VEGETATION MANAGEMENT APPROACHES FOR REDUCING WILDLIFE-AIRCRAFT COLLISIONS

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ABSTRACT: Wildlife-aircraft collisions (wildlife strikes) pose safety risks to aircraft and cost civil aviation over $390 million annually in the USA. We reviewed the results of prior studies to summarize the vegetation management techniques that have proven effective for wildlife strike reduction or have shown potential for achieving the same goal. Habitat components that may affect wildlife use of airports include food, cover, water, and loafing areas. Improperly managed natural and ornamental vegetation on airports can be important attractants for wildlife that pose strike hazards. However, effective vegetation management can reduce these hazards. Maintaining tall herbaceous vegetation may reduce the availability or attractiveness of loafing and feeding sites for some species of birds such as gulls. However, this management strategy may also increase cover and food resources for other hazardous species. Thus, optimum vegetation height management strategies require further research and may be site-specific. Food availability may be reduced by replacing attractive vegetation such as palatable forage with less attractive vegetation. Vegetation management may also include removal of vegetative cover for deer and small mammals and nesting sites for birds such as woody vegetation. Removal of ornamental trees and shrubs may also be used to reduce availability of perches for flocking birds and large predatory birds. Despite more than 30 years of substantive discussion on the importance of these habitat management techniques, few reliable studies of the effectiveness of these techniques have been conducted. Specific needs for reliable data include definitive studies of the response of entire bird communities to vegetation height management in the USA, and field evaluations of vegetation types thought to be unattractive to wildlife under operational airport conditions.

INTRODUCTION

Wildlife-aircraft collisions (wildlife strikes) pose serious safety hazards to aircraft. During the 1990's, bird strikes cost civil aviation at least $390 million annually in the USA (Cleary et al. 2000). Wildlife strikes have caused the destruction of over 300 aircraft and killed over 300 people worldwide (Richardson 1994, 1996; Richardson and West 2000; Thorpe 1996, 1998, Dolbeer et al. 2000). Over 36,000 wildlife strikes have been reported to the U. S. Federal Aviation Administration's (FAA) National Wildlife Strike Database since 1990 (Cleary et al. 2002). Most of these strikes involved birds (97%), although mammals (2%) and other types of wildlife were also struck (Cleary et al. 2002).

Gulls (*Larus* spp.), waterfowl such as Canada geese (*Branta canadensis*), raptors (hawks and owls), and blackbirds (Icterinae)/starlings (*Sturnus vulgaris*) are the species presently of most concern at airports (Cleary et al. 2000, Dolbeer et al. 2000). Because 71% of strikes occur under 500 feet altitude (above ground level), the greatest risk of bird strikes during flights occurs near the airport at takeoff or landing (Cleary et al. 2002). Accordingly, habitat management (Barras et al. 2000), direct wildlife control (Dolbeer 1986; Dolbeer et al. 1993, 2001), and regulatory efforts (Cleary and Dolbeer 1999) for reducing wildlife strikes have focused on airports and wildlife habitats in their immediate vicinity.

Habitat management is one component of an integrated approach for reducing bird use of airports. Habitat management to reduce human-wildlife conflicts is usually aimed at reducing the attractiveness or carrying capacity of the site for species in question by reducing the availability of food, water, cover, and loafing sites (Van Vuren 1998). Many habitat management efforts on

airports focus on the management of vegetation, which can be used directly by hazardous wildlife or support the invertebrate and small mammal populations upon which the species of concern rely (Blokpoel 1976, Baker and Brooks 1981). However, few replicated field evaluations of the effectiveness of vegetation management techniques for reducing wildlife strikes have been conducted.

We reviewed literature to summarize the amount and quality of information published on strategies for vegetation management at airports to reduce wildlife strikes in the USA. Our goal was to determine if there were sufficient data available to make objective recommendations regarding vegetation management to reduce wildlife hazards. Based on these findings, a further objective was to make recommendations regarding future research needs.

Management of Vegetation Height

The management of vegetation height has been proposed as an effective method for reducing bird use of airport habitats. In general, relatively tall vegetation is thought to interfere with visibility, feeding activity, and ground movements of birds of some species (Blockpoel 1976, U. S. Department of Transportation 1993, Transport Canada 1994, U. S. Department of Agriculture 1998). There are no civil regulations requiring that vegetation be managed at a specific height in North America, but recommendations have ranged from 6-10 inches for civil airports (Transport Canada 1994) to 7-14 inches for military airports (Cleary and Dolbeer 1999).

Solman (1966) suggested that grass should be managed to an optimum intermediate height to reduce attractiveness to birds. Bird response to grass of different heights differed by species due to the different patterns of habitat use by the birds (Solman 1973). Blokpoel (1976) was more specific, explaining that tall grass is attractive to large ground-nesting birds and supports large populations of prey such as insects and small mammals. He further stated that short grass does not provide nesting cover for ground-nesting birds and does not support large rodent and insect populations, but does provide loafing and feeding areas for gulls and small insectivorous birds.

Many reports and other publications recommend that airports adopt a “tall grass” management strategy, but few present data to support these recommendations. Most authors recommending this management strategy do so in review articles that involve no presentation of field data on vegetation characteristics (Wright 1968; Creswell 1988; Blokpoel 1976; Burger 1983; Solman 1970, 1973, 1976; Hild 1984, U. S. Department of Transportation 1993, Transport Canada 1994, Dekker and van der Zee 1996, U. S. Department of Agriculture 1998, Cleary and Dolbeer 1999). Others report the effectiveness from anecdotal observations and non-replicated studies (Dekker 2000), or present results that may not be ecologically or statistically significant (van Tets 1969, Mead and Carter 1973, Reznick 1984, Dahl 1984). Heirman (1975) presented evidence that a single bird species (Northern lapwings [*Vanellus vanellus*]) avoided tall grass at an airport in Belgium, and Brough and Bridgeman (1980) conducted a replicated study that demonstrated preference for short (5-10 cm) vegetation over tall (15-20 cm) vegetation among most bird species observed at airfields in the United Kingdom. However, bird species of concern in the USA were not present in these studies (Dekker 2000).

Preliminary studies to determine if tall vegetation reduces bird activity at airports in the USA have produced conflicting results. Buckley and McCarthy (1994) suggested that laughing gulls (*Larus atricilla*) preferentially used vegetation managed at 5 cm versus 45 cm. However, Barras et al. (2000) found no overall difference in bird use (all species) at these heights on the same airport. Additionally, managing vegetation at > 45 cm tripled small mammal abundance on the tall, un-mowed plots (Barras et al. 2000).

The definitions of tall and short vegetation also vary among reports that discuss vegetation height standards. Short vegetation is usually considered vegetation maintained at or near 5 cm (Mead and Carter 1973, Brough and Bridgeman [5-10 cm]1980, Buckley and McCarthy 1994). However, interpretations of tall vegetation have varied. Buckley and McCarthy (1994) compared short vegetation (5 cm) to "tall" vegetation (> 45 cm), whereas Barras et al. (2000) considered vegetation maintained at >45 cm essentially un-managed, due to the low frequency of disturbance required to maintain "tall" heights. Vegetation heights more commonly associated with "tallgrass" management include 15-20 or 25 cm (Mead and Carter 1973, Brough and Bridgman 1980, Dekker and van der Zee 1996, Barras et al. 2000). Thus, the often-recommended tall- or long-grass management regime is functionally equivalent to the intermediate height suggested hypothetically to be optimum for minimizing hazardous birds on airports in early reviews (Solman 1966, 1973).

In summary, few studies have produced reliable data sufficient to support recommendations for managing vegetation height to reduce bird use of airports in the USA. Relatively tall vegetation is thought to interfere with visibility, feeding activity, and ground movements of some species of birds (Blockpoel 1976). However, un-managed or vegetation exceeding 45 cm often produces unacceptably large populations of small mammals and insects that are prey for hazardous birds such as raptors and starlings (Blokpoel 1976, Barras et al. 2000). Studies conducted in Europe generally recommend that vegetation be managed at intermediate heights (15-20 cm, called "tall grass" management in these European studies).

Vegetation Manipulation Impacts on Small Mammal Populations

The impact of vegetation management on small mammal populations has been studied extensively in contexts other than airports. Wilkins and Schmidly (1979) found that small mammal abundance and diversity were positively related to plant diversity and coverage. They stated that the least disturbed vegetative communities supported the most diverse plant and small mammal communities. Grimm and Yahner (1988) also found that disturbance of roadside habitats reduced abundance of most species of small mammals, primarily due to decreased vegetation height and density. This effect can be achieved through mowing (Wilkins and Schmidly 1979, Cornely et al. 1983, Grimm and Yahner 1988, Barras et al. 2000) or other techniques such as grazing (Cornely et al. 1983) or herbicide application (Clark et al.1996). In general, these studies support the findings that frequent mowing of airport vegetation will help minimize small mammal abundance on airports (Barras et al. 2000).

Species Composition of Vegetative Ground Cover

Species composition of airfield vegetation may also affect the relative attractiveness of

airfields for birds and small mammals. Austin-Smith and Lewis (1969) proposed the use of different vegetation types with specific characteristics on airports; these characteristics included low attraction to birds, small mammals and insects, hardy growth, good survival, good ground coverage, and low fire hazard. Smith (1976) evaluated the suitability of hawkweed (*Hieracium pilosella*) in Nova Scotia and found reduced invertebrate and bird use associated with the plant, but hawkweed was unable to compete with local grasses and required extensive use of selective herbicides to maintain a dominant stand. On tropical airfields, *Wedelia* sp. was found to be unattractive to birds and small mammals (Linnell et al. 1997). Pochop et al. (1999) conducted aviary experiments to determine the attractiveness of different vegetation types to Canada geese in Alaska and found that some plants growing locally were less palatable than others to this hazardous bird species. However, these results have not been verified by field evaluations to determine if monotypic stands can be established to reduce bird use of airfields. Also, the results of this and other similar studies are only applicable to a narrow range of airfields, where the bird and plant species evaluated are found.

Tall fescue (*Festuca arundinacea*) is a bunch grass recommended for use on temperate airfields because it may be unattractive to wildlife (Mead and Carter 1973). In fact, wildlife managers have recommended that tall fescue be eliminated in areas where they wish to improve habitat quality for desired bird species (Washburn et al. 2000). This plant is commonly infected with the fungus *Neotyphodium coenophialum*, which may enhance repellency to birds following repeated consumption (Mead and Carter 1973, Conover 1991, Conover and Messmer 1996). Feeding on tall fescue may also have negative impacts on small mammals (Pelton et al. 1991, Coley et al. 1995, Conover 1998), which are a primary attractant to soaring predatory birds that may pose a threat to aircraft (Brooks et al. 1976, Baker and Brooks 1981). Consumption of endophyte-infected fescue can result in delayed sexual maturity (Fortier et al. 2000) and higher mortality rates (Conover 1998) in small mammals, although small mammals familiar with infected fescue may learn to avoid it (Conover 1998).

Poor grass management is another ground cover management technique designed to reduce the attractiveness of airfield habitats to birds. This technique is based on the idea that the general productivity of airfield vegetation should be reduced by removing organic material from grassland habitats after mowing, thereby interfering with nutrient cycling and decreasing the general condition of the vegetation community (Maron 1977, Dekker and van der Zee 1996, Dekker 2000). Dekker and Van Der Zee (1996) conducted limited evaluations of the technique in The Netherlands and found the success of the technique was comparable to that of tall grass management techniques. However, Dekker (2000) cautioned that mechanisms contributing to observed successes of the technique were poorly understood and the poor grass and tall grass techniques may not be effective in other areas of the world.

In summary, the attractiveness of airfield vegetation may be reduced by altering the nutritional quality and species composition of the stand. Some species such as wedelia (Linnell et al. 1997) and hawkweed (Smith 1976) are less attractive to birds than other plants, but may be of limited value because of limited growth requirements. However, tall fescue is a hardy plant of widespread distribution in North America that may be repellent to hazardous birds and small mammals (Conover 1991, Coley et al. 1995, Conover and Messmer 1996, Conover 1998, Washburn et al. 2000), and therefore may be a suitable ground cover for airports.

Management of Woody Vegetation

Trees, shrubs, and hedgerows are other important vegetative habitats for birds on airfields (Solman 1966, Solman 1970, Will 1984, Lefebvre and Mott 1987, Cleary and Dolbeer 1999). Many authors recommend the removal of woody vegetation from airport habitats based on observations of bird use (Solman 1966, Blokpoel 1976, Will 1984, Buckley and McCarthy 1994) or the documented importance of these habitat components to various wildlife species in other situations (Dolbeer 1984, Cleary and Dolbeer 1999, Marcus et al. 2000). Infrequent disturbance of grasslands may result in encroachment of woody vegetation into grasslands (Buckley and McCarthy 1994, Barras et al. 2000), which may enhance small mammal habitats. Trees in ornamental settings or woodlots provide roosting habitats for species of small, flocking birds such as starlings (Lyon and Caccamise 1981; Dolbeer 1984, 1994; Johnson and Glahn 1994; Cleary and Dolbeer 1999), which have been responsible for fatal accidents from bird strikes (Solman 1970; Thorpe 1996, 1998). However, large birds such as cattle egrets (*Bubulcus ibis*) may also form large flocks and roosts in trees and may pose serious strike hazards (Will 1984). Trees also provide cover for deer, which pose the greatest hazard to aircraft when species groups are ranked by damaging strikes (Wright et al. 1998, Dolbeer et al. 2000). Trees also provide nesting sites for raptors such as hawks and owls (Cleary and Dolbeer 1999), which are commonly struck at airports in the USA (Cleary et al. 2000).

SUMMARY

Habitat management is a long-term component of integrated approaches for reducing wildlife use of airports. Many techniques for managing vegetation at airports have been developed, including management of the height and species composition of vegetative ground cover and removal of woody vegetation. Despite more than 30 years of substantive discussion on the importance of these habitat management techniques, few reliable studies of the effectiveness of these techniques have been conducted. Specific needs for reliable data include definitive studies of the response of entire bird communities to vegetation height management in the USA, and field evaluations of vegetation types thought to be unattractive to wildlife under operational airport conditions.

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REFERENCES CITED

Austin-Smith, P. J., and H. F. Lewis. 1969. Alternative vegetative ground cover. Proceedings of the World Conference on Bird Hazards to Aircraft. Pp. 153-160.

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

Barras, S. C., M. S. Carrara, R. A. Dolbeer, R. B. Chipman, and G. E. Bernhardt. 2000. Bird and small mammal use of mowed and unmowed vegetation at John F. Kennedy International Airport, 1998 - 1999. Proceeding of the Vertebrate Pest Conference 19:31-36.

Blockpoel, H. 1976. Bird hazards to aircraft. Clarke, Irwin and Company and Canadian Wildlife Service, Ottawa, Canada. 236 pp.

Brooks, R. J., J. A. Baker, and R. W. Steele. 1976. Assessment of raptor and small mammal populations on Toronto International Airport and recommendations for reduction and control of these populations. University of Guelph, Field Note 72.

Brough, T. E., and C. J. Bridgman. 1980. An evaluation of long-grass as a bird deterrent on British airfields. Journal of Applied Ecology 17:243-253.

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.

Burger, J. 1983. Bird control at airports. Environmental Conservation 10:115-124.

Clark, Donald R. Jr., Cynthia A. Moulton, James E. Hines, and David J. Hoffman. 1996. Small mammal populations in Maryland meadows during four years of herbicide (Brominal) applications. Environmenal Toxicology and Chemistry 15:1544-1550.

Cleary, E. C., and R. A. Dolbeer. 1999. Wildlife hazard management at airports: a manual for airport personnel. Federal Aviation Administration, Office of Airport Safety and Standards, Washington, D. C. 243pp.

Cleary, E. C., S. E. Wright, and R. A. Dolbeer. 2000. Wildlife strikes to civilian aircraft in the United States, 1990-1999. Federal Aviation Administration, Office of Airport Safety and Standards, Wildlife Aircraft Strike Database Serial Report 6, Washington, D.C., 53pp.

Cleary, E. C., S. E. Wright, and R. A. Dolbeer. 2002. Wildlife strikes to civilian aircraft in the United States, 1990-2000. Federal Aviation Administration, Office of Airport Safety and Standards, Wildlife Aircraft Strike Database Serial Report 7, Washington, D.C., 36pp.

Coley, A. B., H. A. Fribourg, M. R. Pelton, and K. D. Gwinn. 1995. Effects of tall fescue endophyte infestation on relative abundance of small mammals. Journal of Environmental Quality 24:472-475.

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

Conover, M. R. 1998. Impact of consuming tall fescue leaves with the endophyte fungus, Acremonium coenophiatum, on meadow voles. Journal of Mammalogy 79:79:457-463.

Conover, M. R., and T. A. Messmer. 1996. Feeding preferences and changes in mass of Canada geese grazing endophyte-infeced tall fescue. Condor 98:859-862.

Cornely, J. E., C. M. Britton, and F. A. Sneva. 1983. Manipulation of flood meadow vegetation and observations on small mammal populations. Prairie Naturalist 15:16-22.

Creswell, P. D. 1988. Bird species, populations, and activities at Christchurch International Airport, New Zealand, between 1986 and 1988: implications for a preventative bird strike program. New Zealand Natural Sciences 15:61-70.

Dahl, H. 1984. The bird strike situation and its ecological background in the Copenhagen Airport. Pages 287-290 *in* M. J. Harrison, S. A. Gauthreaux, Jr., and L. A. Abron-Robinson, editors. Proceedings Wildlife Hazards to Aircraft Conference and Training Workshop. United States Department of Transportation, Federal Aviation Administration, Washington, DC.

Dekker, A., and F. F. van der Zee. 1996. Birds and grassland on airports. Bird Strike Committee Europe 23:291-305.

Dekker, A. 2000. Poor long grass: low bird density ground cover for the runway environment. Proceedings of International Bird Strike Conference 25:227-236.

Dolbeer, R. A. 1984. Blackbirds and starlings: population ecology and habitats related to airport environments. Pages 149-159 *in* M. J. Harrison, S. A. Gauthreaux, Jr., and L. A. Abron-Robinson, editors. Proceedings Wildlife Hazards to Aircraft Conference and Training Workshop. United States Department of Transportation, Federal Aviation Administration, Washington, DC.

Dolbeer, R. A. 1986. Current status and potential of lethal means of reducing bird damage in agriculture. International Ornithological Congress 19:474-483.

Dolbeer, R. A. 1994. Blackbirds. Pages E25-E32 *in* S. E. Hyngstrom, R. M. Timm, and G. E. Larson, editors. Prevention and control of wildlife damage. University of Nebraska Cooperative Extension Service, Lincoln, Nebraska.

Dolbeer, R.A., J. Belant and J. Sillings. 1993. Shooting gulls reduces strikes with aircraft at John F. Kennedy International Aircraft. Wildlife Society Bulletin 21:442-450.

Dolbeer, R. A., S. C. Barras, and R. B. Chipman. 2001. Shooting gulls to reduce strikes with aircraft at John. F. Kennedy International Airport, 1991-2001. Special report for the Port Authority of New York and New Jersey, 38 pp.

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

Fortier, G. M., N. Bard, M. Jansen, and K. Clay. 2000. Effects of tall fescue endophyte infection and population density on growth and reproduction in prairie voles. Journal of Wildlife Management 64:122-128.

Grimm, J. W., and R. H. Yahner. 1988. Small mammal responses to roadside habitat management in South Central Minnesota. Journal of the Minnesota Academy of Science 53:16-21.

Heirman, J. 1975. Further lapwing investigations on Beauvechain Airport. Proceedings of Bird Strike Committee Europe 10:172-176.

Hild, J. 1984. Landscape management on airports for reduction of bird populations. Pages 195-206 *in* M. J. Harrison, S. A. Gauthreaux, Jr., and L. A. Abron-Robinson, editors. Proceedings Wildlife Hazards to Aircraft Conference and Training Workshop. United States Department of Transportation, Federal Aviation Administration, Washington, DC.

Johnson, R. J., and J. F. Glahn. 1994. Starlings. Pages E109-E120 *in* S. E. Hyngstrom, R. M. Timm, and G. E. Larson, editors. Prevention and control of wildlife damage. University of Nebraska Cooperative Extension Service, Lincoln, Nebraska.

Lefebvre, P. W., and D. F. Mott. 1987. Reducing bird/aircraft hazards at airports through control of bird nesting, roosting, perching, and feeding. U. S. Fish and Wildlife Service, Denver Wildlife Research Center, Bird Damage Research Report 390, 90 pp.

Linnell, M. A., M. R. Conover, and T. J. Ohashi. 1997. Use of an alternative ground cover, Wedelia, for reducing bird activity on tropical airfields. Journal of Wildlife Research 2:225-230.

Lyon, L. A., and D. F. Caccamise. 1981. Habitat selection by roosting blackbirds and starlings: management implications. Journal of Wildlife management 45:435-443.

Marcus, J. F., W. E. Palmer, and P. T. Bromley. 2000. The effects of farm field borders on overwintering sparrow densities. Wilson Bulletin 112:517-523.

Maron, J. 1977. Aspects on the utilization of the airport area under consideration of the bird strike problem. Proceedings of the third world congress on bird hazards to aircraft, Paris. Pp140-145.

Mead, H., and A. W. Carter. 1973. The management of long grass as a bird repellent on airfields. Journal of British Grassland Society 28:219-221.

Pelton, M. R., H. A. Fribourg, J. W. Laundrie, and T. D. Reynolds. 1991. Preliminary assessment of small wild mammal populations in tall fescue habitats. Tennessee Farm and Home Science. 160:68-71.

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.

Reznick, K. 1984. Development of bird hazard reduction for airport operational safety. Pages 275-286 *in* M. J. Harrison, S. A. Gauthreaux, Jr., and L. A. Abron-Robinson, editors. Proceedings Wildlife Hazards to Aircraft Conference and Training Workshop. United States Department of Transportation, Federal Aviation Administration, Washington, DC.

Richardson, W. J. 1994. Serious birdstrike-related accidents to military aircraft of ten countries: preliminary analysis of circumstances. Proceedings of Bird Strike Committee Europe 22:129-152.

Richardson, W. J. 1996. Serious birdstrike-related accidents to military aircraft of Europe and Israel: list and analysis of circumstances. Proceedings of Bird Strike Committee Europe 23:33-56.

Richardson, W. J., and T. West. 2000. Serious birdstrike accidents to military aircraft: updated list and summary. Proceedings of International Bird Strike Conference 25:67-97.

Smith, B. M. 1976. Alternative vegetative cover at CFB summerside, PEI National Research Council on biohazards to aircraft. Ottawa, Canada. Field note 33, 4pp.

Solman, V. E. F. 1966. The ecological control of bird hazards to aircraft. Proceedings of the Third Bird Control Seminar, Bowling Green State University, Bowling Green, Ohio, pp38-52.

Solman, V. E. F. 1970. Airport design and management to reduce bird problems. Proceedings of the First World Conference on Bird Hazards to aircraft, National Research Council of Canada, pp143-147..

Solman, V. E. F. 1973. Birds and Aircraft. Biological Conservation. 5:79-86.

Solman, V. E. F. 1976. Aircraft and birds. Proceedings of the 7th Bird Control Seminar, Bowling Green State University, Bowling Green, Ohio, pp83-88.

Thorpe, J. 1996. Fatalities and destroyed civil aircraft due to bird strikes, 1912-1995. Proceedings of Bird Strike Committee Europe 23:17-32.

Thorpe, J. 1998. The implications of recent bird strike accidents and multiple engine ingestions. Proceedings of Bird Strike Committee Europe 24:11-22.

Transport Canada. 1994. Wildlife control procedures manual. Environmental and Support Services, Airports Group. TP11500E. Ottawa, Canada.

U. S. Department of Agriculture. 1998. Managing wildlife hazards at airports. Animal and Plant Health Inspection Service, Wildlife Services, Washington, D. C.

U. S. Department of Transportation. 1993. Airport wildlife hazard management. AC 150/5200-32. Federal Aviation Administration, Office of Airport Safety and Standards, Washington, D. C.

Van Tets, G. F. 1969. Quantitative and qualitative changes in habitat and avifauna at Sydney airport. CSIRO Wildlife Research 14:117-28.

Van Vuren, D. 1998. Manipulating habitat quality to manage vertebrate pests. Proceedings of the Vertebrate Pest Conference 18:383-390.

Washburn, B. E., T. G. Barnes, and J. D. Sole. 2000. Improving northern bobwhite habitat by converting tall fescue fields to native warm season grasses. Wildlife Society Bulletin 28:97-104.

Wilkins, K. T., and D. J. Schmidly. 1979. The effects of mowing of highway rights-of-way on small mammals. Pages 55-1 - 55-13 *in* D. Arner and R. Tillman, eds., Proceedings of the second symposium environmental concerns in rights-of-way management, Ann Arbor, MI.

Will, T. J. 1984. Blackbirds and starlings: population ecology and habitats related to airport environments. Pages 161-169 *in* M. J. Harrison, S. A. Gauthreaux, Jr., and L. A. Abron-Robinson, editors. Proceedings Wildlife Hazards to Aircraft Conference and Training Workshop. United States Department of Transportation, Federal Aviation Administration, Washington, DC.

Wright, E. N. 1968. Modification of the habitat as a means of bird control. Pages 97-116 *in* The problems of birds as pests, R. K. Murton and E. N. Wright, eds. Symposia for the Institute of Biology no. 17. Academic Press, London.

Wright, S. E., R. A. Dolbeer, and A. J. Montoney. 1998. Deer on airports: an accident waiting to happen. Proceedings of the Vertebrate Pest Conference 18:90-95.