APPENDIX K

AVIARY AND FIELD EVALUATIONS OF VARIOUS WILDLIFE CONTROL PRODUCTS AND STRATEGIES FOR AIRPORTS

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AVIARY AND FIELD EVALUATIONS OF VARIOUS WILDLIFE CONTROL PRODUCTS AND STRATEGIES FOR AIRPORTS

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Numerous products and strategies are available to reduce bird and other wildlife activity around airport buildings and runways. Many of these products and strategies are promoted and sold with only anecdotal evidence to support efficacy claims. Wildlife damage biologists frequently are asked for advice on the purported efficacy of these approaches. Too often, no data or insufficient data are available to make informed recommendations about a particular product. Thus, purchases are often made and products or strategies deployed that prove unsatisfactory. Not only do these purchases result in wasted money, but they may also increase hazards if airport personnel believe the deployment of an ineffective strategy has solved the problem.

Evaluation of these devices and strategies under controlled conditions with sufficient replications to provide statistically rigorous results is difficult, especially for birds. The Ohio Field Station (OFS) of the U.S. Department of Agriculture's National Wildlife Research Center (NWRC) is located on a 5,400-acre fenced site, Plum Brook Station [PBS], operated by the National Aeronautical and Space Administration, Erie County, Ohio. PBS provides an ideal outdoor laboratory for wildlife damage control tests. The site contains a 24-cage outdoor aviary and a 10-acre Canada goose pond and grass facility for tests with captive birds. PBS also has large populations of free-roaming deer, starlings and other wildlife. PBS is within 50 miles of several large gull colonies along the shore of Lake Erie where testing also can be done.

Through an interagency agreement with the Federal Aviation Administration (FAA), the OFS has evaluated over 30 wildlife control products and strategies since 1992. These tests provide objective data on the efficacy and limitations of various products and strategies—information that should be helpful to airport personnel and wildlife damage control biologists. Having said this, I emphasize that these tests typically do not provide a definitive, all-encompassing assessment of a product's value or limitations. Product efficacy may vary depending on wildlife species, time of year, context of presentation and other factors. However, the tests do provide objective data on performance under controlled or measured conditions so that at least some conclusions can be drawn regarding potential usefulness in an airport environment.

Below is a listing of publications with abstracts by species group that document the results of these tests. Copies of the full publications can be obtained from university libraries or by contacting the NWRC library at www.aphis.usda.gov/ws/nwrc. I acknowledge the creative test designs developed and work carried out by the various USDA employees listed in the publications. I also gratefully acknowledge the support provided by the FAA, especially S. Agrawal, M. Hovan, and T. Hupf (William J. Hughes Technical Center, Atlantic City, NJ) and E. C. Cleary (Office of Airport Safety and Standards, Washington, DC). The Port Authority of New York and New Jersey, (L.

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GULLS AND RELATED SPECIES

1. Belant, J. L. 1997. Gulls in urban environments: landscape-level management to reduce conflict. Landscape and Urban Planning 38:245-258. ***Abstract:*** Populations of several species of gulls (*Larus* spp.) have increased dramatically throughout coastal areas of North America and Europe during the past several decades. These increases have been attributed generally to protection from human disturbance, reduction in environmental contaminants, availability of anthropogenic food, and the ability of gulls to adapt to human-altered environments. Gull abundance in urban areas has resulted in numerous conflicts with people including hazards to aircraft, transmission of pathogens and parasites through contamination of water sources, damage to buildings from nesting material and defecation, and general nuisance. Various architectural and habitat management approaches presently are available to reduce gull/human conflicts. For example, gull use of putrescible-waste landfills may be reduced by covering refuse, diverting anthropogenic food to covered compost facilities, erecting wire grids over exposed refuse, and manipulation of turf height in loafing areas. Nesting on roofs can be alleviated through modifications of roofing substrate, reducing the number of roof structures present, and placement of overhead wires. Also, attractiveness of airports to gulls can be reduced through drainage of temporary water and by decreasing the availability of prey and loafing sites through habitat management. Architectural design and characteristics of adjacent habitat should be considered during the planning stages of new facilities in areas where use by gulls is likely. Although control activities can be effective at the site where the gull problem occurs, uncoordinated management efforts may cause relocation of problems to surrounding areas. Also, site-specific management will rarely solve the problem across a larger scale (e.g., city-wide). A working group comprised of the respective city or county planning commission, affected businesses and other government agencies, private citizens, and wildlife professionals can provide overall direction for gull management. This working group should define the extent and nature of the problem, develop an appropriate management strategy incorporating ecology of the nuisance species, and conduct periodic assessments of program efficacy. An integrated, landscape-level management approach is necessary to ensure an overall reduction in conflict between gulls and people in urban environments.

2. 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. ***Abstract:*** Two formulations of methyl anthranilate (MA), one (ReJeX-iT^{TM} TP-40 [TP-40]) containing a surfactant, the other (ReJeX-iT^{TM} AP-50 [AP-50]) a miscible, free-flowing powder, effectively repelled captive mallards from pools of water in a pen test and/or free-ranging ring-billed and herring gulls from pools of water at a landfill for 4 to 11 days. With one exception, pool entries and bill contacts with water were reduced ($P \leq 0.02$) in pools treated with either formulation compared to untreated pools. Overall gull activity was reduced ($P \leq 0.01$) when all available water was treated

with AP-50. Repellency of gulls and mallards from water was achieved with concentrations of MA (0.016-0.038%, v/v) 10-60 times lower than needed in previous studies to repel birds from food. These tests indicate that MA-based formulations in low concentrations should have utility in various agricultural and other situations where it is desirable to reduce bird activity in water.

3. Belant, J. L., and S. K. Ickes. 1996. Overhead wires reduce roof-nesting by ring-billed and herring gulls. Proceedings of the Vertebrate Pest Conference 17:108-112. ***Abstract:*** We evaluated the effectiveness of overhead wires in reducing roof-nesting by ring-billed gulls (*Larus delawarensis*) and herring gulls (*L. argentatus*) at a 7.2-ha food warehouse in northern Ohio during 1994-1995. In 1994, stainless steel wires (0.8 mm diameter) were attached generally in spoke-like configurations between 2.4 m upright metal poles spaced at 33.7-m intervals over the main portion of roof. The 6-14 wires radiating from each pole created a mean maximum spacing between wires of about 16 m. Nesting by ring-billed and herring gulls was reduced by 76% and 100% in 1994 and by 99% and 100% in 1995, respectively, compared to 1993 pretreatment levels (1,011 ring-billed gull nests and 98 herring gull nests). Ring-billed gulls that constructed nests after wire installation gained access to the roof where wires were not installed along the roof edge, where wires were broken, by hovering over wires and landing between them, or from structures such as air conditioners that were at or above the level of surrounding wires. Initial placement of overhead wires above roof structures and regular maintenance of broken wires is recommended to increase effectiveness. Mean maximum spacing of 16 m between wires was effective in excluding nesting by herring gulls; however, narrower spacing is necessary to exclude nesting by ring-billed gulls. Also, many of the ring-billed gulls displaced by wires from the warehouse in 1994 relocated to nest on an adjacent building without overhead wires. Thus, although overhead wires can be effective in reducing nesting by gulls on roofs and in other urban situations, management should be considered at a scale broader than specific problem sites as displacement of nesting gulls may cause relocation of the colonies to surrounding areas.

4. Belant, J. L., and S. K. Ickes. 1997. Mylar flags as gull deterrents. Proceedings of the Great Plains Wildlife Damage Control Conference 13:73-80. ***Abstract:*** During 1996, we evaluated the effectiveness of mylar flags for deterring herring gulls (*Larus argentatus*) from 2 nesting colonies (roof and breakwall) and herring and ring-billed *(L. delawarensis*) gulls from 2 loafing sites at a landfill. Mylar flags (15 cm x 1.0 m) attached to wire or lathe supports were positioned at 6-m intervals at nesting colonies and 3- to 12-m intervals at loafing areas. For both nesting colonies, time of nest initiation, nest density, and clutch size in 1996 when flags were present was similar to or greater than values obtained for these parameters at the same colonies in 1995 when flags were not present. The maximum number of chicks observed at the roof colony in 1996 was also similar to the maximum number of chicks observed in 1995. At the landfill, we observed fewer gulls ($P < 0.05$) at 1 loafing site during the 2 weeks when mylar flags (6- and 12-m spacing) were present than during the 2 weeks when flags were not present. In contrast, gull use of the second loafing area did not appear influenced by the presence of mylar flags (3- and 6-m spacing), likely because

of its small size (6 x 90 m) and proximity to a frequently used pond. We conclude that mylar flags are ineffective in deterring herring gulls (and likely other gulls) from nesting colonies but can reduce gull use of loafing areas.

5. Blackwell, B. F., T. W. Seamans, D. A. Helon, and R. A. Dolbeer. 1999. Early loss of herring gull clutches after egg-oiling. Wildlife Society Bulletin: In Press. ***Abstract*****:** Critical to the success of egg-oiling as a means to control growth of bird populations is extension of the incubation period, thereby minimizing renesting attempts. Egg-oiling studies conducted with ring-billed (*Larus delawarensis*) and herring (*L. argentatus*) gulls generally have reported no evidence of abandonment of oiled clutches up to the expected hatching date (EHD). However, comparisons of clutch loss (assumed primarily to predation) up to EHD among control and treatment groups were not reported. Therefore, we evaluated early (oiling 21-27 days before EHD) and late (oiling 7-15 days before EHD) oiling protocols in a herring gull colony on Lake Erie, Erie County, Ohio. Marked differences ($P < 0.01$) were observed among treatments in the number of nests producing chicks (90.0%, $n = 100$, control; 20%, $n = 100$, early oil, and 1%, $n = 100$, late oil). Clutches in nests assigned to the 2 oil groups were more frequently ($P < 0.01$) lost (6% control; 29% early; 38% late) to abandonment, storms, and predation up to EHD. Only 56% of oiled clutches were incubated past EHD. Clutch loss (including nest abandonment) up to EHD did not differ ($P = 0.35$) between nests in the early and late oil groups. Our data suggest that herring gulls were sensitive to oil and that nests were abandoned or clutches lost within the normal incubation period in numbers greater than expected under natural conditions. The effectiveness of egg-oiling in reducing recruitment in herring gull colonies is improved by oiling nests late in the incubation period. Subsequent oil applications will allow for inclusion of late nests and renesting attempts.

6. Dolbeer, R. A. 1998. Evaluation of shooting and falconry to reduce bird strikes with aircraft at John F. Kennedy International Airport. Proceedings of the International Bird Strike Committee 24:145-158. ***Abstract:*** The collision of birds with aircraft is a serious problem at John F. Kennedy International Airport (JFKIA), New York. Gulls (*Larus* spp.), primarily laughing gulls (*L. articilla*), accounted for 84% of bird strikes (an aircraft striking $\geq$1 bird) from 1988-1990, averaging 260 strikes/year. Laughing gulls are present from May-September in association with a nesting colony (7,629 nests, 1990; 3,381 nests, 1997) in Jamaica Bay adjacent to JFKIA. A program to reduce gull strikes was undertaken from May-August 1991-1997 in which 2-5 people stationed on airport boundaries shot gulls flying over the airport. In 6,369 person-hours of shooting, 52,235 gulls were killed, comprised of 47,601 laughing gulls and 4,634 other gulls. In 1996 and 1997, experimental falconry programs were implemented to complement the shooting program. In 1996, the falconry and shooting programs were conducted simultaneously from 21 June-9 August, after which shooting stopped but falconry continued until 20 October. In 1997, falconry began 25 July (1 week before shooting program ended) and ended 25 November. A statistical comparison of mean strike rates for all birds and for gulls only during 1988-1990 (no shooting or falconry), 1991-1995 (shooting but no falconry) and 1996-1997 (shooting and falconry) indicated shooting reduced ($P < 0.01$) strikes but that falconry did not ($P \geq 0.24$). On a positive

note, fewer gulls were shot and struck in 1996-1997 compared to 1994-1995 although the reductions were not statistically significant ($P > 0.05$). Falconry, which provides positive publicity and other unique attributes, can have a role in the integrated bird management program at JFKIA. However, additional years of data are needed to obtain a more definitive assessment of the role that falconry can play in reducing strikes. The falconry program will continue at JFKIA in 1998-2000 which should provide sufficient data for this more complete assessment.

7. Dolbeer, R. A. 1998. Keynote Address: Population dynamics: the foundation of wildlife damage management for the 21st century. Proceedings of the Vertebrate Pest Conference 18:2-11. ***Abstract***: To justify and defend lethal or reproductive control programs to solve vertebrate pest problems, wildlife biologists must have a sound understanding of the population status and dynamics of the problem species. Models are essential to project how populations will respond to proposed management actions, providing a scientific foundation to counter the emotional debates that often arise. Four population models (PM1-PM4) for predicting population responses are described. PM1 and PM2 explore the relative efficacy of reproductive and lethal control for vertebrate species over 10-year intervals. PM3 simulates population responses to actual management actions through 10-year intervals. PM4 simulates population changes for a species at weekly intervals over an annual cycle, exploring the immediate ($\leq$1 year) impact of population management actions. Population simulations using PM1 and PM2 demonstrated that for most vertebrate pest species considered, lethal control will be more efficient than reproductive control in reducing population levels. Reproductive control is more efficient than lethal control only for some rodent and small bird species with high reproductive rates and low survival rates. A simulation (PM3) of the removal of 47,000 laughing gulls (*Larus atricilla*) from the Long Island-New Jersey population accurately predicted the 33% decline of the population over 5 years. A simulation (PM4) of the annual cycle of the common grackle (*Quiscalus quiscula*) population in the eastern United States demonstrated why removing 4.2 million birds in 1 winter had no discernible impact on subsequent breeding populations. Understanding the population dynamics of wildlife species is the cornerstone to successful management, and population models will be essential for this task in the years to come.

8. Dolbeer, R. A., D. P. Arrington, E. LeBoeuf, and C. Atkins. 1996. Can albatrosses and aircraft coexist on Midway Atoll? Bird Strike Committee Europe 23:327-335. ***Abstract:*** Aircraft collisions with birds (bird strikes), especially Laysan albatrosses (*Diomedea immutabilis*), have been a problem at Midway Naval Air Facility since at least the 1950s. Although aircraft movements at Midway presently are reduced relative to 1950-1970 levels, the U.S. Navy in 1993 still reported 57 strikes during 459 aircraft movements. We visited Midway from 15-21 April 1995 to determine the species composition and diurnal pattern of bird flights over Runway 6-24 so that recommendations could be made regarding timing of aircraft movements to minimize strikes. Midway Atoll in 1994-1995 had an estimated 450,000 nesting pairs of albatrosses (900,000 adults), a mean density of 725 nests/ha. We recorded a mean of 363 birds (89% Laysan albatrosses) crossing the runway/minute during daylight hours.

At night (2230-2300), we estimated only 5.7 birds/minute (89% Bonin petrels [*Pterodroma hypoleuca*]) flying over the runway, a 98.5% reduction over mean numbers during daylight. As Midway Atoll goes through the transition from military base to wildlife refuge, nonemergency aircraft movements should be restricted to night from November-mid July. Furthermore, any plans to develop "ecotourism" or other activities for the Atoll will need to factor in this constraint for aircraft movements. Under present conditions, daytime aircraft movements for commercial or private carriers would raise serious safety and liability issues.

9. Dolbeer, R. A., J. L. Belant, and J. Sillings. 1993. Shooting gulls reduces strikes with aircraft at John F. Kennedy International Airport. Wildlife Society Bulletin 21:442-450. ***Abstract:*** The collision of birds with aircraft is a serious problem at John F. Kennedy International Airport (JFKIA), New York City. Laughing gulls comprised 47% of the birds colliding with aircraft from 1988 to 1990, averaging 170 bird strikes per year. This species is present from May to September in association with a 7,600-nest colony (1990) adjacent to the airport. Other gulls (herring, great black-backed, and ring-billed), which are present year-round, comprised 37% of the strikes and another 52 species of birds comprised the remaining 16%. The airport has an active bird management program involving habitat alteration and the use of bird-frightening techniques to discourage birds from feeding, drinking, and loafing on airport grounds. However, these measures do little to prevent laughing gulls and other gull species from flying over the airport to non-airport feeding sites. An experimental program to reduce gull collisions with aircraft was undertaken in 1991 and 1992 in which 2 to 5 people stationed on airport boundaries used shotguns to shoot gulls flying over the airport from mid-May to early August. There were high levels of gull activity at JFKIA in the summers of 1991 and 1992, as evidenced by the ability of shooters to kill 26,038 laughing gulls and 2,314 other gulls flying over the airport in 2,206 person-hours of shooting. Shooting did not appear to condition gulls to avoid flying over the airport. The shooting program at JFKIA substantially reduced the incidences of strikes between all species of gulls and aircraft, by 70% in 1991 and 89% in 1992. The laughing gull nesting colony in its present location presents an unacceptable safety hazard to aircraft. The annual killing of large numbers of laughing gulls on the airport, while effective in reducing strikes, may not be effective in eliminating the colony from its present location. Discussions should continue with NPS personnel to develop a plan to relocate the colony from Jamaica Bay. This plan could include habitat alteration, nest destruction, and other harassment and management techniques at the colony. However, a seasonal shooting program should continue on the airport to minimize the number of gull-aircraft collisions until the laughing gull colony is relocated from Jamaica Bay.

10. Dolbeer, R. A., and J. L. Bucknall. 1994. Shooting gulls reduces strikes with aircraft at John F. Kennedy International Airport, 1991-1993. Bird Strike Committee Europe 22:375-396. ***Abstract:*** The collision of birds with aircraft is a serious problem at John F. Kennedy International Airport (JFKIA), New York. Laughing gulls (*Larus articilla*) comprised 47% of the birds colliding with aircraft from 1988 to 1990, averaging 180 bird strikes per year. This species is present from May to September in association with a 7,600-nest colony (1990) adjacent to the airport. An experimental program to reduce gull collisions with aircraft was undertaken in 1991-

1993 in which 2-5 people stationed on airport boundaries used shotguns to shoot gulls flying over the airport from May to August. IN 3,401 person-hours of shooting, 35,692 gulls were killed (13,866 in 1991, 13,466 in 1992 and 7.340 in 1993) comprised of 32,534 laughing gulls and 3,158 other gulls. The number of laughing gulls struck by aircraft during the shooting period (20 May-15 Aug) was the same time period for 1988-90. Strikes by the other gull species were reduced by a comparable amount. In spite of the removal of 32,000 laughing gulls in 1991-1993 (over twice the number of adults in the Jamaica Bay colony in 1990), the nesting colony declined by only about 20% from 1990 to 1993. Thus, although shooting is an effective means of reducing the incidence of bird strikes, the program has not significantly reduced the nearby nesting colony. Our recommended long-term solution is to relocate the nesting colony away from JFKIA. A seasonal shooting program should continue to minimize the number of gull-aircraft collisions until this relocation is achieved.

11. Ickes, S. I., J. L. Belant, and R. A. Dolbeer. 1998. Nest disturbance techniques to control nesting by gulls. Wildlife Society Bulletin 26:269-273. ***Abstract:*** Urban-nesting gulls throughout the lower Great Lakes often conflict with human activities. We evaluated 5 nest disturbance techniques (nest-and-egg removal, egg removal, nest-and-egg destruction, egg destruction, and egg replacement) to reduce herring gull (*Larus argentatus*) and ring-billed gull (*L. delawarensis*) nesting in urban habitat, primarily roofs, in northern Ohio. Nest disturbance techniques were more effective in causing colony abandonment for ring-billed gulls than for herring gulls. Nest disturbance conducted for 1 year at an established ring-billed gull colony, and for <1 week at a newly established ring-billed gull colony caused abandonment. Nest disturbance conducted for 1 to 10 years did not cause herring gulls to abandon 5 of 6 established colonies; however, reductions were observed in annual maximum number of nests or eggs. Egg removal was at least as effective as nest-and-egg removal and required about 60% less effort. Egg replacement was the least effective of the techniques evaluated. Unless structural damage to buildings is of concern, egg removal is recommended over other nest disturbance techniques evaluated for inexpensive, long-term reductions of roof-nesting colonies. Nest-and-egg or egg destruction is recommended for ground-nesting colonies. Use of other control methods (e.g., habitat modification, frightening techniques) in addition to nest disturbance may increase the potential for colony abandonment.

12. Seamans, T. W., and J. L. Belant. 1999. Comparison of DRC-1339 and alpha-chloralose for reducing herring gull populations. Wildlife Society Bulletin 27:In Press. ***Abstract*****:** Results of several herring gull (*Larus argentatus*) control programs using DRC-1339 (3-chloro-4-methyl-benzenamine hydrochloride) suggested that the published median lethal dose (LD_{50}) of 2.9 mg of DRC-1339/kg of body weight may not be accurate in some environments. We conducted laboratory trials to estimate LD_{50} values of DRC-1339 and of alpha-chloralose (AC) for herring gulls inhabiting fresh water. We also conducted field trials to compare effectiveness of these compounds in simulated gull control operations. We calculated the LD_{50} for DRC-1339 as 4.6 mg/kg and 43.1 mg/kg for AC. Mean (± SD) time to death for DRC-1339-dosed birds varied from 34.0 (± 12.2) hours at LD_{96} to 109.5 (± 55.5) hours at LD_{27}. AC time to death varied from 2.3 (± 0.5) hours at $>LD_{99}$ to 5.8 (± 0.0) hours at LD_{13}. In field trials, DRC-1339 baits treated at 27.4 mg/kg (LD_{99}) resulted in 29% known mortality. In contrast, AC baits with a 30 mg/kg dosage ($<LD_{01}$) resulted in 50% capture success and no mortality. AC baits at 58 mg/kg (LD_{99}) resulted in 89% capture success and 41% mortality. With AC baits at 95 mg/kg ($> LD_{99}$), 65% of gulls were captured with 82% mortality. AC was more effective than DRC–1339 in removing gulls from a nesting colony. We recommend AC as a gull population management chemical because it is fast acting, humane, and can be used as a nonlethal capture agent.

BLACKBIRDS AND STARLINGS

13. Belant, J. L., S. K. Ickes, L. A. Tyson, and T. W. Seamans. 1997. Comparison of d-pulegone and mangone as cowbird feeding repellents. International Journal of Pest Management 43:303-305. ***Abstract:*** We compared the effectiveness of d-pulegone and mangone as feeding repellents to captive adult male brown-headed cowbirds (*Molothrus ater*) during October-November 1995. For each repellent, we conducted 4-day, 1- and 2-choice cage tests using concentrations (g/g) of 0.1%, 0.01%, and 0.001% with millet. During 1- and 2-choice tests, 0.1% d-pulegone reduced ($P < 0.01$) cowbird feeding but lower concentrations did not. In contrast, concentrations of mangone as low as 0.001% reduced ($P < 0.05$) food consumption during 2-choice tests. Consumption of mangone-treated millet, however, was similar ($P > 0.05$) among 1-choice tests and similar to total food consumption observed during 2-choice tests. We conclude that mangone is less effective than d-pulegone and would likely be ineffective as a repellent for seed treatment. We recommend field tests to further assess the effectiveness of d-pulegone as an avian feeding repellent.

14. Belant, J. L., P. P. Woronecki, R. A. Dolbeer, and T. W. Seamans. 1998. Ineffectiveness of five commercial deterrents for nesting starlings. Wildlife Society Bulletin 26:264-268. ***Abstract:*** We evaluated the effectiveness of phenethyl alcohol (PEA), eyespots, magnetic fields, and avian-predator effigies to deter European starlings (*Sturnus vulgaris*) from nesting in artificial cavities in Ohio during 1993, 1995, and 1996. Each year, 81 nest boxes attached to utility poles were assigned at random equally among 3 treatments (including control): 1993 - PEA or eyespots, 1995 - magnetic fields of 88 or 118 Gauss, and 1996 - great horned owl or merlin effigy.

Starlings nested in 84% (1993), 58% (1995), and 90% (1996) of the boxes. There was no difference ($P \geq 0.13$) among treatments each year in 6-7 measures of starling nesting activity. Four species other than starlings (eastern bluebirds [*Sialia sialis*], house wrens [*Troglodytes aedon*], tree swallows [*Tachycineta bicolor*], and house sparrows [*Passer domesticus*]) occupied 13 (1993), 23 (1995), and 2 (1996) nest boxes. We conclude that PEA, eyespots, magnetic fields ≤118 Gauss, and avian-predator effigies are ineffective as deterrents for starlings nesting in artificial cavities.

15. Clark, L., and J. L. Belant. 1998. Contribution of particulates and pH on cowbirds' avoidance of food treated with agricultural lime. Applied Animal Behavior Science 57:133-144. ***Abstract:*** Agricultural lime used as a grain coating can be repellent to graniverous birds. However, whether repellency is achieved depends upon the method of preparation. The primary mechanism for mediating repellency is pH. Cowbirds avoid seed coated with agricultural lime (5% wt/wt) when the pH exceeds 12.3. A second underlying component mediating repellency exits that is based on avoidance of particulates. If the particulate seed coating consists of particles sized ~63-150 um, and has a pH of 11.4 or less, the repellent potency is about half that observed for raw unprocessed lime. Together, these data help explain emerging conflicting reports on the efficacy of agricultural lime as a bird-repellent. Finally, short-term data on food and water intake and energy balance suggest that periodic intake of agricultural lime does not adversely affect birds.

16. Dolbeer, R. A., and S. K. Ickes. 1994. Red-winged blackbird feeding preferences and response to wild rice treated with portland cement or plaster. Proceedings of the Vertebrate Pest Conference 16:279-282. ***Abstract:*** The California wild rice (*Zizania aquatica*) industry considers red-winged blackbirds (*Agelaius phoeniceus*) their most important pest problem. Farmers often have asked if crop-damaging blackbirds can be killed by mixing dry Portland cement or plaster-of-Paris with grain bait. We conducted a series of tests to determine the effect of cement or plaster mixed with wild rice fed to captive redwings and to determine feeding preferences of redwings for wild rice in relation to other grains. Birds would not eat cement- or plaster-treated rice when untreated rice was available and no mortality occurred when birds were offered only treated rice over a 4-day period. Thus, treating grain with cement or plaster will not kill redwings, but cement or plaster might serve as useful bird repellents for seed grain. Proso millet was strongly preferred over wild rice by redwings, indicating millet would be an excellent candidate as a lure crop and as a bait for trapping or for delivering a chemical. Sunflower would perhaps not be preferred bait or lure crop in wild rice areas and cracked corn would not be preferred bait.

17. Dolbeer, R. A., D. F. Mott, and J. L. Belant. 1997. Blackbirds and starlings killed at winter roosts from PA-14 applications: implications for regional population management. Proceedings of the Eastern Wildlife Damage Management Conference 7:77-86. ***Abstract***: The surfactant PA-14, registered with the U.S. Environmental Protection Agency in 1973 by the federal Wildlife Services (WS) program, was used for 19 years (1974-1992) for lethal control of roosting blackbirds (Icterinae) and European starlings (*Sturnus vulgaris*) in the USA. In 1992, the WS

program withdrew the registration of PA-14 because of costs required to provide additional EPA-requested data. There were 83 roosts encompassing 178 ha treated with 33,300 L of PA-14 from 1974-1992. An estimated 38.2 million birds (48% common grackles [*Quiscalus quiscula*], 30% European starlings, 13% red-winged blackbirds [*Agelaius phoeniceus*], and 9% brown-headed cowbirds [*Molothrus ater*]) were killed, an average of 2.0 million/year. The annual kill represented ≤1.3% of the national winter population of blackbirds and starlings. We found no evidence using North American Breeding Bird Survey (BBS) data that PA-14 applications caused declines in regional breeding populations. Furthermore, there was no evidence of secondary poisoning or other adverse environmental effects from PA-14 applications. If regional population management of blackbirds and starlings is to be implemented to reduce agricultural damage or conflicts with native songbirds, new approaches, such as reproductive control, are needed because PA-14 alone will not be adequate. However, PA-14 could have a role in such regional programs in addition to solving localized roost problems. PA-14 was a useful management tool safely applied in human-populated areas (where most roost problems occur); its reregistration should be considered as part of an integrated management program for blackbirds and starlings.

GEESE AND MISCELLANEOUS BIRDS

18. Belant, J. L., S. K. Ickes, L. A. Tyson, and T. W. Seamans. 1997. Comparison of four particulate substances as wildlife feeding repellents. Crop Protection 16:439-447. Abstract We compared the effectiveness of dolomitic lime, activated charcoal, Nutra-lite (a silica-based compound), and white quartz sand as feeding repellents for brown-headed cowbirds (*Molothrus ater*), white-tailed deer (*Odocoileus virginianus*), and Canada geese (*Branta canadensis*). In 4 day, 2-choice aviary tests with cowbirds, consumption of treated millet (1% to 4% g/g) was less ($P < 0.01$) than consumption of untreated millet for all particulates except Nutra-lite at 1% g/g. Greatest reductions in consumption occurred with lime-treated millet, followed by charcoal, Nutra-lite, and sand. Overall mean daily consumption of treated millet by cowbirds in 1-choice tests was similar ($P > 0.05$) to total consumption of millet in comparable 2-choice tests for each particulate. However, millet treated with 4% lime reduced cowbird consumption for 1 day. Similarly, in 4-day, 2-choice tests field tests involving free-ranging deer, deer consumed less corn treated (4% g/g) with lime or charcoal than corn treated with Nutra-lite or sand. Corn treated with sand did not reduce ($P = 0.44$) consumption by deer relative to untreated corn. Lime applied to turf in 10- x 21-m enclosures at an application rate of 270 kg/ha did not suppress grazing by geese. Nutra-lite applied to turf at the manufacturer-recommended rate of 2,568 kg/ha reduced overall goose presence on treated plots in enclosures for 3 days but suppressed goose grazing for 1 day only. We conclude that lime is more effective overall as a white-tailed deer and brown-headed cowbird feeding repellent than is charcoal, Nutra-lite, or sand. Lime has considerable potential as a feeding repellent in agricultural and possibly turf situations. Charcoal could be used effectively in situations where lime is impractical.

19. Belant, J. L., T. W. Seamans, R. A. Dolbeer, and P. P. Woronecki. 1997. Evaluation of methyl anthranilate as a woodpecker repellent. International

Journal of Pest Management 43:59-62. ***Abstract:*** We evaluated the effectiveness of ReJeX-iT^{TM} TP-40 (hereafter TP-40), containing 40% methyl anthranilate (MA) for deterring woodpeckers from food and from damaging wood siding. During December 1993-February 1994 we conducted three 2-week trials at four sites using six pairs of feeders containing untreated or TP-40-treated suet (5.0, 2.5, or 1.25% g/g). We then placed 10 (1995) and four (1996) pairs (1 each TP-40-treated and control) of boxes with wood siding containing untreated suet at seven and four sites with known woodpecker activity for 2-3 weeks to assess damage to the siding. We also applied TP-40 to woodpecker-damaged wood siding of 14 residential buildings during 1994-1996. Suet-eating birds, primarily downy woodpeckers (*Picoides pubescens*), were repelled ($P < 0.01$) by treated suet at all concentrations compared with untreated suet. In contrast, damage (primarily by downy woodpeckers) to wood siding on untreated and TP-40-treated boxes was similar ($P \geq 0.32$) in both years. Also, 5 of 10 buildings treated with TP-40 received woodpecker damage in areas treated previously. We conclude that TP-40 deters woodpecker from food but does not reduce woodpecker damage to wood siding. This difference in repellency is likely a consequence of rapid degradation of TP-40 from siding (49% in 3 days) and that woodpeckers do not ingest wood, which minimized their exposure to TP-40. We conclude that chemical repellents will generally be ineffective in reducing woodpecker damage to wood and that other techniques, including exclusion, frightening devices, and alternate forms of wood siding (e.g., wood composites) should be developed.

20. Belant, J. L., T. W. Seamans, L. A. Tyson, and S. K. Ickes. 1996. Repellency of methyl anthranilate to pre-exposed and naive Canada geese. Journal Wildlife Management 60:923-928. ***Abstract:*** To improve our understanding of the effectiveness of avian feeding repellents, we evaluated whether Canada geese (*Branta canadensis*) exhibited learned avoidance of ReJeX-iT AG-36 (AG-36), a methyl anthranilate (MA) formulation containing 14.5% MA (vol/vol). During 2 experiments in August-September 1995, we pre-exposed geese orally to 0.0, 1.3, or 4.0 g AG-36 and released them onto 10- x 10-m grass plots treated with AG-36 at rates of 22.6 and 67.8 kg/ha. Mean numbers of bill contacts and mean numbers of geese observed on control and treated plots were similar ($P \geq 0.21$) for geese pre-exposed or naive to AG-36. Overall, mean numbers of bill contacts and mean numbers of geese also were similar ($P \geq 0.56$) on control and treated plots. Mean mass of droppings on control and treated plots was similar ($P > 0.99$) during the experiment with 22.6 kg/ha AG-36 but was greater ($P = 0.01$) on control plots during the experiment with 67.8 kg/ha AG-36. We conclude that learned avoidance of AG-36 by Canada geese pre-exposed orally to 1.3 or 4.6 g AG-36 did not occur and that AG-36 applied to turf in enclosures at rates of 22.6 and 67.8 kg/ha was not effective as a grazing repellent for geese.

21. Belant, J. L., L. A. Tyson, T. W. Seamans, and S. K. Ickes. 1997. Evaluation of lime as an avian feeding repellent. Journal of Wildlife Management 61:917-924. ***Abstract:*** We evaluated the effectiveness of dolomitic hydrated lime as a feeding deterrent to captive brown-headed cowbirds (*Molothrus ater*) and Canada geese (*Branta canadensis*) during July-September 1995. We conducted 1- and 2-choice tests using grains with caged cowbirds and geese, and applications of lime to turf in dry and

slurry form for geese. Lime mixed with millet or whole-kernel corn at 25, 12.5, and 6.25% (g/g) reduced cowbird and goose feeding in 4 day, 2-choice (treated or untreated grain) cage trials. Reductions in total food intake occurred for both species during similar 1-choice tests with lime (25% [g/g]) and millet or corn. Body mass of cowbirds and geese increased or remained constant during 2-choice tests. In contrast, body mass declined for both species during 1-choice tests. Application of lime to enclosed 10- x 10-m-grass plots in powder or slurry form at an application rate of 544 kg/ha also reduced goose feeding on treated plots for 2-3 days. Mean numbers of geese and mean fecal mass on control and treated plots were similar during both turf experiments. No phytotoxicity of grass was observed $\geq$40 days posttreatment. We recommend additional studies to determine the lower limit of repellency of lime to various bird species and its utility for turf and crop damage reduction.

22. Belant, J. L., and T. W. Seamans. 1999. Alpha-chloralose immobilization of rock doves in Ohio. Journal of Wildlife Diseases 35:239-242. ***Abstract*****:** The effectiveness of 3 dosages (about 60, 120 and 180 mg/kg) of alpha-chloralose (AC) were compared for immobilizing pigeons (*Columba livia*). Responses to immobilization using about 180 mg/kg AC also was compared in pigeons food deprived for 24 hr and not food deprived. Mean ($\pm$ SE) time to first effects (33 $\pm$ 2 min) and mean time to capture (94 $\pm$ 5 min) was significantly less for pigeons receiving 180 mg/kg than for pigeons receiving lower dosages ($\geq$53 $\pm$ 3 min and $\geq$153 $\pm$ 17 min, respectively). Ten, 10 and 8 pigeons immobilized with 60, 120 and 180 mg/kg AC recovered within 24 hr, respectively; all pigeons recovered within 29 hours. Although food-deprived pigeons showed effects of AC immobilization earlier than did pigeons with food, time to capture was similar between these 2 groups. This new formulation should improve capture success of pigeons substantially and improve the ability to resolve nuisance pigeon problems.

23. Blackwell, B. F., T. W. Seamans, and R. A. Dolbeer. 1999. Plant growth regulator enhances repellency of anthraquinone formulation to Canada geese. Journal of Wildlife Management 63:1336-1343. ***Abstract:*** There is a need for nonlethal methods of reducing conflicts between burgeoning populations of resident Canada geese (*Branta canadensis*) and humans at airports and other settings. An anthraquinone-based formulation (Flight Control^{TM} [FC], 50% anthraquinone [AQ], active ingredient) has shown promise in deterring grazing by Canada geese. We hypothesized that the addition of a plant growth regulator (Stronghold^{TM} [SH]) might enhance the effectiveness of FC by minimizing the exposure of new, untreated grass. To isolate the effects of grass height, plant growth regulator, and the combination of a repellent with a plant growth regulator on grazing by geese, we conducted 3 experiments, each using 24 geese in 6 18 x 31-m pens, in northern Ohio during 1998. We evaluated the response of geese to short (4-11 cm) and tall grass (16-21 cm) in a 9-day test. Next, SH (applied at 1.2 L/ha) was evaluated as a grazing repellent in a 14-day test. Finally, we evaluated the effectiveness of FC (2.3 L/ha), combined with SH (0.9 L/ha SH), as a grazing repellent in a 22-day test. We found no difference (P = 0.53) in the number of geese per observation in tall- (1.7 $\pm$ 1.5; $\bar{x} \pm$ SE) and short-grass plots (2.3 $\pm$ 1.5), nor in bill contacts per minute (P = 0.78) in tall- (12.6 $\pm$ 9.3) versus

short-grass plots (11.1 ± 7.9). In the SH test, 14 days postapplication, mean grass height was 12.9 cm in untreated plots and 7.2 cm in treated plots. However, the number of geese per observation on untreated (1.8 ± 1.3) and treated plots (2.2 ± 1.3) did not differ (P = 0.57). Also, there was no difference (P = 0.71) in the number of bill contacts per minute in untreated (15.3 ± 9.9) and treated plots (18.1 ± 14.2). In contrast, over a 22-day FC/SH test, the mean number of geese per observation was 2.6 times greater (P < 0.01) on untreated (2.9 ± 0.5) than on treated plots (1.1 ± 0.5). Further, the mean number of bill contacts per minute was 8.2 times greater (P < 0.01) on untreated (54.4 ± 11.2) than treated plots (6.6 ± 2.3). We observed no abatement in repellency 22 days posttreatment. Thus, we conclude that SH greatly enhanced the repellency of FC to grazing Canada geese. The use of a plant growth regulator with FC should reduce goose foraging on turf.

24. Dolbeer, R. A., J. L. Belant, and L. Clark. 1993. Methyl anthranilate formulations to repel birds from water at airports and food at landfills. Proceedings of the Great Plains Wildlife Damage Control Conference 11:42-53. ***Abstract:*** We conducted 2 sets of experiments to evaluate methyl anthranilate (MA) as an avian repellent. The first set (May-Aug 1991) evaluated 2 Rejex-It™ formulations of MA applied to water at John F. Kennedy International Airport (JFKIA), New York. Our second set of experiments (Aug-Sep 1992) tested the hypothesis that MA mixed with a landfill cover material (ConCover 180$^{R)}$ would reduce consumption by birds when applied to food in a controlled environment (captive birds in cages). At JFKIA, fewer birds were seen in treated standing water than in untreated water, which supported results obtained in previous cage trials. In the landfill cover experiments, MA was repellent to cowbirds and ring-billed gulls at food sources, although a higher concentration (0.5% MA) was required to repel ring-billed gulls than cowbirds (0.15% MA). Cowbirds were repelled by similar concentrations of MA during tests using millet mixed with ConCover 180^{R}. MA appears promising as a bird repellent when applied to standing water and may help deter birds from feeding in landfills when incorporated into a landfill cover material such as ConCover.

25. Dolbeer, R. A., T. W. Seamans, B. F. Blackwell, and J. L. Belant. 1998. Anthraquinone formulation (Flight Control) shows promise as avian feeding repellent. Journal of Wildlife Management 62:1557-1563. ***Abstract:*** We evaluated the effectiveness of Flight Control™ [FC] (50% anthraquinone [AQ]) as a grazing repellent for Canada geese (*Branta canadensis*) and as a seed-treatment repellent for brown-headed cowbirds (*Molothrus ater*) in northern Ohio in 1997. For the turf test, FC was applied at 4.5 L/ha in 6 18.3- ∗ 30.5-m pens. There were 2.5 times more (P < 0.01) bill contacts/min observed on untreated plots (26.4 ± 6.0; $\bar{x}$ ± SE) compared to treated plots (10.4 ± 3.8) during a 7-day test with captive geese. Mean numbers of geese per observation were also greater (P = 0.02) on untreated plots (2.6 ± 0.4) compared to treated plots (1.4 ± 0.4). Residue analyses indicated AQ declined from 2.02 kg/ha at application to 0.22 kg/ha after 1 week. Individually caged cowbirds were presented untreated millet or millet treated with FC at 0.1, 0.5 and 1.0% (g/g) levels in 1- and 2-choice tests for 3--4 days. Flight Control™ was repellent to cowbirds at all levels in both 1- and 2-choice tests. In the 2-choice test, birds in the 1.0% treatment level lost body

mass (P = 0.04), whereas birds at the other levels did not. Each group of treated birds in the 1-choice test lost mass ($P \leq 0.01$), whereas the control group did not. Birds in the 0.5 and 1.0% groups ate minimal amounts; 3 of 12 birds died. We conclude that FC was an effective foraging repellent for Canada geese in a 7-day pen experiment and for brown-headed cowbirds as a seed repellent in aviary experiments. Flight Control™ shows promise as an avian feeding repellent. Further lab and field studies are needed to refine minimum repellent levels and to enhance retention of AQ on treated vegetation.

26. Gabrey, S. W., and R. A. Dolbeer. 1996. Rainfall effects on bird-aircraft collisions at two United States airports. Wildlife Society Bulletin 24:272-275. ***Abstract:*** We examined the influence of rainfall on bird-aircraft collisions at 2 major United States airports. Presence of standing water from rainfall did not increase the probability of bird-aircraft collisions at John F. Kennedy International airport during April-October, 1986-1990. However, at O'Hare International Airport there was evidence that standing water increased collision rates. During April-October 1992-1994, collision rates were higher 1 day after ≥2.54 cm rain than at other times. Although this analysis showed no clear-cut influence of rainfall on bird-aircraft collisions, airport operations personnel, as precautionary measures, should continue efforts to remove standing water and deter bird use of puddles. Detailed long-term data on daily bird-aircraft collisions, rainfall, and bird use of standing water are needed from other airports so that a more comprehensive and generalized analysis of collisions in relation to rainfall can be made.

27. Woronecki, P. P., R. A. Dolbeer, T. W. Seamans, and W. R. Lance. 1992. Alpha-chloralose efficacy in capturing nuisance waterfowl and pigeons and current status of FDA registration. Proceedings of the Vertebrate Pest Conference 15:72-78. ***Abstract:*** During 1990 and 1991 we conducted safety, efficacy and clinical trials required to register alpha-chloralose (A-C) for capturing nuisance waterfowl and pigeons with the U.S. Food and Drug Administration (FDA). We determined the Most Effective Dose (MED) to be 30 and 60 mg of A-C/kg of body weight for capturing waterfowl and pigeons, respectively. We conducted 11 field trials in 4 states, capturing 587 waterfowl and 1,370 pigeons with 8% mortality for ducks, 0% for geese, and 6% for pigeons. We submitted a New Animal Drug Application to FDA in October 1991 and received registration in 1992 for use of A-C by Wildlife Services biologists.

DEER

28. Belant, J. L., T. W. Seamans, and C. P. Dwyer. 1996. Evaluation of propane exploders as white-tailed deer deterrents. Crop Protection 15:575-578. ***Abstract:*** In response to increased white-tailed deer (*Odocoileus virginianus*) depredation of agricultural crops and encroachment on airports, we evaluated the effectiveness of systematic and motion-activated propane exploders as deer frightening devices. We conducted 3 experiments in a 2200-ha fenced facility in northern Ohio with high (91/km^2) deer densities during 1994-1995. Systematic exploders were calibrated to

detonate once at 8- to 10-minute intervals whereas motion-activated exploders detonated 8 times/deer intrusion. Systematic propane exploders were generally ineffective, deterring deer from corn for ≤2 days only, whereas motion-activated exploders repelled deer for 0-6 weeks. Repellency of motion-activated exploders varied seasonally, possibly in response to variations in deer density, availability of alternate food, or reproductive and social behavior. We recommend motion-activated exploders over systematic exploders as deer frightening devices for crop damage mitigation and on airports; however, systematic exploders may have utility for short-term (a few days) use.

29. Belant, J. L., T. W. Seamans, and C. P. Dwyer. 1998. Cattle guards reduce deer crossings through fence openings. International Journal of Pest Management 44:247-249. ***Abstract:.*** In response to increased white-tailed deer (*Odocoileus virginianus*) encroachment on airports, we evaluated the effectiveness of cattle guards as deer exclusion devices. We conducted 3 experiments in a 2,200 ha fenced facility in northern Ohio with high (91/km^2) deer densities during 1994-1995. During each experiment, we monitored deer crossings at 2-3 cattle guards (4.6 [L]x3[W]x0.5 or 1.0[D] m) constructed at fence openings for 2 weeks pre- and post-installation. For each experiment, the mean daily number of deer crossings after installation of cattle guards was reduced ($P < 0.01$) by ≥88% compared to respective crossing rates during pretreatment. Reductions in deer crossings using cattle guards with 0.5 or 1.0 m deep excavations were similar (95-96% vs. 98%) overall. Cattle guards at permanent openings used for vehicular traffic appear a viable technique to exclude deer from fenced airports and other facilities where deer exclusion is desired.

30. Belant, J. L., T. W. Seamans, and L. A. Tyson. 1997. Evaluation of three electronic frightening devices as white-tailed deer deterrents. Proceedings of the Vertebrate Pest Conference 18:107-110. ***Abstract***: We evaluated the effectiveness of the motion-activated Usonic Sentry (with and without strobe), motion-activated Yard Gard, and Electronic Guard for deterring white-tailed deer (*Odocoileus virginianus*) from preferred feeding areas during February-April 1996. We conducted 2 4-week experiments, monitoring deer use (number of intrusions and corn consumption) at 8 feeding stations in a 2,200-ha fenced facility in northern Ohio with high deer densities (≥38/km^2). During these experiments, we positioned 1 of the devices at each of 4 sites. The mean (± SE, n = 4) daily number of deer intrusions at feeding stations during treatment (96.5 ± 12.6-169.0 ± 22.0) was similar ($P \geq 0.13$) to or greater ($P \leq 0.04$) than the mean daily number of deer intrusions during pre- or posttreatment (109.8 ± 15.6-148.8 ± 21.4). Corn consumption declined ($P < 0.05$) only at stations with Usonic Sentrys without strobes for 1 week. We conclude that the electronic frightening devices tested were generally ineffective in deterring white-tailed deer from preferred feeding areas.

31. Belant, J. L., T. W. Seamans, and L. A. Tyson. 1997. Predator urines do not deter white-tailed deer from feeding areas or trails. Proceedings of the Vertebrate Pest Conference 18:359-362. ***Abstract:*** We assessed whether bobcat (*Lynx rufus*) or coyote (*Canis latrans*) urine could reduce white-tailed deer (*Odocoileus virginianus*) use

of established feeding areas or trails. A 4-week experiment evaluating deer use of 8 feeding stations, 4 each with coyote or bobcat urine was conducted at a 2,200-ha fenced facility in northern Ohio with high deer densities (38/km^2). At this same facility, we also monitored deer use of 4 trails where coyote urine was applied. For both experiments, urine was placed in holders positioned at ground level within 2 m of the area being protected . The number of deer entering feeding stations after 2 weeks exposure to predator urines was 15-24% less ($P \leq 0.05$) than the number of deer entering feeding stations during pretreatment. Deer use of trails did not decrease in response to presence of coyote urine. We conclude that predator urines used as a chemical barrier were of limited effectiveness in deterring high concentrations of white-tailed deer from areas with established sources of food and ineffective in deterring deer from trails.

Belant, J. L., L. A. Tyson, T. W. Seamans, and S. K. Ickes. 1997. Mylar flags do not deter white-tailed deer from feeding areas. Journal Wildlife Research 2:210-212. Abstract: We evaluated the effectiveness of mylar flags for deterring white-tailed deer (Odocoileus virginianus) from feeding areas during December 1996. We conducted a 3-week experiment, monitoring deer use (number of intrusions and corn consumption) at 10 feeding stations in a 2,200-ha fenced facility in northern Ohio with high deer densities (>21/km2). We positioned 2 mylar flags (15 cm x 1 m) attached to lathe at each of 5 sites; remaining sites received lathe only (untreated). Mylar flags did not reduce (P > 0.43) the number of deer intrusions into feeding stations or the amount of corn consumed relative to feeding stations without mylar flags. We conclude that mylar flags are ineffective for deterring white-tailed deer from feeding areas during winter.

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