Risk assessment in relation to restoration of wetlands (lakes and wet meadows) in proximity to airports, a basic model.

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ABSTRACT

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In 1998, the Danish Environmental authorities intended to restore approximately 16.000 ha of low-level areas into functional wetlands, primarily lakes and wet meadows under a national water management plan (VMP2). The primary aim of VMP 2 was to reduce the outwash of nitrogenous and phosphorous compounds from cultivated farmland areas to lakes, fjords and coastal and offshore areas around Denmark. VMP 2 was also intended to increase biodiversity, and birds were expected to be among the first conspicuous species to colonise restored wetlands.
In Denmark, the authorities responsible for airport management are obliged by the National Aviation Authority to take actions to prohibit the establishment of habitats or landscape features within 13 km from airports that potentially attract birds. Hence an obvious conflict of interest exists between the Environmental and Aviation authorities in relation to restoring or establishing wetlands in suitable places near airports.
To evaluate the potential bird strike risk from new wetlands close to airports, a general assessment of expected bird occurrence (based on species specific ecology) in relation to various types of wetlands, wetland size and shape and management strategies, was compared to existing bird strike statistics from Denmark 1992-2005. This comparison formed the basis for developing a basic geographical model, which set out guidelines for what habitat changes may be permitted without increasing the risk of bird strikes, as well as proscribing high risk actions in areas close to airports. Basically the model outputs predict that only very minor habitat changes should be made within 6 km of airport runways, whereas larger wetland projects may be considered at distances between 6 and 13 km, pending careful evaluation of potential bird movements across airport areas between the new and existing wetlands. The model can be considered a basic tool in wetland management near airports, but the applicability and usefulness to specific airports will depend somewhat on specific local and regional knowledge of bird occurrence and movements.

Introduction

In 1987 the Danish government launched the water management plan, VMP 1, in order to reduce a marked long-term outwash of nitrogenous and phosphorous compounds from cultivated farmland areas into lakes, fjords and shallow coastal and offshore areas. These compounds had lead to undesirable increases in general eutrophication levels and to more frequently recurring incidences of oxygen depletion in waters over extensive areas. The first water management plan was followed by a second (VMP 2 in 1998) and a third (VMP 3 in 2004), which together intended to restore c. 16,000 ha low-lying areas into functional wetlands, primarily lakes and wet meadows. At the end of 2006, the implementation of the plans had led to restoration of approximately 6,800 ha, of which c. 3,800 ha consisted of lakes and c. 3,000 ha consisted of wet meadows and marsh-like habitats along existing streams. Basically, these habitats should reduce the discharge by converting nitrogenous compounds into atmospheric nitrogen, but restoration of wetland habitats should also aid in increasing the general biodiversity and improve nature quality and restoration/establishment of wetlands was expected to immediately improve the conditions for birds species associated with these habitats.

Following the Danish Aviation authorities' (SLV) guidelines BL 3-16, Danish airport management authorities were obliged to oppose the establishment of habitats within a distance of 13 km from the airports, that potentially attract wildlife that would pose any risk to flight safety. Given their flying behaviour, birds have long been recognised as critical species in relation to flight safety, and subject to specific attention from airport authorities, both within airport confines and in adjacent areas.

In Denmark, the area covered by 13 km zones around airports amounts to 13.5% of the total country area, and most of which belongs to a huge number of landowners with different interest in land use and management. Thus, very frequently private and public landowners apply for establishing small lakes and ponds on their property on aesthetic grounds and/or for recreational use, while airport authorities automatically oppose these projects with the argument that more birds may be attracted to the general area, increasing the risk of bird-aircraft collisions. Generally, final decisions of permits to establish new wetland habitats close to airports have been a matter dealt with by the Nature Protection Board of Appeal, an mechanism for arbitration organised within the Ministry of Environment. As decisions taken by this board are based on a legal framework, it has often not been possible to accommodate aviation perspectives into judgements, especially since no reference material or guidelines existed that combined bird occurrence in habitats close to airports with risk assessments of bird strikes. Thus there was an urgent need for more strict guidelines on this subject, a need that was amplified by the implementation of the water management plans.

Acknowledging the conflict of interest and the need for a management tool, the Danish Forest and Nature Agency contracted the National Environmental Research Institute (NERI) to produce a technical report that should set out guidelines and recommendations for restoration and establishment of lakes and meadows in proximity to airports. This report should specifically consider the potential attraction of birds to these habitats and assess the associated potential changes to the risk of bird-aircraft collisions. The report would be based on existing knowledge on bird occurrence and behaviour in relation to specific types of wetland habitats in order to predict the species composition and abundance that could be expected to result from wetland restoration projects, as well as taking into account the general patterns of large/regional and short/local bird movements and movements between adjacent wetlands. Finally, the report would make specific analyses of bird strikes recorded in Denmark in order to pinpoint the bird species most frequently involved in bird strike incidences, and to assess where, in relation to the airport and at what altitude, most bird strikes happen.

The present paper summarises very briefly the main parts of the NERI report. The original report is written in Danish, and can be accessed as an electronic publication at http://www2.dmu.dk/Pub/TA23.pdf.

Methods

Data on bird occurrence and expected numeric responses to restored wetlands by species associated with wetland habitats were assessed through a compilation of existing literature. The majority of the literature used originates from a series of Danish monitoring surveys conducted in relation to re-established lakes and meadows during recent years (all published in Danish: Søndergaarg & Jeppesen 1991, Brøgger-Jensen & Nøhr 1992, Jacobsen 1994, Ringkøbing Amstkommune 1995, Toft 1999) and from national monitoring programmes covering migrating and wintering waterbirds in Danmark (e.g. Clausen et al. 1997). Internationally publish papers on the relationships between duck community composition and abundance in relation to habitat type and structure (e.g. Elmberg et al. 1993, 1997), as well as studies of disturbance effects on waterbirds from hunting and other recreational activities (e.g. Madsen 1998a, 1998b, Madsen & Fox 1995), was also included.

Bird species were roughly classified as species associated with wetlands (lakes and meadows), both as breeding and staging, and species that were not associated with these habitats. This is an arbitrary classification, which considers species as wetland species if they have the potential of occurring in relatively high numbers in these habitats at some time during the annual cycle.

Data on recorded bird strikes in Denmark during 1992-2005 was obtained from annual bird-strike reports (e.g., Pihl 1993, Hounisen 1998, Junker-Hansen 2006, Copenhagen Airport), covering the airports of Ålborg (EKYT), Billund (EKBI), Esbjerg (EKEB), Karup (EKKA), Kastrup (EKCH), Odense (EKOD), Rønne (EKRN), Roskilde (EKRK), Skrydstrup (EKSP), Sønderborg (EKSB), Thisted (EKTS), Århus (EKAH), Værkøse (EKVL) and Vandel (EKVA), which reported bird strikes to the Aviation authorities (SLV) in relation to obligations under BL 3-16. In total 1,964 bird strikes were recorded during the period 1992-2005. Of these, successful bird identifications were obtained for 1,045 incidences, involving 74 different species.

Bird strike data includes only incidences recorded within airport near-zone, defined as strikes recorded while the aircraft are on the ground and at altitudes below 1,500 feet during take-off and below 1,000 feet during landing. One bird strike record may include more than one bird. The data includes bird strikes recorded by both military and civil aircrafts.

Results and discussion

Bird occurrence in restored wetland habitats

Restoration or establishment of lakes and wet meadows will generally improve the conditions for birds associated with these types of habitats, leading to an increase in species richness and in species number during all periods of the annual cycle. The number occurring will, however, to some extent depend on the size, shape and heterogeneity of the area, and on the occurrence and intensity of human recreation activities and habitat management.

In association with lakes, the number of breeding birds will generally increase with lake size, but bird numbers will also depend on factors such as water depth, shore-line vegetation and the presence of small islet/islands, that set limits to foraging area and presence of predator free nest or roosting sites. Thus, most birds will occur in larger, shallow lakes with extensive and variable shore-line vegetation and with many small islets or islands, compared to larger deep lakes with a narrow uniform shore-line consisting of, e.g., reed (*Phragmites* sp.) vegetation and with no islets present.

During migration and winter, lakes will be used for both foraging and roosting, and may thus potentially attract relative high numbers of waterfowl such as ducks geese and swans. There exist no specific studies on densities of waterfowl and lake size, but a crude assessment based on counts in a number of Danish lakes suggests that in lakes of larger size than 2-3 ha, waterbirds are likely to occur in large numbers (>1,000). Basically it is considered that newly created lakes of less than 0.5 ha will not lead to marked increases in bird

densities of either breeding or resting species. However, knowledge of regional bird occurrence would greatly improve the assessments of what to expect with respect to the abundance of wintering and staging bird species in a specific area.

The density of breeding birds in meadows is generally lower than in lakes. Meadows constitute, however, an attractive breeding habitat for several waders or shorebirds, and are likewise attractive to several herbivorous waterbird species, which may exploit this habitat for both foraging and roosting year round. To most of these species, however, the meadow habitat is most attractive when the grass sward height is kept low, which in many areas is a management objective obtained either by hay cutting or grazing by cattle. As for lakes, larger areas will attract a larger number of birds, and especially staging birds, than smaller areas.

An important factor determining bird occurrence within and close to airport areas when new wetland habitats are established relates to local movements. Although difficult to assess, movements of birds associated with lakes and open meadows, will often make movements between different regional wetland areas and/or between inland wetlands and coastal areas. Thus to avoid a potential increase in the number of birds that would have to pass over airport areas during daily movements, new wetlands areas should be established so that local movements predictably will not cross or take place parallel to runways (Fig. 1).

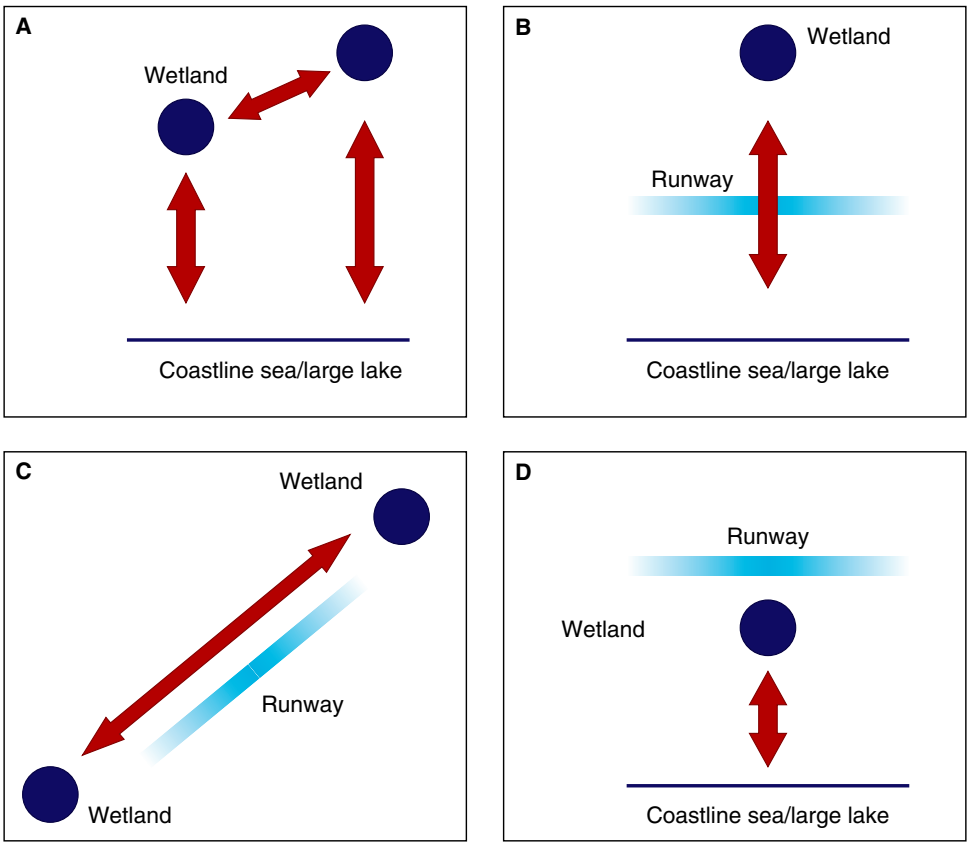

Fig. 1. A) Schematic description of bird movements (arrows) between wetland areas (blue circles) and sea or large lake shorelines (black line), and B)-D) examples on different locations of wetlands in relation to airport runways (light blue bar) and expected bird movements.

Bird strikes

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The total number of bird strikes recorded during 1992-2005 within airport near-zone comprised 1,964 records. Of these, 552 were with unknown birds, 1,045 with identified species and 367 were strikes were the birds have been identified to a group, e.g., swallows, doves, gulls etc. Including the last two categories, passerine species comprised by far the largest group with 600 strikes and 24 identified species. Next on the list were gulls and terns with a total of 336 strikes with 8 species, owls and raptors with 270 strikes including 13 species, 90 strikes with 3 species of doves and pigeons, 56 strikes with 12 species of waders, 22 strikes with 4 species of crows, 18 strikes with 2 species of hens/pheasants, 4 strikes with 2 species of ducks and 1 strike with 1 species of water hen.

Of identified species the species most frequently involved in bird strikes were Kestrel *Falco tinnunculus* with 182 records (17.4%). Swift *Apus apus* were recorded with 99 records (9.5%), Common Gull *Larus canus* with 88 records (8.4%), Herring Gull *Larus argentatus* with 83 records (7.9%), Wood Pigeon *Columba palumbus* and Rock Pigeon *Columba livia* with 70 records (6.7%), Starling *Sturnus vulgaris* with 61 records, Skylark *Alauda arvensis* with 57 strikes, Swallow *Hirundo rustica* with 54 records, Black-headed Gull *Larus ridibundus* with 48 records, Buzzard *Buteo buteo* with 31 records, Meadow Pipits *Anthus pratensis* with 29 records and Lapwing *Vanellus vanellus* with 27 records.

The temporal occurrence of bird strikes in Denmark (Fig. 2) shows that 58.6% of all strikes occur during June, July and August. The vast majority is constituted by small and medium species, which probably is a result of the extremely high abundance of small sized bird populations, characterised by high annual reproduction (producing many young per year), compared to more stable populations of larger sized birds, having much lower annual reproductive rates.

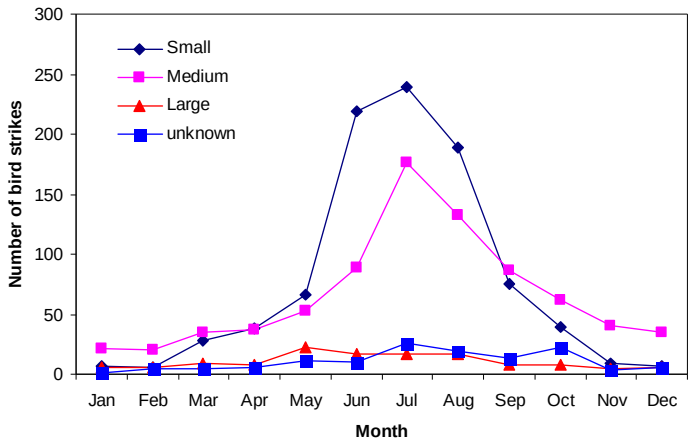

Fig. 2. The temporal distribution of Danish bird strikes (N=1,964) grouped on small (<100 g), medium (100-1,000 g) and large (> 1,000 g) birds.

The vertical distribution of birds strikes (Fig. 3) shows that the majority of bird strikes takes place while the aircrafts are on the ground or below 100 feet during both take off and landing. Calculated from an approach angle of 3°, almost 60% of all bird strikes are recorded within 600 metres from the runways. Including bird strikes recorded up to an altitude of 500 feet, more than 90% of the bird strikes are recorded within 3,000 metres from the runways. The remaining 10% occur at altitudes between 500 and 1,500 feet, while the aircrafts are at a distance between 3,000 and 6,000 metres from the runways. Tentatively the frequency of

bird strikes when aircrafts are above 1,000 feet during take off and landing does not deviate from the frequency of bird strikes recorded while aircrafts are *en route*, thus there seems to be no change in the risk of bird strikes with distance to airports, when aircraft are more than 6 km away from the runway.

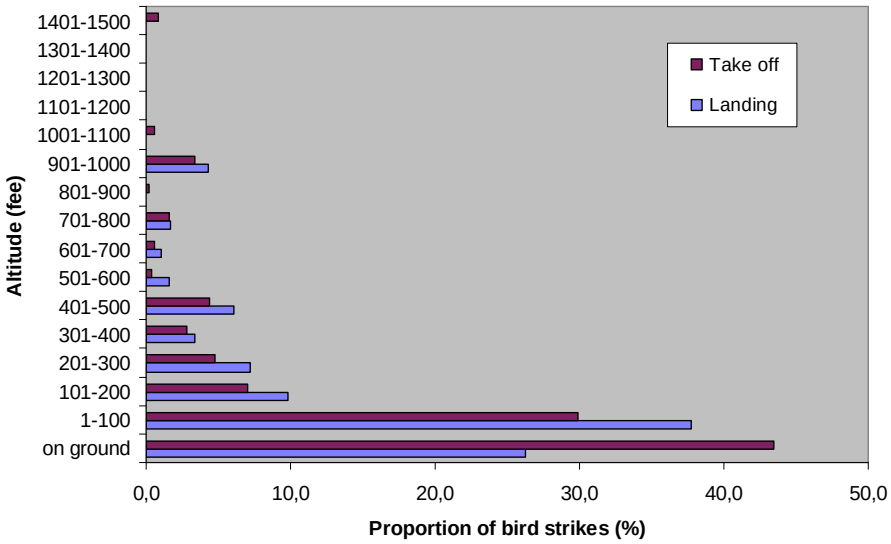

Fig. 3. The vertical distribution of bird strikes recorded in the near-zone of Danish airports 1992-2005 during take offs (N=501) and landings (N=978).

Basic management approach when establishing wetlands near airports

Based on the existing knowledge on bird occurrence in association with wetland habitats, general bird movement patterns and on bird strike data, it is considered that it is possible to re-establish or establish new wetland areas within a distance of 13 km from airports, without increasing the risk of bird-aircraft collisions. The precise decision regarding the type and size of a given wetland habitat, lake or meadow, and at what distance such an area can be located in relation to a specific airport will depend, however, in each case, on in-depth local assessments of expected bird occurrence and on the existing species specific bird strike frequencies. Thus a pre-assessment of a given area should include at least the following points:

Area description:
1) What type of wetland habitat will appear after restoration actions have taken place (lake, wet meadow, bog)?
2) What will be the geographical and biological features of the area (size, outline, vegetation)?
3) The location of the habitat in relation to existing wetlands and coastlines of large lakes or the sea?
4) The location in relation to the airport and airport runways?
5) Which birds are known to occur in existing regional wetlands and coastal areas?
6) Which human activities are expected to affect the wetland habitat?

Expected bird occurrence:

1) Which breeding/staging bird species could be expected to occur?
2) What number of birds could be expected?
3) Where will birds be expected to make regional and local movements day/night, to/from existing wetland or coastal areas?

Location of new wetlands

With respect to assessment of location of wetlands in relation to airports, a basic geographical model (Fig. 4) is proposed as a working tool when actual projects have to be evaluated.

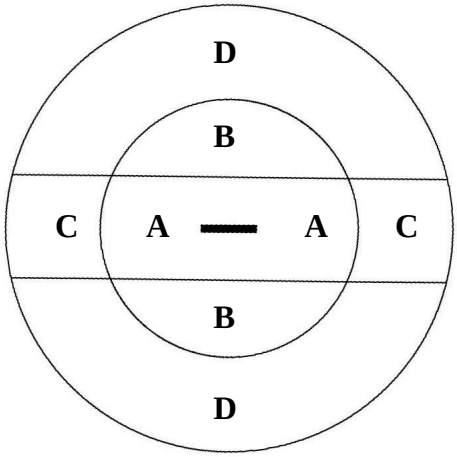

Fig. 4. Schematic drawing of geographical 'management' zones showing airport runway (black bar in centre) and a 6 km (from end point of airport runways) and 13 km zone. A rectangular zone with an orientation that parallels the runway is 6 km wide, 3 km to each side of the runway, subdivide the circular zones. Capital letters denote the different zones used in the following text.

Distance of 0-6 km from airports:

- Re-establishment and establishment of wetland habitats should not take place closer than 6 km from airports in extension of runways and within a distance of 3 km from these (zone A in figure 4).
- Re-establishment of extensive meadow areas adjacent to streams and rivers may be critical, as periodic flooding may make such areas very attractive to foraging waterfowl (zone B in Figure 4)
- Small lakes (< 0.2 ha) can be re-established in zone B (Fig. 4), but an assessment of the location in relation to existing wetlands and coastlines should be made to avoid bird movements close to or across airport areas .

Re-established wetland habitats within 6 km from airport should be designed or managed so they do not provide optimal breeding and roosting sites to birds. Likewise restrictions should be implemented to avoid introduction of, e.g., shooting ducks and feeders that may increase local bird densities.

The distance of 6 km from airports should be measured from the end point of runways.

Distance of 6-13 km from airports:

- Small lakes (< 0.2 ha) and meadow areas can be re-established between 6 and 13 km from airports in the area extending of runways (zone C in Figure 4).
- Re-establishment of larger lakes (> 0.2 ha) and meadow areas in zone D (Fig. 4) is assessed acceptable. However, since large wetland areas may attract a large number of birds, careful evaluation of location of such areas should be made in relation to existing wetlands and coastal zones.

Concluding remarks

Although the present recommendations and design of the management model for establishing wetland habitats in areas close to airports are based on data exclusively obtained from Denmark, it is believed, that the basic approach of the present model have a potential for more general use. Given that the crucial step in the model design is related to the analysis of the vertical distribution of bird strikes, the importance of recording the altitude of bird strikes should be emphasised. Thus, if adequate data exists, separate models can be made for individual airports which are not just based on averages from national bird strike databases.

Assessed from the list of species involved in bird strikes in Denmark, waterbirds, such as ducks and geese, are not involved in bird strikes in substantial numbers, even though several Danish airports are located close to wetland areas or directly on coastlines. The dominant species in the bird strike statistic, e.g., Kestrel, gulls, swifts and swallows, represent species that, although occurring in wetland habitats, most probably are species that are strongly attracted to the open grassland habitat found between airport runways. Thus, the management of the 'airport habitat' may be equally important in relation to the risk of bird strikes than the establishment or restoration of new wetland habitats, given that new wetland areas may increase the potential number of birds and species that may be attracted to airport areas.

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