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PREDICTING THE BIRDSTRIKE HAZARD FROM GULLS AT LANDFILL SITES

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Abstract

Understanding the factors that affect hazardous bird populations associated with landfill sites is crucial to the development of useful and accurate bird avoidance models.

Three common species of gulls in the UK that are hazardous to aircraft; Herring gulls (*Larus argentatus*), Black-headed gulls (*Larus ridibundus*), and Lesser black-backed gulls (*Larus fuscus*) were monitored at six UK landfill sites over a two year period. Numbers fluctuated significantly between sites and seasons. Regression analysis produced equations that fitted the number of gulls on landfill sites in summer to their proximity to inland or coastal breeding sites. Gull numbers were higher at all landfill sites in winter. During this period, no sites were found that did not have a gull presence. The prevalence of flightlines was therefore evaluated. The overriding factor that determined whether a flightline would exist was proximity to roost, i.e. flightline length. Other factors did not have a significant effect. Studies showed that flightlines occurred to 52% of landfills that were situated within 13km of the roost.

The results from these studies suggest that the birdstrike risk from gulls can be predicted for different landfill developments. Bird Avoidance Models that contain roosting and breeding gull population data may be upgraded with landfill location data and the seasonal hazard associated with each site predicted. Data could be used to alert pilots to the varying risk associated with specific sites in different seasons, and also to target bird management resources appropriately.

Key words: hazardous birds, gulls, corvids, scavenging birds, landfill, waste management, garbage, monitoring, flight safety, Bird Avoidance Model

1. Introduction

Birds forage at landfill sites throughout the world (THRELFALL 1968, HARRIS 1970). Studies in the UK have shown that gulls (*Laridae*) are the predominant species at landfills (MUDGE & FERNS 1982). Gulls are known to be particularly hazardous to aircraft (MACKINNON 2001). In the UK alone, gulls are involved in 42% of all birdstrikes (HORTON et al 1983). Large concentrations of gulls at landfills have caused problems since the 1920s (BELANT et al. 1993). Landfills now provide gulls with an abundant and dependable source of food throughout the year (MONAGHAN, METCALFE & HANSELL 1986). Landfills that attract large numbers of birds to the vicinity of an airfield may therefore pose a significant risk to flight safety.

Richardson (1994) found that 59% of military birdstrikes in Europe were not closely associated with an airport. Instead, they occurred during cruise, low-level or weapons range flights. Military aircraft are particularly vulnerable to *en route* incidents, since they frequently fly at low levels and are less robust than civil aircraft (DEFUSCO 2000). Between 1987 and 1991, 28% of all US Air Force (USAF) birdstrikes occurred during low-level operations, leading to more than $250 million of damage, and the loss of four aircraft and five aircrew (RUBIN 1992). It is important, therefore, to tackle the problem of birdstrikes that occur *en route*, as well as those that occur on airfields.

The factors that influence the numbers of gulls at landfill sites are unclear. Sites may support several thousand birds during summer, or they may be completely absent (BAXTER 2000). Proximity to other bird concentrations such as breeding colonies, coastlines or winter roost sites, could be equally as influential as food availability. Gulls are thought to commute over 30 miles a day between winter roost and feeding sites (HORTON, BROUGH & ROCHARD 1983). Little is known about their movements between summer breeding and feeding sites. Seasonal migrations may also influence the numbers of birds present in a given area (BAXTER 2001). Comparing the numbers of birds at different landfill sites to their distance from breeding sites, and measuring the movements of birds between roost sites and landfill sites would allow the impact of landfill sites on flight safety, at different times of year, to be determined.

HORTON et al (1983) found that gulls show fidelity to specific feeding sites. Flightlines from roosts / breeding colonies to landfill sites may thus be predictable. It is not possible or desirable, however, to control all bird populations across the world (DEFUSCO 2000). Consequently, methods of reducing *en route* birdstrikes must include avoidance of hazards. Identifying the distributions or concentrations of birds may allow them to be avoided. Bird densities may, however, vary throughout the year and even throughout the day, but from one year to the next they remain relatively similar (LACK 1986). It is possible, therefore, to plot bird maps that show high-hazard areas for specific times of year and day (BLOKPOEL 1976). Geographical Information Systems (GIS) technology can be used to incorporate large amounts of information into a spatial model.

The Central Science Laboratory's Bird Strike Avoidance Team began a field study in 1999 to determine the effectiveness of bird control techniques on landfill sites. Over four years, data was also collected from six different landfill sites during periods when no deterrence was deployed.

This study investigates the factors that influence the numbers of gulls that use landfill sites and the presence of gull flightlines between landfills, reservoirs, breeding colonies or the coast. Regression analysis was used to develop a model for predicting the numbers of different species of gulls on landfill sites during summer. Binary Logistic Regression was also conducted to produce a model to predict the probability of gull flightline presence between inland winter roost sites and domestic landfills. The main factors thought to influence the presence of flightlines were also evaluated.

2. Methods

2.1 Summer Monitoring

Hourly counts of gulls were undertaken between dawn and midday or midday and dusk on two days each week at six landfill sites in England during summer 2000 and 2001. Each gull species was defined as being on the landfill if it was noted feeding on fresh waste or covered waste, bathing or loafing on-site or circling over the site. The mean daily maximum count of adult birds was compared to the distance of the landfill from the breeding colonies of each gull species. These were mapped from local bird reports and a national gull census from 1990. The relationship between number of birds on site and distance from breeding colony was evaluated using regression analysis to derive a predictive equation.

2.2 Winter Monitoring

Fieldwork was carried out during winter 1997/1998 in Cambridgeshire, England and winter 2001/2002 in Yorkshire, England. Roosts were visited at dusk to identify the direction of gull arrival. Flightlines from the direction of a domestic landfill, were confirmed by visiting the landfill site to review departure routes of birds and by monitoring flyover birds either by car, or from specific points on the flightline using binoculars. Proximity of landfill sites to other roosts, other landfill sites, the size of landfill (based on maximum licensed input rate of domestic waste), and the length of flightline was compared to its presence or absence. Regression analysis was then used on those factors that showed a significant effect to predict the probability of flightline occurrence.

3. Results

3.1 Presence of gulls on landfill sites during summer

Herring gull breeding colonies in the study areas were coastal. Breeding colonies for Black-headed gulls and Lesser black-backed gulls were either coastal or inland.

An equation to determine the relationship between distance from breeding colony and landfill site was derived for each species. A negative curved relationship, indicating that proximity to a breeding colony exponentially increases the number of birds feeding on a landfill site, was derived.

Regression analysis was used to convert the exponential curve into a straight line by taking the log of the x variable. This was used to derive a model and predict the maximum distance each gull species was likely to travel from a breeding colony to a landfill site. The following results were obtained.

Table 1. *Mean summer bird counts and proximity to coast (Herring gull breeding colonies)*

	Heathfield	Risley	Whitehead	Pilsworth	Peckfield	Erin
BHGulls	170	91	71	38	4	6
LBBGulls	4	106	172	557	53	33
Hgulls	2141	20	69	47	2	0
Distance from Coast (km)	10	35	39	48	79	105

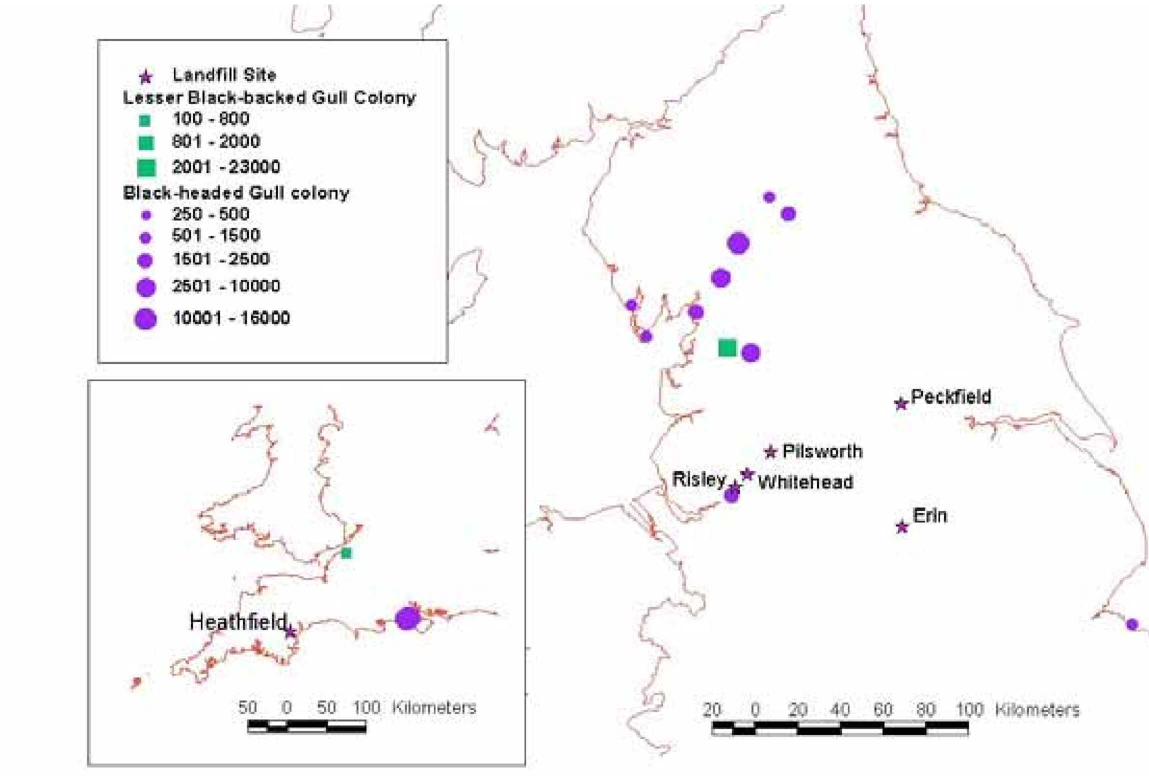

Figure 1. *Location of study sites and inland gull colonies*

Data from the study suggests that Black-headed gulls will travel a maximum of 45 km from a breeding colony, Herring gulls up to 75 km and Lesser Black-backed gulls up to 117 km. These data assume that all adult birds will be breeding at a colony.

The following figures represent the relationship between the mean maximum daily count of each species present at a landfill site and the distance of that site from the nearest breeding colony.

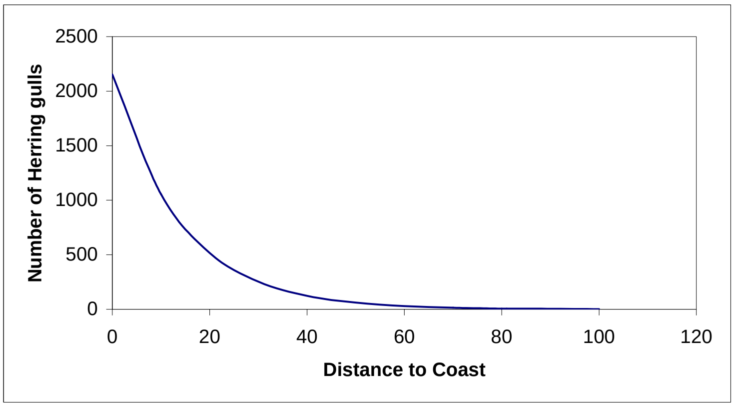

Figure 2

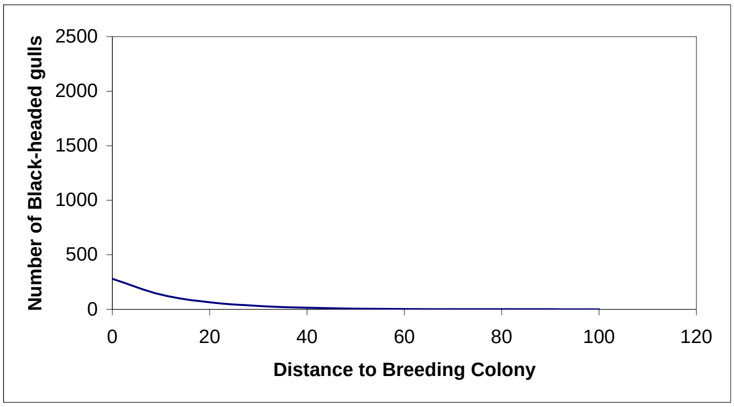

Figure 3

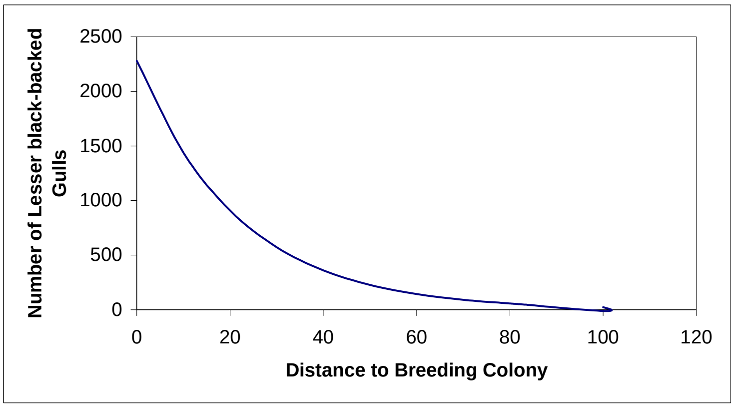

Figure 4

Regression analysis derives the following equations based on the above relationships to determine the numbers of birds likely to be found at a landfill site during summer.

Herring Gulls	Black-headed Gulls	Lesser black-backed Gulls
$y = 2153*10^{-0.031x}$	$y = 279*10^{-0.032x}$	$y = 2280*10^{-0.021x}$

y = number of birds, x = distance from colony / coast

These equations predict that, for example, significant numbers of gulls (100 individuals) could be expected at sites that are 14km (Black-headed gulls), 43 km (Herring gulls) and 68km (Lesser Black-backed gulls) from their breeding colonies.

3.2 Results – Factors influencing the presence of flightlines between roost sites and landfill sites in winter

Unlike summer, all landfill sites visited had a gull presence during winter. The factors that are thought to influence the probability of a flightline of gulls occurring between a roost site and a landfill facility during winter were investigated. Gulls were not separated to species level. The gulls at each roost site were predominantly a mix of Herring and Black-headed gulls. Lesser Black-backed gulls infrequently occur in the UK during winter. The following table details the factors investigated and evaluates their influence on the presence of gull flightlines.

Table 2.

Factor	*U*	N	Probability
Length of flightline	5.574	68	0.000
Nearest other domestic landfill to the landfill	0.590	68	0.555
Maximum licensed input rate category of the landfill	1.470	68	0.140
Other domestic landfills within 6km of the landfill	0.802	68	0.442
Nearest other roost to the landfill	0.189	68	0.058
Other roosts within 10km of the landfill	0.135	68	0.893
Other roosts within 20km of the landfill	0.916	68	0.360
Other roosts within 30km of the landfill	0.133	68	0.358

All tests = Mann Whitney U tests

Only distance between roost and landfill (length of flightline) showed a significant effect on the probability of a flightline occurring. The proximity of additional roosts (nearest other roost to landfill) may require further data to determine whether the near significant probability represents an actual result. Of the 109 potential winter flightlines only 15 were present. 80% of flightlines under 10km long were present. 46% of potential flightlines below 20km were present and 31% below 30km. The longest flightline confirmed during these studies was 29km. The following figure models the length of flightline against the probability of a flightline occurring.

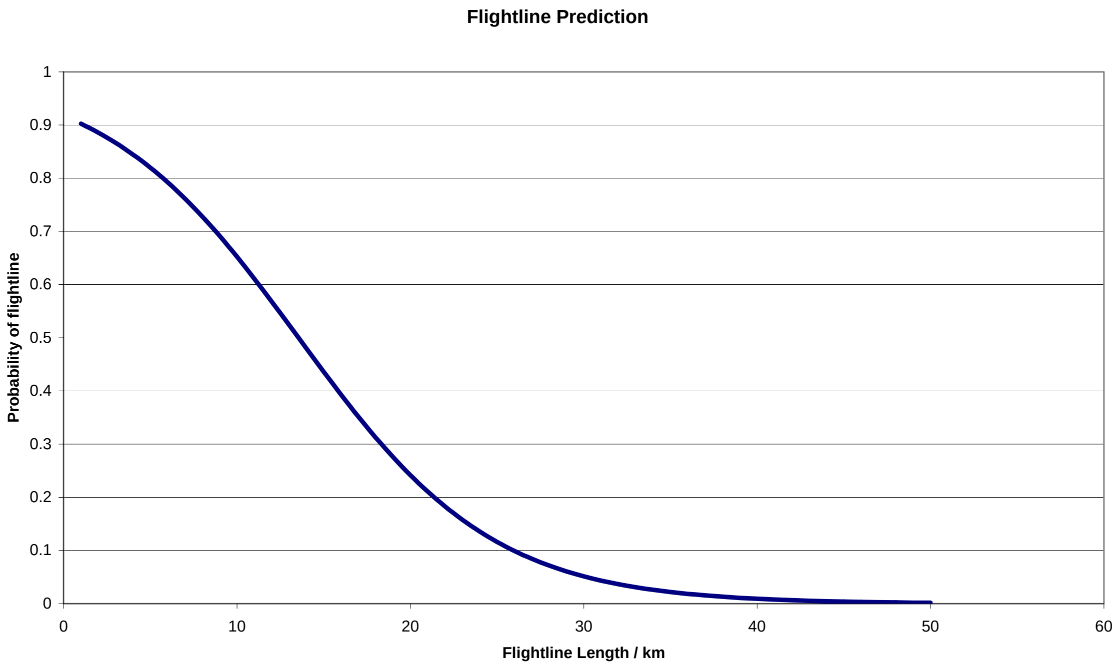

Figure 5. Model of Flightline Prediction

The above figure can be summarised in the form of an equation that can be used to predict the likelihood of a flightline of given length occurring. The equation is as follows:

logit (p) = – 0.773x + 2.402 [where p = probability of flightline and x = flightline length]

This can be rearranged to determine the probability of a flightline occurring as

$$P = \frac{e^{-0.1773\,x + 2.402}}{1 + e^{-0.1773\,x + 2.402}}$$

Both the number of landfill sites used (6) to determine summer population size and the number of roost (7) sites visited to determine the winter probability of a flightline occurring provide relatively small datasets. The models of summer population sizes of gulls, however, provide a good fit for all species (Accumulated analysis of deviance; Black-headed gulls 109.063, $P<0.001$; Herring gulls 31.639, $P<0.005$; Lesser Black-backed gulls 23.75, $P<0.017$). The maximum flightline length observed in winter during this study (29km) is lower than that which has been observed during other studies (HORTON et al 1983). The data used does, however, provide a model with good fit (Accumulated analysis of deviance 42.59, $P<0.001$).

4. Discussion

BELANT et al (1993) states that dependence upon garbage, notorious for having a low protein content, is less in the breeding season as gulls showed a preference for feeding their chicks on fresh fish caught at sea. This statement agrees with this study that shows that landfill sites support fewer gulls in summer. Breeding gulls may also need to provision chicks on a regular basis throughout the day. This may therefore limit the distance they can travel from a colony

to forage for food. Our studies, however, suggest that gulls may actually travel further during summer to locate food on landfill sites than they will in winter.
During the winter months, when food is more difficult to obtain and there are no chicks to feed, adult gulls may revert to foraging on landfills because of the guarantee of finding food. Birds may be thus be able to travel further as they have no requirement to provision young. The prevalence of roosting sites in comparison to breeding colonies may, however, reduce the distance birds need to travel to locate a landfill in winter. Quality of the food may also be less important than accessibility during short winter days. Coastal food availability may be reduced during poor winter weather and gulls may be forced to forage inland.

The models derived from this study provide estimates of the numbers of gulls that may use landfill sites in summer, and the probability of a potentially hazardous winter flightline of gulls developing between a landfill site and a roosting site. Models based on relatively small samples need to be ground truthed to ensure flight safety is not compromised. The model can assist with predicting hazardous flightpaths when planning low level military flying routes. Current Bird Avoidance Models (BAM) suggest that landfill sites and the direct surrounds (the main hazard around a landfill site occurs within one kilometre of the site (BUDGEY in press 2003), should be avoided at all times. Whilst this may be the case, it is important to understand that a significant hazard may occur when birds fly between sites on flightlines. Information that helps us to model the probability of a significant hazard occurring that is not currently detailed in a BAM may help us to increase low level flight safety. Similarly, if we are able to show that hazardous birds are not present on some sites at some times of year, the impact of the model may be enhanced when the hazard returns. Current models that include information on breeding sites, roosting sites and landfill sites can therefore be adapted to show additional hazards and allow pilots to decide on the most appropriate flight paths to take.

The models may also be used to assist with safeguarding aerodromes. In cases where a new site may be thought to impact on flight safety, the models could be applied to assist with the prevention or mitigation of sites that present a significant hazard. The impact of existing site closure and the probability of new, potentially hazardous flightlines of birds developing, could also be reveiwed. In instances where several bird attracting sites are proposed for development, it may also be possible to use the models to predict which sites would result in the most hazardous development.

In addition to using the models to assist with the safeguarding of aerodromes, they could also be used to assist with the development of the most appropriate bird management plans for the landfill sites themselves. Sites that can be clearly shown to attract large numbers of birds throughout the year and have a high probability of creating hazardous flightlines of birds that cross the approaches to a runway, should be targeted with methods that effectively deter all birds. At sites that, perhaps, do not attract birds throughout the year and are unlikely to result in hazardous flightlines of birds close to and airfield or its approaches, less intensive measures could be implemented.

5. Summary

It is clear from the results of this study that the presence of gulls on landfill sites during summer is primarily linked to proximity to breeding area. In winter, proximity to roost (length of potential flightline) is the most prevalent factor. Clusters of sites in this study did not appear to impact on the presence of gulls on landfills although the effect of additional roost sites in an area requires further research. Additional data should be gathered by marking and tracking adult breeding birds from their nesting grounds to their feeding grounds. Species

specific roost counts should also be undertaken in winter and flightline observations that include a breakdown for species abundance would assist in refining the models. Current models have practical applications to assist with safeguarding aerodromes, management plans for landfills and to highlight potentially hazardous flightlines of birds that could impact on military low flying flight safety.

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