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All Birds Are Not Created Equal: Risk Assessment and Prioritization of Wildlife Hazards at Airfields

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Abstract

In order to most effectively control wildlife at an airfield, airport managers must first identify and prioritize the hazards posed by the different species present in their environment. A formula including ten primary risk factors is presented in order to determine the relative threat posed by individual species or groups of similar species. The ten primary risk factors are:

       1) The overall population of the wildlife species (in total number of individuals)

       2) The size (mass and surface area) of an individual animal within the species

       3) The average number of animals encountered (i.e. average group size)

       4) The amount of time spent in the airfield environment (migration, hibernation, etc.)

       5) The time of day when the species is most active

       6) The location of the species with respect to flight operations (AGL, distance from runways, etc.)

       7) The time spent by the species in the air or actively moving

       8) The number of reported strikes involving the species

       9) The ability of the species to actively avoid aircraft collisions

       10) The ability to actually influence the species through wildlife control

This assessment can be utilized to provide a list of wildlife species at an airfield that pose the greatest risk to aviation and the order in which they should be addressed in a wildlife control program. This list can then be used to prioritize wildlife control activities and serve as an index to help determine the overall effort and money that should be spent on assuaging the strike hazard of any particular species. While only a guideline, this formula can serve as an effective method of setting wildlife control priorities at an airfield.

KEYWORDS: Risk Assessment, Priorities, Hazard Analysis, Wildlife Control, Bird strike Factors, Species, Relative Threat

Risk Analysis

In order to effectively control wildlife at an airfield, airport managers must first identify and prioritize the hazards posed by the different species present in their environment. The model formula proposed allows airport operators to carry out a professional risk assessment of wildlife on their airfield and develop a wildlife control protocol for dealing with these risks in the most efficient and productive manner. It can be used to evaluate all species at an airfield, so that a uniform, relative risk evaluation for the species can be determined, and effective control measures developed to address those risks. This assessment can be completed in order to provide a list of the species at an airfield that pose the greatest risk to aviation and the order in which they should be addressed in a wildlife control program. Not all species are equally hazardous to flight operations and the risk analysis should be completed with consideration of ten factors. One must take into account a significant number of criteria when determining the order that the species fall into and exactly how they might affect the overall operation of aircraft at any particular airfield. To this end, airport managers should consider the following factors in establishing the priority of wildlife control on their airfields:

1) **The overall population of the wildlife species (in total number of individuals)**

Population size may appear to be an obvious consideration when determining the overall threat to aircraft operations posed by a particular wildlife species, however many times, airport managers do not conduct accurate and quantifiable surveys in order to determine the absolute number of individuals involved. Accurate determination of species presence becomes important in not only assessing the direct danger posed by a particular species but also is critical in assisting airport managers in assigning relative risk status to that species and prioritizing its control in their overall wildlife control program. Obviously, the greater the number of individuals present in the environment, the greater the likelihood of striking an aircraft. Higher numbers of animals do not always translate directly into a greater threat to aircraft, but it is reasonable to assume the odds of striking one of 20,000 starlings is much greater than hitting one of two great blue herons. Therefore, the species that have the highest number of individuals found within an airfield's environment are assigned higher risk factor in the relative risk hazard compilation.

Total numbers should be measured by valid survey count protocols, though purely empirical studies may not be possible (or advisable) in light of the overall mission to protect aircraft operations. Population counts conducted during routine wildlife patrols may be sufficient to gauge total numbers, as long as the patrols cover the entire airfield environment and are carried out in a prescribed, systematic manner. Oftentimes, without complete surveys, species numbers can be underrepresented in casual observations, and hence, not addressed properly in the wildlife control program. Assumptions based on these types of observations may result in an airport operator overlooking a serious risk factor. As an example, at an Israeli Air Force base in northern Israel, the bird strike threat posed by birds was considered to be present during daylight hours on or near the runways. It was assumed that most birds in the area did not fly at night and therefore, bird control after dark was not afforded serious consideration at the airfield. However, this was not the case, as thousands of birds sought refuge each night on the airfield habitat, coming in to roost in the trees just before sunset and leaving early in the morning just prior to sunrise. Only after routine evening patrols were established and direct surveys conducted was the concern actually discovered (and later rectified).

2) **The size (mass and surface area) of an individual animal within that species**

Simplistically, the size of an individual animal striking an aircraft is proportional to its body size – directly correlated to surface area - but more notably, it is generally correlated with the avoidance capabilities of a particular species. Hence, a 6-oz. swallow has a much greater speed and movement capability than does a 15-lb. Canada goose, thereby decreasing the risk of being struck by a passing plane. This factor is not an absolute as there are some smaller, slow-moving animals and vice versa, but as a general rule of thumb, the correlation holds true. Meadowlarks and curlews are examples of smaller-sized birds that are highly inept at avoiding oncoming aircraft. Their patterns of flight, along with their inefficient flight movements make them highly susceptible to being struck by an oncoming aircraft. Typically though,

larger birds have a more difficult time in attaining flight momentum and need a wider turn radius, resulting in a higher bird strike rate.

However, even more important to the overall equation is the fact the larger an animal's body mass, the more significant damage it could impart to an aircraft. In prioritizing the wildlife strike hazards on an airfield, an animal's mass plays a large part in the determination. The force of a bird striking an aircraft is dependent on the velocity of the aircraft (the speed of the bird is generally much smaller) and the mass of the bird. The equation $e=1/2mv^2$, where the resultant kinetic force imparted to the aircraft is one-half of the mass of the bird times the velocity at impact squared, represents the potential damage that a bird can inflict on an aircraft. There could be 200 separate bird strikes at an airfield involving single sparrows, starlings, or larks but the damage that they are likely to inflict to a 747 is relatively insignificant. A single bird strike involving a large Canada goose, on the other hand, could wreak havoc on even the largest of planes, costing hundreds of thousands of dollars to repair and potentially risking the lives of the crew and passengers onboard. Concentrating efforts on eliminating the presence of 50 swallows, for example, scattered throughout an airfield may not be as important as focusing on removing a lone duck in a ditch.

3) The average number of animals encountered (i.e. average group size)

There are actually two sides to this variable, though in the majority of cases, those birds that travel in flocks are potentially more of a hazard to aircraft operations than those that move about in small groups or individually. Birds traveling in flocks are often confined in their overall movements to the vagaries of the flock – where they flock goes, they follow. A bird traveling along within a large flock may not have the spatial surroundings to actively avoid an oncoming plane. Reducing the freedom of escape paths and the ability to maneuver in a crowd results in a higher risk potential to aircraft, as not every individual in a group may be capable of avoiding a collision. Individuals within a flock are also not as vigilant and may have slower reaction times due to the complacency of traveling in a large group. The old saying "There is safety in numbers" may be true for protection against predators trying to single out an individual in a large group but is not true for thwarting large aircraft on a collision course.

More importantly, the number of birds in a group can greatly affect the overall "size" of the strike. A collision or ingestion of a large number of smaller birds may be equivalent to hitting a single larger bird – as the mass of the birds is additive. Ingesting several dozen starlings into an engine can be as damaging as ingesting a much larger single duck. Because of the flocking nature of birds and the fact that both birds and airplane are traveling through space instead of presenting stationary targets, some bird encounters can involve more than 100 birds at a time. These types of collisions can be as serious, if not more so, than other types of bird strikes involving larger birds.

The other side to this is the fact that larger conglomerations are easier to see and pilots may be able to actively avoid them if they are capable of detecting them at a distance. Flocks of birds are also generally more predictable in their behavior patterns and pilots may be able to plan their routes away from the flocking birds.

4) The amount of time spent in the airfield environment (migration, hibernation, etc.)

The amount of time spent in the environment will also play a factor in determining overall risk to aircraft by the species, as the more time the animal spends in the habitat, the higher the odds of it becoming involved in a collision. A bird that passes through the area and may only be spotted near the airdrome once obviously poses much less of a risk than one that spends all year in the local environment. The

average number of days in the year that a species is present is a reasonable factor in analyzing to what degree an animal will be in harm's way.

5) The time of day when the species is most active

Related to the amount of time spent in the area is the role of the activity levels and timing of the species, particularly since many airfield flight regimens are based quite heavily on normal business of operating hours. Birds that are most active during the heaviest times flight operations pose a significantly higher risk of bird strikes than do those that are active outside the regular flight time parameters. Obviously the day of the week is not of consequence (weekdays vs. weekend days), as wildlife does not distinguish between arbitrary daily designations. However, diurnal and nocturnal behavior patterns are highly significant, as those birds and wildlife that are active at night should not typically be exposed to as many potential strike situations as those species that are primarily active during the day. In order for a bird strike to occur, both bird and plane must not only be in the same place as one another but they must also be there at the same time. If either factor does not coincide, there will not be an incident. Simplistically, a bird can cross a runway frequently without posing a threat, as long as it does so when planes are not operating in that particular area of the airdrome.
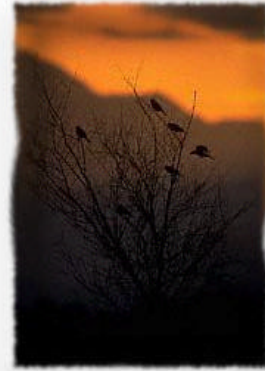
6) The location of the species with respect to flight operations (AGL, distance from runways, etc.)

The location of the wildlife species is also critical in determining its potential threat to aircraft operations. Those species that do not venture inside the aircraft operating area (AOA) or do not seek out locations near active movement areas do not pose as much of a strike hazard as those that may forage on the runways or in the drainage ditches alongside taxiways. Complicating this is the 3-D spatial component of the movement of the species. Those species that may be located farther from the active parts of the AOA but fly at great heights may pose more of a threat than a species that spends its time within the AOA but does not fly very far off the ground. Snow geese, for example, travel at much greater heights than do plovers. Even though a snow goose may rarely spend time on a particular airfield and a plover may spend an excessive amount of time within the confines of the AOA, the snow goose can actually pose a much greater threat since it flies at heights that coincide with aircraft flying altitudes and the plover may not fly more than several feet off the ground. Thus the odds of striking a plover are only significant when a plane is on landing or takeoff and even if a significant number of plovers are present on an airfield, if they are located well away from the runways and rarely spend time near movement areas, their hazard scores can be minimal. The score for snow geese in this factor can be much higher since they fly at considerable heights that may cross both approach and takeoff glidepaths, as well as "go arounds", low level approaches, or any general flight below several thousand feet.

Even approach and takeoff patterns of aircraft can be a factor in formulating the degree of risk posed by a particular species. Determining that a particular species of birds is normally located "x" meters from the active runway may not be an equivalent risk to another species that is equidistant from the runway but in a very different portion of the airdrome. If a particular population of birds is located in a very specific sector of the airfield (along a river bordering the airfield, for example), flight operations for that particular airfield may dictate that the risk assessment would actually be minimized or exaggerated. A bird located 100 meters off to the side of a runway poses a very different threat than one situated 100 meters off the approach end of the same runway. This positional effect is particularly true for military airdromes where fighter aircraft operate, as takeoffs for fighters are normally quite precipitous. If prevailing winds routinely prescribe a specific takeoff direction, the presence of a bird species at either the takeoff or approach end of the runway may make a significant difference in the threat to the aircraft.

7) The time spent by the species in the air or actively moving

An additional factor that must be weighed in the determination of hazard scores is the time spent in the air by the bird species (or actively moving about the airfield in the case of wildlife hazards). Those species of birds that spend a great deal of their time foraging on the ground or rarely change locations do not pose as great of a threat as those species that move about the airfield frequently. If an individual animal doesn't move, it isn't likely to be hit. Again, in order for a bird strike to take place, both bird and plane must share the same airspace at the same moment in time. Since at the majority of airfields, planes spend little time moving about on the ground at high speeds and any incident involving a taxiing aircraft is most likely inconsequential (birds can also readily avoid slow-moving planes on the ground), the more time a bird spends in the air, the more likely its path will cross that of an aircraft.

8) The number of reported strikes involving the species

History is also a great predictor of future occurrences. Ideally it would immensely useful to evaluate prior bird strikes over the course of several years at an individual airfield. Knowing what bird or wildlife species have caused greater numbers of strikes at the airfield environment is generally quite predictive of futures problems, assuming conditions and/or control methods have not radically changed. Oftentimes however, an airport manager does not have a detailed and extensive data collection of reported strikes at their disposal and so they must rely upon figures provided by the FAA or a similar entity. In the FAA's National Wildlife Strike Database, rankings of the numbers of strikes have been compiled and are shown below. Not all species may be represented in each airfield's environment so those species should obviously be eliminated from the final hazard formulations, but overall, the database provides a relative strike risk for general categories of species.

Strike Rate Data (Based on data from FAA National Wildlife Strike Database, 1/91 – 5/98)

Species Group	Strikes Reported	% with Damage	% with Major Damage	% with Effect on Flight
Gulls	2599	20	8	18
Blackbirds/Starlings	1052	6	2	10
Sparrows	622	2	<1	6
Geese	532	56	21	32
Hawks	452	25	7	21
Ducks	401	41	13	23
Deer	367	87	46	77
Rock Dove	346	20	11	20
Herons	215	20	6	20
Swallows	209	1	<1	3
Shorebirds	196	11	2	11
Owls	171	17	7	10
Vultures	152	67	24	40
Crows/Ravens	149	11	4	11
Mourning Dove	139	16	9	10
American Kestrel	138	11	9	10
Coyote	49	13	3	26
Cranes	28	56	20	25
Eagles	24	38	5	23
Osprey	18	50	18	36
Pelicans	17	53	13	27

9)   The ability of the species to actively avoid aircraft collisions

Not all birds are created equal and not all species are equally capable of actively avoiding a collision with an oncoming aircraft or staying out of the way of aircraft movement areas altogether. Crows, for example, are quite adept at avoiding aircraft, as are northern harriers, American kestrels, and ravens. Others, like storks, curlews, and geese are notoriously unskilled at avoiding impacts with faster aircraft (though with geese, it can depend on their location and flight status). Those species that are able to actively avoid oncoming aircraft do not warrant high hazard scores and thereby do not justify as much attention as other species.

10) The ability to actually influence the species through wildlife control

Though all efforts can be placed upon clearing the airdrome of each and every bird, not all species respond to the forms of harassment used in a wildlife control program. Some birds respond to harassment by vacating the area and returning on the rare occasion or not at all. Others are more difficult to exorcise and continue to return (or do not leave the AOA at all) when harassed (irrespective of the method of control used). Since many airport managers do not employ lethal means to remove animals from the airfield, they are held to utilizing the various forms of harassment at their disposal. Geese, for example, respond very well to the presence of a Border Collie and vacate the area promptly. Red-winged blackbirds on the other hand may leave for short periods but return the next day or sometimes, hours later. Swallows and swifts respond very little to any form of harassment and rarely even shift to another area of the airfield after being harassed.

Final Formulation

A risk assessment rating system is applied to each species in order to determine a risk "value". In order to determine this risk value, each of the above risk factors should be evaluated for each species (or group of similar species – all species of "ducks" for example, may be able to be consolidated into one category

and treated as a single unit) and ranked proportionately on a scale from 1 to 100 (100 percent being the most significant threat for that factor present on the airdrome – all other species are expressed as a percentage of the highest risk species). Inversely proportional scores should be used for the final two factors (ability to avoid collisions and ability to control the species) since these risks are inversely related to the other risk factors (e.g the ability to control a species is inversely related to its ultimate risk to aircraft operations). The resultant scores for a species should then be multiplied together to derive a final risk score ("*R*").

The formula that describes this relationship is as follows;

R =log x

where x = Overall Population Size x Mass of Individual x Group Size x Time on Airfield x Time of Day x Location x Degree of Movement x Strike History x Avoidance Ability (inv.) x Ability to Control (inv.)

Below is a typical tabulation for one species at an airfield (results will vary for each airfield habitat, even for identical species).

Species Group	Pop	Size	Group	Time Spent	Time Of Day	Location	Movement	Strikes	Avoid (inv)	Control (inv)
Canada Geese	90	30	100	100	100	100	100	21	90	100

The final risk score in this example would be (*log* 5.103^{18}), or 18.71. The scores for all species are tabulated in this manner and ranked accordingly. Categorizing these final risk values (as high, moderate , or low, for example) is useful, but the most practical application of the risk values is their relative significance to one another. Because each person conducting this assessment will evaluate the factors in a slightly different manner and assign risk variables based on their own experience and perceptions, the risk values can vary from person to person. Therefore, the most useful application of the analysis is the relative relationship of risk values for each species on the airfield environment. It is helpful to assign the species with the highest overall risk ranking in the final tabulation a value of 100 percent and all other species as a proportional risk of that value. A "relative hazard percentage" is based on a percentage scale, starting with the highest priority species at 100 percent and working downward (hence, a species with a score of 52 percent of the score of the top-ranked species is 52 percent as much of a risk as that species).

Once the risk values have been determined in this manner for all species identified, there will be a prioritized range of values. This allows an airport manager to develop a wildlife control program that can deal with all significant risks, but with an emphasis on those species that are rated highest. Ultimately, this can serve as an index to help determine the overall effort and money that should be spent on control of each species in the wildlife control program.

A Case Study – Dover Air Force Base

The following chart is the resulting ranking based on the hazard scores from the species (or group of species) on or near Dover AFB in Dover, Delaware. The two scores, the overall ranking and the relative hazard percentage, are compilations of all of the above described risk factors.

Species Group	Overall Risk Ranking	Relative Hazard Percentage
Canada Geese	1	100
Snow Geese	2	94
Seagulls (all species)	3	8
Ducks (all species)	4	6
Vultures	5	5
Flocking Birds *	6	4
Raptors	7	1
Egrets/Herons	8	1
Crows	9	<1
Songbirds	10	<1
Shorebirds	11	<1
Kestrels	12	<1
Owls	13	<1
Swallows	14	<1
Groundhogs	15	<1
Deer	16	<1
Foxes	17	<1
Rabbits	18	<1

* Flocking birds consists of species such as red-winged blackbirds, starlings, grackles, etc.

The primary reason for conducting a risk assessment and prioritization in this manner is the possibility of discovering risks (or lack thereof) that may not be readily apparent in general field observations or that may be counterintuitive to existing wildlife control protocol. Concentration on particular populations of birds may be ultimately more productive than generalized control of all species on the airdrome. Similarly, it may behoove airport managers to focus their control efforts on the usage of specific forms of harassment or habitat management, in order to most effectively utilize their staff or resources. Analysis of this type may also help managers in determining whether or not to purchase or implement particular control procedures or methodologies (such as the institution of a long-grass policy or purchase of trained Border Collies) on their airfields.

As an example, a few interesting items that were discovered from the summary data at Dover AFB:

1) Overall, the geese (Canada geese and snow geese) comprise roughly 97 percent of the serious strike threat to the C-5 fleet at Dover AFB. Control of these individuals should be the highest priority and their complete exclusion from the airfield and patrol zones should be the key mission in the wildlife control program. The usage of Border Collies is the critical feature of Dover's program that reduces this hazard.

2) Seagulls and ducks represent the next highest threats, though their scores are less than 2 percent of the <u>overall</u> threat posed by the geese (though they are 8 and 6 percent respectively of the threat posed by the top-ranking risk species, Canada geese). This means that roughly 2 percent of the focus of the wildlife program should be on excluding these individuals from the

area. Ducks are particularly responsive to the Border Collies and the seagulls are highly responsive to both the dogs and remote-control airplanes (RPVs).

3) Vultures are a minimal but justifiable concern at Dover AFB. The factor that ulimately brings their hazard score down is the ability to control them. Though RPVs are effective in removing the immediate threat of the vultures from the vicinity of the airfield, they return in the same numbers the next day and do not seem to be influenced in the long-term. The threat of the RPVs most likely is seen as an annoyance, not as a predator. The vultures' return the next day signals this fact. Since the Border Collies are unable to be used effectively against the vultures (unless they are loafing or feeding on the ground), ultimate predatory deterrent cannot take place and the effect on the birds is only transitory. However, attempts to exclude vultures at almost all other airfields have met with dismal success and in comparison to other methods, the temporary relief afforded by the RPVs is outstanding.

4) Though deer are a large and dangerous animal, they appear to pose minimal threat to Dover's fleet. This is primarily due to the fact that there are few deer on the base itself and those that are within the perimeter do not venture from the woods located well away from the aircraft movement area. Since they remain in place, they stay out of harm's way and are not a significant concern for the overall wildlife management program.

5) All other animals and birds do not pose a sizeable strike threat to Dover's fleet. Songbirds, for example, may be struck regularly but do very little damage and concentrating efforts on reducing their numbers through active measures (like with use of dogs, pyrotechnics, or RPVs) is inefficient because it takes away efforts from the more critical species (particularly geese). Passive measures, like habitat management and long grass policies are certainly helpful in reducing this strike potential but exorbitant amounts of money should not be spent to help alleviate the problem.

Summary

A risk assessment rating system is applied to each species at an airfield in order to determine a risk "rating". This list should be used to prioritize wildlife control efforts and can be used as an index to help determine the overall effort and money that should be spent on assuaging the strike hazard of the particular species. While only a guideline, this formula can serve as an effective method of setting wildlife control priorities and may, in the long run, help airport operators improve the facilitation of wildlife control on their airfield.