



EVALUATION OF THE EFFICACY  
OF  
PRODUCTS AND TECHNIQUES FOR AIRPORT BIRD CONTROL

by

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## INTRODUCTION

Ever since the recognition of birds as hazards to aircraft safety, there has been serious interest in techniques and products that could control this hazard. Indeed, the need for effective bird control measures at airports and elsewhere has only increased over the years. The constantly expanding level of air traffic, and the development of larger, faster, and quieter jet-engined aircraft, has raised the risk of serious bird strikes. In Canada, with the passing of the day-to-day management of airports from Transport Canada to private airport authorities, the authorities are assuming responsibility (and significant potential liability) for the control of the bird hazards at their airports. It is important that the airport authorities show due diligence by employing bird control measures that are appropriate for their particular situations. They must use appropriate products and techniques but it also is important to them that they know what is the most cost-effective approach.

Over the past 30-40 years, many techniques and types of equipment have been used or proposed for use to control birds at airports and other locations. There is much first hand experience with this equipment and these techniques but most of it is unpublished and not available to other interested workers. Much of what is published on bird control techniques is scattered and difficult to locate. Consequently, without a serious compilation, review, and evaluation of bird control products and techniques, money has been wasted “re-inventing the wheel” with ineffective equipment and inappropriate methods. This had led to the dangerous creation of a false sense of security in many situations. Transport Canada recognized the need for a critical analysis of all available and proposed equipment and techniques for airport bird control. Therefore, Transport Canada has funded this critical review.

The emphasis of this report is to evaluate, rigorously and objectively, each of the identified control measures. It is designed to complement the existing “Wildlife Control Procedures Manual” (Transport Canada 1994). The report provides information on the efficacy of the various control methods listed in the Transport Canada manual, and on additional products and techniques. The reviews and evaluations presented here focus on measures that can be used at airports and/or in surrounding areas, but do not include on-aircraft measures. A brief description of each type of equipment and its use is provided, together with a summary review of tests or experiments that have been conducted. A critical evaluation of the efficacy of each technique and type of equipment follows. Advantages and disadvantages of each approach are discussed. This report does not include any new tests of equipment or techniques. However, studies of promising but inadequately tested approaches are recommended. This report is based on a thorough review of the extensive worldwide literature on bird control techniques, and on a survey of bird control professionals that work at airports and elsewhere. The reviews also take account of the experience and judgement of the authors and other LGL Limited personnel.

## **BIRD CONTROL AT AIRPORTS**

No two airports are exactly alike in regard to their bird control problems. Each airfield is attractive to birds for a different variety of reasons, and the reasons vary with the species of birds involved and the time of year. Birds can be attracted to airports for food (e.g., earthworms, grasshoppers, and seeds), water, and shelter; and because the airports provide suitable nesting habitat or woods for overnight roosting. Each species of bird has its own behaviours, habitat preferences, preferred foods, loafing and roosting habits, flocking tendencies, and times of seasonal occurrence. As well, features that are nearby or even at some distance from airfields can create different bird hazards to aircraft safety at each airport. For example, flightlines of birds between a nighttime roosting area and a daytime feeding area such as a landfill, can create serious hazards if the airport lies between these areas. Nevertheless, there are some characteristics of birds and requirements of bird control that are common to most airports.

Airports generally are large, open areas. Consequently, products and techniques that are effective over large areas are best, generally speaking. Birds must be kept off the airfield altogether; moving birds to another part of the airfield usually is not a solution. Not all species of birds are attracted to these open habitats, and not all those that are attracted create hazards to aircraft safety. Typical “problem” groups are gulls, waterfowl (ducks and geese), rock doves, blackbirds, starlings, crows, hawks, eagles, owls, and snow buntings. Products and techniques that are effective on these groups can thus often address most of the bird control problems at an airport. Airports may require year-round, and sometimes round-the-clock, control measures. Therefore, bird control at airports requires techniques that achieve long-term deterrence of birds from the airfield and environs. It is not a situation where techniques that achieve short-term results are acceptable, although short-term effectiveness is required at times. In other words, habituation is of much greater concern at airports, where long-term effectiveness is essential, than in other situations (such as agriculture) where dispersing/deterring birds for a few days or weeks (e.g., before harvest) is sufficient (and the issue of habituation of less concern). Occasionally, even nocturnal control is necessary. Where overflights of birds are a problem, control programs beyond the airport are required.

The basis of any successful airport bird control program is habitat control — making the airfield less attractive to birds (or at least the most problematic species) addresses the fundamental source of the problem. Of course, because each species or group of birds has its own habitat preferences, modifying what is attractive to one species may well provide better conditions for another. Nonetheless, the modification of large areas of suitable habitat and the removal of particularly attractive features, can greatly reduce the extent of active control required. Trying to clear an entire airfield of birds solely with active control measures is a formidable task. Habitat modification can also be effective by limiting the areas of an airfield that attract birds, and thus active control can be focussed more effectively in these restricted areas.

There is, as yet, no single “silver bullet” for airport bird control. It is unlikely that there will ever be just one magic control method. Birds are very adaptable and can and do habituate to any control method used over the long term. The best control programs therefore employ a variety of products and techniques. Aside from these, however, management commitment is ultimately the driving force determining the success of an airport bird control program. This is reflected in a trained and motivated field staff, and an adequate supply of appropriate and well-maintained control products.

## **REVIEW METHODOLOGY**

This evaluation of bird control products and techniques includes an extensive review of the worldwide literature, including unpublished “grey literature” sources, interviews with bird control experts at airports and elsewhere, and the personal experience of LGL staff who have studied this subject since the mid 1960s. No specific bibliographic database search was conducted to locate published literature for this review. Rather, the literature was assembled from LGL files that have been accumulated over the past 30 years. These files include papers from the major ornithological, animal behaviour, and wildlife damage control journals, such as the Journal of Wildlife Management, Wildlife Society Bulletin, Proceedings of the Vertebrate Pest Conference, and Proceedings of the Eastern Wildlife Damage Management Conference. The publications of the International Bird Strike Committee/Bird Strike Committee Europe and Bird Strike Committee Canada were reviewed. Also included are unpublished consultants' reports on various bird control studies. A very large body of literature has been produced on bird control techniques and products. This review does not attempt to list even the majority of this literature, but does include the most relevant references. Over 300 papers are cited.

Experienced bird control workers from a variety of agencies were contacted for this review. These included bird control staff at several of Canada's major airports and some American airports, bird control consultants who provide services to airports, landfills, and other facilities, falconers, landfill managers, and government researchers. LGL staff, including co-author Dr. R.A. Davis, have attended most of the recent Bird Strike Committee meetings in Canada, the United States, and Europe and have obtained information from presentations and discussions there. Also, LGL Limited has conducted bird control research at landfills and airports involving overhead lines, pyrotechnics, raptor trapping, and other control products and techniques. In addition, LGL has designed and implemented operational control programs at airports and landfills.

Despite the widespread use of bird control products and techniques, we found that the available data are inadequate for a quantitative evaluation of the effectiveness of most deterrent techniques. There are few comprehensive, objective, properly designed, quantitative studies. Consequently, in many cases evaluations still must be subjective. In part, this is because it is difficult to compare products and techniques. A myriad of difficult-to-control variables affect the performances and thus the comparative evaluations of bird control products. Products can be presented in a variety of situations and combinations. Complex environmental factors play an important role — the availability of alternate local attractions (e.g., roost sites, feeding areas); time of year and day and its effect on bird numbers and behaviour; why birds are attracted to the airport in the first place (e.g., food, water, nesting, loafing or roosting). Often a product on its own is largely ineffective because of habituation, but can be an effective part of a multi-product/method approach. Especially important is to know whether occasional killing was employed to reinforce the product/method. All these factors make it difficult to compare products/techniques or even the same product/technique in different places.

Airport bird control programs potentially can be evaluated by comparing the number of bird strikes reported before vs. after the implementation of particular products/techniques. In reality, however, this is an unreliable indicator. The number of reported strikes can vary significantly without any relation to the actual number of strikes. Numbers of reported strikes have been known even to increase with the implementation of an effective bird control program, because there is better reporting. Also, looking only at reported strikes overlooks the many other factors that play a role in determining the bird strike hazard and that should be controlled in any test of effectiveness.

A series of questions was developed to address the difficulties associated with product/technique comparisons and evaluations. These follow below.

1. What is the biological basis for the control measure? Is there a biological reason to expect the measure to be successful?
2. Were the tests conducted long enough to demonstrate that the birds will not habituate?
3. Did the technique move the birds off the airport or did it merely move the birds to a different part of the airport?
4. Were there any special circumstances associated with the test that allowed the measure to succeed? Would the measure be less successful in other situations where the special circumstances were not present?
5. Would the technique be successful if the birds had no alternate habitat nearby?
6. Are there any objective data available? It is important to distinguish between manufacturer's claims and independently demonstrated effectiveness.
7. Does the success of a technique depend upon the skill and knowledge of the operator?

8. Is there potential for successful use of a technique to solve one problem but create a new hazard? This certainly applies to habitat manipulation measures.
9. Is there adequate information to evaluate the equipment/technique objectively?
10. What are the conditions where the equipment/technique is useful? Most useful? Not useful?
11. Is the technique promising but more information is required?
12. How should this equipment/technique be tested?
13. What species is the equipment/technique designed for or most effective on?
14. Have any studies been conducted at an airport?

## **BIRD CONTROL PRODUCTS AND TECHNIQUES**

This review for the most part uses the categories and follows the sequence of products/techniques as listed in the Transport Canada “Wildlife Control Procedures Manual” (Transport Canada 1994). Visual deterrents (rather than chemical deterrents as in the Transport Canada manual) follow auditory deterrents because many of these products provide both auditory and visual stimuli. Additional equipment and techniques that are not listed in the Transport Canada manual are discussed under the appropriate categories, or follow at the end of this section. Brief descriptions of each product/technique and its application are presented here, but more complete information is available in the Transport Canada Manual.

### **HABITAT MODIFICATION**

Habitat modification is practiced at a great many airports and airbases around the world. (e.g., U.S. Fish and Wildlife Service 1979, 1984; Transport Canada 1984; Searing et al. 1996; John Floyd, U.S.D.A., Wildlife Services, pers. comm.). Habitat modification involves the removal and/or alteration of habitat features. Typical actions include the pruning or removal of trees and shrubs; removal of standing water (ponds, puddles); revegetation of barren areas with plant species tall enough to prevent use by open country birds such as gulls; planting of crops less attractive to problem birds, and allowing grassy areas to grow taller. Other techniques address nesting and resting sites provided by airport buildings, and removal of perching sites on airfields. Habitat modification should consider habitat features in the vicinity of the airport as well as on the airport itself. An overview of habitat modification issues and techniques is provided in the Transport Canada Manual (Transport Canada 1994). Bird control products/techniques, such as netting and lines, that prevent access to habitat features that attract birds are discussed under “Exclusion Methods” later. Discussed under “Chemical Repellents” are chemicals that control birds' food sources, such as worm control. Some of these alter the habitat for prey species rather than addressing features that birds use directly. The effectiveness of a tall grass policy on airports has been studied at several locations.

## Tall Grass

**Description.** – Airports need to have short grass immediately adjacent to runways so that signs and lights are visible. However, many airfields also have areas of short grass away from runways and in other infield areas. Allowing these grassy areas to grow taller reduces their use by many bird species, especially some particularly hazardous to aircraft safety (e.g., gulls). “Tall” grass generally refers to grass that is at least 15-20 cm in height; “short” grass generally is <10 cm.

**Biological Basis.** – Tall vegetation appears to be effective because it impedes certain birds' access to food sources (e.g., soil invertebrates) and obstructs the birds' lines of sight to approaching predators, thus creating an unsafe feeding or loafing environment. However, other species of birds are adapted to taller grass habitats and very long grass can attract rodents and attendant raptors (Wright 1968).

**Literature.** – Brough and Bridgman (1980) compared gull use on plots of longer (15-20 cm) and shorter (5-10 cm) grass on 13 airfields in the United Kingdom. They found that the longer grass was very successful at reducing the numbers of birds, particularly gulls. At Copenhagen Airport, Dahl (1984) found that “medium length” grass (about 20 cm) was much more effective at reducing use by loafing gulls than was longer or shorter grass. The latter grass lengths were not defined and the author did not present his data in the cited paper. The “long grass policy” at RAF stations which operate fixed wing aircraft, requires maintenance of grass at 18-20 cm for most of the year and has proven effective at reducing bird strikes (Deacon 1996). Hupf and Floyd (1995) also found a long grass management policy to be effective in reducing on-airport populations of hazardous bird species (Canada geese, starlings, laughing gulls). “Tall” grass in their context was >14 in (35 cm) and averaged 22-24 in (56-61 cm). Of five species that accounted for 85% of bird strikes at Ottawa/MacDonald-Cartier Airport, four (ring-billed gull, snow bunting, swallows and rock doves) were found to be more attracted to short grass (5-10 cm) areas than long grass (15-20 cm) (Potter 1996). At Vancouver International Airport, extremely long grass (up to 75 cm) has been found to keep geese and ducks out; only great blue herons used such tall grass areas (Dave Ball, Vancouver International Airport, pers comm.). Dolbeer and Seamans (1997) evaluated the response of Canada geese to short (5-10 cm) and tall (16-20 cm) grass in an outdoor pen test. Interestingly, the geese showed a preference for the tall-grass plots.

Gulls, a hazard to aircraft safety at many airports, spend substantial proportions of each day resting, preening, and sleeping. This behaviour is called loafing. Gulls loaf on level areas with little or no vegetation to impede their vision and their ability to detect approaching predators. Many, but not all, major loafing areas have standing water. Thus the attractiveness of gull loafing habitat can be minimized by removing standing water and revegetating barren areas. The importance of loafing areas for gulls was illustrated during a recently completed study in the Tampa Bay area (Patton 1988). A major landfill that had been used by up to 60,000 gulls was

closed. The gulls dispersed to five of the six surrounding landfills in the following winter. Numbers at the sixth landfill decreased rather than increased. The decrease was associated with the loss of loafing habitat adjacent to the landfill (Patton 1988). Thus an important feeding area can be rendered less attractive if suitable nearby loafing habitat is not available. Stout and Schwab (1979) also found a very direct connection between gull use of an airbase for loafing and their use of two nearby landfills for feeding. A major, multi-year experiment is being conducted at O'Hare International Airport in Chicago to determine the bird use of large plots (40-50 acres) of grass at different heights. The results are not yet available (R. Sliwinski, U.S.D.A., Wildlife Services, pers. comm.).

An alternative to a tall "grass" policy has been investigated. Dekker and Zee (1996) tested the effectiveness of a "poor grass regime", a herb-rich vegetation community (i.e., more wildflowers and fewer grasses) that commonly is found on poorer soils. Based on five years experience at two airports in The Netherlands, Dekker and Zee found that "bird numbers on poor grass were as low or lower than on long grass. Furthermore the species composition of the remaining birds changed to smaller, less heavy species, thus decreasing the risk of a bird strike causing damage." (p 303). "Poor grass" apparently performs the same structural functions as tall grass (i.e., impeding access to food and detection of approaching predators), but also supports fewer small mammals and invertebrates because it is a nutrient-poor plant community. Therefore there is less food for birds. Botanical expertise would be required to implement this approach.

Habitat modification actions, such as mowing and ploughing, can attract significant numbers of birds in the short-term by making prey more available (e.g., worms and other invertebrates for gulls, rodents for hawks and gulls). Potter (1996) suggested that mowing be conducted either late in the day or overnight to reduce the attractiveness of these activities but did not test this technique. Night mowing has been effective when tried at Vancouver International Airport (D. Ball, YVRAA, pers. comm.).

***Evaluation.*** – The effectiveness of a "tall grass" strategy, or the use of some type of tall ground cover, has been shown to be effective at reducing the use of airfields by several if not all of the most hazardous species (e.g., gulls, waterfowl, rock doves, starlings, snow buntings). Tall-grass habitats do attract some other species hazardous to aircraft safety, such as hawks and owls however.

***Recommendation.*** – A tall grass/vegetation strategy is recommended, with the proviso that the situation should be monitored to ensure that new more serious hazards are not created with the attraction of "tall grass" bird species. Also, the "poor grass regime" reported on by Dekker and Zee (1996) shows promise.

*Literature Reviewed.* – Brough and Bridgman 1980; Dahl 1984; Deacon 1996; Dekker and Zee 1996; Dolbeer and Seamans 1997; Garber 1996; Hupf and Floyd 1995; Patton 1988; Potter 1996; Stout and Schwab 1979; Transport Canada 1984; Wright 1968; U.S. Fish and Wildlife Service 1979, 1984.

## AUDITORY DETERRENTS

The classification of the following products and techniques as auditory deterrents is somewhat arbitrary. Many of these products also present visual stimuli to birds and, to some extent at least, birds respond to these as well as to the sounds.

### Shotguns and Rifles with Live Ammunition

Shotguns and rifles, when fired into the air, produce a loud bang, then a “whirring” noise that may disperse birds whether or not some birds are hit and killed. (A rifle should not be used in this manner, given the potential hazard to people at distances of 2-3 km or greater.) Shooting has been used to frighten or kill birds at fisheries operations (Lagler 1939; Davidson 1968; Anderson 1986; NCC 1989), in agricultural fields (Nomsen 1989), and at airports (DeFusco and Nagy 1983; BSCE 1988). In these situations, birds are commonly killed. In most cases, this is done mainly to reinforce the effectiveness of non-lethal bird scaring devices that are also in use, not in an attempt to kill a significant proportion of the birds present. Other pyrotechnic devices would probably be at least as effective as “shooting to miss” with live shot. Hence, it is doubtful that live shot should be used to scare birds from an airfield unless it was the only technique readily available. (See also “Live Ammunition-Shooting” later.)

Shotguns produce their loudest noise at the gun which may be 50-100 m from the birds, whereas the noise from the pyrotechnics occurs very close to the birds. Thus, live ammunition is not a very effective deterrent.

Birds habituate to shots, especially in the case of species that are not widely hunted. For example, shooting at cormorants and herons, and killing some of them, only temporarily repelled the species from fish farms (EIFAC 1988; Coniff 1991). Shooting was not effective in dispersing egrets from airports; most egrets returned shortly after being shot at, even if some birds were killed (Burger 1983; Fellows and Paton 1988). Shooting also was not effective in dispersing roosting geese (Taylor and Kirby 1990).

Ammunition for a 12-gauge shotgun (and the cost to deploy a person to use the shotgun) is expensive in comparison to the low operating costs of exploders, which are discussed below. However, a shotgun is more easily deployed. There would be a safety concern in using live shotgun ammunition in an area where airport activities were underway; however, the maximum distance that shotshells could injure people or birds is 60-90 m, depending on the size of the shot being used. Thus shotguns do not have the potential to injure at long range like rifles do.

## Pyrotechnics

**Description.** – Pyrotechnics include a wide variety of noise-making shells fired from shotguns, starter pistols, and flare pistols. They include shellcrackers, flares, firecrackers, rockets, and mortars. They all emit loud, banging noises, produce flashes of light (and therefore also have a visual deterrent component), or both. Pyrotechnics are widely used at airports to scare birds.

**Biological Basis.** – The banging noise from some pyrotechnics resembles that from a shotgun. That resemblance no doubt enhances the effectiveness of these devices in scaring birds that are hunted. Pyrotechnics also produce startle reactions in birds. However, birds can gradually habituate to pyrotechnic devices. Other supplementary scaring techniques, including the occasional shooting of a bird with live ammunition, are often used to reduce the rate of habituation to pyrotechnics.

### Shotgun-based

Scare or Bird Frite cartridges, commonly referred to as cracker shells, are usually deployed from 12-gauge shotguns. A single shot or pump action gun with a short barrel and no choke should be used for safety reasons. Shellcrackers contain a firecracker that is projected approximately 45-90 m (50-100 yd) and then explodes (Mott 1980; Salmon and Conte 1981; Littauer 1990a). This has the advantage of being able to place the explosion closer to the birds. The noise from the explosion frightens the birds causing them to flush or change flight direction.

Exploding shells have proven useful in repelling and dispersing birds at airports (Burger 1983; DeFusco and Nagy 1983; BSCE 1988), at landfill sites (Southern and Southern 1984; Davis and Davis 1994), in fruit orchards (Nelson 1990b), and on cereal crops (Booth 1983). Shellcrackers have longer range than do smaller cartridges launched from starter's pistol (see below). This can have the advantage that less manpower is required to cover an area (Mott 1980). When fish-eating birds are dispersed from aquaculture ponds by shellcrackers, the effect is relatively short-term: most birds are deterred from returning for a few hours to a few days (Draulans 1987). In a few rare situations, birds have been prevented from returning for longer periods (up to four weeks) before habituation took effect.

At some times in the past, shellcrackers have been difficult or impossible to obtain at short notice. Thus, if this method is to be applied, an adequate supply of shellcrackers should be kept in stock as a contingency measure. Hussain (1990) recommended caution in using shellcrackers in areas of dry vegetation where fires can start. This is also a concern around fuel.

## Flares

Flares are modified shotgun shells, fired from a pistol or shotgun, or brightly burning firecracker-like devices that can be deployed from hand-held launch units or placed on the ground to burn. When fired, the flare leaves a trail of smoke that may frighten birds (Koski and Richardson 1976). Flares are not as effective as cracker shells. However, when used in conjunction with other deterrent methods, flares might be useful in influencing the direction in which birds disperse, although there may be a fire hazard in some situations.

## Pistol-based

Pyrotechnics can be fired as far as 25 m into the air from a 15 mm flare pistol or a 6 mm blank pistol. Firecrackers are commonly called noise, bird, whistle, or clow bombs (Mott 1980; Salmon and Conte 1981; Salmon et al. 1986). Pistol-based pyrotechnics have a shorter range than do shotgun based shellcrackers.

Small pyrotechnic shells launched from pistols include “bangers”, “screamers or whistlers” and “crackers”. They are widely used in deterring birds from airports, agricultural areas, and landfill sites (e.g. Miller and Davis 1990a,b). Because these devices can be fired into the air toward birds, they are the most useful of the firecracker-type deterrents. However, in general they have shorter range than do 12-gauge shellcrackers, and produce a weaker “bang”. The Ruggieri pistol and “Capa” cartridges offer an improved range of approximately 300 m (Briot and Eudot 1994; Ball 1997). “Bangers” and “whistlers” effectively deterred black-crowned night-herons and great blue herons from predated fish at a fish hatchery (Andelt et al. 1997).

Pistol-based pyrotechnics can be very effective if they are used properly. If they are not used properly, then birds can easily habituate to them, and control is not attained. In landfill situations, where gulls are difficult to control, proper use of pyrotechnics has achieved control of gulls at the Tower Landfill near Denver (Davis and Davis 1994) but improper application has been unsuccessful at the Britannia Landfill near Toronto (Miller and Davis 1990a,b). Pyrotechnics are major components of most airport bird control programs in North America.

Screamer shells were found to be 100% effective at dispersing Canada Geese from urban parks even though broadcasts of alarm/distress calls were not (Aguilera et al. 1991). The use of screamer shells had some long-term effects on the goose distribution. After five days of using screamer shells, Aguilera et al. (1991) found an 88% reduction in the number of geese using a site during the following five days.

The rope-firecracker is a pyrotechnic device made of cotton rope with waterproof firecrackers attached (Littauer 1990a). The rope is lit at one end. It burns slowly from one end to the other, and intermittently ignites the next firecracker along the rope; each firecracker makes a loud noise when it detonates. Rope-firecrackers have been suggested for use in deterring birds from landfill sites, fish-farms and agricultural areas (Salmon and Conte 1981; Booth 1983; DeFusco and Nagy 1983). Firecrackers are useful for deterring birds from a small area for a short time.

Store-bought firecrackers (normally used for holiday celebrations), attached to a piece of wood and ignited, were reported to scare thousands of roosting blackbirds from a residential area. The firecrackers were deployed for three consecutive nights (Bliese 1959). Better and safer techniques are now available.

### Rockets and Mortars

Rockets (e.g. marine signal rockets, skyrockets and star shells) are normally projected from a launching rod and make a hissing sound as they travel (Hussain 1990). Some rockets may explode (e.g. jupiter shell), producing a display of fireworks and a loud noise at the same time. Mortars would be used in the same way as other pyrotechnic devices to disperse birds (Koski and Richardson 1976). Rockets would be useful at night, but would not be useful during the day unless they also produced a loud bang. Mortars, on the other hand, would be useful during both day and night. The noise produced by a mortar is much louder than an exploder or shotgun, and thus would probably disperse birds from a larger area. Skilled operators may be required. There have been several accidents related to the use of mortars and many operators have abandoned use of them for safety reasons.

***Evaluation.*** – Pyrotechnics undoubtedly are among the most used bird control devices on airports. Pyrotechnics can and do scare birds but, without effective presentation, birds commonly habituate to the loud bangs. Presentation is the critical factor. Because of their portability and flexibility of use, pyrotechnics that are fired from shotguns or pistols are the most effective type. Extremely effective bird control programs have been based primarily on the use of pyrotechnics. Contrastingly, bird control programs that have employed much larger numbers of pyrotechnic shells have been largely ineffective. A relatively small number of pyrotechnics, used at appropriate times and in appropriate circumstances with regard to the behaviour of the birds, can keep hundreds of birds away. The technique is labour intensive. One effective technique, used successfully on gulls at landfills, has been to use pyrotechnic shells to prevent birds from landing, rather than allowing them to land and then dispersing them. The best methods of presentation likely vary from species to species, and experimentation is required, but the general approach is to be selective in your shots. Do not fire too often. The more indiscriminately that pyrotechnics are used, the more quickly birds will habituate. Do not fire until the birds are close enough that

the shot will explode very close to them. Do not waste shots at birds that are too far away. Properly used, pyrotechnics can train birds to avoid coming to a formerly attractive area.

FOD (foreign object damage) can be a concern with pyrotechnics used near active runways. It is important to remove shells and shell casings from areas where they may be sucked into jet engines (Jarman 1993).

### **Advantages**

1. Rockets and mortars are potentially effective over large areas.
2. Pyrotechnics are effective both during the day and at night.
3. Direction and intensity of firing can be controlled.
4. They can be used as complementary devices with other deterrents.

### **Disadvantages**

1. Pyrotechnics cannot be used in situations where fire would be a hazard, e.g. near dry vegetation or fuel.
2. Shooting at birds may not be acceptable in some public places.
3. Shotgun- and pistol-launched shells are useful only over relatively small areas at any one time.
4. Use of pyrotechnics is labour-intensive.
3. Birds can habituate to pyrotechnics if they are used improperly.
4. Pyrotechnics may be difficult or impossible to deploy in some situations.
5. Pyrotechnics can pose hazards to operators and bystanders if not used carefully.

**Recommendation.** – Recommended, if used selectively and sparingly as discussed above. Shotgun- and pistol-launched shells are the most adaptable types of pyrotechnics.

**Literature Reviewed.**—Andelt et al. 1997; Aguilera et al. 1991; Anderson 1986; BSCE 1988; Bartelt 1987; Beck 1968; Bliese 1959; Bomford and O'Brien 1990; Booth 1983; Briot and Eudot 1994; Burger 1983; Coniff 1991; Cummings et al. 1986; Davidson 1968; DeFusco and Nagy 1983; Davis and Davis 1994; DeHaven 1971; Draulans 1987; EIFAC 1988; Elgy 1972; Faulkner 1963; Feare 1974; Fellows and Paton 1988; Fitzwater 1978; Geist 1975; Green 1973; Grun 1978; Handegard 1988; Kevan 1992; Koski and Richardson 1976; Kress 1983; LGL Ltd. 1987; Littauer 1990a,b; Lucid and Slack 1980; Mattingly 1976; Miller and Davis 1990a,b; Mott 1980; NCC 1989; Nelson 1970; Nelson 1990a; Nomsen 1989; Noriss and Wilson 1988; Parsons et al. 1990; Radford 1987; Salmon and Conte 1981; Salmon et al. 1986; Southern and Southern 1984; Taylor and Kirby 1990; USDA 1991; U.S. Dep. Interior 1978.

## Gas Cannons and “Exploders”

**Description.** – Gas cannons or “exploders” are mechanical devices that produce loud, banging noises to frighten birds. The “bangs” are produced by igniting gas (acetylene or propane). The noise of the explosion resembles or is louder than that of a 12-gauge shotgun (Feare 1974; Nelson 1990a). Blasts are emitted at adjustable time intervals (Salmon and Conte 1981; Salmon et al. 1986), sometimes close together, controlled by an automatic timing device. A photo cell can be included to turn the system off at night. Some gas cannons can be set to fire at random intervals and to rotate after each explosion so that subsequent shots are aimed in different directions. Remote control firing mechanisms are also available whereby a person can directly control the timing and number of shots from a distance. Remotely operated cannons can also rotate after each shot.

**Biological Basis.** – The sudden, loud bang from a gas cannon is capable, at least initially, of scaring birds away from an area. This flight response probably is related to the similarity of the bang to that of a shotgun shot (for those species that have been hunted), and to a 'startle' reflex reaction. However, without reinforcement that this bang represents a potential threat to the birds, birds soon habituate to these sounds.

**Literature.** – Gas cannons can be effective at dispersing birds if the frequency of the explosions is varied and if the cannons are moved every second or third day of use to a different area. Sometimes it is necessary to elevate the cannons if foliage or equipment interfere with the sound of the blast (U.S. Dep. Inter. 1978; Hussain 1990). Birds habituate to the sound of the explosions, particularly if no other techniques are used to reinforce the threat of the cannon (DeFusco and Nagy 1983; BSCE 1988). Rotary mounts, variable firing intervals, and use of other complementary deterrent methods are helpful in delaying habituation. Gas cannons, in combination with other dispersal methods such as pyrotechnics, have been found to reduce numbers of gulls visiting landfills (e.g. Risley and Blokpoel 1984; Miller and Davis 1990a,b).

For dispersing gulls at airports, one cannon for every 50 m of runway has been reported to be effective (DeFusco and Nagy 1983). (It is not advisable to position gas cannons near runways, given the risk of aircraft striking these propane-fueled explosive devices.) However, cannons have also been found ineffective for long-term bird dispersal programs at many airports because of habituation (BSCE 1988). Cannons may be most helpful where only short-term deterrence is needed. Sugden (1976) indicated that cannons are among the most useful methods for reducing waterfowl damage to grain crops. Propane cannons were very successful at frightening cormorants at shipyards (Martin and Martin 1984) and can be valuable in reducing blackbird damage on cornfields (Dolbeer et al. 1979). For dispersing blackbirds, one cannon for every 4-10 ha works well (LGL Ltd. 1987). Setting cannons to fire at 30 s intervals can disperse blackbirds and Starlings from roosting areas (U.S. Dep. Interior 1978).

Gas cannons have proven to be effective deterrents for areas up to 4 ha in the cases of non-game species (Salmon et al. 1986), 18-24 ha for dabbling ducks in grain fields (Stephen 1960, 1961), and 50 ha for scaup on small lakes (Ward 1978). In the study by Ward (1978), the cannons were used in combination with scarecrows and lights.

**Interviews.** – A common complaint made by people that we spoke with regarding gas cannon systems is the limited period of their effectiveness. Birds habituate to the sound of the cannons within a relatively short period of time – a matter of days in some cases. Gulls at the Nottawasaga and Wasaga Beach landfill sites came to ignore the bangs of propane cannons there. In fact, observations were made of gulls perching atop the cannons, lifting off the units with the 'click' noise that preceded the explosion, then immediately settling back down atop the cannons (Steen Klint, Environmental Services Department, County of Simcoe, Ontario, pers. comm. 1998). Gulls regularly stood on the ground within 2-3 m of the units. Mark Adam (Falcon Environmental Services, Inc.) commented that (1) these units are very loud and this can be a serious problem where you have to control birds near residential areas (noise complaints); (2) the automated timer could lead to the scaring of birds at an inappropriate time, such as into the path of an aircraft taking off/landing. There is an indication that repetitive use of cannons may actually attract gulls to landfills (R.A. Davis, LGL Limited, pers. obs.).

At the Calgary International Airport, birds also have been found to habituate to the sounds of the cannons. However, cannons are still employed on an as needed basis and do scare birds away at least for short periods (Brian Richmond, Calgary Airport Authority, pers. comm. 1998). Bird control staff there have found that shorter periods between shots keeps the birds more on edge and thus more easily dispersed. Brian Richmond added that maintenance of the cannon units is an ongoing problem and while the best effect is achieved by moving the units around, they are not easy to move.

Dave Ball (Vancouver International Airport, pers. comm.) mentioned that they have positioned gas cannons at problem sites on the airfield, such as puddles where birds gather, and directly fire the cannon with a remote control device when needed. In this case, the cannons are being used like pyrotechnics.

**Evaluation.** – As with pyrotechnics, the efficacy of gas cannons varies with the method of presentation. Birds quickly habituate to gas cannons that fire at regular intervals and are not moved. Within a relatively short period of time the cannons become completely ineffective. Variation in the frequency of firing, number of shots per firing sequence, direction of firing, and location of the cannon on the airfield will prolong the period of effectiveness. Two or three shots in rapid succession, with variable firing intervals and rotation after each shot, is one good technique. The greatest control and variability can be achieved with remote firing of the cannon

under the direction of the bird controller. Birds likely will habituate eventually, however, unless other supplementary techniques (including occasional killing) are employed.

### **Advantages**

1. Direction, timing and volume of the blasts can be controlled.
2. Gas cannons are movable.
3. They are automatically operated and require checking only once a day.
4. They are effective day and night.

### **Disadvantages**

1. Birds can rapidly habituate to the sound of the blasts.
2. Cannons must be supplemented with other deterrent devices.
3. Older gas cannons should not be used in areas where fire would be a problem.
4. Compared to the size of an airfield, the effective area is relatively small.
5. Regular maintenance is required.

**Recommendation.** – Cannons should not be relied upon as the sole or even the major component of a bird control program. Cannons are recommended for occasional use as part of an integrated airfield bird control program, in conjunction with other products and techniques. Cannons must not be deployed near fuel because the igniter for the cannon could ignite the vapour.

**Literature Reviewed.** – Bomford and O'Brien 1990; Booth 1983; Bradley 1981; BSCE 1988; Conover 1984; DeFusco and Nagy 1983; Devenport 1990; Dolbeer et al. 1979; Feare 1974; Hussain 1990; LGL Ltd. 1987; Littauer 1990a; Martin and Martin 1984; Miller and Davis 1990a,b; Mott 1978; Naggiar 1974; Nelson 1990a; Payson and Vance 1984; Risley and Blokpoel 1984; Salmon and Conte 1981; Salmon et al. 1986; Sharp 1978; Stephen 1960, 1961; Stickley and Andrews 1989; Sugden 1976; Truman 1961; U.S. Dep. Interior 1978; Ward 1978.

### **Agri-SX**

**Description.** – Two bird control products marketed by the Agri-SX company of Quebec — the “Rotating Hunter” and the “Falcon Imitator” — are discussed here. Each product combines visual (hunter or falcon images) and auditory (propane cannons) stimuli to deter birds. These units are relatively new to Canada, although they apparently have been in use in Europe for several decades.

The “Rotating Hunter” consists of two propane cannons, and the metal silhouette of a person with a gun, on a rotating base atop a tripod. The entire system is taller than a person. The two cannons fire alternately in opposite directions, and the guns and “hunter” swivel with the force of each shot and with the wind. The frequency of the shots and on/off periods of each unit can be controlled with a mechanical timer. Agri-SX claims that the “Rotating Hunter” protects 20 ha of open land.

The noise stimulus of the “Falcon Imitator” also is provided by a propane cannon. The propane cannon pulse propels a “plunger” which pushes a fringed rubber disk up an 8 m pole (supported by a tripod). The plunger drops back quickly while the disk parachutes back down more slowly. This “lure” is said to imitate a falcon chasing a bird. As with the “Rotating Hunter”, the timing and on/off periods can be controlled. The “Falcon Imitator” is said to be effective within a 150 m radius; the “birds never get accustomed to the falcon imitator” according to the manufacturer’s promotional material.

**Biological Basis.** – The loud bang of a propane cannon is known to be effective at scaring birds for short periods of time (see discussion of gas cannons above), but birds soon habituate to the noise. Scarecrows, like the hunter image, also have short-term effectiveness. On a biological basis, it would appear that birds would habituate to these Agri-SX products relatively quickly although perhaps less rapidly than to a gas cannon alone because of the visual stimuli of the hunter and falcon images.

**Literature.** – There are no published or unpublished independent studies of these Agri-SX units. However, see the discussion about gas cannons above, and “Visual Deterrents - Scarecrows, Flags, and Streamers” later in this section.

**Interviews.** – The company’s promotional literature lists more than 20 locations where the “Rotating Hunter” and “Falcon Imitator” have been used to control birds. These include agricultural, industrial, and airport settings. Personnel at several of these sites were contacted for information.

Overall, opinions of the efficacy of these products ranged from very satisfied to “no better than a propane cannon”. No one considered these products to be the magic answer to all their bird control problems but rather a part of a multi-faceted program. None of the locations contacted employed the Agri-SX products on their own; they were used along with other control products and techniques. No comprehensive, rigorous test of the “Rotating Hunter” and “Falcon Imitator” is available. Consequently, the following review comments must be regarded as anecdotal.

One of the most heavily promoted endorsements of the Agri-SX products in the company literature is the removal of a nesting colony of gulls at the Daishowa pulp and paper plant at Quebec City. We spoke with Marcel Barriere of Daishowa, Inc.. A colony of mostly ring-billed gulls had grown to approximately 25,000 pairs by 1992 or 1993. During 1993 and 1994, there was a large-scale egg removal program at the colony, conducted by the Canadian Wildlife Service. Gull numbers declined subsequently to about 15,000 pairs. In 1995, one Agri-SX “hunter” and two “falcon” units were installed. In conjunction with the use of pyrotechnics, gulls were eliminated from the site in 1995.

The Agri-SX system has been used each year since at the Daishowa site and there still are no gulls. Each year the Agri-SX equipment has had to be used less often to scare the gulls away. Apparently the gulls have moved to an existing “natural” colony site on an island away from the Quebec City area. Concurrent with the gull control program at Daishowa, the municipality of Quebec City implemented a widespread program to reduce the number of food sources for the gulls. Regulations were enacted to prohibit the feeding of gulls by the public; household garbage had to be enclosed in hard containers rather than plastic bags that the gulls could tear. Apparently there was a marked reduction in the number of gulls throughout the entire Quebec City area.

Because of the coincidental use of other control products (pyrotechnics) and methods (egg collecting, regional garbage control), the elimination of nesting gulls at the Daishowa site cannot be attributed solely to the Agri-SX products. It also is impossible to measure the relative contribution of the Agri-SX systems to the overall result.

The “Rotating Hunter” and “Falcon Imitator” also have been used at sanitary landfill sites. We spoke with Steen Klint (Environmental Services Department, County of Simcoe) about the efficacy of these units at the Nottawasaga and Wasaga Beach (Ontario) landfills, and with Larry Conrad about his experiences at the Britannia Landfill (Mississauga, Ontario). Again, in both cases, the units were used in conjunction with other products and techniques. These included pyrotechnics, overhead lines, habitat management, and occasional killing. Klint and Conrad each considered the “Falcon Imitator” to be more effective than the “Rotating Hunter”. Neither felt that they could rely on these products alone to control birds at these sites, but the units did scare gulls away. It is not known how long these units were in place and thus if there was the opportunity to investigate habituation to the devices by the gulls.

Mark Adam of Falcon Environmental Services, Inc., a bird control company, has familiarity with the “Rotating Hunter” and “Falcon Imitator” at landfill and industrial facilities. He did not find these products to be any more effective than propane cannons without the “hunter” or “falcon” features. In his experience, other propane cannons on the market have more sophisticated and reliable electronic timing mechanisms. The Agri-SX units employ older mechanical timers that are less accurate and less dependable. Adam also felt that the design of the

“Falcon Imitator” was ill-suited to Canadian winters. Snow, ice, and freezing rain would impede the movement of the “falcon” up and down the 8 m pole. Overall, he considers regular propane cannons to be as effective and significantly less expensive, than the Agri-SX products. Nevertheless, he suggested that these units could be part of a broader bird control program.

In March 1998, 12 “Rotating Hunters” and 6 “Falcon Imitators” were installed at the Jean Lesage Airport in Quebec City. This is the first implementation of the Agri-SX products at a major Canadian airport. Pyrotechnics will be used as well. The results of this program may provide a more comprehensive evaluation of the efficacy of these units.

***Evaluation.*** – At present the jury is still out on the Agri-SX products, and will be until rigorous and independent tests are conducted. The results of the installation at Jean Lesage Airport hopefully will be instructive. (No controlled studies are being conducted there, unfortunately.) These Agri-SX products probably are quite similar to gas cannons as bird deterrents. Although habituation may occur more slowly than with gas cannons alone, habituation is still a considerable concern given the need for long term effectiveness at airports. It is likely that “Rotating Hunters” and “Falcon Imitators” will suffer from the same limitations, and be used best in the same manner, as gas cannons.

***Recommendation.*** – Given the considerable cost of these units, their similarity to the less expensive gas cannons, the more sophisticated timing devices available on gas cannons, and the lack of adequate testing, a major purchase is not recommended. Testing of one or a few units may be considered if the bird control program is not reliant on these.

***Literature Reviewed.*** – Only company promotional literature.

#### Phoenix Wailer Systems

***Description.*** – The Phoenix Wailer is a sound broadcast system that differs from other similar systems in the wider variety of sounds (audible to humans and ultrasonic) and greater flexibility of presentations that it permits. This, it is claimed, addresses the risk of habituation by birds. Several models have been available in Canada: Phoenix Wailer MkI and MkII, Phoenix Airport Wailer MKIII, and Marine Wailer. The Phoenix Wailer models are terrestrial units; the Marine Wailer is a waterproof version, apparently of the same device, that comes in a self-contained unit supported above the water by a quadrapod attached to floats. These systems were used as bird deterrents in England, then were imported to Canada. They are manufactured and sold in Canada now.

All Phoenix Wailer systems broadcast electronically-produced sounds. The frequency range of the two low frequency speakers in each unit is 450-4000 Hz; that of the four high frequency speakers in each unit is 3500-27,000 Hz. The selection, duration, spacing, and speaker location of sounds is programmable and can be randomized. Source level is adjustable. Units can be set to turn on and off automatically based on light-level (sunrise/sunset) or using a 24-hour timer. The Phoenix Wailer MkII system is capable of broadcasting 94 “irritating” electronically-produced noises, including ultrasonic sounds. The Airport MKIII system emits an additional 16 natural bird calls (alarm and distress calls, and calls of predators). A line of speakers can be set up along a runway and protect up to 3,000 ft, the manufacturer claims.

**Biological Basis.** – Birds will respond to distress and alarm calls of their own and, occasionally, some other species, and the calls of predators (see below). Birds also may exhibit avoidance responses to novel unnatural sounds, such as some of the synthetic electronic sounds produced by the Phoenix Wailer systems, if these sounds are loud and sudden enough. However, few species of birds hear ultrasonic sounds (>20,000 Hz, see “Ultrasonic Sounds” later) and these species do not appear to respond to these sounds. Also, habituation to sounds with no biological meaning is a common occurrence, although habituation to distress, alarm, and predator calls is slower.

**Literature.** – Since the introduction of Phoenix Wailers systems to Canada, the results of several studies have been published. An initial telephone survey of seven wailer users (six agricultural, one airport) in Nova Scotia and New Brunswick (Hounsell 1992), and a limited study at Yarmouth Airport (Nova Scotia; Hounsell 1994) were favourable. However, these studies were based largely on anecdotal evidence. A brief study at the Moncton, New Brunswick airport was too short and was complicated by the shooting of gulls during the test period (Hounsell 1995). The only reasonably rigorous tests, although each with limitations, have been conducted at the Calgary International Airport (Troughton and Revel 1996) and on ring-billed gulls at a landfill site near Ottawa (Topping 1994). The results of these studies clearly were not positive. Troughton and Revel (1996:21) concluded that “The data suggest that the wailer may be a short-term deterrent but there is no evidence to suggest that the Phoenix Wailer works in the long-term. Regular wildlife control activities should be continued in areas where the wailers are installed.”. Topping (1994) concluded that gulls at the landfill site were not discouraged from using the areas around the wailers. In fact, the numbers of gulls actually increased over both test periods, and loafing gulls were frequently observed within 3 m of a blasting speaker. Blokpoel (as cited in the Minutes of Bird Strike Committee Canada 19 [1993], page 10) commented that the Phoenix Wailer did not work to move ring-billed gulls from a nesting colony at Hamilton, Ontario.

**Interviews.** – Seven Phoenix Wailer MKIII units currently are in operation at the Halifax International Airport (Shawn Hicks, pers. comm. 1997, 1998). These units are part of a bird control system at the airport that also includes propane cannons, pyrotechnics, and occasionally falconry. Mr. Hicks did not regard the Phoenix Wailers to be the magic solution to bird problems at the airport. He also mentioned that there are ongoing annual maintenance costs associated with the wailer units. Occasionally the units at Halifax have been struck by lightning.

Phoenix Wailers are still in use at the Calgary International Airport but the wildlife control staff are not confident about their effectiveness (Brian Richmond, Calgary Airport Authority, pers. comm. 1998). They also have had problems with coyotes and rodents chewing the electrical wires, and with coyotes rubbing against the units and knocking them over. The two Phoenix Wailers in use at Vancouver International Airport are not considered to be effective by most of the controllers there.

Mark Adam, of Falcon Environmental Services, Inc., has observed Phoenix Wailer MkII and MKIII units in operation and considers them to be ineffective at deterring birds (pers. comm. 1998). In one case, he found that a Phoenix Wailer system kept pigeons away from an industrial site for only one day.

**Evaluation.** – The synthetic “electronic” noises produced by Phoenix Wailers have no biological relevance to birds and thus are ineffective for airport purposes. Birds may be dispersed initially by these sounds, as a avoidance response to a novel stimulus or as a startle reaction to a loud and sudden noise. However, habituation will occur rapidly. Research to date (see below) has shown that the few species of birds that can detect ultrasonic frequencies do not respond to them. Therefore this component of Phoenix Wailer broadcasts also are ineffective. The broadcast of avian distress and alarm calls can be effective, and in this regard Phoenix Wailers systems show promise. (The use of distress and alarm calls is discussed in greater detail below.) However, the method of delivery of these bird vocalizations by Phoenix Wailers – short bursts of audio; random delivery of a mixture of calls, ultrasound, and nonsense “electronic” sounds – is poor. Systems designed specifically to broadcast distress and alarm calls, and that permit more direct control of the selection, timing, and frequency of delivery, are better.

**Recommendation.** – Not recommended for long term use on airfields. Phoenix Wailers may be effective for short periods of time where problem birds repeatedly concentrate (e.g., around a spring runoff puddle). It is an expensive product for this application though.

**Literature Reviewed.** – Hounsell 1992, 1994, 1995; Topping 1994; Troughton and Revel 1996.

## Bird Gard AVA and Bird Gard ABC

These products broadcast electronically-synthesized (Bird Gard AVA), or electronically-reproduced (Bird Gard ABC), alarm and distress calls of a short list of pest bird species. See “Distress and Alarm Calls” below for a discussion of this method of bird control.

### Av-Alarm

**Description.** – Av-Alarm is a commercially-available electronic sound-producing device that broadcasts synthetic sounds in the 1500 to 5000 Hz frequency range at sound levels of 118 dB at one metre. To be effective, Av-Alarm sounds should be selected to match natural frequencies of alarm and distress calls of the species of concern, or to match the frequencies of intra-flock communications. Sounds are projected through speakers that each cover an angle of 120°. The timing and frequency of broadcasts can be controlled by interval timers and photocells. The unit can be powered either by a 12-volt battery or by 110/220-volt 50-60 Hz A.C.

**Biological Basis.** – Given that the sounds produced by Av-Alarm units are synthetic, there would appear to be no biological bases for the sounds to repel birds. However, the sudden onset and/or loud volume of the sounds may startle birds into departing an area on occasion. Birds also may avoid some novel sounds initially.

**Literature.** – Av-Alarm has been used primarily in the agricultural industry to deter birds from food crops. Most evaluations of its success have been subjective. However, Av-Alarm has been tested as a method of deterring waterfowl from agricultural and coastal areas, and at airports.

Av-Alarms appear to have been used successfully to reduce numbers of small birds feeding on various crops (see Koski and Richardson 1976 and DeFusco and Nagy 1983 for reviews). Preliminary tests from a more recent study suggest that Av-Alarm was an effective method of reducing damage to grapes that was caused by European starlings, cape sparrows and masked weavers (Jarvis 1985). Although most tests of Av-Alarm have been on landbirds in agricultural areas, some reports suggest that Av-Alarm can also be useful in reducing numbers of gulls and plovers at airports (BSCE 1988).

Av-Alarm units appear to have some deterrent effect by themselves, but may be more useful in combination with other scaring methods. For example, Av-Alarm had some deterrent effect on Starlings feeding on blueberries, but the addition of shotguns, gas cannons or decoy traps sometimes appeared to result in less depredation (Nelson 1970). Martin (1980) used an integrated system consisting of Av-Alarm, a propane cannon, and other manually deployed devices to reduce numbers of birds that used a waste-water holding pond, but he did not attempt to isolate the value of the deterrent devices separately. Likewise, Potvin et al. (1978) found that an Av-Alarm and propane cannon in combination were more effective in deterring landbirds from corn fields in Quebec than was either of these devices by itself.

Negative evaluations of Av-Alarms were provided by Booth (1983), who reported that Av-Alarms were not as effective as distress calls in repelling birds. LGL Ltd. (1987), Bomford and O'Brien (1990), and Devenport (1990) noted that birds habituate to the noise. Thompson et al. (1979) noted that the heart rate of Starlings increased only slightly when they were exposed to Av-Alarm whereas marked increases in heart rates occurred when birds were subjected to broadcasts of distress and alarm calls of starlings from both North America and Europe.

We are aware of only one rigorous study of the effectiveness of Av-Alarm as a deterrent device for waterfowl in agricultural situations. Canada Geese were successfully deterred from agricultural fields surrounding a wildlife refuge in Wisconsin (Heinrich and Craven 1990). During their experiments, control and experimental fields were interspersed and it is not known whether the device would have been as effective if there had not been nearby areas of suitable habitat without the deterrent device.

Wiseley (1974) studied the effect of a gas-compressor simulator on the distribution and behaviour of Snow Geese on the Yukon North Slope. This study provides an indication of how Snow Geese might react to noises that do not have a biological significance to them. The simulator caused geese to break from their normal flight formations, to flare, to call, to increase or decrease their speed of flight and to land. They avoided an area within 800 m of the simulator where the most intense sound was broadcast. Thus noise from an Av-Alarm or Phoenix or Marine Wailer may cause similar reactions by Snow Geese.

Crummet (no date; 1973) conducted two experiments suggesting that Av-Alarm might be an effective method of dispersing water-associated birds in aquatic situations. He did not, however, provide sufficient details to permit evaluation of changes in numbers of birds with respect to distance from the deterrent device before and during the experiment, or to assess the possibility that factors other than the Av-Alarm may have contributed to the observed changes in numbers.

***Evaluation.*** – The Av-Alarm broadcasts synthetic sounds that are produced electronically, similar to the Phoenix Wailer but with a much smaller repertoire of sounds. Given the limitations of the

Phoenix Wailer systems see above), the Av-Alarm is likely to be even less effective. The synthetic sounds broadcast by these systems do not have a biological basis and therefore are unlikely to be effective over the long time frames required at airports. There may be some limited use for Av-Alarms on airports where local, short term dispersal is required.

### **Advantages**

1. Can be used to disperse birds in many types of habitats.
2. Av-Alarms may be effective at night.
3. Av-Alarm is not as species specific as some deterrent systems.
4. Av-Alarm does not require constant human attention, but changes in location and adjustments in the characteristics of the sounds will reduce the rate of habituation.

### **Disadvantages**

1. Birds appear to quickly habituate to the sounds if Av-Alarm is used by itself.
2. Other devices may have to be used to make the Av-Alarms effective.
3. Personnel working near Av-Alarms should wear hearing protection devices.

**Recommendation.** – Not recommended as a long term bird deterrent, or as a critical component of an integrated bird control program. Phoenix Wailers probably are more effective given the larger repertoire of available sounds and greater flexibility of delivery. Av-Alarm may be more effective when used in combination with other devices such as pyrotechnics and gas cannons.

**Literature Reviewed.** – Bomford and O'Brien 1990; Booth 1983; BSCE 1988; Crummet n.d., 1973; DeFusco and Nagy 1983; Devenport 1990; Gunn 1973; Heinrich and Craven 1990; Jarvis 1985; Koski and Richardson 1976; LGL Ltd. 1987; Martin 1980; Nelson 1970; Potvin et al. 1978; Sharp 1978; Thompson et al. 1979; Wiseley 1974.

## Distress and Alarm Calls

**Description.** – Distress and alarm calls are given by many species of birds when they are captured, restrained, injured, or otherwise in danger. The calls are species-specific, signal danger, and warn other members of the species to disperse. In some cases, distress calls of one species are recognized, and cause dispersal, by another species (Aubin and Brémond 1989; Aubin 1991). Commercial systems are available that broadcast taped distress calls. Many of these units are mobile; some can be mounted on vehicles (Elgy 1972; Currie and Tee 1978). Solar- and wind-powered models now exist. In recent years, high quality digital recordings have become available as well.

**Biological Basis.** – The link between distress and alarm calls and escape responses is very strong because of its high survival value. It is the biological significance of the calls that makes them a

powerful tool for bird dispersal. It takes more time for habituation to occur with distress and alarm calls (vs. artificial noises, for example) because of the biological relevance of these calls.

**Literature.** – Playbacks of recorded distress or alarm calls are used commonly in attempts to disperse birds from airports, agricultural and residential areas, aquaculture facilities, and some other locations. It is important to broadcast the sound at the most effective location and time in order to have the greatest possible deterrent effect. Thus, a mobile vehicle is desirable. In order to maximize effectiveness and minimize habituation, it is important that the sound be played sparingly and at times when the birds are likely to be most responsive (cf. Transport Canada 1986). This requires a human operator rather than an automatic timer. The effectiveness of this method also depends on the quality of sound that is broadcast; therefore, high quality equipment should be used (Brémond et al. 1968).

Playbacks of distress or alarm calls are widely used in dispersing gulls from airports, and occasionally from landfills and reservoirs (e.g. DeFusco and Nagy 1983; Payson and Vance 1984; Transport Canada 1986; BSCE 1988; Howard 1992). Playbacks have also been very successful in dispersing large flocks (up to 10,000) of European Starlings from roosting sites (Frings and Jumber 1954; Block 1966; Pearson et al. 1967; Feare 1974; G.F. Searing, LGL Limited, pers. comm. 1998). Keidar et al. (1975) found that distress calls deterred flocks of Skylarks and Calandra Larks from feeding on agricultural crops. Smith (1986) reported that birds were dispersed from airports by repeated broadcasts of distress calls. Spanier (1980) reported that juvenile and adult Black-crowned Night Herons could be deterred from commercial fish ponds by playing recordings of their distress calls. Playbacks of distress/alarm calls are most effective if they are begun before birds have established a routine or normal activity pattern in an area. They should also be applied before or as birds are entering an area rather than after they have arrived and settled there to feed or roost (Elgy 1972; Searing, pers. comm.).

Gulls emit an alarm/distress call when they have been captured or sense danger (Frings et al. 1955). When they hear an alarm call, gulls do not react in the same way as starlings. Gulls initially fly toward, and circle over, the source of the alarm call, apparently to investigate; then, they slowly fly away (Hardenberg 1965; Brough 1968; Stout et al. 1974). At airfields this behaviour can present problems if the gulls are attracted toward an active runway (Cooke-Smith 1965; Brough 1968) and care must be taken to avoid this situation. Gulls should be attracted away from a runway to distress calls and then moved further away with pyrotechnics.

Playback of distress or alarm calls is often most effective if used in conjunction with another deterrent method, e.g. firing of shellcrackers (Transport Canada 1986). Brough (1968) conducted 405 trials at five Royal Air Force (RAF) airfields over a one year period. Recorded distress calls were effective in dispersing gulls (including herring gulls) from the airfields. The distress calls were also used in conjunction with pyrotechnics. Brough found that the combination of distress calls and pyrotechnics was most effective, followed by distress calls alone, and then pyrotechnics alone. The combination of distress calls and pyrotechnics was later used by base firemen at RAF bases to disperse birds (Blokpoel 1976). Many other workers have found the distress call/pyrotechnics combination to be effective (Brough 1965, 1968; Busnel and Giban 1968; Bridgman 1969; Dahl 1984).

Mott and Timbrook (1988) found that distress/alarm calls are effective at dispersing Canada Geese from nuisance situations at campgrounds. Their call combination did not include a typical distress call; it included an alarm call of a lone goose and the calls made by a flock of geese as they flew away after being harassed. The calls alone resulted in a 71% reduction in the number of geese using the campgrounds after five days of broadcasting calls. When supplemented with racket bombs, 96% of geese left. However, Aguilera et al. (1991) found that Canada Geese in parks reacted to the same alarm/distress calls by becoming alert and sometimes moving up to 100 m away from the source of the call, but the birds did not leave the area. The presence of nearby alternative habitat may determine the effectiveness in a particular situation.

Proper deployment of distress/alarm calls will increase their efficacy and reduce habituation. Habituation may occur if the call is played continuously (Langowski et al. 1969; de Jong 1970; Burger 1983). For example, Starlings habituated to distress calls played continuously but not to those played intermittently for intervals of 2-95 s. The U.S. Department of Interior (1978) recommended playing calls for 10-15 s each minute when Starlings and blackbirds are entering a roosting area. Block (1966) reported that broadcasting distress calls for 10 s per minute for 50 min successfully dispersed Starlings. To minimize the rate of habituation, the broadcast of distress/alarm calls should be repeated as soon as birds attempt to return after being dispersed (Slater 1980). This does not allow birds time to recover from the stimulus. Mott and Timbrook (1988) reported that Canada Geese did not habituate to playbacks of distress/alarm calls, but they mentioned that birds recognised the vehicle that broadcast the sounds and retreated before it began broadcasting. Thus the true stimulus for dispersal is ambiguous. In a five-year test in Holland, Hardenberg (1965) found little evidence of habituation by gulls to distress calls emitted by loudspeakers deployed along the edges of runways at an air force base. Brough (1968) found no habituation during a one-year test at five U.K. airfields.

Other factors may influence the effectiveness of distress/alarm calls. Species found in open habitats, such as prairie, field, tundra and marine habitats, may depend on visual cues, while species found in forested areas may rely on distress calls that they can hear (Boudreau 1972). Some species, like gulls, respond to alarm calls after they have visually confirmed that there is danger. Flocks usually react more strongly than individuals, and resting or loafing birds are more easily dispersed than feeding birds. Some species of birds such as the Oystercatcher and Wood Pigeon (European species) are reported not to emit distress calls (Bridgman 1976). Distress calls are sometimes effective over long distances (Aubin and Brémond 1989).

**Interviews.** – The distress call/pyrotechnic combination has been found effective on gulls at Calgary International Airport (Brian Richmond, Calgary Airport Authority, pers. comm., 1998). They find that the distress calls agitate the gulls and enhance the follow-up pyrotechnics. The digital recordings are preferred over cassette tapes at Calgary because of the clearer sound they produce.

**Evaluation.** – Alarm and distress calls have been known for over 30 years to be effective at dispersing some, but not all, species of birds. Because broadcast systems are mobile and versatile, distress/alarm calls can be very useful in airport situations. Alarm/distress calls also can be used to create agitation in birds, thus enhancing the dispersal effect of other techniques, such as pyrotechnics.

There are some limitations. The initial curiosity of most gulls toward such calls makes these calls a potential initial attractant rather than deterrent. Distress calls are not readily available for all species (e.g., some species of shorebirds; Gunn 1973), and some species do not have distress/alarm calls.

Broadcast devices are available that “detect” birds (by sound and radar) and broadcast distress/alarm calls only when birds are present, rather than on a pre-determined broadcast sequence. This delays the onset of habituation.

### **Advantages**

1. Habituation to distress or alarm calls may be relatively slow if they are used sparingly and in conjunction with other complementary deterrent methods.
2. This technique can be used day or night.

## **Disadvantages**

1. Many species of birds do not emit distress or alarm calls.
2. Distress and alarm calls have not been recorded for many species. Recordings of these calls would need to be obtained in order to be available for timely use.
3. Most distress/alarm calls are at least partially species specific. Broadcasting the call of one species may not disperse other birds.
4. Weather conditions may affect transmission of sound.
5. Playback of distress or alarm calls is not likely to be useful unless the timing of the playbacks is controlled by an on-site operator. Thus, the method is labour-intensive.

**Recommendation.** – Highly recommended. The use of distress and alarm calls is considered to be an essential component of an airport bird control program. As with all bird control systems, proper presentation by trained bird control staff will significantly enhance the effectiveness of these calls. See the discussion of effective use of distress/alarm calls above.

**Literature Reviewed.** – Aguilera et al. 1991; Aubin 1991; Aubin and Brémond 1989; Beklova et al. 1981, 1982; Block 1966; Boudreau 1968, 1972; Brémond 1980; Brémond and Aubin 1989, 1990, 1992; Brémond et al. 1968; Bridgman 1976; BSCE 1988; Burger 1983; Currie and Tee 1978; DeFusco and Nagy 1983; de Jong 1970; Elgy 1972; Fay 1988; Feare 1974; Fitzwater 1970; Frings and Frings 1967; Frings and Jumber 1954; Frings et al. 1955, 1958; Gunn 1973; Grun and Mattner 1978; Howard 1992; Inglis et al. 1982; Keidar et al. 1975; Kreithen and Quine 1979; Kress 1983; Langowski et al. 1969; Littauer 1990a; Morgan and Howse 1974; Mott and Timbrook 1988; Naef-Daenzer 1983; Payson and Vance 1984; Pearson et al. 1967; Rohwer 1976; Salmon and Conte 1981; Schmidt and Johnson 1983; Slater 1980; Smith 1986; Spanier 1980; Transport Canada 1986; U.S. Dep. Interior 1978.

## Calls of Predators

**Description.** – Most predator sounds could be broadcast using the same equipment as distress or alarm calls. Predators of birds include other birds (such as hawks or falcons), certain mammals, and humans (Gunn 1973; Thompson et al. 1968).

**Biological Basis** – The playback of the call of a predator signals that a predator is nearby, and birds may react to this with heightened awareness and perhaps flight. In natural situations, predators usually hunt silently so that they do not “announce” their presence. Thus, the playback of predator calls would seem to be an unnatural presentation of a stimulus.

**Literature.** – Broadcasts of the protest calls of the Sparrow Hawk successfully repelled House Sparrows, and habituation was not observed after 6 days of exposure to the sounds (Frings and Frings 1967). The playback of a Peregrine Falcon call was effective at dispersing gulls from Vancouver International Airport (Gunn 1973; LGL Ltd. 1987).

Although predator sounds can have a startling effect on birds, they can also attract birds in some situations. For example, crows and blackbirds will mob or attack Great Horned Owls, particularly when they have newly-fledged young. This reaction also occurs around nests or rookeries of gulls and terns.

***Evaluation.*** – It is difficult to evaluate the efficacy of broadcast predator calls for dispersing/deterring birds. The biological basis is unclear, and although studies to date have been positive, there have been few of them. More research needs to be conducted on many aspects of predator sounds and responses by pest birds.

***Recommendation.*** – Predator calls show sufficient promise that they are worth testing. However, predator calls should not be a critical component of any airport bird control program until proven effective.

***Literature Reviewed.*** – Frings and Frings 1967; Thompson et al. 1968; Gunn 1973; LGL Ltd. 1987.

### High Intensity Sound

***Description.*** – High intensity sounds can be produced by sonic booms, blasting using explosives, horns, and air-raid sirens.

***Biological Basis.*** – Very high intensity sound could produce distress, pain, or discomfort; thereby causing birds to leave an area where the noises occurred. Secondly, at greater distances, the sounds could cause startle reactions that scared the birds but did not cause discomfort.

***Literature.*** – Thiessen et al. (1957) conducted preliminary tests using an air-raid siren to disperse ducks from ponds. They found that repeated broadcasts of intense sound caused some birds to vacate the pond after two or three days. Their methods and sound level measurements were not clearly explained. Holthuijzen et al. (1990) reported that a number of Prairie Falcons flew away from their nests after blasting from explosives occurred. The sound levels of the blasts, measured at the entrances of two aeries, averaged 136 and 139 dB, respectively. However, the falcons returned to their nests within minutes. Bell (1971) reported that the reactions of birds to sonic booms varied considerably. Most species reacted by flying away, running or crowding together.

Although not a sophisticated device, a bicycle horn that was inserted into an agitator of a washing machine produced an “ear-splitting” noise that dispersed roosting blackbirds from a residential area (Bliese 1959).

***Evaluation.*** – High intensity sounds produce variable responses when birds are exposed to them. Most high intensity sounds cannot be reproduced easily, nor are they immediately effective in repelling birds. A horn attached to a boat or vehicle may be useful as a supplementary device in lagoons and marshes, and smaller water bodies. However, to produce sound levels high enough to repel birds at a practical distance would require extremely high intensities near the sound source. Because high intensity sounds can cause hearing damage and other human health effects (Fuller et al. 1950; Frings 1964; Wright 1969; Kryter 1985), this technique impractical at most airports.

***Recommendation.*** – Not recommended.

***Literature Reviewed.*** – Bell 1971; Bliese 1959; Davis 1967; Ellis et al. 1991; Fringes 1964; Fuller et al. 1950; Holthuijzen et al. 1990; Kryter 1985; Thiessen et al. 1957; Wright 1969.

### Ultrasonics

***Description.*** – Ultrasound is normally defined as sound at frequencies too high to be detected by humans. The upper limit of human hearing is generally taken to be 20,000 Hz, although few adults have effective hearing at frequencies that high. The obvious advantage of ultrasound as a dispersal or deterrent technique, if it were effective, would be that it would not be audible to humans. In many situations, other types of noise-based deterrents (e.g., propane cannons) are annoying to humans.

***Biological Basis.*** – Suppliers of ultrasound-emitting devices have for many years claimed that their devices can deter birds. However, most species of birds do not hear ultrasound (Fay 1988; Hamershock 1992). Therefore, ultrasound is not an effective deterrent.

***Literature.*** – Even though some birds can detect sounds up to or slightly above 20,000 Hz, they do not appear to be affected by broadcasts of ultrasound, probably because they do not use ultrasonic communication. Woronecki (1988) found that pigeons did not exhibit a fright response when exposed to ultrasound. Also, there was no evidence of a reduction in the number of pigeons nest-building or egg-laying when the nesting area was ensonified with ultrasound. Beuter and Weiss (1986) found no evidence that gulls either heard or reacted to ultrasounds. Griffiths (1988) reported that a combined sonic-ultrasonic bird repelling device did not affect several species of birds (e.g. chickadees and jays). Based on the known frequency ranges for hearing by the above species, it is unlikely that any of them could hear ultrasound.

Previous reviewers have concluded that ultrasonic methods are ineffective in scaring birds (e.g. Koski and Richardson 1976; DeFusco and Nagy 1983; Bomford and O'Brien 1990). Likewise Hamershock (1992), based on an extensive review, found that ultrasound did not reduce bird numbers by more than 5%, if at all. Ultrasound has also been found ineffective in repelling rodents (Lund 1984; Bomford and O'Brien 1990), but showed some promise in repelling bats, many of which have good hearing at ultrasonic frequencies (Martin 1980; Fay 1988).

***Evaluation.*** – Ultrasound is not effective as a bird deterrent device.

***Recommendation.*** – Not recommended.

***Literature Reviewed.*** – Beuter and Weiss 1986; Bomford and O'Brien 1990; BSCE 1988; DeFusco and Nagy 1983; Erickson and Marsh 1992; Fay 1988; Frings and Frings 1967; Griffiths 1988; Hamershock 1992; Koski and Richardson 1976; Lund 1984; Martin 1980; Truman 1961; Woronecki 1988.

### Aircraft Engine Noise and Infrasonic

Research has recently been undertaken to investigate the potential for (1) the controlled generation of certain discrete noise frequencies of aircraft engines or other aircraft parts, and (2) low frequency sound (infrasound) to disperse birds (Short et al. 1996). No results of this research are available yet. For either technique to be successful, not only would birds have to be able to detect these signals they also would have to associate the signals with danger sufficient to make them depart an area. Habituation to these signals also would have to be considered.

### VISUAL REPELLENTS

Vision-based deterrents present a visual stimulus that is novel, startling, or that the birds associate with danger. The danger can be a predator, a simulated predator, the results of a predator attack (dead bird or model thereof), or some unusual object that birds avoid because it is unfamiliar. Lights, scarecrows, dyes, reflecting tape, predator decoys, kites, balloons, smoke, and dead or live birds are visual stimuli that may disperse birds. Some products incorporate both visual and auditory stimuli.

Many birds discriminate the colour of light at wavelengths between 400 and 700 nm, comparable to humans (Pearson 1972; Martin 1985). In addition, some species, including pigeons, hummingbirds, Mallards, Belted Kingfishers, boobies and some passerines (Martin 1985; Meyer 1986; Reed 1987; Maier 1992) also perceive ultraviolet light (<390 nm). Humans do not detect ultraviolet light. Pigeons and some songbirds have also exhibited sensitivity to the plane of polarization of light (Martin 1985), to which humans have very limited sensitivity. Since birds can apparently detect colour, it could be an important consideration during the construction and development of devices that are used to deter and disperse birds.

## Scarecrows

**Description.** – Scarecrows are one of the oldest devices that have been used to control birds (Frings and Frings 1967; Hussain 1990). Most scarecrows are human-shaped effigies; they have been constructed from a wide variety of inexpensive materials such as grain sacks or old clothes stuffed with straw. The more realistic the facial features and the human shape, the more effective scarecrows are likely to be. Painting scarecrows a bright colour can increase their detectability (Littauer 1990a). Commercially-manufactured scarecrows also are available, such as the Scarey Man mannequin. The Scarey Man Fall Guy unit is a 1.46 m tall, plastic mannequin that intermittently inflates with air, bobs up and down, illuminates with an internal light, and emits a high-pitched wail (Stickley et al. 1995 as cited in Andelt et al. 1997).

**Biological Basis.** – Scarecrows, by mimicking the appearance of a predator (a person), cause birds to respond with prompt flight to avoid potential predation. The greater the realism, in appearance and behaviour, of the scarecrow the greater its effectiveness. Because the threat that birds might associate with scarecrows is perceived rather than real, habituation is likely to occur relatively quickly unless other scare techniques are used in conjunction.

**Literature.** – In general, scarecrow-type devices have proven ineffective when used in isolation or else effective for only a short time as the target species habituate to the visual stimulus (Blokpoel 1976; Conover 1979, 1983, 1985b; Boag and Lewin 1980; Hothem and De Haven 1982). Scarecrows are more effective if they are moved every 2-3 days (DeFusco and Nagy 1983; LGL Ltd. 1987; Hussain 1990). Scarecrows that move in the wind and that are used with other deterrent devices (e.g. gas cannons) are more effective than immobile scarecrows that are not used with complementary devices. Littauer (1990b) suggested that periodically driving a vehicle near the scarecrow, or placing the scarecrow on a stationary vehicle, could increase its effectiveness. A mannequin tested on Rufous Turtle Doves in a flight cage was found to have a larger effective area than a stuffed crow or kite (Nakamura 1997).

More recently, several types of mechanical pop-up scarecrows have been created. Nomsen (1989) reported that a human-like scarecrow that popped up from a double propane cannon when it fired was very successful in keeping blackbirds from feeding over 4-6 acres of sunflowers. Ducks and geese were observed to be much easier to frighten off than blackbirds.

Another model of scarecrow consists of an inflatable, human-shaped bag that is mounted on a battery-powered compressor or electric fan. It inflates every five minutes. Timers can also be connected to a photo cell switch which would allow the scarecrow-inflation sequence to begin at dusk or dawn. Once inflated, the scarecrow stands up and then emits a screeching, siren-like noise before it deflates (Littauer 1990a; Coniff 1991). Coniff (1991) reported that this kind of scarecrow set up near a catfish pond effectively frightened cormorants. Numbers of great blue herons and black-crowned night-herons initially decreased at a fish hatchery following

implementation of two Scarey Man Fall Guy human effigies, but the herons quickly habituated to the devices and numbers increased after the first four nights (Andelt et al. 1997).

Littauer (1990b) described another mechanical scarecrow model with a mannequin head attached to a steel rod. A propane cannon projects the head approximately 30 inches into the air. No information was available on the effectiveness of this kind of scarecrow.

Some species of birds become habituated to scarecrows whether or not they move. Naggiar (1974) reported that scarecrows (stationary) and shooting were not effective in deterring wading birds from fish ponds. After two hours, birds became accustomed to the scarecrow.

Cummings et al. (1986) used a propane cannon and a CO<sub>2</sub> pop-up scarecrow to deter blackbirds from sunflowers. They found that most birds were frightened away by the scarecrows; fewer birds returned during the treatment period than were observed during the control period. Cummings et al. speculated that the birds that returned had become habituated to the scarecrow in some cases, and in other cases, that feeding patterns were too well established to allow effective deterrence of the birds.

Scarecrows have been tested for use in deterring birds from landing on oil-contaminated tailings ponds in Alberta. Ward (1978) tested a “bird-scaring raft” with a large fluorescent orange scarecrow, two continually-burning lights, and a gas cannon. The deterrent rafts were not able to exclude all birds. Ducks, in particular Lesser Scaup, were the most sensitive to the rafts. American Coots and grebes were the least affected.

Boag and Lewin (1980) found that a human effigy was effective in deterring dabbling and diving ducks from small natural ponds. When the effigy was present, the total number of ducks on the ponds declined by 95%. Over the same interval there was only a 20% decline on adjacent control ponds, indicating that the effigy was quite effective.

Boag and Lewin (1980) also attempted to evaluate the efficacy of 27 effigies placed around a 150 ha tailings pond. Counts of dead birds found in the pond were compared to counts from the previous year when effigies were not deployed. Although numbers of dead waterfowl were slightly higher in the year with effigies (104 vs. 98), the effigies were still considered effective. More waterfowl and shorebirds were believed to be present in the area during the year when effigies were deployed, and retrieval efforts were more intensive in that year.

***Evaluation.*** – Scarecrows are a flexible deterrent technique. They can be deployed on land or water, are mobile, and are inexpensive to construct. Scarecrows can be used in combination with other control products to enhance the overall deterrent effect. Over the long-term, however, scarecrows have proven to be ineffective. Their best use is in circumstances where temporary and local control is sufficient.

**Recommendation.** – Recommended only for short-term and local deterrence; not to be relied upon for long term deterrence of birds.

**Literature Reviewed.** – Andelt et al. 1997; Boag and Lewin 1980; Coniff 1991; Cummings et al. 1986; DeFusco and Nagy 1983; Devenport 1990; EIFAC 1988; Frings and Frings 1967; Kevan 1992; LGL Ltd. 1987; Littauer 1990a,b; Nakamura 1997; Naggiar 1974; Nelson 1990b; Nomsen 1989.

### Reflectors and Reflecting Tape

**Description.** – Reflecting tape is an elastic, 3 layered tape that has a silver metal layer coated on one side and a coloured (usually red) synthetic resin on the other side (Bruggers et al. 1986). This type of tape flashes when it reflects sunlight, and produces a humming or crackling noise when it stretches or flaps in the wind. Because of its noise and reflective features, reflecting tape has been used to deter birds in agricultural settings.

**Biological Basis.** – There is very little biological basis for the effectiveness of reflectors and reflecting tape. Birds would avoid these products initially because of their natural caution toward unfamiliar objects. They also would exhibit startle responses to the bright flashes of light and sudden noise. Because the biological basis is not strong, however, habituation is likely to occur quickly.

**Literature.** – Several early studies suggested that reflectors could be used to deter birds from crops and airports. These studies have been summarized by Koski and Richardson (1976). More recent studies have concentrated on the use of reflecting tape rather than just bright flashy objects. Reflecting tape produces noise when it flaps in the wind, and the auditory stimulus is believed to make reflecting tape more effective than other reflectors.

Mylar flags were tested for their effectiveness as gull deterrents by Belant and Ickes (1997). Flags were tested at two nesting colonies and two loafing sites at a landfill. Belant and Ickes (1997) concluded that the reflecting tape was ineffective in deterring the herring gulls (and likely other gulls) from nesting colonies but can reduce herring and ring-billed gull use of loafing areas.

Bruggers et al. (1986) used reflecting tape (0.025 mm thick and 11 mm wide) to deter birds from cornfields, sunflowers and sorghum. The tape was successful in deterring birds when it was suspended above the ripening crops in parallel rows, and when the entry point into the fields was also protected. High winds may have also increased the effectiveness of the tape by increasing the noise it makes. Dolbeer et al. (1986) used reflecting tape to repel blackbirds from crops by stringing tape at intervals of 3, 5, and 7 m. The tape was suspended from poles spaced 3 m apart and the tape sagged 0.5-1.0 m at its low point between poles. The 3 m spacing was more effective at repelling birds than were the 5 and 7 m spacings. Reflecting tape did not deter all species of birds and it was not effective when it became twisted such that the reflecting side was no longer visible.

Summers and Hillman (1990) tested a red fluorescent tape (20 mm wide) in fields of winter wheat in the U.K. to deter Brant. One half of a 20.2 ha field was the control area and the other half was the treatment. A second control field (7.5 ha) was set up in another area that had one gas cannon and two scarecrows. Lines were strung at 40-60 m intervals across the rows of wheat in the experimental field. The tape proved more successful than the cannon and scarecrows in repelling Brant. Geese caused a 1% reduction in grain yield in the taped field, but a 6% reduction in the untaped field. Geese apparently grazed within 2 m of the edges of the fields with tape.

Reflecting tape was ineffective in deterring birds from ripening blueberries (Tobin et al. 1988). Tape was set up in the fields 10 to 12 days before the first bird and berry counts were taken. During this time, the birds could have become habituated to the tape. Also, only 7-10 strands were set up per plot, which may have not been enough to deter birds.

***Evaluation.*** – Reflectors could be useful as bird deterrents in limited applications on airfields. Reflecting tape is easy to set up and is readily moved to other locations. Reflectors could also be placed around the edges of ponds. Improved effectiveness would be achieved by combining tapes with complementary scaring devices (e.g. cannons, scarecrows).

***Recommendation.*** – Reflectors and reflecting tape are recommended only for limited use on airfields.

***Literature Reviewed.*** – Belant and Ickes 1997; Bruggers et al. 1986; Dolbeer et al. 1986; Koski and Richardson 1976; Summers and Hillman 1990; Tobin et al. 1988.

## Predator Models

**Description.** – Predator models are designed to resemble a predator, usually an owl or hawk. Models vary from very poor to very life-like imitations of the predator. One (poor) example is the “plastic owl” commonly used on buildings to deter pigeons, sparrows and swallows.

**Biological Basis.** – Predator decoys are used to disperse and deter birds by mimicking the appearance and/or action of real predators. Avoiding predators has high survival value and thus there is a strong biological basis for the use of predator models. The model must be realistic, however, or pest birds will habituate.

**Literature.** – Decoys or models usually have been used to scare birds from agricultural crops (Conover 1979, 1983, 1984, 1985b; DeFusco and Nagy 1983; Crocker 1984). Conover (1979, 1983) found that stationary, mounted hawks and hawk-kites (see below) deterred birds from feeding stations and corn fields but that their effectiveness was short-term. Belant et al. (1997e) found plastic, hand-painted effigies of great horned owls and merlins ineffective in reducing starling use of nest boxes. There was no significant difference among nest boxes with or without the effigies in the proportion of nest boxes with nests, eggs, or nestlings.

Models of predators sometimes attract rather than repel birds (Conover 1983; LGL Ltd. 1987). For example, blackbirds and crows often mob owls or owl models. However, Conover (1982, 1985b) found that a moving plastic owl model with a plastic crow model in its talons repelled crows from gardens and small fields. A stationary version of the same model was not effective at deterring birds.

**Evaluation.** – Given that models are less realistic than live birds, predator models are limited in their effectiveness. Pest birds will eventually learn that the model is not the real thing and therefore, is not a threat. If short-term deterrence is sufficient, then predator models are a option. They are inexpensive and easy to deploy. Their effectiveness can be enhanced by moving them frequently.

**Recommendation.** – Recommended only for situations where very short-term and local control is needed. Generally not recommended for use on airfields.

**Literature Reviewed.** – BSCE 1988; Belant et al. 1997e; Conover 1979, 1982, 1983, 1984, 1985b; Crocker 1984; DeFusco and Nagy 1983; Frings and Frings 1967; Hothem and DeHaven 1982; Inglis 1980; Koski and Richardson 1976; LGL Ltd. 1987; Naef-Daenzer 1983; Saul 1967; Stout and Schwab 1979.

## Hawk Kites and Balloons

**Description.** – Hawk kites are a mobile variation of stationary predator models. Hawk-shaped kites are tethered to the ground or suspended from helium balloons or poles to keep them aloft.

**Biological Basis.** – Hawk kites work on the principle that prey species will flee an area in response to perceived danger. In the absence of an actual threat, birds will soon learn that there is no need to flee and at that point the kite is no longer effective.

**Literature.** – Kites that mimic hawks and other raptors have been used to frighten birds from corn and sunflower crops (Harris 1980; Conover 1983) and from grapes (Hothem et al. 1981; Hothem and DeHaven 1982). Usually these kites are suspended from helium-filled balloons or hung from poles in order to keep them aloft with or without wind.

Conover (1983) conducted experiments with four different designs of hawk-kites (Mausebussard, Falke, Steinalder and Habicht). These varied in the species represented, size, wing-span and colouration. Each kite was attached to the middle of a braided nylon line that was strung between two bamboo poles set 3 m apart. The kites did not effectively deter birds from feeding on corn. Because the kites were not attached to balloons, they were less mobile (40 m range of movement for kites with balloons vs. 2 m range for kites only), and therefore, probably less effective at scaring birds. When movement was incorporated into the deterrent (kites were suspended from balloons) the kites became effective at deterring birds from feeding in corn fields (Conover 1984).

Hothem et al. (1981) used four kites, with balloons, to repel birds from vineyards: 1 eagle kite with a 1.35 m wingspan, 1 eagle kite with four circular holes in the leading edge of the wings, 1 kite with a falcon image on the lower side, and 1 eagle kite made of cloth (1.65 m wingspan). All kites were attached to helium balloons (diameter 1.2 m). The balloons were tethered with 23 kg test nylon line; each day the length of the tether was adjusted to be between 8 and 52 m. One kite-balloon was set up per 1.0-1.1 ha of vines for a 7-day evaluation period (treatment), and then removed for another 7-day period (control). To reduce the likelihood of habituation, kites and the colour of balloons (5 different colours) were changed every 1-2 days. Although results suggested that bird damage was reduced during the 7-day period with the kite-balloons, the decrease in damage was not significant. The sample size may have been too small for a meaningful test.

Hothem and DeHaven (1982) tested a “kite-hawk” to reduce bird damage in vineyards. The kite had a 1.3 m wingspan and was coloured to resemble an immature Golden Eagle. The kite was suspended from a blue helium-filled balloon with diameter 1.7 m. Based on six 7 day-on/7 day-off treatment periods, no difference was found in the percent loss of grapes (2.8% for treatment vs. 2.9% for control). However, damage levels were found to have increased with increased distance from the kite-balloon, suggesting that the deterrent may have been effective over a very small area. Kites were damaged when winds exceeded 8 km/h, but generally lasted up to 14 days.

Brant reportedly were repelled from a large area (5 km in radius) when a helium-filled diamond-shaped kite was tethered to a line on the ground and moved along that line in an erratic pattern (DeFusco and Nagy 1983). The Brant apparently did not habituate to this device.

High winds can decrease the effectiveness of kites. Harris (1980) reported that kite-balloons could not withstand high winds on the Manitoba prairies. The rate of habituation is not clear; some workers have reported slow or no habituation (DeFusco and Nagy 1983), whereas others have reported more rapid loss of effectiveness. Inglis (1980) reported that Wood Pigeons habituated to a kite-balloon after only 4 hours.

***Evaluation.*** – Kites and balloons can be useful as bird deterrents on airfields, but their usefulness is limited by habituation. Kite-balloons are easy to set up and can be moved relatively easily to other locations. They could be effective around a small pond or temporary wet area that attracts birds, for example. Kites and balloons have some practical limitations. Balloons may be difficult to keep inflated. High winds (a problem on open airfields) and rain could destroy their effectiveness. It would be necessary to use other complementary scaring devices (e.g. cannons, scarecrows) to extend the effectiveness of hawk kites and balloons.

***Recommendation.*** – Hawk kites and balloons are recommended only for situations where short-term and local control is sufficient.

***Literature Reviewed.*** – Conover 1983; DeFusco and Nagy 1983; Harris 1980; Hothem et al. 1981; Hothem and DeHaven 1982; Inglis 1980.

### Gull Models

***Description.*** – Gull models in this context refer to replicas or actual specimens of dead gulls, typically presented on the ground as though they have fallen and died there.

***Biological Basis.*** – Dead birds, either actual or models, serve as a warning that some form of danger is, or recently has been, present in the area. Initially birds often approach a dead bird to look at it, but they usually leave the area after discovering the unnatural position of the bird.

**Literature.** – Bird bodies have been used to repel and scare birds from agricultural areas (Naef-Daenzer 1983) and from airports (see Koski and Richardson 1976, Inglis 1980, and DeFusco and Nagy 1983 for reviews). Models of dead birds also have been useful in scaring birds in certain circumstances. For example, models of dead gulls, or actual dead gulls displayed prominently, have been useful in scaring gulls away from some airports (Saul 1967; Stout and Schwab 1979; Howard 1992). However, in most countries these methods have not been found to be sufficiently effective to be adopted operationally (BSCE 1988).

Some success has been achieved by using dead gulls or gull models deployed in unnatural positions or in positions assumed by dead or injured birds. Stout et al. (1974) used model gulls to disperse glaucous-winged gulls from an airfield at Shemya in the Aleutian Islands and ring-billed gulls from a landfill near an air force base in Pasadena, Texas. In the latter case it was necessary for the gulls to be airborne so that they all could see the model gull on the ground. Distress calls were played to make the gulls fly. In the Netherlands, stuffed gulls in injured positions were found to be effective only if they were frequently moved to avoid habituation (Hardenberg 1965). Crucified corpses and polystyrene gull models were successful at keeping gulls off loafing areas at Auckland and Wellington airports in New Zealand. The secret to success here was that alternate loafing areas were available. At a third airport with no alternate loafing areas, the gull models were less successful (Caithness 1970).

Mock gulls were used as part of the intensive gull control program conducted annually at the large ring-billed gull colony at Toronto's Leslie Street Spit. The mock gulls consisted of gull wings tied to a plastic bottle. They were thrown into the air to simulate injured gulls. The mock gulls were used in conjunction with falconry, pyrotechnics, and distress calls in a program that successfully prevented ring-billed gulls from nesting in large parts of the area (Watermann 1985, 1986, 1987; Watermann and Cunningham 1989). Several airport and landfill control programs kill gulls that are then thrown up into the air when pyrotechnics are used. This reportedly reinforces the effectiveness of the pyrotechnics.

**Evaluation.** – As with many of the visual deterrent products discussed thus far, dead gulls and models of dead gulls (or other species) will deter some birds but the period of effectiveness is limited by habituation.

**Recommendation.** – On their own, gull models are recommended only for situations where short-term and local control is sufficient. However, models of dead birds (or stuffed birds) can be an effective component of an integrated bird control program.

**Literature Reviewed.** – BSCE 1988; Caithness 1970; DeFusco and Nagy 1983; Hardenberg 1965; Inglis 1980; Koski and Richardson 1976; Naef-Daenzer 1983; Saul 1967; Stout and Schwab 1979; Stout et al. 1974; Howard 1992; Watermann 1985, 1986, 1987; Watermann and Cunningham 1989.

### Falconry

**Description.** – Trained falcons and other hawks are used by professional falconers to chase birds from specific areas by pursuing and occasionally killing them.

**Biological Basis.** – Most birds have evolved well-developed escape behaviours that are triggered by the sight of those species of falcons and other hawks that could prey on them. There is a sound evolutionary basis for prey species to avoid falcons.

**Literature.** – Raptors have been used to disperse birds from a number of airports, including some in Canada (Blokpoel 1976; Koski and Richardson 1976; DeFusco and Nagy 1983; Blokpoel 1984; Hild 1984; BSCE 1988; Erickson et al. 1990). Peregrine falcons were flown against gulls at an airfield in Britain in a two year study in the late 1940's (Wright 1965). The falcons were successful but needed to be flown at least once, and sometimes more often, each day to keep gulls away.

Further studies of falconry have been conducted on a variety of species (Seaman 1970; Heighway 1970; Mikx 1970). Heighway (1970) reported on an operational study of peregrines at a Royal Naval Air Station on the north coast of Scotland. A team of eight peregrines flown by two full-time trainers took two years to establish control over the resident gull populations that used the area. Pyrotechnics and carbide cannons were used to supplement the falconry efforts. On average, it was necessary to replace two falcons each year. A team of four goshawks was successfully used at an airbase in Holland to clear the runways of gulls and other species. Again, techniques such as pyrotechnic devices were employed to supplement the raptors. It is important to note that the gulls showed no signs of habituating to the goshawks during the two-year study (Mikx 1970). On the other hand, Hahn (1996) reported on the use of falcons at a military airfield in Germany and concluded that “we cannot recommend falconry as a routine method for bird control at civil airfields.”

Operational bird control programs at five Canadian airfields use, or have used, falconry as a key element. The airports are Lester B. Pearson International Airport (Toronto), Dorval Airport (Montreal), North Bay Airport, CFB Trenton, and CFB Shearwater (Blokpoel 1980; Mason 1980; Transport Canada 1984; LGL Limited, per. obs. 1998). All of these programs involve the use of supplementary techniques in addition to the falconry — including shellcrackers (pyrotechnics), distress calls, and killing. In addition, the gulls have learned to associate the patrol truck with danger and the truck itself becomes a scaring device (the gulls are able to distinguish the bird

patrol control truck from other vehicles that are present [Mason 1980]). Overall, the falconry-based programs at these airports have been considered to be successful (e.g. Environmental Assessment Board 1987a,b; Mason 1988). In fact, Mason (1988) believed that gulls learned not to fly over the airport because of the bird deterrent program.

Recently raptors, along with other deterrent methods, have been used to restrict the nesting area of ring-billed gulls at a large colony at Toronto (Blokpoel and Tessier 1987). Various species of raptors were tethered on perches for most of the study, and only occasionally allowed to fly free. The raptors plus other techniques (pyrotechnics, mock or model gulls, killing, distress calls) were successful in keeping the gulls from nesting in certain areas, but some other species, such as Canada geese were not affected (Watermann 1985, 1986, 1987). In 1997 and 1998, a significant portion of the large Eastport (Hamilton, Ontario) Ring-billed Gull colony was denied to nesting birds through the use of falconry (U. Watermann and M. Givlin, Bird Control International, pers. comm. 1998).

Falconry techniques have been applied at sanitary landfill sites (SLS) in Trenton and North Bay (Blokpoel 1980). A quantitative study of the effectiveness of the gull control program was conducted at the Quinte SLS (Trenton, Ontario) in spring 1983 (Risley 1983; Risley and Blokpoel 1984). The bird control team visited the landfill at least twice per day and applied a variety of control techniques including flying of falcons or other hawks, firing various shell crackers, throwing dead gulls in the air, and firing live ammunition. The methods used and time of day varied and gull habituation appeared to be low (Risley 1983). The study concluded that the gull control program at Quinte SLS was very effective. The effectiveness seemed to derive from the cumulative effects of several bird control episodes (Risley and Blokpoel 1984). Falconry is presently part of control programs at the Halton Regional Landfill and the Niagara Road 12 Landfill in Grimsby, Ontario and at a landfill near Montreal.

In a study by Kenward (1978, in Inglis 1980), Goshawks were unsuccessful in deterring Wood Pigeons from Brassica fields. After repeated attacks by the Goshawk, the pigeons usually resettled and continued to feed.

The use of falconry in conjunction with other deterrent techniques has been shown to be effective at dispersing gulls, with little sign of habituation. However, several workers have noted that falconry has several shortcomings that need to be considered before employing the technique (Wright 1965; Blokpoel 1980; Mason 1980; Transport Canada 1984; Environmental Assessment Board 1987a). Falcons and hawks used to be hard to obtain and many of the most effective performers (e.g., peregrine falcons) were/are endangered species. However, the recent great expansion in captive breeding programs have made raptors, even peregrines, easily available. Several raptors are required for any successful control program. Transport Canada (1984) suggests that the optimum number for control at Lester B. Pearson International Airport, for

example, is 20 individual raptors of 5 species. This allows for raptors of different sizes to specialize on each of the problem species at the airport. Where gulls are the main concern, a few individuals of a single species of large falcon would be sufficient. Several individuals are needed because falcons cannot be flown continuously. Falcons become tired; they cannot be flown for a day after eating a full meal; and they cannot be properly flown when they are moulting. In addition, falcons can become injured or lost when they are being flown.

Falconry is successful only if it is conducted by well-trained and dedicated falconers. Falconry is an art, and the training, flying, and care of the birds requires strong dedication and skill (Blokpoel 1980). Because of the long hours involved, and the potential for sickness or missed time by the falconer, a multi-person crew of falconers is preferable. Finally, falcons cannot be flown during bad weather such as fog, heavy rain, or high winds (Wright 1965; Blokpoel 1980; Transport Canada 1984). These are conditions that often encourage gulls to use inland feeding and loafing areas. The lack of falcons at these times could make control of gulls difficult.

***Evaluation.*** – There is a sound biological basis to the use of falconry for bird control. Pest birds are readily dispersed by falcons and will not habituate because the threat is real. Allowing a falcon to kill a pest bird on occasion strengthens the threat. The fact that falconry is a “hands on” technique that is deployed selectively further enhances its effectiveness over an automatic product that is controlled by a timer.

Experienced handlers and trained raptors are required; neither may be available on short notice. Raptors can not be used at night, or during periods of high winds or heavy rains.

***Recommendation.*** – Falconry is recommended as a highly effective component of an airport bird control program. Falconry can be used in conjunction with other deterrent techniques.

***Literature Reviewed.*** – Blokpoel 1976; Blokpoel 1980; Blokpoel 1984; Blokpoel and Tessier 1987; BSCE 1988; DeFusco and Nagy 1983; Environmental Assessment Board 1987a,b; Erickson et al. 1990; Heighway 1970; Hild 1984; Kenward 1978 in Inglis 1980; Koski and Richardson 1976; Mason 1980; Mason 1988; Mikx 1970; Risley 1983; Risley and Blokpoel 1984; Seaman 1970; Transport Canada 1984; Watermann 1985, 1986, 1987; Wright 1965.

## Aircraft

Aircraft, both fixed wing and helicopters, have been used intentionally to chase or haze birds from an area, especially in agricultural situations. Regulations exist in Canada to prevent close aircraft approach to seabird colonies because of the disturbance this can wreak on the nesting birds. However, many birds obviously have adapted to the noise and visual stimuli associated with aircraft at airports and are not dispersed or harassed. Although it is clear that birds can be dispersed or harassed by aircraft in many situations, probably including airports if the hazing is intentional, this technique is not practical at airports where the chase aircraft would themselves become hazards to aircraft safety. Also, bird-aircraft collisions are a potential hazard. At least one aircraft has crashed during a bird-hazing flight, apparently when manoeuvring to avoid a bird flock (U.S. National Transportation Safety Board, file no. 1612).

**Recommendation.** – Not recommended.

## Radio-Controlled Model Aircraft

**Description.** – Standard remote-controlled model aircraft can be used to harass or scare birds. The aircraft can be enhanced by painting a raptor shape on the body. Falcon-shaped model aircraft have been used.

**Biological Basis.** – Model aircraft imitate falcons and other hawks and can be used to harass and chase birds out of specific areas.

**Literature.** – Radio-controlled (RC) model aircraft have shown some promise in scaring birds away from airports, agricultural areas, aquaculture operations, and landfill sites (e.g. Saul 1967; Ward 1975a; DeFusco and Nagy 1983; Parsons et al. 1990). RC model aircraft require skilled operators (Littauer 1990a). For that and other reasons, they have not been widely adopted in dispersing birds at airports (BSCE 1988).

Model aircraft have been used to deter piscivorous birds, such as cormorants and herons, from aquaculture operations (Coniff 1991; Parsons et al. 1990). Flying one model plane for every 200-300 acres has been recommended for larger land-based fish farms (Littauer 1990a). Model aircraft have proven to be useful in reducing numbers of gulls visiting a landfill site in the southeastern United States (R. Davis, LGL Limited, unpubl. obs.). In this situation, large-winged slow-moving model aircraft circled over the landfill continuously during daylight hours. The program was successful but very labour-intensive. Model aircraft with supplementary noisemaking devices have been used to disperse problem birds in Israel (Yashon 1994).

An experimental falcon-shaped aircraft was successful at deterring starlings and killdeer at Vancouver International Airport and ducks and geese at Westham Island, Vancouver, B.C. (Ward 1975a; Solman 1981). Most birds exhibited avoidance behaviours similar to those caused by a real falcon. However, a falcon-shaped model aircraft is difficult to fly and requires a highly-skilled operator. Another effective approach is to paint a raptor design onto a more conventionally-shaped model aircraft (Saul 1967).

Disadvantages of using radio-controlled aircraft are that the direction of dispersal of birds often is not controlled, and that damage to planes and birds may result if birds and model aircraft collide (Coniff 1991). Good weather and suitable landing and fuelling areas are necessary. A major concern is that flying of model airplanes near active runways could pose a hazard to the full-sized aircraft.

***Evaluation.*** – Model aircraft would be effective only over the relatively small areas that can be seen by the operator. Other advantages and limitations are noted below.

#### **Advantages**

1. Birds may habituate only slowly to a model aircraft that actively hazes them, especially if it is falcon-shaped.
2. Circling model aircraft can be used to prevent birds from returning to, and landing in, an area.
3. This technique is likely to be less species specific than are many others.

#### **Disadvantages**

1. Skilled operators are necessary.
2. The technique is labour-intensive.
3. Nearby landing and refuelling areas are needed.
4. Direction of bird dispersal is not easily controlled.
5. Model aircraft cannot be used in heavy winds, rain or snow.
6. Safety concerns about operations near active runways.

***Recommendation.*** – Recommended, but only for areas of the airport that are not adjacent to active runways and taxiways. It may be difficult to employ the technique because of the need for skilled operators.

***Literature Reviewed.*** – Coniff 1991; BSCE 1988; DeFusco and Nagy 1983; Inglis 1980; Littauer 1990a; Parsons et al. 1990; Saul 1967; Solman 1976, 1981; Ward 1975a.

## Lights

**Description.** – Attempts to use lights to disperse or repel birds have involved flashing, rotating, strobe and search lights (Krzysik 1987).

**Biological Basis.** – The biological basis for the deterrent effectiveness of lights is unclear. Lights have not been a long-term feature of the environment that birds would have evolved a natural reaction to. It may be that lights in certain situations are a novel stimulus and thus elicit an avoidance response. This would seem to be most true of flashing, rotating, or strobe lights. Lights at night may blind or otherwise disorient night-active species. Lights may also serve to warn birds of an approaching danger, such as an aircraft.

**Literature.** – Searchlights have been used to deter ducks from landing and feeding in grain fields, and tests have shown that some nocturnal migrants illuminated by light beams take evasive action (see Koski and Richardson 1976 for review). Although searchlights are effective deterrents in some situations, they sometimes attract birds at night, especially when it is cloudy or foggy.

Most information on the use of strobe lights in deterring birds has involved aircraft and airfields where birds pose serious safety hazards. Recent information on the use of strobe lights in airfield situations indicates mixed levels of success. Lawrence et al. (1975) reviewed various types of evidence — anecdotal, statistical and experimental — and concluded that strobe lights have some deterrent effect. A study in the UK in 1976 revealed that the use of aircraft landing lights during the daytime produced a decrease in bird strikes. The simultaneous use of strobe anticollision lights, produced a further decrease in bird strikes. Strobe lights appeared to be more effective at deterring lapwings than gulls. However, Zur (1982) found no significant reduction in the number of bird strikes on DC 9 aircraft with strobe lights versus those without strobe lights.

Briot (1986) observed the reactions of crows, magpies and jays that were tethered to the ground to overflights by low-flying aircraft with and without white 100,000 candela strobe lights flashing at 4 Hz. The distance between the bird and aircraft when a bird attempted to fly was recorded. No significant difference was observed in the flushing distance between overflights with and without strobe lights. However, a slight increase in scare distance with an increase in flash frequency was recorded. However, the experimental procedure may have affected the results. The tethered birds may have been reluctant to fly as the aircraft approached.

In a study of the effects of strobe lights on Laughing Gulls and American Kestrels, Bahr et al. (1992) found that strobe light frequencies of 50 Hz elicited faster responses in heart rates than frequencies of 5, 9 and 15 Hz. However, the lower strobe frequencies appeared to produce the greatest overall increases in heart rates. A study by Briot (1986) hinted that scare distance increased with an increase in strobe frequency. Laty (1976) suggested that frequencies not exceed 100 Hz. Gauthreaux (1988) used a frequency of 1.3-2 Hz in laboratory studies with migratory sparrows. Other studies have shown that frequencies from 8-12 Hz produce stress in gulls, pigeons, and starlings (Belton 1976; Solman 1976). Belton (1976) found that gulls delayed approaching a feeding area by 30 to 45 min when it was illuminated by a white or magenta strobe at 2 Hz. No repellent effect was observed when the strobe light flashed at higher frequencies to 60 Hz.

In a comprehensive, laboratory-based study using laughing gulls and American kestrels, Green et al. (1993) investigated responses to strobe lights of varying wavelengths (colour) and frequency. The tests clearly demonstrated that the test birds were aware of and responded physiologically (increased heart rates) to strobe-light stimuli. However, overt avoidance reactions were not observed. The authors concluded that while strobe lights may attract the attention of birds, they do not result in obvious fright responses, at least in the absence of other threatening stimuli. If birds were to associate the strobe light with a threat, such as an approaching aircraft, evasive responses might be initiated by the birds. Suggested frequencies, colours, intensity, and elements of motion were recommended for testing.

A few studies using strobe lights, amber barricade lights, and revolving lights on aquaculture facilities (Salmon et al. 1986; Nomsen 1989; Littauer 1990a) indicate that these lights are effective in deterring night-feeding birds (e.g. herons). The lights probably produce a blinding effect so that birds become confused and cannot easily catch fish. In some cases, birds became habituated to the lights, and even learned to avoid the lights by landing with their backs to them. Andelt et al. (1997) found bright rotating lights to be ineffective in frightening night-feeding black-crowned night-herons and great blue herons from a trout hatchery. The herons shifted to the unlit portion of the hatchery, but caught fish as effectively in lighted and unlit sections.

Mossler (1979) experimented with the use of flashing lights at a refuse dump. A "light board" was constructed with car lamps flashing (0.75 Hz) in sequence from the centre of the board outwards. This pattern was thought to mimic the flapping of wings. The flight board was carried by a person walking toward a flock of gulls, and flight responses were monitored. The strongest responses noted were to red and blue lights. However, the use of the flashing light board provided no significant change in flight responses compared to that elicited by a person approaching the gulls without the light board. Use of the light board mounted on a car elicited a lesser flight response by gulls than had been observed to a car without the light board.

Lefebvre and Mott (1983, in Krzysik 1987) found that flashing amber lights, in combination with movable owl decoys, were successful in dispersing a starling roost. Gauthreaux (1988) observed that Savannah Sparrows maintained in outdoor cages with a view of the horizon oriented themselves directly away from a red strobe light. However, they did not show any significant response to white strobe light or constant red or white light.

Lights have had limited success at deterring birds from oil spills. Blinking lights were found to be 50-60% effective at dispersing all birds from oil spills (U.S. Dept. Interior 1977, in DeFusco and Nagy 1983). Some tests have shown lights to be effective in dispersing waterfowl, waders, sparrows, gulls, and other species (DeFusco and Nagy 1983). Other tests, however, have shown lights to be ineffective against waterfowl (Boag and Lewin 1980), gulls, blackbirds and starlings (DeFusco and Nagy 1983).

During the 1970s, Syncrude Canada experimented with weather-proof lights in combination with human effigies to deter migratory waterfowl from tailings ponds near the Athabasca River. Functional problems and high costs led to the eventual abandonment of this system in the late 1970s (T. Van Meer, pers. comm.). SUNCOR Inc. also experimented with flashing lights in an attempt to deter migratory waterfowl from similar, smaller tailings ponds. Beacons were added to an existing deterrent system consisting of effigies and propane cannons. Their subjective evaluation was that lights did not increase the success of the system, and the use of the beacon lights was subsequently discontinued (J. Gulley, pers. comm.).

***Evaluation.*** – Flashing and strobe lights could be useful in deterring birds from an airport at night and during twilight periods. A steady light, such as a searchlight, is not as effective as flashing and revolving lights and may attract birds during some weather conditions.

Flashing or strobe lights could be set up around an airport. They are most likely to be useful in combination with other deterrent devices such as cannons, Phoenix Wailers, and effigies. Flashing lights might increase the effectiveness of these other techniques at night.

#### **Advantages**

1. Lights are easy to deploy and require very little maintenance.
2. Lights could be effective for deterring certain birds in certain situations at night.

#### **Disadvantages**

1. Lights can be used only in very specialized circumstances at an airport. They must not interfere with the vision of the aircraft flight crews and air and ground traffic controllers.
2. Lights may not be effective for some species during daylight hours.
3. Lights may attract birds on foggy, misty nights.
4. Effectiveness on large water bodies has not been tested.

**Recommendation.** – Lighting systems are recommended only for testing and selected limited use. They are as yet an unproven bird control technology and should not be a core component of an airport bird control program.

**Literature Reviewed.** – Andelt et al. 1997; Bahr et al. 1992; Belton 1976; Boag and Lewin 1980; Briot 1986; Gauthreaux 1988; Green et al. 1993; Koski and Richardson 1976; Laty 1976; Lawrence et al. 1975; Littauer 1990a; Lefebvre and Mott 1983; Mossler 1979; Nomsen 1989; Salmon et al. 1986; Solman 1976; Thorpe 1977; Zur 1982.

### Dyes

**Description.** – The literature contains many observations on the use of coloured objects, such as scarecrows, flags, and balloons to frighten and repel birds from agricultural crops and aquacultural operations. However, there is little research on the use of coloured dyes as a method to deter birds.

**Biological Basis.** – The biological basis for any avoidance by birds of certain colours is unclear. Any initial avoidance may be as a reaction to a strange novel stimulus. Avoidance reactions to coloured water may be associated with previous experience with bad tastes and/or polluted/oiled areas.

**Literature.** – Coloured runways had no deterring effects on birds (ACBHA 1963), but a pond dyed greenish-yellow was reported to have temporarily deterred waterfowl as long as “dye-free” ponds were present nearby (Richey 1964). When all the ponds were dyed, the colour had no repelling effect and ducks landed in the dyed water.

Lipcius et al. (1980) tested young mallards' responses to coloured water. The ducks were deprived of food for 24- and 48 h periods, and then placed in a pen adjacent to a pool. Across from the pool was a feeding tray. The mallards were exposed to clear and coloured water (dyes were water-soluble); the colours tested included red, yellow, orange, green, blue, indigo, violet and black. Orange was the most effective and consistent colour in delaying mallards from entering water. Other colours were generally less effective and showed less consistency in mallard responses. Among colours, black was one of the least effective in deterring or delaying mallards from entering water. The results suggested that black water may even attract mallards. Lipcius et al. (1980) suggested that it would be worthwhile to conduct further related research, including tests of orange dyes or coloured objects as a method of deterring seabirds from oiled waters.

***Evaluation.*** – Dyes, if effective, would be useful to deter birds from landing in puddles and ponds on airfields. Dyes would be easy to apply and require little maintenance except perhaps occasional re-application. They would not be effective at night. Dyes are still an unproven approach to bird control, however. They show some promise but have not been tested adequately yet.

***Recommendation.*** – Not recommended for situations where control is essential. Suitable for testing only.

***Literature Reviewed.*** – ACBHA 1963; Koski and Richardson 1976; Lipcius et al. 1980; Maier 1992; Martin 1985; Meyer 1986; Pearson 1972; Reed 1987; Richey 1964; Salter 1979.

### Smoke

Smoke has been used to disperse birds from nesting and roosting sites (see Koski and Richardson 1976 for review) but is not practical for use on airports.

## CHEMICAL REPELLENTS

Chemical aversion agents have been used to control birds around commercial and residential areas (Fitzwater 1988; Woronecki et al. 1990), in agricultural situations (Clark 1976; Conover 1984; Knittle et al. 1988), at airports (DeFusco and Nagy 1983; BSCE 1988) and, less commonly, at sanitary landfill sites (Caldara 1970; White and Weintraub 1983; Woronecki et al. 1989). Birds tend not to habituate to chemical repellents.

### Tactile Repellents

***Description.*** – Most tactile repellents are sticky substances that deter birds from sitting on perches, such as building ledges, antennas, and airfield lights and signs. The chemical paste can be applied with a caulking gun, putty knife, spray can, or small tube. Recently, natural plant products also have been tested in this regard (Clark 1997).

***Biological Basis.*** – The sticky materials do not trap birds, but repel birds presumably because of the tacky “feel”. The biological basis for this avoidance behaviour is unclear. Plant compounds that have been tested caused agitation and hyperactivity in the birds. This reaction may be associated with the uptake, through dermal contact with the birds' feet, of chemicals in the plant compounds.

***Literature.*** – No studies were found that reported on the efficacy of sticky tactile repellents. Clark (1997) reported that starlings became agitated and hyperactive after their feet were immersed in 5% oil extracts of the spices cumin, rosemary, and thyme. Starlings avoided perches treated with either R-limonene, S-limonene, ?-limonene, or methiocarb. These experimental results suggested that it may be possible to develop non-lethal, plant-based dermal repellents.

Mechanical means can be used also to repel birds from perching in unwanted situations. For example, a series of sharp objects, nails, wires etc. can prevent birds from landing on perches such as light fixtures, ledges, and poles. Some commercial products such as “Nixalite” are available for use.

***Evaluation.*** – It is difficult to evaluate rigorously any of the sticky tactile repellents because there have been no quantitative efficacy reports. Sticky substances are laborious to apply and require that all perches be identified and treated, but do remain sticky for a year or more, depending upon climate. They are not effective at temperatures below about -9°C. These sticky materials are not aesthetically pleasing if that is a requirement, such as on certain building surfaces. Natural plant products show promise but have not been tested in the field yet.

***Recommendation.*** – The chemical and mechanical tactile repellents can be used at airports but the resulting use, or lack of use, by birds should be properly documented.

### Behavioural Repellents

***Description.*** – Frightening agents and repellents such as Avitrol (4-aminopyridine) and Methiocarb (3,5-Dimethyl-4-(methylthio)phenyl methylcarbamate) are poisons that, in sublethal doses, may cause disorientation and erratic behaviour. They are usually added to bait. Typically only a portion of a bait presentation (e.g., 10% of corn kernels) is treated with the chemical so that only a small number of the birds to be dispersed are affected. When the treated bait is ingested, a distress response occurs (DeFusco and Nagy 1983; White and Weintraub 1983; Brooks and Hussain 1990). Distress calls from affected birds can start 15 min after ingestion, and can last up to 30 min after ingestion. Besides emitting distress calls, affected birds may become disoriented and exhibit erratic behaviour, often flopping about on the ground. This behaviour often alarms other birds, and causes them to fly away. If too high a dose is ingested, the bird will die. Tremors and convulsions occur before death if birds receive an overdose of the aversion agent, and these may induce other birds to leave the area.

***Biological Basis.*** – There is a well-documented biological basis for the effectiveness of these chemicals, if used in the correct dosages. Unaffected members of a flock will disperse in response to the distress calls and stressed behaviour of flockmates.

**Literature.** – These agents have been used primarily on starlings, blackbirds and other passerine birds. However, Avitrol has also proven useful in dispersing gulls (e.g. Caldara 1970; Wooten et al. 1973; DeFusco and Nagy 1983; White and Weintraub 1983). The U.S. Air Force tested Avitrol at seven air bases and found it to be effective against gulls, starlings, crows, pigeons, and house sparrows (Seaman 1970). Avitrol also has been used successfully on loafing gulls at a naval air station in Norfolk, Virginia, on a crow roost at Friendship Airport near Baltimore, Maryland, and on pigeons at a hangar at Montreal International Airport (Blokpoel 1976). It has also been used successfully on gulls at landfills (Sweeney and McLaren 1987).

Avitrol is toxic and can be difficult to administer in a dose sufficient to cause the desired effect but not to kill the bird immediately. Death may be delayed and affected individuals may be able to fly away before dying elsewhere. This can lead to public relations problems.

Another problem with continued use of Avitrol as a control technique is the development of bait-shyness. Gulls will learn rapidly to identify and avoid the kinds of bait food (usually bread) that cause the unpleasant effects on their flock-mates. New baits can be substituted but there is a limited number of suitable bait types that can be used. Changing the bait also means that the appropriate amount of chemical to apply to the bait must be re-determined.

**Evaluation.** – Chemical aversion agents require attracting birds to an area and allowing them to feed in a pre-baiting and baiting sequence. This can create hazards in an airport situation. Thus, a more direct dispersal method is likely to have better results.

In situations where flocks of birds, especially feeding birds, do not immediately threaten air safety, it may be appropriate to use a chemical aversion agent. Feeding birds are particularly difficult to disperse from an abundant food source, and aversion agents may be useful in breaking the attraction to the food source. Supplementary dispersal methods would be needed, along with the aversion agent, in order to obtain maximum effectiveness. Effectiveness of baiting could be influenced by environmental conditions, number of birds, and bait preference. Birds have been shown to develop a conditioned aversion to some agents. Considerable care would be necessary in the use of potentially harmful agents like Avitrol and Methiocarb, and some mortality should be expected.

The direction of movement of dispersed birds is not controlled when using these behavioural repellents, and this could pose problems at airports.

**Recommendation.** – Chemical behavioural repellents, such as Avitrol and Methiocarb, are recommended for incorporation in an overall bird control program for parts of the airport where there are not direct bird hazards to operating aircraft. Realize, however, that these chemicals are for specific uses and should be applied carefully. Permits are required and the agent must be administered by a licenced Pest Control Officer.

**Literature Reviewed.** – Blokpoel 1976; Brooks and Hussain 1990; BSCE 1988; Caithness 1968; Caldara 1970; Clark 1976; Conover 1984, 1985a, 1989; Crocker and Perry 1990; Cummings et al. 1992; DeFusco and Nagy 1983; Devenport 1990; Fitzwater 1978, 1988; Green 1973; Knittle et al. 1988; Rogers 1978; Seaman 1970; Skira and Wapstra 1990; Sweeney and McLaren 1987; Truman 1961; Wakeley and Mitchell 1981; White and Weintraub 1983; Wooten et al. 1973; Woronecki et al. 1989, 1990.

### Benomyl and Tersan

**Description.** – Benomyl and Tersan are commercial fungicides developed to treat fungal infections of turf. These (and other) chemicals also are effective at reducing earthworm populations. When sprayed along runway edges, earthworm populations there can be controlled. This addresses problems associated with birds, particularly gulls, attracted to airfields to feed on the worms in short grass areas. Benomyl has low toxicity to birds. Because earthworm control is a non-registered use for Benomyl, permits for this purpose have been difficult to obtain recently (Demarchi and Searing 1997). The future status of this restriction should be determined before planning to apply Benomyl or Tersan. Terraclor is another horticultural fungicide manufactured for seed and soil treatments at planting, and which also has been used to reduce earthworm densities (Demarchi and Searing 1997).

**Biological Basis.** – Benomyl, Tersan, and Terraclor reduce bird populations at airfields by reducing the population of earthworms, a food source. They are most applicable to the control of gull and plover numbers on an airfield during warmer months.

**Literature.** – Application of Benomyl at the Windsor International Airport reduced earthworm populations on treated runway verges (Tomlin and Spencer 1976). Similarly, Terraclor significantly reduced earthworm densities on treated plots at Vancouver International Airport (Demarchi and Searing 1997). No literature was reviewed regarding the efficacy of Tersan.

Allan and Cordrey (1992) tested two lumbricides on an airfield in the U.K. – one containing gamma HCH plus thiophanate-methyl, and another containing carbaryl. However, they recommended that the use of these chemicals be restricted to small-scale and occasional applications, and that any birds feeding on dead or dying invertebrates be dispersed. The concern is to reduce the pesticide intake of the birds and the pesticide loading of the environment.

**Evaluation.** – These earthworm control products apparently are effective at reducing earthworm populations, and therefore address this reason for birds (gulls primarily) to be attracted to the short grass areas adjacent to runways. They do not appear to be in widespread use at airports; perhaps because of environmental concerns.

**Recommendation.** – Occasional use of Benomyl and Tersan, and other tested and approved products that have been shown to control earthworm populations, is recommended for use where earthworms are creating major bird hazards near runways. This use would only be necessary at some airports.

**Literature Reviewed.** – Demarchi and Searing 1997; Larose 1996; Tomlin 1981; Tomlin and Spencer 1976.

### Methyl Anthranilate - ReJeX-iT

**Description.** – ReJeX-iT is the trade name for a commercial bird aversion agent based on a naturally-occurring plant compound, methyl anthranilate. ReJeX-iT works as a non-toxic taste aversion agent because its taste is unpleasant to birds. ReJeX-iT is available in liquid and powder forms that permit application by spreader, sprayer, or fogger. It can be mixed in bait or in water. A bead formulation also has been tested (Cummings et al. 1998). Methyl anthranilate may be more widely applicable than previously available chemicals, which are difficult to use because of their toxicity. Ortho-aminoacetophenone, a non-toxic chemical similar to methyl anthranilate, also appears to have potential for repelling or dispersing birds at low concentrations (Mason et al. 1991).

**Biological Basis.** – Methyl anthranilate is a known taste aversive for birds. Many birds avoid eating Concord grapes because they do not like the taste of the methyl anthranilate that the grapes naturally contain. Although known biologically to be effective, the efficacy of ReJeX-iT as a bird aversive agent has been shown to depend to a large degree on its formulation, concentration, and the practicalities of application.

**Literature.** – A number of studies using captive and free-ranging birds have been conducted and published. These include laboratory studies, and studies at sanitary landfill sites and airports, studies of the aversive effects on birds feeding on fruit, grain and turf, and birds using standing water. Species studied include Canada geese, gulls, starlings, and woodpeckers among other species. The results of these studies show that ReJeX-iT can be effective at deterring birds in certain situations but the formulations used in some studies were not effective.

Both dimethyl and methyl anthranilate were strongly avoided by captive mallards and Canada geese when birds were offered both treated and untreated grain (Cummings et al. 1992). When offered only treated grain both ducks and geese reduced their food intake, but the mallards, and to a lesser degree the Canada geese, gradually increased consumption during the 2-4 days of the experiment. Cummings et al. (1992) assumed that the birds were habituating to the chemical, but they were not given an alternative food source, and the increased consumption may have been caused by increased hunger.

The methyl anthranilate formulations tested by Belant et al. (1995) repelled captive mallards in pen tests and free-ranging ring-billed and herring gulls from pools of water in field trials. However, in another test, Belant et al. (1996) found that the concentrations they used were not effective as a grazing repellent for Canada geese. Similarly, Cummings et al. (1995) also found that the particular formulation they tested showed limited effectiveness to reduce captive goose activity on treated grass plots, but showed promise given further refinements of the formulation. Belant et al. (1996) did show that there was no learned avoidance by pre-exposed geese. Problems with the application of ReJeX-iT precluded effective testing of its ability to repel birds from ponds at airports (Dolbeer et al. 1993). However, the results were promising; bird numbers did decrease at treated ponds post-treatment vs. pre-treatment.

Tests at landfill sites have shown positive and negative results. Vogt et al. (1994) reported that gull numbers were reduced at each of three landfills during periods of treatment with ReJeX-iT. However, it was unclear to what extent the reduction in numbers was related directly to the taste-aversion effects of ReJeX-iT. The action of the spray used to apply the ReJeX-iT also caused gulls to move away, and pyrotechnics, wires and flags were used in conjunction with the ReJeX-iT at one site. In another case, a sizable landfill nearby provided an alternate food source for the gulls. Contrary to these findings, gulls numbers did not decrease during the ReJeX-iT treatment period at a major landfill near Toronto (Davis et al. 1995). Although gulls rejected food items sprayed with ReJeX-iT, the gulls did not leave the landfill or the active face. The gulls simply continued foraging, looking for unsprayed food items. It became apparent that the effective application of ReJeX-iT was not feasible at this large landfill simply because the active tipping face was too busy. It was impossible to keep the exposed waste treated with ReJeX-iT without interrupting the flow of disposal trucks and bulldozers.

The repellent effects of ReJeX-iT mixed with the synthetic landfill cover ConCover were tested with captive ring-billed gulls and brown-headed cowbirds by Dolbeer et al. (1993). Both species were repelled by the ConCover/ReJeX-iT mix; a higher concentration of ReJeX-iT was required to repel the ring-billed gulls than the cowbirds.

***Evaluation.*** – ReJeX-iT has potential for selective bird control at airports. It is a natural, low toxicity product and it has been shown to be effective in certain applications. However, concerns regarding formulations, concentrations, frequencies of applications, and the practicalities of application must be addressed. Cost also may be factor; ReJeX-iT can be costly if coverage of a large area is required.

***Recommendation.*** – ReJeX-iT is recommended for selective test use on airfields. One should not assume that ReJeX-iT will immediately provide positive results. Experimentation with different formulations, application frequencies, and concentrations may be required and these should be carried out on a small scale before large-scale applications are attempted.

**Literature Reviewed.** – Avery 1992; Belant et al. 1995, 1996, 1997; Cummings et al. 1992, 1995, 1998; Davis et al. 1995; Dolbeer et al. 1992, 1993; Mason et al. 1991; Porter 1995; Sinclair and Campbell 1995; Vogt 1992; Vogt et al. 1994.

#### Other Taste Aversives

Several other food treatments have been tested for their effectiveness at repelling birds. D-pulegone and Mangone, a form of d-pulegone, are found naturally in certain plants. D-pulegone has been demonstrated to deter blackbirds, starlings, northern bobwhite, and domestic dogs from feeding (Mason et al. 1989; Mason 1990; Mastrota and Mench 1994; Avery et al. 1996; Mason and Primus 1996; and Wager-Page and Mason 1996 in Belant et al. 1997b). Belant et al. (1997b) conducted tests to compare the relative repellency of these chemicals on caged brown-headed cowbirds fed treated millet. They concluded that mangone is less effective than d-pulegone and would likely be ineffective as a repellent for seed treatment. However, they felt that d-pulegone deserved further testing.

Belant et al. (1997c) felt that the use of dolomitic hydrated lime warranted additional testing as a taste aversive following the results of their tests on cowbirds and Canada geese. Lime could be a lower-cost alternative to methyl anthranilate in their opinion. The results of tests of dolomitic lime, activated charcoal, Nutra-lite (a silica-based compound) and white quartz sand as taste aversives on cowbirds and Canada geese revealed that lime and charcoal showed potential (Belant et al. 1997d).

**Evaluation.** – The efficacy and applicability of these products for airport bird control are undetermined. More testing is required.

**Recommendation.** – Not recommended at this time.

**Literature Reviewed.** – Belant et al. 1997a, b, c, d.

### EXCLUSION METHODS

A variety of devices and materials have been used to provide apparent or actual barriers to prevent birds from entering areas. If birds are physically excluded from an area or feature, then the efficacy of the technique is obvious. Birds will continue to be excluded as long as the physical barrier is maintained. There are other techniques that exclude by providing an apparent, rather than an actual physical, barrier to access. However, we found few research papers that reported on the efficacy of these “virtual” exclusion methods. In the following discussion, general considerations regarding physical barriers are presented first, followed by the results of studies on “virtual barrier” exclusion methods.

## General Considerations Regarding Actual Physical Barriers

**Description.** – Actual physical barriers include devices and materials (1) to cover or surround an area (netting and fencing); and (2) to prevent perching, roosting and nesting on surfaces (Nixalite, Bird-B-Gone, Avi-Away, and fine wires strung along ledges). Bird-exclusion netting is made out of polyethylene, other synthetic materials, or cotton, and is available in a variety of mesh sizes. Nixalite and Bird-B-Gone are strips of short metal (Nixalite) or plastic (Bird-B-Gone) prongs placed along perches such as window ledges or pipes. Avi-Away is an electrical cable that can be placed along perches; a bird receives a mild shock when it lands on the cable. Taut stainless steel wires also can be run along perches to prevent birds from landing. These methods are described in greater detail in the Transport Canada “Wildlife Control Procedures Manual” (Transport Canada 1994).

**Biological Basis.** – If access is denied to a feature of an airport that is attractive to birds, such as a feeding, loafing, roosting, or nesting area, then the feature will not be as attractive. Birds likely will leave the immediate area and look elsewhere for these features.

**Literature.** – Netting is sometimes used to prevent songbirds from feeding on high-value crops such as cherries, blueberries, and grapes (Grun 1978; Twedt 1980; Biber and Meylan 1984; Cocci 1986). Netting is also occasionally used in attempts to keep birds out of airport facilities, buildings, or other locations (LGL Ltd. 1987; Skira and Wapstra 1990). Netting is widely used to deter fish-eating birds from aquaculture facilities on land and offshore (EIFAC 1988; Kevan 1992).

Fences made out of poultry wire (or cable), plastic (Vexar Fencing), netting, and electrical wire, have all been used to deter birds from fish culturing facilities (Mott 1978; Meyer 1981; Ueckermann et al. 1981). Fencing has also been used to keep pigeons from roosting on ledges of buildings, and electrified fences have been effective in some situations for deterring both birds and mammals where regular fences were ineffective (see Koski and Richardson 1976).

**Evaluation.** – Because of high costs, it would not be practical to use these exclusion products where birds must be kept out of large areas. These devices would be most useful in situations where the risk was confined, or for deterring birds from landing at specific sites such as nest sites. Other deterrent devices, such as pyrotechnics, may enhance deterrent efforts when netting is being used (EIFAC 1988).

Constructing fences may be effective for excluding birds from airfields if birds are flightless (i.e. moulting or brood rearing adult, or pre-fledging young, geese and ducks) and if the area of concern was relatively small. Fences and nets might be useful in keeping moulting waterfowl or broods from runways, or in combination with trapping (see below) to move flightless birds from the area. Fences generally would not be practical in many airport situations because the areas involved would be too large to fence, and because most birds would be able to fly over them.

### **Advantages**

1. These materials are readily available.
2. When properly installed and maintained, actual physical barriers exclude birds permanently from the treated area.

### **Disadvantages**

1. None of these techniques is practical for large areas.

**Recommendation.** – Recommended for site-specific problems.

**Literature Reviewed.** – Barlow and Bock 1984; Biber and Meylan 1984; Blokpoel and Tessier 1987; Cocci 1986; Devenport 1990; Dolbeer et al. 1988; EIFAC 1988; Galbraith 1992; Glahn et al. 1991; Grun 1978; Kevan 1992; Koski and Richardson 1976; Littauer 1990b; Lucid and Slack 1980; Meyer 1981; Moerbeek et al. 1987; Mott 1978; NCC 1989; Salmon and Conte 1981; Salmon et al. 1986; Skira and Wapstra 1990; Spear 1966; Twedt 1980; Ueckermann et al. 1981; Whittington 1988.

### Overhead Wires and Lines

**Description.** – A grid, or series of parallel lines, of fine wire or monofilament line is strung on a level plane over the area from which birds are to be excluded. The spacing of the lines varies from approximately 1.5 to 12 m, depending on the species and feature to be treated. At airports, overhead lines can be strung over ponds and puddles, for example. Sometimes wires/lines around the sides of the area are required as well.

**Biological Basis.** – The reason or reasons for the repelling effect of overhead lines or wires are not well understood. Wires that are closely spaced, e.g. 1 m or less, may come close to forming an actual physical barrier. However, birds can be deterred by wires whose spacing is much greater than the dimensions of the bird. The element of surprise seems to be important — the unexpected encounter of a bird with a thin, difficult-to-see line has a startling effect.

**Literature.** – As early as 1936, overhead wires or lines were recommended as a method of deterring waterbirds from reservoirs and fishponds (McAtee and Piper 1936). In the past two decades, widely-spaced overhead wires have been used to reduce the numbers of gulls attracted to landfill sites, reservoirs, pools, picnic areas, and beaches in the U.S.A. and Canada. Wire spacing has varied widely, from less than 1 m to as much as 25 m. Even lines that are very widely spaced relative to the wingspan of gulls seem to have some deterrent effect. The gulls are reluctant to fly down between the lines. In a few cases, systematic counts of gulls and other birds have been made in the presence and absence of the wires. These studies have shown that the deterrent effect on gulls is quite pronounced (e.g. Blokpoel and Tessier 1984; Forsythe and Austin 1984; McLaren et al. 1984), even when deterring gulls from their own nests (Blokpoel and Tessier 1983; Belant and Ickes 1996). Areas as large as 220 acres have been covered by wires in order to deter gulls from landfill sites (Dolbeer et al. 1988).

Other types of sites where overhead lines or wires have been applied include fish-rearing facilities (Ostergaard 1981; Salmon and Conte 1981; Barlow and Bock 1984; Salmon et al. 1986; Moerbeek et al. 1987), airports (Blokpoel and Tessier 1987), fruit crops (Steinegger et al. 1991; Knight 1988), and backyard feeding stations (Agüero et al. 1991; Kessler et al. 1991). The effectiveness of overhead wires or lines varies widely among species and circumstances. However, some deterrent effect has been shown for a variety of waterbirds, including various gulls, ducks, geese and cormorants (Pochop et al. 1990).

The required line spacing is highly variable, depending upon the species of bird being deterred, the activity of the birds, and the structure or crop that needs protection. To repel gulls from a fish hatchery or nesting colony, the lines must be close together, whereas at a landfill site they can be 3-12 m apart (McLaren et al. 1984; Pochop et al. 1990).

**Evaluation.** – The principal disadvantages to overhead wires and lines are cost and poor mobility. There are several advantages also:

1. Overhead lines do not rely on the skill and motivation of bird controllers.
2. They do not require continuous attention.
3. Gulls at least do not seem to habituate to overhead lines.
4. Gulls that do gain access under the lines are extremely nervous and, therefore, very susceptible to active dispersal techniques.

While overhead lines/wires could not be installed over large areas at an airport without incurring considerable cost, widely-spaced lines/wires would be an effective and relatively permanent solution where a bird problem is localized.

**Recommendation.** – Recommended for exclusion of birds from relatively small open areas (up to a few ha).

Literature Reviewed. – Agüero et al. 1991; Amling 1980; Blokpoel and Tessier 1983, 1984, 1987; Forsythe and Austin 1984; Kessler et al. 1991; Knight 1988; Koski and Richardson 1976; McAtee and Piper 1936; McLaren et al. 1984; Ostergaard 1981; Pochop et al. 1990; Steinegger et al. 1991.

### Foam

Foam has been used at some sanitary landfill sites as an alternative to earth for the daily cover material. Although quantitative data are not available, gulls that were attracted in large numbers to one landfill site seemed reluctant to walk into the foam cover (manufactured by Rusmar Foam Technology) used at that site (R. Harris, LGL Ltd., unpubl. obs.). The effectiveness of foam would also depend upon weather conditions; for example, its effectiveness would be reduced in rainy or windy weather. The applicability of foam to airport situations seems limited. It could perhaps be used to cover small areas that, for one reason or another (e.g., food source, pond/puddle), are particularly attractive to birds.

### Bird Balls™

Bird Balls™ is a relatively new and promising product that has been used to exclude water birds from industrial ponds in the western United States since 1993. Birds are denied access to a pond by covering the entire water surface of the pond with these plastic (HDPE), 4-in diameter spheres. Although birds could probably land in the pond, and the balls would shift aside, the balls “hide” the water surface from the birds. Birds do not see the area as a pond. The balls are superior to netting or floating membranes in that they adjust to fluctuating water levels and snow loads, readily shift around in-water obstacles, are unaffected by all but the strongest winds (>50 mph; Mike Taber, Wildlife Control Technology, Inc., pers. comm), are very easy to install (empty the bags of loose balls into pond), and require significantly less maintenance. Bird Balls™ are initially substantially more expensive than overhead lines and netting. Current cost ranges from U.S. \$0.85-3.00 per sq ft (10 balls). Wildlife Control Technology, Inc. is the sole North American distributor.

We are aware of no independent, objective studies of the efficacy of Bird Balls™. Nevertheless, the technology appears to be simple, straightforward, and sound.

## REMOVAL METHODS

Removing birds by poisoning, trapping, or shooting generally is effective over only the short term. Long term bird control, as discussed previously, requires addressing the reasons why birds are attracted to the airport or fly by the airport. Nevertheless, there are occasions when killing birds is required to address an immediate threat to aircraft safety. Shooting birds, in particular, also can be used effectively to enhance the efficacy of non-lethal control methods, such as pyrotechnics. Lethal control methods likely would not reduce populations of common pest species over the long term. They may reduce local populations of common species over the short term and on a local scale, or reduce the local numbers of uncommon/rare and less mobile problem species. Major gull problems on an airport, for example, are not going to be controlled by killing gulls unless the killing is on an unprecedented scale.

See the Transport Canada Manual for a description and discussion of poisons — Rid-A-Bird perches, Ornitol (Avitrol), and strychnine — used for bird control.

### Traps

**Description.** – Trapping is one of the oldest methods used to control birds (Shake 1968). Birds can be live-trapped using mist-nets, cage traps, cannon-nets (Hardman 1974; Draulans 1987; Beg 1990), or large funnel-shaped lead-in traps. Pole-traps were once used on fish and game farms (Randall 1975). However, pole-traps are non-selective in catching and killing birds. They are useless as a method of saving birds lives and are illegal in many countries.

**Biological Basis.** – Birds are trapped and subsequently either released at a distance far enough from the airport that they are unlikely to return, or are killed. Appropriate attractants, placements, and trap designs are available for a wide variety of species.

**Literature.** – Successful deployment of traps depends on many factors — such as the total number of birds, availability of food outside of the trap, and the birds' behaviour (i.e. wariness of traps, Nelson 1990b). Shake (1968) found that attempts to trap red-winged blackbirds near corn fields were ineffective because the population of birds was high in comparison to the number of birds that physically could be trapped. However, Mott (1978) reported that a small population of green-backed herons was captured by mist nets at a fish farm and released 40 km from the capture site. The birds did not return. Trapping was effective at controlling pigeons that roosted on the roofs of buildings and in city parks (Truman 1961). Birds that are hazardous to aircraft, such as hawks and owls, are sometimes trapped at airports and released in areas of suitable habitat distant from the airport (e.g. Hughes 1967; Wernaart and McIlveen 1989). It is important to release the birds far enough away and in suitable habitat; otherwise, many of them are likely to return to the trapping area. Moving traps to new locations every two days will increase the

number of birds caught. In agricultural situations it is recommended to place traps in an area before birds arrive.

***Evaluation.*** – Catching and moving birds can be time consuming, depending on the species and situation. Building traps can be expensive, especially if large numbers are needed. Complex traps may require considerable manpower and time to set up and maintain. Trapping in general, whether to kill or to move birds, is a short-term solution to an immediate problem.

***Recommendation.*** – Trapping may be useful in special circumstances, such as for raptors. However, it should be noted that removal of experienced resident raptors may lead to their replacement by naive birds that are not experienced with airports and aircraft.

***Literature Reviewed.*** – Beg 1990; Clark 1976; Davidson 1968; Draulans 1987; Fitzwater 1978; Hardman 1974; Hussain 1990; Jarvis 1985; LGL Ltd. 1987; Lucid and Slack 1980; Mott 1978; Nelson 1970, 1990b; Randall 1975; Shake 1968; Truman 1961; Wernaart and McIlveen 1989.

### Live Ammunition-Shooting

Gulls are responsible for bird hazards to aircraft at and near many airports. Shooting of gulls on airports is of limited effectiveness as a long term deterrent. In the short term, some gulls are removed and others are frightened away, but the dispersed birds soon return or are replaced by other birds (Heighway 1970; Blokpoel 1976; Harrison 1986). Shooting of gulls, however, is a useful control technique when used to increase the effectiveness of other scaring techniques such as distress calls, pyrotechnics, and models (Cooke-Smith 1965; Mason 1980; Harrison 1986). Killing should be used sparingly, and usually is limited by a permit required from the Canadian Wildlife Service. The occasional killing of gulls is an integral part of many control programs at landfills and airfields.

Over 50,000 gulls were shot at John F. Kennedy International Airport between 1991 and 1997 to reduce strikes with aircraft. This was a unique situation in which a colony of several thousand laughing gulls became established in Jamaica Bay adjacent to the airport. The gulls regularly traversed the airfield on route to feeding areas. While the best solution would have been to remove the nesting colony, this was not done because of its location in a National Park. In this situation, shooting was effective at changing the bird's flight patterns to avoid the airfield. The number of aircraft striking laughing gulls declined by 61% in 1991 and 76-89% during 1992-1997, compared to the mean number of 136 strikes during 1988-1990 (Dolbeer and Bucknall 1997). However, the numbers of birds killed would not be allowed on a routine basis.

***Recommendation.*** – Selective shooting is recommended as a component of airport bird control programs.

## Surfactants and Water Spray

Water cannons and sprinkler systems, using water or water with wetting agents (surfactants), are sometimes employed to control “pest” birds (Harke 1968; Smith 1970; Lustick 1976; Glahn et al. 1991). Water spray has been used as a lethal control method to prevent birds from roosting in urban and agricultural areas. Surfactants are sometimes added in order to penetrate feathers. Once the feathers are wet, the body temperature of birds drops and, if the weather is cold, they may die. Spear (1966) suggests that a sprinkler or water spray system is useful as a method of keeping birds away from waterways.

The surfactant PA-14 was used widely for the control of blackbird and starling roosts between 1974 and 1992. Over this period an estimated 38.2 million blackbirds and starlings were killed through the application of PA-14 (Dolbeer et al. 1997). PA-14 did solve local roost problems, but Dolbeer et al. (1997) found no evidence (using North American Breeding Bird Survey data) that PA-14 applications caused declines in regional breeding populations of these species.

***Recommendation.*** – Water spray, with or without surfactants, is recommended as a lethal control method or to disperse roosts birds. Water spray could also be used for short term dispersal of loafing flocks but it would be easier to use pyrotechnics.

## OTHER PRODUCTS AND TECHNIQUES

The products and techniques in this section are not discussed in the Transport Canada Manual and do not fall readily into any of the preceding categories.

### Lure Areas

Lure areas can be established as a means of attracting and holding birds so that they will not move elsewhere where their presence is undesirable (Sugden 1976). The most efficient attractant would be food, although water may also work. Most lure areas in agricultural settings are established near roosting areas to intercept birds, usually waterfowl, that would otherwise feed in surrounding agricultural fields. The lure crops are generally the preferred food of the species involved. The main objective of establishing the lure area is to attempt to concentrate feeding activities inside the lure areas rather than having the birds dispersed among the surrounding fields where they would damage farmer's crops. Lure areas established for airport bird control should incorporate the same principles.

Lure areas that satisfy needs other than food have also been established successfully. High-water roosts for shorebirds were constructed and successfully attracted wading birds away from an airfield (Saul 1967; Caithness 1970). The most likely candidate groups for lure areas are waterfowl and blackbirds.

Attracting birds to a lure area requires careful consideration. The lure area must be far enough from the airfield and flight paths to ensure that the attracted birds will not create a new hazard. Otherwise, the lure area, by attracting more birds into the area, might increase the risk of bird strikes. The lure area should ideally intercept and “short-stop” the birds at the lure area, well before they would approach the airport. Once the birds arrive at the designated area, adequate supplies of the attractant, such as food, must be maintained. Lure areas must also be positioned so that other disturbances will not affect them. Because lure areas would need to be away from the airfield, the land likely would not be owned or controlled by the airport. This may be a difficult constraint.

***Recommendation.*** — There probably are few airports in Canada where the establishment of lure areas would be warranted and possible. Nevertheless, bird roost and flight patterns should be studied and lure areas should be considered.

***Literature Reviewed.*** — Caithness 1970; Fitzwater 1978; Hooper et al. 1987; Koski and Richardson 1976; Nomsen 1989; Saul 1967; Sugden 1976; Ummels 1983.

### Magnets

Two magnetic devices developed by Sho-Bond Corporation (Japan) presently are being marketed as bird deterrents. The “Birdmag” consists of spherical magnets (1.5 cm diameter) strung along a wire at 25-cm intervals. The wire would be strung along ledges where birds would gather to rest, nest, or roost. “Birdpeller” consists of four, 1.5-cm diameter hemispherical magnets attached to a propeller at 6-cm intervals. The manufacturer states that these products generate magnetic fields which disorient birds, and birds avoid areas with these magnetic fields. The Earth's natural magnetic field is used as a navigation aid during migration or homing by many species of birds (Moore 1975; Southern 1974, 1978; Wiltschko et al. 1981). It also is known that anomalies in the Earth's magnetic field, and introduced magnetic fields, can lead to disorientation in birds (Alerstam 1990; Able 1994). However, the ability of introduced artificial magnetic fields to repel birds has not been tested extensively.

Belant et al. (1997) placed magnets with field strength of up to 118 Gauss in nest boxes used by European starlings. This magnetic field was ineffective in deterring starlings from nesting in these boxes. More testing is required before any substantive conclusions can be drawn on the ability of introduced magnetic fields to repel birds. At present, it seems more likely that magnetic fields may disorient but not repel birds.

***Recommendation.*** — Not recommended.

***Literature Reviewed.***—Alerstam 1990; Able 1994; Belant et al. 1997; Moore 1975; Southern 1974, 1978; Wiltschko et al. 1981.

## Microwaves

**Description.** – Microwaves produce high energy electro-magnetic waves.

**Biological Basis.** – The electro-magnetic energy associated with microwaves can cause stress, discomfort, and behavioral effects in both birds and mammals (including humans). If the energy is powerful enough, heating and physical damage can occur. The hypothesis is that birds would avoid areas where they were disturbed in this manner.

**Literature.** – Humans and other mammals can detect microwave energy at average power densities below 1 mW/cm<sup>2</sup> and at peak power densities below 100 mW/cm<sup>2</sup> (King et al. 1971; Frey and Messenger 1973). At higher power levels, thermal effects occur. In birds, thermal effects may occur at levels as low as 50 mW/cm<sup>2</sup> (Byman et al. 1985); in rats thermal effects have been noted at levels as low as 5-10 mW/cm<sup>2</sup> (Stern et al. 1979). Evidence reviewed by King et al. (1971) indicates that microwave radiation can produce a wide variety of physiological effects in humans, and that microwaves at densities below the “safety limit” of 10 mW/cm<sup>2</sup> accepted in North America can affect nervous activity. This human safety limit has been controversial, in part because of evidence that significant effects can occur at levels well below 10 mW/cm<sup>2</sup> (Steneck et al. 1980). In some countries, considerably lower safety limits have been established (Assenheim et al. 1979).

Evidence concerning the effects of microwaves on birds is conflicting, but it is clear that overt effects can be produced if power densities are sufficiently high. Tanner and his collaborators (1965-1969) have shown that intense microwave fields (average power 10-50 mW/cm<sup>2</sup>) can cause temporary muscular and neurophysiological disturbances in chickens, pigeons, gulls, and budgerigars. Responses to these fields included extension of legs and wings, unsteadiness of gait, and collapse. Of particular relevance to the deterrent potential were the experiments of Tanner et al. (1969) that showed that the feeding behaviour of caged Leghorns could be changed by radiating at an intensity of 40 mW/cm<sup>2</sup> one of two feeding containers. The chickens chose to feed at the non-irradiated food source. After 12 days of irradiation, the hens did not return to the pre-radiation patterns of feeding until four days after the radiation ceased. Furthermore, they immediately avoided the radiated area when radiation commenced again. These levels of radiation, however, are considerably higher than levels that are safe for humans.

A few studies have reported that radars have caused behavioral changes in flying birds (Poor 1946; Drost 1949; Knorr 1954; Hild 1971; Wagner 1972). However, numerous other investigators using both similar radars (Eastwood and Rider 1964; Gehring 1967; Houghton and Laird 1967; Bruderer 1971; Able 1974, and many others) and higher-powered tracking radars (e.g. Williams et al. 1972; Emlen 1974) have not noticed strange behaviours in the birds that they were tracking, even at close distances.

Short et al. (1996) briefly described a study being developed to investigate the ability of birds to detect modulated radar signals, and the possible use of modulated radar signals to deter birds. The strength of this radar would be at levels below those dangerous to birds or people.

**Evaluation.** – Available evidence suggests that microwave radiation does not deter birds unless power levels are high enough to pose a potential hazard to humans and perhaps the birds themselves. Microwaves have not been adopted as a practical or safe bird deterrent technique (Hunt 1973; BSCE 1988).

**Recommendation.** – Not recommended.

**Literature Reviewed.** – Able 1974; Assenheim et al. 1979; Bruderer 1971; BSCE 1988; Burger 1983; Byman et al. 1985; Drost 1949; Eastwood and Rider 1964; Emlen 1974; Frey and Messenger 1973; Gehring 1967; Hild 1971; Houghton and Laird 1967; Hunt 1973; King et al. 1971; Knorr 1954; Koski and Richardson 1976; Poor 1946; Seubert 1965; Steneck et al. 1980; Stern et al. 1979; Tanner 1965, 1966; Tanner et al. 1967, 1969; Wagner 1972; Williams et al. 1972.

### Lasers

**Description.** – Lasers produce high energy electro-magnetic waves.

**Biological Basis.** – The electro-magnetic energy associated with lasers can cause stress, discomfort, and behavioral effects in both birds and mammals (including humans). If the energy is powerful enough, heating and physical damage can occur. The hypothesis is that birds would leave areas where they were disturbed in this manner.

**Literature.** – Lasers have been suggested as a technique for dispersing birds (Lustick 1972, 1973; Lawrence et al. 1975). Although Lustick's experiments suggested that starlings, mallards, and herring gulls were disturbed by either pulsed or continuous laser light, the light had to be directed at sensitive areas on the birds. When aimed at the feathers, birds did not react even though the laser was capable of igniting their feathers.

Seubert (1965) described experiments in which caged gulls were exposed to pulsing lasers. Pulsed light at low powers (1-2 joules) produced some flinching but no distress or alarm calls. Light pulses of 100-200 joules directed at the birds singed feathers and caused bleeding in the bird's eyes. However, the gulls reacted no more to the stronger light than to the 1-2 joule light. A continuous laser was also tested (power not stated) but the gulls looked directly into the beam of intense red light with no appearance of discomfort.

More recently, Mossler (1980) tested whether the beam from a helium-neon laser would deter gulls at a landfill from feeding on highly-attractive food. The gulls showed some limited behavioural reactions to the laser beam, but it did not deter them from feeding.

***Evaluation.*** – Although lasers may in some situations be able to disperse birds, the required power levels would be hazardous to humans. Therefore, lasers are not practical as bird deterrents at airfields.

***Recommendation.*** – Not recommended.

***Literature Reviewed.*** – Burger 1983; Frey and Messenger 1973; Koski and Richardson 1976; Lawrence et al. 1975; Lustick 1972, 1973; Mossler 1980; Seubert 1965.

## SUMMARY AND RECOMMENDATIONS

Bird control products can be categorized by the manner in which they deter or disperse birds — novelty avoidance, startle reaction, predator mimics, warning signals, and killing (Rochard 1996). Many of the least effective products/techniques are based on the presentation of novel stimuli and/or stimuli that startle birds by the suddenness or loudness of their presentation. Birds tend to avoid any novel stimulus, such as the synthetic sounds produced electronically by the Phoenix Wailer, because birds do not know whether this is a threat or not. This has obvious survival value. (Some birds may initially investigate, rather than avoid, a novel stimulus.) Once the stimulus is no longer novel, however (and birds quickly learn what is a threat and what is not), the stimulus has lost its effectiveness on those birds. Similarly, “startle” devices (e.g., gas cannons) lose their effectiveness once they become an expected part of the birds' environment and no longer startle. Although there is a biological basis to these products, any deterrent/dispersal effects are short-lived.

The biological basis behind bird control products/techniques that mimic known threats to birds, such as scarecrows and hawk kites, tends to be stronger and longer-lived. The period of effectiveness is related directly to the realism of the model – in appearance, behaviour, and sound. Birds will quickly habituate to a “Canadian Tire” owl. They will habituate more slowly to a stuffed owl with a crow in its talons that moves and calls. A real owl tethered to a post works even better. Even with the best models, unless the presentation is occasionally supplemented (with killing, for example), birds eventually learn that there is no real threat. Similarly, stimuli that communicate a “warning signal” to the target bird that a predator is nearby (e.g., distress/alarm calls), or has been in the vicinity (e.g., model of dead prey bird), work well. Habituation does not readily occur.

Killing birds in and of itself generally is of immediate or short-term use only. In conjunction with other products/techniques, killing can be a very effective supplementary technique.

Airport bird control has some specific requirements that differ from other bird control situations, such as control in agricultural settings. Ability to control where and when birds are dispersed is important. A potential bird hazard is created rather than removed if birds are flushed across an active runway, for example. The most critical requirement, however, is the need for an airport bird control program to be effective over the long-term. In agricultural situations, deterring birds until a ripening crop is harvested is sufficient. At airports, bird hazards can be present 12 months of the year, and even 24 hours of the day. Given this, habituation to products/techniques by birds becomes a major concern. Birds will habituate more quickly to control devices that have a weak biological basis and little variety of presentation.

We sorted the bird control products and techniques reviewed in this report into three broad categories: (1) Not Recommended, (2) Limited Recommendation, and (3) Highly Recommended. This evaluation was based on the answers to three key questions. (1) Is there a sound biological reason to expect the product/technique to work? (2) How quickly and to what degree do birds habituate to the product/technique? (3) Are cost and practicalities of implementation a consideration?

### Not Recommended

Nine products/techniques are **Not Recommended**. The use of High Intensity Sound, Microwaves, and Lasers are not recommended because the energy levels required are dangerous to humans (and birds and other mammals). Very few species of birds have been shown to detect Ultrasound, and those that can have not shown an avoidance reaction. Aircraft Hazing and the use of Smoke are not recommended because they are impractical for use on airfields. Insufficient research has been conducted on the use of Magnets, Lights, Dyes, Aircraft Engine Noise, Infrasound for bird control; however, the research to date does not suggest that these products are strong candidates for airport bird control.

### Limited Recommendation

The majority of the bird control products/techniques reviewed here fall into the “okay, but ...” category. They can repel or disperse birds but they are limited in their effectiveness because of habituation, weak biological basis, limited application, and/or implementation problems. These products work best when part of an integrated program, and should not be considered individually as key components of a control program. They may, in some circumstances, be useful tools to have in your bird control “toolbox”.

This **Limited Recommendation** category includes several auditory, visual, and chemical repellents. Birds tend to habituate relatively quickly to Gas Cannons and, we expect, to the similar “Falcon-Imitator” and “Rotating Hunter” units from Agri-SX as well, although there has been little testing of the last two products. The use of remotely-fired gas cannons may extend the period of their pre-habituation usefulness.

The distress/alarm calls of the Phoenix Wailer are likely to be more effective than the ultrasounds and synthetic electronic noises also broadcast by these units. Similarly, the synthetic noises produced by the AV-Alarm have no biological basis beyond novelty and startle avoidance reactions, which are susceptible to quick habituation. Bird Gard AVA and Bird Gard ABC are distress call players that offer small repertoires of distress/alarm calls of a limited number of species.

Most visual deterrents also are susceptible to habituation — Scarecrows, Reflecting Tape, Predator Models, Hawk Kites and Balloons, and Gull Models. Chemical repellents – Tactile, Behavioural, ReJeX-iT, and those for control of earthworms (Benomyl, Tersan, and Terraclor) – can be effective but only for specific limited applications. Other taste aversives besides ReJeX-iT are unproven. Foam, playbacks of Predator Calls, and Lure Areas have potential for bird control in certain situations but have been inadequately tested. Trapping and Surfactants and Water Spray are suitable for limited applications.

Model Aircraft can be successful for bird control but they are very labour intensive and they cannot be used near active runways and taxiways at the airport.

### Highly Recommended

The most important aspect of a successful airport bird control is that it must be designed for the specific problems at that airport. It is important to gain an understanding of the numbers and species of birds at the airport and to determine those species and times that create the greatest threat to aircraft safety. The bird control program should then be focussed on the identified high priority species and times.

A handful of products/techniques are **Highly Recommended**. These can be considered core elements of an effective airport bird control program. They provide long-term control, with little habituation if implemented correctly; the active approaches require the frequent involvement of skilled, motivated staff.

### Habitat Modification

The best passive technique for long-term bird control at airports is Habitat Modification. This addresses the root cause of bird problems by modifying the habitat at the airport that is attracting birds. Undertake a comprehensive study of bird use of the airport that includes the entire annual cycle of bird presence (i.e., wintering, nesting, and migration). This study should identify the species that create bird hazards and how they use the airfield and other airport and adjacent facilities. Modify the habitat to remove or alter those features that attract the most problematic species. It is important to insure that the new habitat will attract only species that pose a smaller hazard to aircraft safety. This is necessary since it is not possible to make the habitat unsuitable for all species.

The second component of habitat management is to install, where feasible, physical barriers such as Fencing, Netting, and Overhead Wires and Lines to exclude birds from identified critical areas at the airport. Bird Balls could be used to cover ponds. Physical barriers permanently exclude birds from treated areas, but they must be maintained and monitored. The use of perch barriers such as Nixalite, Bird-B-Gone, Avi-Away, and Fine Wires on buildings, signs, and airport light fixtures may also be appropriate.

### Active Bird Control

Habitat Modification will have reduced the numbers of problem species attracted to the airport. However, other hazardous species will inevitably still be present. An active control program will be necessary to eliminate these species. Techniques that should be key components of an airport active bird control program are Pyrotechnics, Falconry, Distress and Alarm Calls, and Shooting. These could be supplemented with selected techniques from the previous section (Limited Recommendation). For example, the use of gull models (stuffed specimens) to supplement pyrotechnics can be effective at reinforcing the concept that the pyrotechnics might be dangerous to the bird's health. Falconry use at airports is somewhat controversial. It can be a useful technique if properly implemented. Falconry is not appropriate at all airports.

### Conclusion

One theme dominates our analyses of the many techniques for airport bird control. That is, none of the techniques that have been evaluated will work consistently over the long term unless they are applied properly by appropriately trained personnel. This point cannot be overemphasized! There are no single magic solutions for bird control. All successful programs have a biological basis and are operated by well-trained staff. If any significant bird hazard problems exist at an airport, then a full-time staff is likely to be needed.

Operation of a successful airport bird control program requires a major commitment from airport management to insure that adequate funding is in place and that bird control is seen as a high priority activity to insure aircraft safety.

## RECOMMENDED FUTURE STUDIES

1. Several bird control products are relatively new on the market, are heavily promoted, and are expensive. Some Canadian airports have purchased and installed these devices, at significant expense in some cases. These products should be subject to independent testing rather than relying on the unproven claims of the manufacturer. While certain of these products have potential for effective bird control, others do not. Yet airport operators are looking at the claims for these products without the benefit of an unbiased review. The most heavily marketed products are — the “Falcon-Imitator” and “Rotating Hunter” units from Agri-SX, the Phoenix Wailer, ReJeX-iT, and Bird Balls™.
2. Habitat modification, with few exceptions, is the basis for effective bird and wildlife control at airports. We recommend that more research be conducted in this area. It is our opinion that there is much to be learned and gained from further investigation and experimentation. Also, sharing of habitat management information among airports would be useful.
3. Finally, we strongly recommend that information regarding the efficacy of bird control products and techniques be passed on to airport operators and wildlife control personnel. Transport Canada continues to have a major role to play in the testing and dissemination of information on bird control techniques. The Bird Strike Committee Canada is another important vehicle for the exchange of bird control information.

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