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INFLUENCE OF LAND USE ON BIRD MOBILITY, A CASE STUDY OF EINDHOVEN AIRPORT, 1998-1999.

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Abstract

Density of birds in the air principally determines bird strike risk. Traditionally the attention was focused on birds present in the runway environment. Not only these birds, but also birds that cross the runway on their flights to and from locations outside the airport cause collisions. This raises the question to what extent bird presence in the airport vicinity relates to bird flying activity above the runway.

In the period between August 1998 and August 1999 systematic visual observations in the form of standardised horizon scans with binoculars were carried out once a week on 19 observation points at and around Eindhoven Airport in a circular area with a 5.5-km radius. Additional investigations were conducted in order to track the flight paths of those species that crossed the runway.
The 19 observation points were situated in a grid in such a manner that a good representation of the land use at the airport and its vicinity was achieved. Land use was subdivided in 10 land use groups. The most abundant groups in the research area were meadows and agricultural fields (mainly maize), built up and forested areas.

The year-round mass of birds in the air ranged between 40 and 280 kg / km^3, with an average of 214 kg / km^3. The lowest density was found above heath land and the highest above maize fields and agricultural meadows.
A clear relation was found between short distance flights and land use. Long distance flights were mainly related to land use at the start and at the end. The track in between hardly related to land use. Outside migratory season the number of species crossing the runway was small. These species mainly frequented the close vicinity of the runway. Number of birds from further away, crossing the runway, was limited.

One achievement has already been made: a recommendation resulted in the cancelling of the construction of a 35 ha recreation lake in a newly built city part 1.5 kilometre away from the runway, because of the high risk of collisions with commuting gulls.

Key Words: Eindhoven airport & vicinity, Land use, Bird density, Bird movements, Habitat modification.

Introduction

Over 90 % of bird strikes in civil aviation occur on airports and in its vicinity below an altitude of 200 metres. The risk of bird strikes is principally determined by the density of birds in the air. Traditionally attention was focused on birds on the airport. Besides these local birds also birds that cross the runway on their flights to and from locations outside the airport do constitute a significant part of the bird strike problem. These flights comprise several types of bird movements, ranging from large-scale seasonal migration to small-scale local flights. In this study the relations with land use and both bird density in the air and bird movements are investigated.

Material and Method

Location

Eindhoven Airport is located in the south of the Netherlands, west of the city of Eindhoven. The small-scale landscape is covered with small villages, heavy meadows and arable fields, forests and heath. Water bodies (natural fens or artificial recreation lakes) are mostly smaller than 50 ha. The study was carried out in an area with a radius of 5.5 km from the rotation point of the aircraft at the runway. At an average angle of climbing and landing of 3.3 % this is the area in which the departing and approaching aircraft have an altitude of up to 200 metres.

Density of birds in the air

19 observation points were situated in a 2 km-grid around a sand-hill on the airport (figure 1) in the 5.5-km area. In order to register the bird density a so called horizon scan was carried out once a week between August 1998 and August 1999. In app. 5 minutes the horizon was scanned over 360° in a radar like way using a tripod mounted binocular (10x42) with an aperture of 6.3° slightly in height of the binocular position and angle with the ground. Within

the observation points there was a high variation in viewing distance to trees and buildings.

For every bird observed, species, flock size, distance, altitude and azimuth were registered. Distance was estimated in three classes; 0-500 m, 500-1,500 and >1,500 m. Altitude was estimated in 4 classes, based on the 4 quarters of the binocular view (fig 2a). The records were registered per azimuth of 30°. For each observation point volumes per distance, azimuth (30°) and altitude were calculated. To estimate the bird density in kilograms per km^3, the flock size was multiplied by the species specific weight.

Bird movements

In order to qualify the measured bird densities observations of bird movements were carried out. Each movement consists of a track connecting the place of origin and destination. On these places birds breed, roost, rest, forage, drink, display and hide. Based on these activities nine types of bird movements were distinct.

Land use

To relate both density of birds in the air and bird movements to land use an inventory within 1.5 km of each observation point was carried out in April ‘99. This enabled the identification of land use in 1998 (crop remains) and in 1999 (seedlings). Land use was subdivided in ten categories: maize, cereals, arable fields and meadows, airport grassland, tarmac (runway and highways), built up area, forest, heath and water. The amount of covered area of each land use type was scored for each azimuth (30°) for the first 1,500 metres (= distance 1 and 2) per observation point (≈ 6.5 ha at distance 1).

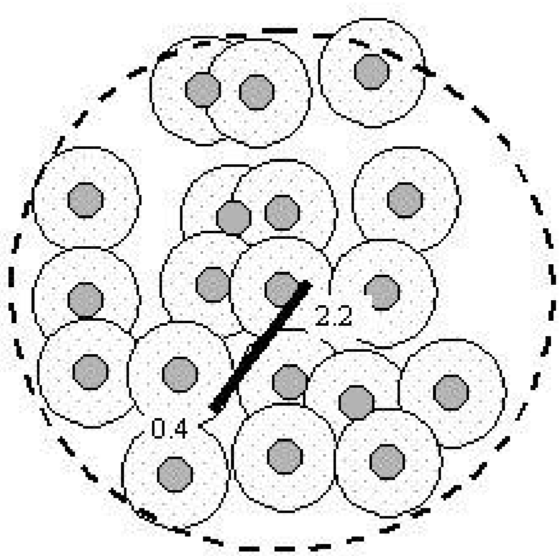


Figure 1. Positions of the 19 observation points in the 5.5-km area. The inner circle represents the first distance (0 – 0.5 km), the outer the second (0.5 – 1.5 km)

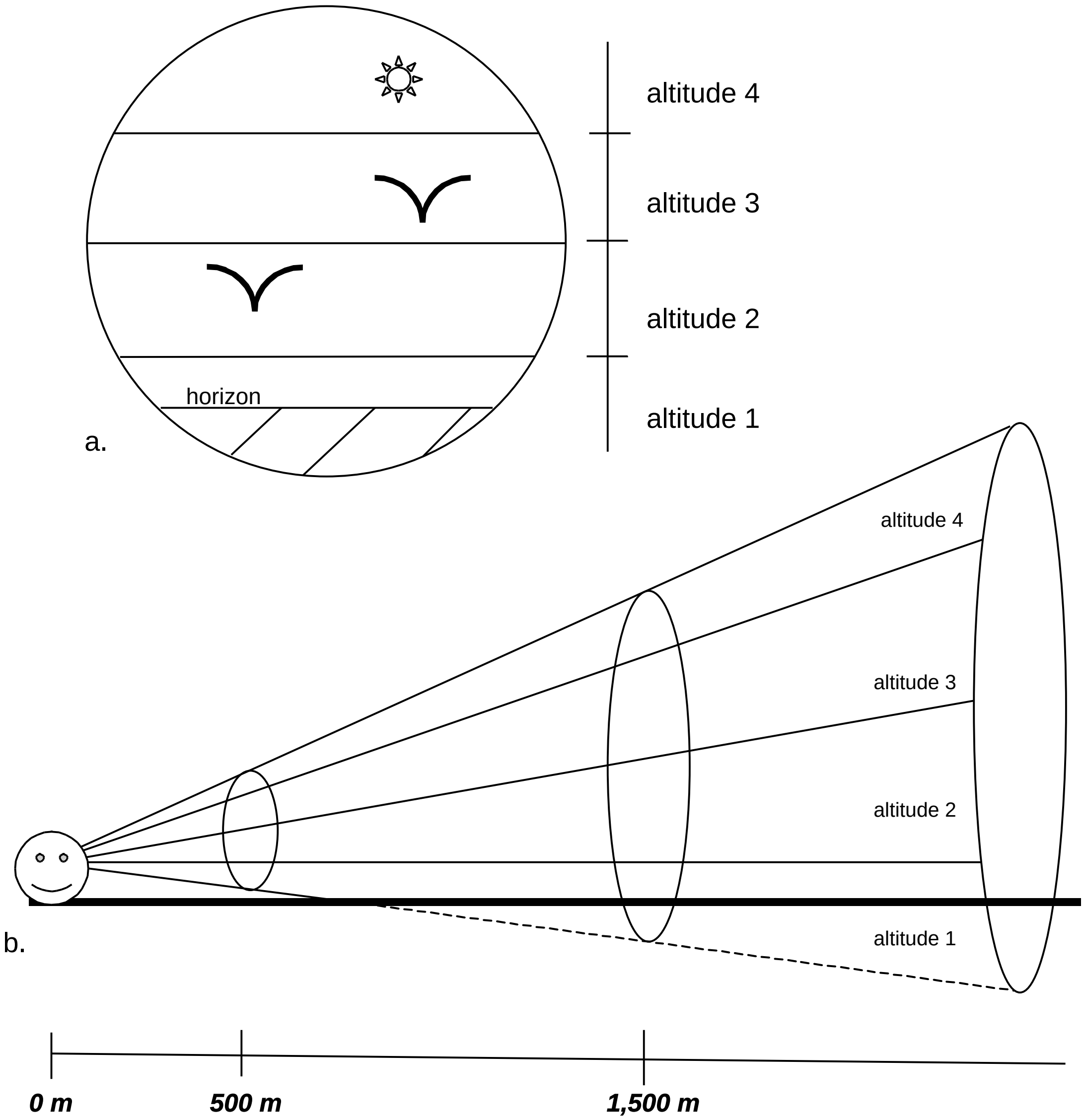


Figure 2. Binocular (a.) and side (b.) view of the horizon scan

Results

Volume

Due to the high amount of obstructions, mainly consisting of trees and buildings with an average height of 15 metres, not all observation points could be situated in the 2-km grid; some parts of the 5.5-km area were not covered, other parts overlapped (figure 1). The obstructions also resulted in a realised observed volume that was app. 70 % of the arithmetical volume. The corrected volume ranged a factor 8 between the observation points. The observation points with the smallest volumes were situated in built up areas, those with the largest volumes in agricultural areas. 75 % of all obstructions were within 500 metres. In order to prevent bias of calculated densities 23 azimuth sectors of 30° were removed. In these sectors the obstructions were closer than 50 metres. Since the end of the visible cone varied due to detection capability (weather conditions, species and number in flock), no volume could be calculated for the third distance (is >1,500 m.). The volume of distance 1 (0.35 km^3) was 26 times that of the volume of distance 2 (8.25 km^3). The height of the observation point, angle with the ground and the aperture of 6.3° resulted in an observed altitude range of 0 to 61.2 metres for distance 1 and 0 to 163.7 metres for distance 2. General data of the observed volume are given in table 1.

Table 1. General data of the observed volumes

Distance class	1	2	3	1+2	1+2+3
Distance in metres	0 – 500	500 – 1,500	> 1,500	0 – 1,500	> 0
Max. volume (km^3) per observation point	0.028	0.72		0.748	
Min. volume (km^3) per observation point	0.0037	0.087		0.0907	
Total arithmetical volume (km^3)	0.49	12.84		13.33	
Total observed volume (km^3)	0.35	8.25		8.60	
Obstructed volume (%)	28.6	35.7		35.5	
% obstructions within distance x	75.4	22.4	2.2	97.8	100.0
Altitude range observed volume (metre)	0 – 61.2	0 – 163.7	>0	0 – 163.7	>0

Observed birds

In total 850 horizon scans were conducted during 47 sessions, resulting in 11,859 records, 12.1 tons of birds and 43,920 individual birds (i.e. 51.7 birds per scan); 32 % of the birds were observed in the first distance class, 44 % in the second and 24 % in the third. Flock size increased with distance. The mean bird size, expressed as the mean weight per individual, was more or less the same in the first two distance classes. In both classes the mean bird size corresponded with Lapwing-sized birds. Bird size in the third distance class differed significantly from the first two classes. Although 145 species were present in the 5.5-km area during the study period, only 69 species were observed in the three distances. 11 species, making up for 86 % of all records, were observed at all observation points. 19 species, nearly 0.1 % of all records, were observed at only 1 of the 19 observation points. General data of the observed birds are given in table 2.

Table 2. General data of the observed birds

Distance	1	2	3	1+2	1+2+3
# groups	5,234	4,911	1,714	10,145	11,859
# groups per scan	6.16	5.78	2.02	11.94	13.95
# species	58	47	31	66	69
# individuals	14,151	19,220	10,549	33,371	43,920
# individuals per scan	16.65	22.61	12.41	39.26	51.67
# individuals per group (flock size)	2.70	3.91	6.15	3.29	3.70
Total mass (tons)	3.3	4.3	4.5	7.6	12.1
# gram / individual	233	224	502	267	323

Observed bird movements

Most of the observed bird movements led to foraging places. Outside the breeding season large flocks flew between roosting and foraging sites in dawn and dusk. During daytime birds flew several times between places where they foraged and rested (or nested in periods with hungry nestlings). Most birds didn't display in the air. Only meadow birds and birds of prey had long lasting display flights. Sometimes birds fled for predators, for the bird control unit or for planes. Birds of prey and swallow-like species foraged in the air. Some gull species had special places for drinking and cleaning (see Black-headed gulls at 'Meerhoven', page 9). The bird movements above described took place in the lower air layers. Only birds of prey within convection bells overreached these. The last type of bird movement is migration. Since most time migration took place at high altitudes (Bird Migration Warning) migration could hardly be observed.

Land use

Main land use types in the 5.5-km area were forest (21 %) and built up areas (21 %). The land use types in the agricultural area comprised a total area of 48 % (consisting of maize (16 %), cereals (1 %), meadows (17 %) and arable fields (14 %)). The grassland of the airport covered 5 % of the total area. Heath (3 %), water (0.5 %) and tarmac (2 %) complete the area. Land use remained largely unchanged in the observation period. Largest was the transformation of agricultural land into built up areas.

The different types of short vegetation showed a gradient from rich to poor soils. Rye-grass meadows were the richest due to fertilisers and slurry, heath the poorest. The grassland of the airport has been agriculturally exploited before the introduction of poor grass policy 5 years ago. This policy already resulted in a vegetation that is in the transitional phase of the rye-grass and heath vegetation gradient.
In 59 % of all 6.5-ha patches (=area covered per azimuth 30° for the first 500 metres), forests covered at least 10 % of the patch. The coverage was constituted of many hedgerows in the agricultural area and some large closed woods. Meadows, maize and built up areas were present in 49 %, 46 % and 45 % of the patches respectively. Figure 3 shows the map of the 5.5-km area.

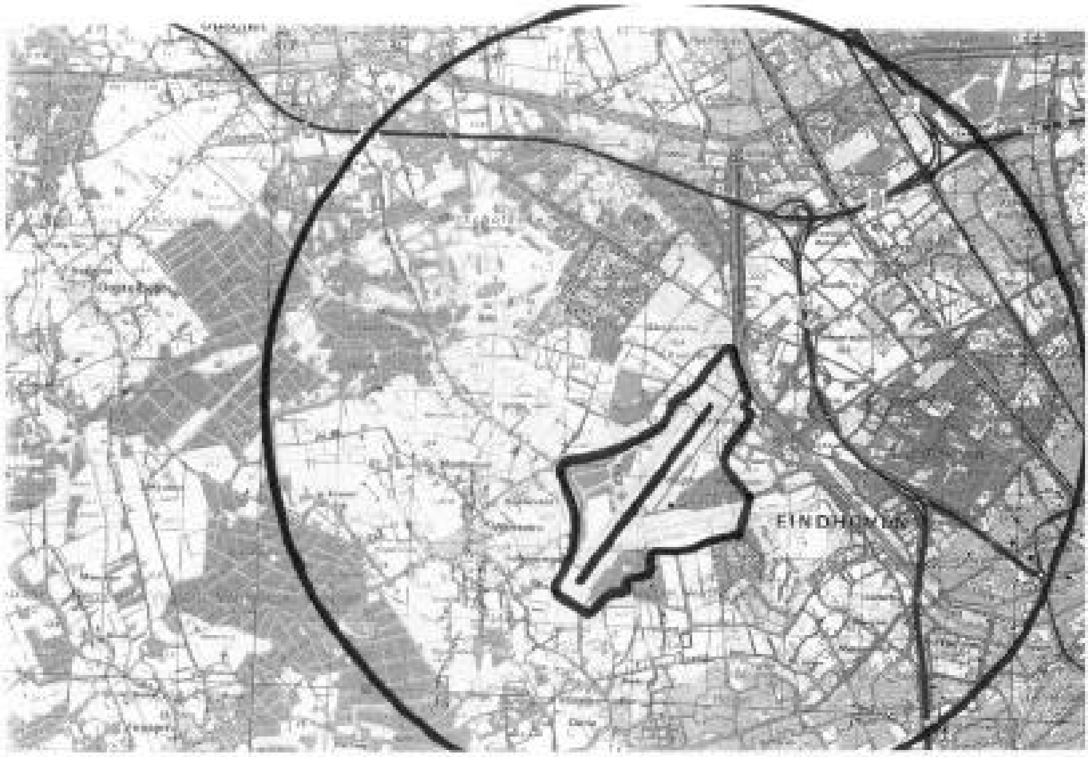


Figure 3. Map of the 5.5-km area. Runway, airport and 5.5-km circle marked

Densities of flying birds in the 5.5-km area
The total year-round density in the 5.5-km area, represented by the 19 observation points, was 860 and 50 birds per km^3 for distance 1 and 2 respectively. In kilograms the densities were 200 and 11 kg / km^3. Figure 4 makes clear that the density in the first 500 metres per observation point was not uniformly distributed over the landscape. Between the observation points, the density ranged a factor 12, from 45 to 559 kg / km^3.

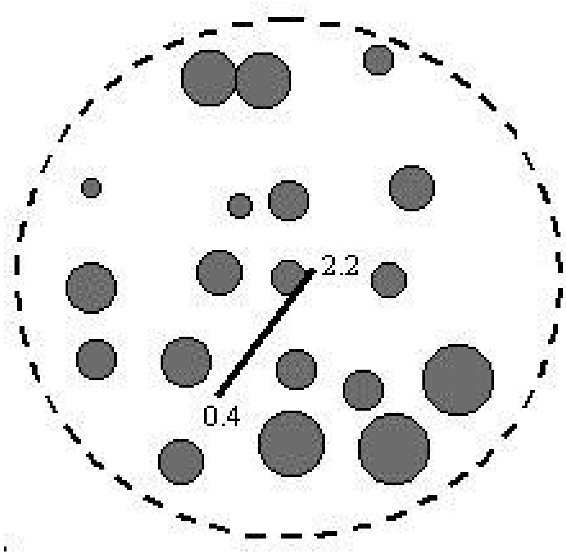


Figure 4. Relative densities in the first 500 metres per observation point in the 5.5-km area

Densities of flying birds per land use
Comparing figure 3 and 4 suggests that the measured densities relate with land use. The highest densities of flying birds, measured for distance 1, were found above agricultural exploited and built up areas and water (up to 280 kg / km^3), the lowest above heath (up to 40 kg / km^3). Densities above the grassland of the airport were intermediate (fig 5). In winter densities of birds in the air were highest, especially above maize and cereals.

Observed species in horizon scan
Whether a bird is observed in the horizon scan depends mainly on rarity and home range.
In total 69 species were observed in the horizon scan. 11 species have been observed overall in the 5.5-km area. These species were Wood pigeon, Carrion crow, Swift, Jackdaw, Starling, Black-headed gull, Feral pigeon, Small birds ('not determinable' - mostly ***Fringilla*** and ***Carduelis*** species), Buzzard, Barn swallow and Stockdove. All these species were numerous and / or had a large home range.
19 species have been observed at only one of the 19 observation points. These species were either rare (Hobby) or limited to one habitat type (Little ringed plover), secretly flying (Cuckoo) or 'non-flying' (Chiffchaff).

Densities of House martin, Swift and Wood pigeon are good examples of four types of the combination of rarity and home range.

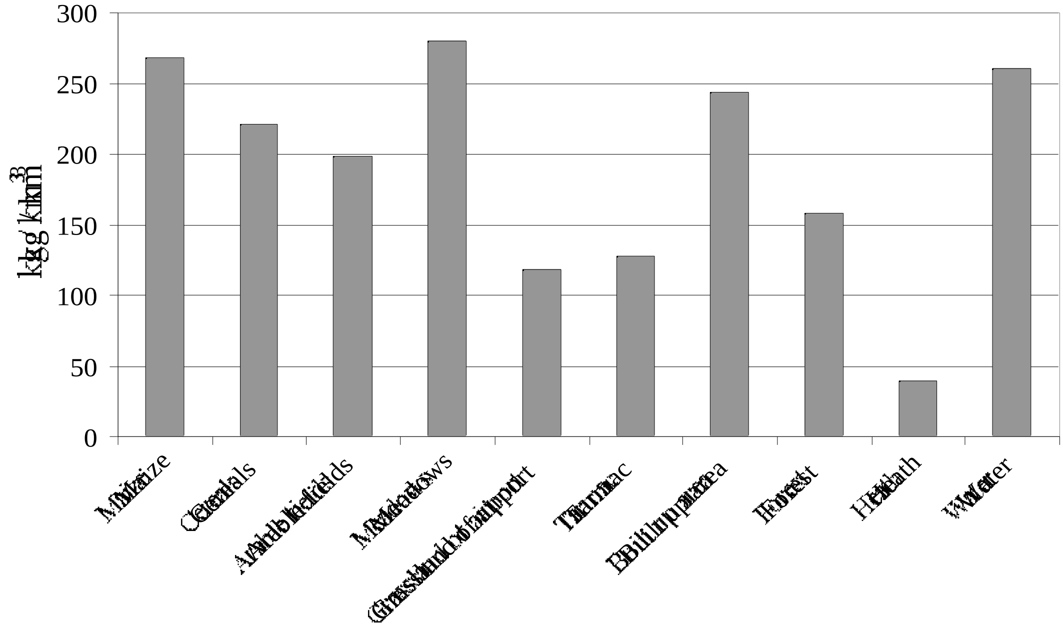


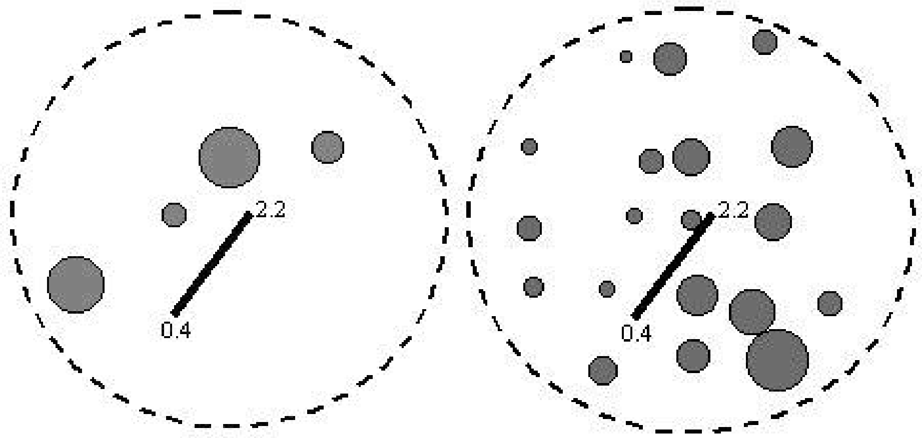
Fig 5. Year-round densities of flying birds (kg / km^3) above all land use types in the 5.5 km area; 0 - 500 meters from the observation points; August ' 98 - July '99

Both House martin and Swift had a small number of breeding places. The House martin was found breeding four times. Each nest was situated in a farm shed within distance 1 of four different observation points. Swifts bred in the old city part of Eindhoven. The House martin had a small home range; foraging flights were mainly within a radius of 500 metres from the breeding place. Swifts had a large home range; foraging flights over 10 km from the breeding place were not unusual. Swifts were observed foraging at all the 19 observation points. House martins only were observed foraging at the four observation points where they were breeding (figure 6).

Although the Wood pigeon, breeding numerously overall, had a small home range during breeding season, it was observed at all 19 observation points in May – July ’99. The density map corresponded with the breeding density. In wintertime the home range was larger, which resulted in a more uniform distribution pattern over the area (figure 7).

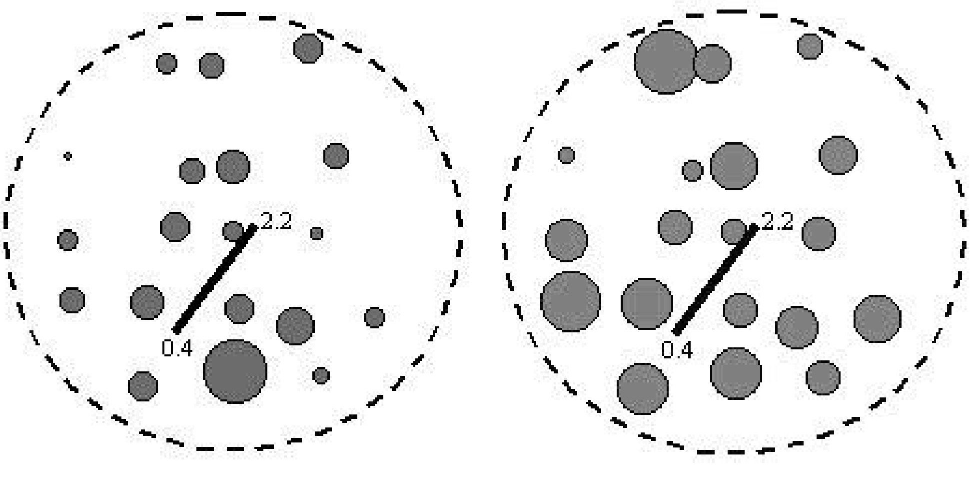
Not only Wood pigeon, but also many other species appeared to have a larger home range outside the breeding season. Non-migratory birds spread out, alone or in flocks, over an area that exceeded the territory in breeding season. When migrating, birds were observed all over the 5.5-km area.

Not any type of movement covered the full home range. The home range was mainly determined by the locations of nesting / sleeping and foraging sites.



a. ***b.***

Figure 6. Relative densities in the first 500 metres of all observation points in May – July ‘99
a. House martin (N=20), b. Swift (N=798)



a. ***b.***
b.

Figure 7. Relative densities in the first 500 metres of all observation points.
a. Wood pigeon May–July ’99 (N=142,. b. Wood pigeon winter ’98 /’99 (N=1,967)

Species spectrum per land use type
The species spectrum of the agricultural exploited area differed slightly with that above forests and built up areas, but considerably of that above heath and runway environment.
10 bird species made up 91 % of the year round overall density (measured for the first 500 metres), ranging from 93 % above maize and meadows to 79 % above heath. These species were Wood pigeon, Jackdaw, Carrion crow, Feral pigeon, Starling, Black-headed gull, Lapwing, Stockdove, Buzzard and Fieldfare. Densities of the 10 species above forests, agriculturally and built up areas were directly related with land use. These were land use types that were used for either breeding or roosting and foraging. Densities of the 10 species above heath and water were not related with the land use underneath. The density was either caused by birds breeding or roosting in the surrounding forests and / or by birds flying from and to locations on either side of these land use types.

Densities of Wood pigeon, Jackdaw, Carrion crow, Starling, Lapwing, Stockdove, Buzzard and Fieldfare above the runway environment were both directly and not related to the grassland of the airport. Sometimes they foraged on the field, mostly they only crossed the runway between forage and roosting places on both sides of the airport. Whether birds did avoid the open area of the grassland during their flight was investigated in another research (Poot ***et al***, this conference).

Densities of Feral pigeon and Black-headed gull were not related to the grassland of the airport. Feral pigeons, kept by pigeon-fanciers, were crossing the runway from and to pigeon-houses. Black-headed gulls crossed the runway flying between forage and cleaning places on both sides of the airport (see also Black-headed gulls at 'Meerhoven', page 9).

Bird movements above the runway environment
During the observation period 145 species were present in the 5.5-km area. Besides the 11 'overall observed species' (page 7) only 65 other species have been observed flying above the runway environment (several sources). One third of these species was breeding in the forest strips and built up area surrounding the grassland (see figure 3), but did not cross the runway (for example Songtrush and Black redstart). Only the Kestrel, breeding in the hangars, foraged on rodents in the runway environment. Meadow birds - 6 species in total - were breeding in the grassland of the airport and only crossed the runway for displaying and mobbing. Swifts that bred outside the airport were foraging on the insects above the grassland. The rest of the birds (32 species) were only observed during migration (figure 8). Some of them used the runway environment to forage for some days, but most birds were only passing, whether avoiding the open area or not (see also Poot ***et al***, this conference).

Black-headed gulls at 'Meerhoven'
The density map of Black-headed gulls in the air in winter suggests a very low bird strike risk above the runway (figure 9a). Highest densities were found above the built up areas, lowest densities above the agricultural and forested areas and runway

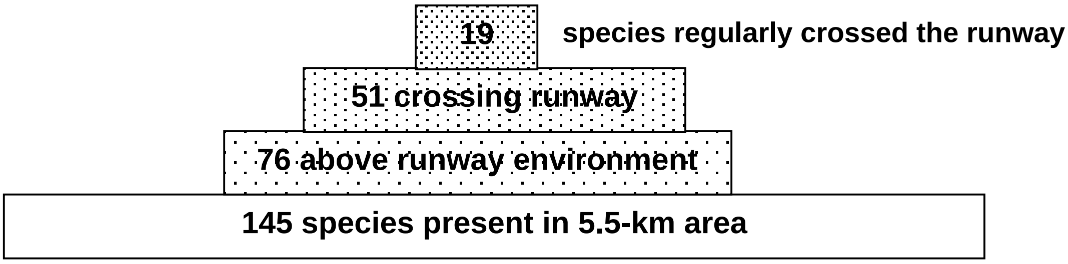


Figure 8. Distribution of runway crossing and non-crossing species; August '98 – July '99

environment. Tracking the flight paths showed the opposite: a high bird strike risk due to up to 700 commuting Black-headed gulls.
Gulls, mainly Black-headed, used the flat roofs on the industrial area in the south-east part of the 5.5- km area outside the breeding season for sleeping. In the morning they flew to a recreation lake north-east of the 5.5-km area for cleaning and drinking. Afterwards they headed for the meadows west of the airport to forage (figure 3). These flight paths caused no bird strike risk. During foraging the Black-headed gulls were hardly flying between foraging places. Most of the days they stayed on the meadow they started. This caused the low measured density of flying birds above the meadows (figure 9a).
Heavy rainfall in winter '98/'99 caused shallow pools on the building-plot of 'Meerhoven'. Meerhoven is a new city part situated 1.5 km east of the runway – outside the airport – with a 35-ha recreation lake planned in the central part. Just some days after the heavy rainfall the Black-headed gulls exchanged the recreation lake for the shallow pools to drink and clean. From here they headed directly to the meadows. The flight paths between Meerhoven and the meadows led the gulls over the runway causing a high bird strike risk (figure 9b). The described flight pattern was one of the reasons to cancel the 35-ha lake. Instead of the lake a park will be realised.

Conclusions and Discussion

Method
The horizon scan is a useful method for measuring bird density in the air. The measured density declines disproportionately with distance. This could be caused by two factors:

- the increased observed altitude in greater distances while birds mostly are concentrated in the lower air layer;
- detection capability of the human eye.

More research should be carried out to quantify the influence of these factors.

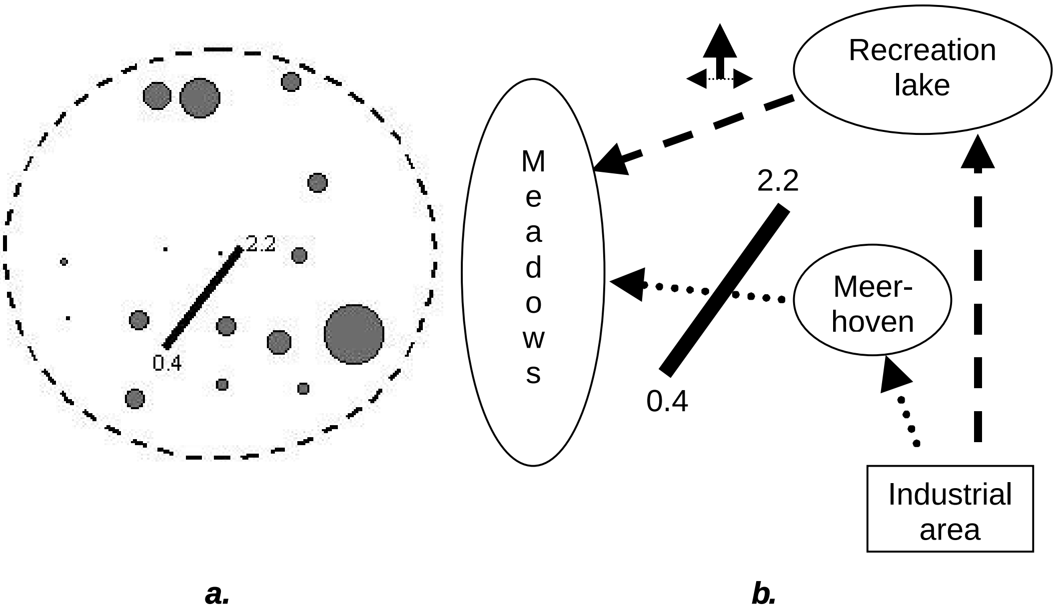


Fig 9. a. Relative densities of Black-headed gulls in the 5.5-km area in winter 1998 – 1999 (N = 680)
b. Flight paths of Black-headed gulls before (◀— —) and after (◀····) the creation of shallow pools on Meerhoven

The registration of birds per azimuth / distance hindered the calculation of densities per land use type. Nevertheless the high number of samples has levelled out the bias.

Densities
Not only densities above agricultural areas, but also above the runway environment and even heath, were mainly determined by only 10 bird species. These species mainly frequented the agricultural areas, used for foraging. This resulted in a significantly lower bird density above the runway environment (poor soil) and heath (poorest soil) compared with the density above agricultural areas (rich soil). Densities above land uses maize, cereals and arable fields were dominated by periods of crop remains and bare soil. Densities in periods of standing crops were significantly lower.

On the average bird species above the runway environment and heath were smaller, mainly non-flocking, than the species above agricultural areas.

Bird movements
The places of origin and destination of the flight paths of the birds were directly related to the land use types, providing food and shelter. The track in between was at best partly related to land use underneath. The agricultural areas were mainly used

for foraging. The forested and built up areas were mainly used for nesting, resting and roosting. Since the agricultural areas bordered on forests and built up areas most movements consisted of small flight paths between these land use types.

Only 19 species regularly crossed the runway. These 19 species frequented the runway environment and its close vicinity. Only during migratory season a higher number of species – still not more than 50 in total – crossed the runway.

Final conclusions

Density of birds in the air above the runway is mainly determined by birds present in the runway environment or close vicinity and hardly by birds outside the 5.5-km area … yet, since changes in land use outside the 5.5-km area may cause bird movements crossing the runway in future.

Knowledge about densities of birds in the air is not sufficient to determine the bird strike risk. Additional information is needed about species specific flying activity and their flight paths. Also knowledge on behavioural aspects in relation to departing and approaching aircraft is needed.

Impoverishment of the soil results in a lower bird density and a species spectrum of smaller non-flocking birds.

Reference

Poot M.J.M., R. Lensink, I. Tulp, J. van der Winden, S. Dirksen, A. de Hoon & L.S. Buurma 2000. Spatial patterns of bird movements on and around an airport, a case study on Eindhoven Airport 1998 – 99. Paper RS7 for the 25th Meeting IBSC, April 2000, Amsterdam.

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