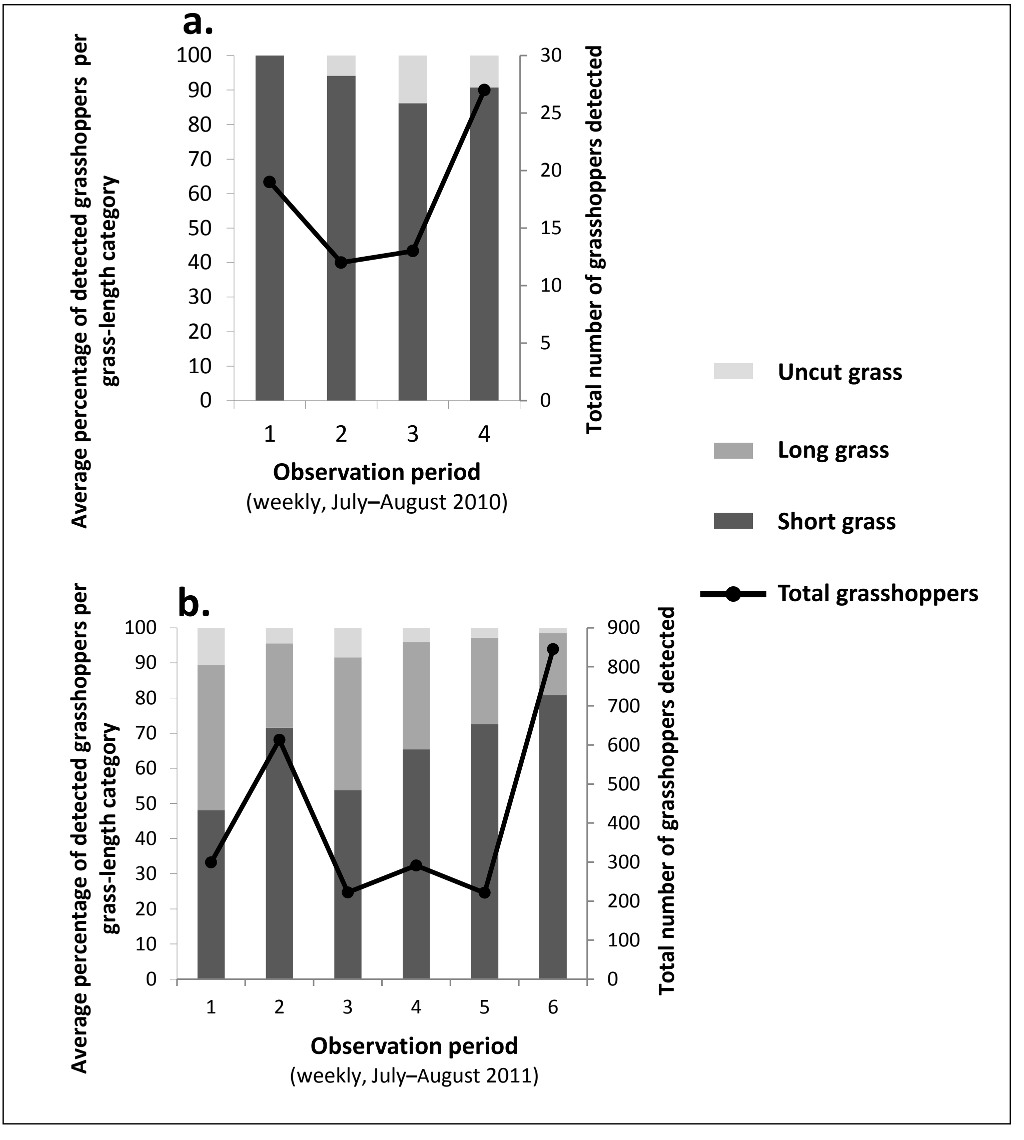

Figure 4. Number of grasshoppers detected during weekly transect censuses varied across the 4 weekly survey periods between July 27 and Aug 17, 2010, but the proportion of the total detections found in short-cut grass was consistently higher in each period than in uncut grass (a). Similar patterns were seen during a 6-week sampling period (July 4 to August 10, 2011), when a third category (long-cut grass [15 to 30 cm) was added, with greatest proportion of grasshoppers consistently found in short-cut grass despite variation in absolute numbers of insects per period.

conclude that while relative abundance of grasshoppers may have been equal between long-cut and short-cut grass, grasshopper accessibility was highest where grasses were short.

Many birds involved in damaging collisions with aircraft were associated with airports as a result of being attracted by foraging opportunities (Blackwell et al. 2013). Natural food sources are the most common attractants in 58 airports surveyed across Canada (Hesse et al. 2010). Given that grass can harbor a variety of prey and forage food that attracts seedeaters, herbivores, insectivores, and scavengers (Soldatini et al. 2010, DeVault and Washburn 2013, Washburn and Seamans 2013), grass management can be an important tool in mitigating bird presence at airports. In our study, we detected the smallest proportion of available grasshoppers in uncut grass (>30 cm). Further, our data suggest that grasshopper detections decrease with increasing grass length, and these data partially explain the greater attraction of crows to short-cut grass compared to both long-cut and uncut grasses in 2010. Although crows may not represent the greatest collision threat in many airports, their numbers have increased in recent decades in response to urbanization (Marzluff et al. 2001), thus, possibly, increasing their hazard level. Additionally, by decreasing grasshoppers at airports, we are also decreasing prey that very likely represent an attractive food source for other species.

Allowing grass at airports to grow >30 cm may reduce both the availability of grasshoppers and presence of crows. Though the fewest numbers of grasshoppers were seen in 30-cm-long grass, the relationship between grass-length category and grasshopper abundance suggests that cutting the grass to an intermediate length might be an effective deterrent. Brough and Bridgeman (1980) found that grass maintained at 15 to 20 cm in length reduced bird numbers by two thirds. We suggest that reducing crow numbers at airports might be accomplished by maintaining grass length between 20 and 25 cm; at the Prince George Airport. Care should be exerted, though, to monitor that mid-length grass does not increase accessibility of small rodents (Oduntan et al. 2012) or serve as a potential attractant for foraging raptors (DeVault and Washburn 2013). If airport mower blades are unable to mow at 20 to 25 cm, mowing could be done before grasshopper season, specific to each airport, to allow for the grass to grow to a sufficient length to deter crows. Additionally, all mowing should take place at night to avoid the attraction of opportunistic feeders that prey on insects exposed by mowers (Blackwell et al. 2013).

Conclusions

Airport grass management studies suggest that maintaining a long-grass policy could be an effective strategy to reduce bird–aircraft collisions (DeVault and Washburn 2013, Washburn and Seaman 2013). Our study provides additional evidence that maintaining grass >20 cm may help alleviate the issue of ground-foraging insectivorous species, such as crows, at airports. Long grass may obstruct crows' visual detection of both prey (grasshoppers) and predators. We make these recommendations acknowledging that habitat management techniques aimed at reducing foraging birds should first and foremost specifically target food availability of hazardous birds (Washburn et al. 2011) and that crows may not be of primary concern at some airports. We also acknowledge that the diversity of birds found at some airports may reduce the effectiveness of long grass, as measures to exclude different species may attract others (Soldatini et al. 2010). For example, long grass appears less effective at deterring larger, problematic species, such as foraging geese (Seamans et al. 1999). As Blackwell et al. (2009) state, information about wildlife habitat use and airports should be incorporated into collision risk assessment; that is, each airport should create its own database on wildlife use and use this study, as well as others as guidelines to create an effective management plan.

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Neither author is in conflict of interest associated with the results of, and corresponding recommendations associated with, this study. All work was conducted with approval of the UNBC Animal Care and Use Committee, and all practices followed the guidelines for the care and use of animals in research as outlined by the Canadian Council on Animal Care, and the Association for the Study of Animal Behaviour.

Literature cited

Allan, J. 2000. The costs of bird strikes and bird strike prevention. Proceedings of the National Wildlife Research Center Special Symposium 3:147–153.

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., 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.

Brough, T., and C. Bridgeman. 1980. An evaluation of long grass as a bird deterrent on British Airfields. Journal of Applied Biology 17:243–253.

Brown, K., R. Erwin, M. Richmond, P. Bucklet, J. Tanacredi , and D. Avrin. 2001. Managing birds and controlling aircraft in the Kennedy Airport–Jamaica Bay Wildlife Refuge Complex: the need for hard data and soft opinions. Environmental Management 2:207–224.

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.

Cleary, E. C., and R. A. Dolbeer. 2005. Wildlife hazard management at airports: a manual for airport personnel. USDA National Wildlife Research Center Staff Publications, Paper 133. Fort Collins, Colorado, USA.

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 B. E. Washburn. 2013. Identification and management of wildlife food resources at airports. Pages 79–92 *in* T. L. DeVault, B. F. Blackwell and J. L. Belant, editors. Wildlife in airport environments: preventing animal–aircraft collisions through science-based management. Johns Hopkins University Press, Baltimore, Maryland, USA.

Dolbeer, R. A. 2006. Height distribution of birds recorded by collisions with civil aircraft. Journal of Wildlife Management 70:1345–1350.

Dolbeer, R. A., and P. Eschenfelder. 2003. Amplified bird-strike risks related to population increases of large birds in North America. Proceedings of the International Bird Strike Committee Meeting 26:49–67.

Hering, P. E. 1934. The food of the American crow in central New York State. Auk 51:4760–476.

Hesse, G. , R. V. Rea, and A. L. Booth. 2010. Wildlife management practices at western Canadian airports. Journal of Air Transport Management 16:185–190.

Marzluff, J. M., K. J. McGowan, R. Donnelly, and R. L. Knight. 2001. Causes and consequences of expanding American crow populations. Pages 331–363 in J. Marzluff, R. Bowman and R. Donnelly, editors. Avian ecology and conservation in an urbanizing world. Kluwer Academic Publishers, Norwell, Massachusetts, USA.

Oduntan, O. O., A. F. Akinyemi, and O. A. Abiodun. 2012. Assessment of bird strike occurrences and bird species abundance at the Murtala Muhammed International Airport, Lagos. International Research Journal of Agricultural Science and Soil Science 2:223–227.

Onsager J. A., and J. E. Henry. 1977. A method for estimating the density of rangeland grasshoppers (Orthoptera, Acridade) in experimental plots. Acrida 6:231–237.

Seamans, T. W., R. A. Dolbeer, M. S. Carrara, and R. B. Chipman. 1999. Does tall grass reduce bird numbers on airports? Results of pen test with Canada geese and field trials at two airports. Proceedings Joint Meeting of Bird Strike Committee Canada and Bird Strike Committee 1:161–170.

Sodhi, N. 2002. Competition in the air; birds versus aircraft. Auk 119:587–595.

Soldatini C., Y. V. Albores-Barajas, T. Lovato, A. Andreon, P. Torricelli, A. Montemaggiori, C. Corsa, and V. Georgalas. 2011 Wildlife strike risk assessment in several Italian airports: lessons from BRI and a new methodology implementation. PLoS ONE 6(12):e28920.

Soldatini, C., V. Georgalas, P. Torricelli, and Y. V. Albores-Barajas. 2010. An ecological approach to birdstrike risk analysis. European Journal of Wildlife Research 56:623–632.

Thorpe, L. 2003. Fatalities and destroyed aircraft due to bird strikes, 1912–2002. Proceedings of the International Bird Strike Committee Meeting 26:85–113.

Verbeek, N. A., and C. Caffrey. 2002. American crow (*Corvus brachyrhynchos*). *In* A. Poole, editor. The birds of North America online. Ithaca, New York: Cornell Lab of Ornithology, <http://bna.birds.cornell.edu/bna/species/647>. Accessed January 5, 2015.

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. USDA National Wildlife Research Center, Staff Publications Paper 396. Fort Collins, Colorado, USA.
Washburn, B. E., and T. W. Seamans. 2013. Managing turfgrass to reduce wildlife hazards at airports. Pages 105–116 *in* T. L. DeVault, B. F. Blackwell and J. L. Belant, editors. Wildlife in airport environments: preventing animal-aircraft collisions through science-based management. Johns Hopkins University Press, Baltimore, Maryland, USA.

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Ken A. Otter is a behavioral ecologist at the University of Northern British Columbia, where he has been working for the past 15 years. He has a variety of interests on how avian behavior is influenced by human-induced disturbances to the landscape. His work ranges from changes in reproductive success among habitat patches altered by logging to movement patterns of birds in response to human structures. It was in tracking avian movement patterns around airports that sparked and interest in what was attracting species to these spaces and how management might be used to mitigate these.