WISSENSCHAFTLICHE REIHE
Heft 46/2016

# Auswirkungen von Flugzeug-Einflugschneisen auf die Vogelwelt unter besonderer Berücksichtigung von Großvögeln und Arten aus dem Anhang I der EU-Vogelschutzrichtlinie

## Teil 2: Freilandstudie und Folgerungen für den Nationalpark Donau-Auen

Bei Großvögeln kam es bei Flugbetrieb im Bereich der Einflugschneise zu auffälligen Mustern in der Aktivität und Raumnutzung. Im Bereich der Einflugschneise zeigte sich eine verminderte Nutzung der Fläche, wovon auch sehr wertvolle Lebensräume betroffen sind.

**Gábor Wichmann, Norbert Teufelbauer, Yoko Muraoka**

nationalpark donauauen
KOSTBARE NATUR FÜR GENERATIONEN

# Auswirkungen von Flugzeug-Einflugschneisen auf die Vogelwelt unter besonderer Berücksichtigung von Großvögeln und Arten aus dem Anhang I der EU-Vogelschutzrichtlinie

## Teil 2: Freilandstudie und Folgerungen für den Nationalpark Donau-Auen

GÁBOR WICHMANN, NORBERT TEUFELBAUER & YOKO MURAOKA

Wien, Juni 2008

KOSTBARE NATUR FÜR GENERATIONEN

## Zitiervorschlag:

Wichmann, G., Teufelbauer, N. & Y. Muraoka (2008): Auswirkungen von Flugzeug-Einflugschneisen auf die Vogelwelt unter besonderer Berücksichtigung von Großvögeln und Arten aus dem Anhang I der EU-Vogelschutzrichtlinie, Teil 2: Freilandstudie. Verfasst im Auftrag der Nationalpark Donau-Auen GmbH. BirdLife Österreich, Wien: 24 S.

## Anschrift der Verfasser:

*Gábor Wichmann, Norbert Teufelbauer*
BirdLife Österreich - Österreichische Gesellschaft für Vogelkunde
Museumsplatz 1/10/8
A-1070 Wien

*Yoko Muraoka*
Hintere Zollamtsstraße 3/7
A-1030 Wien

## Titelfoto:

Flugzeug im Landeanflug über der Donau (N. Teufelbauer).

# Inhaltsübersicht

**Avoidance on the wing: immediate responses of flying birds to large low-level civil aircraft** ..... **4**

1. Introduction ..... **5**
2. Methods ..... **6**
3. Results ..... **9**
4. Discussion ..... **12**
5. Acknowledgements ..... **15**
6. References ..... **15**

**Zusätzliche Ergebnisse** ..... **19**

7. Zusätzliche Ergebnisse zur Aktivität ..... **19**
8. Überprüfung direkter Effekte ..... **20**

**Zusammenfassung** ..... **22**

**Folgerungen für den Nationalpark Donauauen** ..... **23**

9. Literatur ..... **24**

# Avoidance on the wing: immediate responses of flying birds to large low-level civil aircraft[1]

*Abstract.* We studied the impacts of low-level aircraft on flying birds in the Donau-Auen National Park, an important site for riverine forest species and breeding raptors in northeast Austria. Due to its proximity to Vienna International Airport, the area is frequently overflown by arriving or departing large commercial aircraft at low altitudes. Whereas overall activity was not influenced by air traffic, the spatial distribution of birds in the airspace differed between disturbed and undisturbed periods pooling all species recorded and in gulls, but not in raptors. The former groups showed a pronounced decrease in flight activity at times of air traffic in distances of 400-800 m to the centreline. Low-flying (≤25 m) birds displayed horizontal avoidance behaviour of aircraft. Adversely, birds flying above tree-top level generally kept larger lateral distances which did not differ between disturbed and undisturbed periods. Birds vertically avoided aircraft by altering flight altitudes at times of air traffic depending on cloud cover (descending at times of high cloud cover, climbing when the sky was clear). The observed lateral and vertical avoidance behaviour implies that air traffic might represent a barrier for local bird movements between feeding, breeding, and roosting areas affecting about 480 ha of this important bird area. Our results highlight the growing conflict between nature conservation and increasing amount of air traffic.

Keywords: air traffic, disturbance, behavioural responses, flying birds, direct effects, local flights

[1] Eingereicht bei *Biological Conservation*.

# 1. Introduction

Low-flying aircraft have been identified to pose various adverse effects on birds. Disturbance by aircraft can affect time-activity budget, energy expenditure, and productivity through changes in behaviour and distribution of birds caused by visual and/or acoustic disturbance stimuli (e.g. Owens 1977; Bunnell et al., 1981; Bélanger and Bédard, 1990; Stock and Hofeditz, 1994). The extent to which overflights may disturb wildlife depends on a variety of interacting factors including (1) quality and quantity of the disturbance stimulus (e.g. aircraft type and flight pattern; frequency and regularity of occurrence) (Owens, 1977; Küsters and van Raden, 1998; Ward et al., 1999), (2) extrinsic features (e.g. habitat characteristics and availability) (Trimper et al., 1998; Gill et al., 2001) and (3) intrinsic factors (e.g. species, age and experience, flock size, stage of the reproductive cycle) (Bélanger and Bédard, 1989; Sossinka and Niemann, 1994; Stalmaster and Kaiser, 1997; Delaney et al., 1999). Rotary-winged and smaller fixed-wing aircraft fly more slowly and at lower altitudes than large civil aircraft and are therefore considered to cause the most disturbance (Küsters and van Raden, 1988; Ward et al., 1999). Hence, effects of large commercial aircraft on birds have hardly ever been considered (e.g. Burger, 1981a, b). Besides, the vast majority of studies on aircraft-induced disturbance on birds focus on individuals at rest, perching, feeding, or breeding. Reports of how birds respond to aircraft while airborne are rare or anecdotal, and restricted to migrating birds (Bellrose, 1971; Larkin et al., 1975).

Due to the space required, noise and safety reasons, airports are typically located outside city centres, often in the vicinity of extensive natural areas. This also applies to Vienna International Airport, Austria's largest and busiest civil airport, which is situated close to Donau-Auen National Park, an important site for riverine forest species and breeding raptors. The area is frequently overflown by large subsonic aircraft during climb and descent. The objective of our study was to determine immediate responses of flying birds to air traffic in this important bird area.

# 2. Methods

*Study area*

The study was conducted in the Donau-Auen National Park (48°12'-48°10' N, 16°29'-16°58' O), an area of riverine floodplains alongside the river Danube in northeast Austria (Provinces of Vienna and Lower Austria; Figure 1). Comprising one of the largest remaining natural floodplains in Central Europe, the site covers about 93 000 ha of side arms, oxbow lakes, floodplain forest, and seasonally flooded meadows and has been included in the European 'Natura 2000' Network according to the EC Habitats Directive (Council Directive 92/43/EEC of 21 May 1992) and the EC Birds Directive (Council Directive 79/409/EEC of 2 April 1979). The Danube floodplains support, among others, nationally important breeding populations of white stork (*Ciconia ciconia*), black kite (*Milvus migrans*) and white-tailed eagle (*Haliaeetus albicilla*) (Teufelbauer and Frank, in press).

The flight path of planes departing from or arriving at the north/south runway 16/34 (i.e., aligned 160°/340° in relation to the magnetic North Pole) of nearby Vienna International Airport (48°06'37"N, 16°34'11"E) runs across the National Park at a length of approx. 4 km. In 2007, the airport handled 254 670 aircraft movements, of which c. 18% passed over the National Park area (Vienna International Airport, 2008).

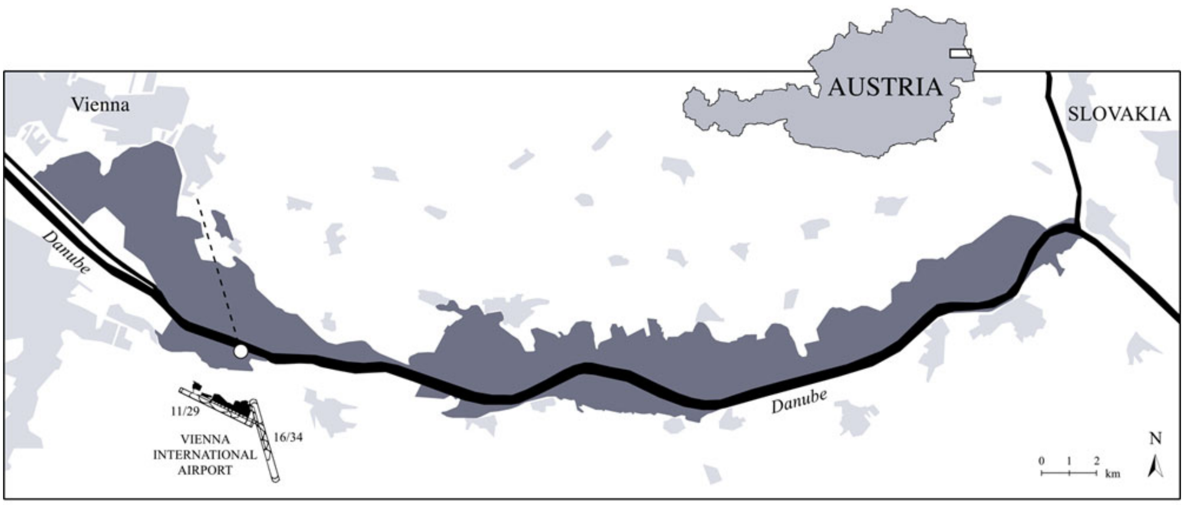



**Figure 1.** Schematic illustration of the river Danube and its surrounding floodplains in northeast Austria with Vienna International Airport situated south of the western part of the National Park. The dotted line marks the flight path used by aircraft departing from or arriving at runway 16/34, one of two intersecting airstrips. The white circle indicates the location of the observer.

*Data collection*

The study was conducted on 9 days with good weather conditions (i.e., no rains or heavy winds) between 13 April and 19 July, 2007. On average, observation periods fell between the hours of 0945 and 1400 CEST (totalling 38.6 h). Overall, 463 scan samples were carried out at one location on the southern river bank right underneath the flight trajectory, 1 800 m NNW of runway 16/34 (Figure 1). Scan samples were conducted every 5 minutes for a median duration of 70 s (interquartile range: 60-80 s) which did not differ between the observers G.W. and N.T. (Mann-Whitney U-test: $U = 4613$, $p = 0.24$, n = 203). Birds were observed with 10 × 42 binoculars (6.3° angular field of view). The considered area covered the twofold field of view above the tree-tops of the northern river bank. If necessary, we used a 20-60× telescope for identifying far-flying birds after a scan was completed. The observer recorded all birds flying above the river and the floodplain forest north of the Danube. The surveyed area was divided into 3 zones (west, centre, east) between which the observer switched randomly to avoid systematic count error. The initial location of each observed bird was noted on a map (scale 1:10 000). Trees at the northern river bank (approx. 25 m high) were used as a reference to determine altitudes of flying birds. Flight altitudes <100 m (80% of all cases) are therefore considered to be adequately estimated. During scan samples, over-flying aircraft and the time at which they passed the northern river bank were recorded. The amount of aircraft traffic varied between observation periods. Air traffic occurred in 38.2% of all intervals. The median interval between aircraft flights was 2 min 18 s. In 64.1% of all cases, air traffic occurred within 3 min. Arriving planes flew at altitudes of approx. 100 m. Flight altitudes of departing planes ranged from 100 to 300 m (Vienna International Airport, unpubl.).
Meteorological data (including wind direction, temperature and cloud cover) were provided by Vienna International Airport with a temporal resolution of 30 min.

*Observed species*

During 463 scan samples conducted we obtained 275 bird-scans of 744 individuals (Table 1). Observations were mostly restricted to non-passerine species of which raptors, gulls and corvids were the most abundant groups recorded. We observed 8 species (20% of all individuals) listed in Annex I of the EC Birds Directive (79/409/EEC). Among Annex I species, black kite (9.1%) and honey buzzard *Pernis apivorus* (20%) were the most frequent species observed.

**Table 1.** Number, percentage and frequency of occurrence in scan samples of systematic groups plus species recorded. Asterix (*) indicate species listed in the Annex I of the EC Birds Directive.

| Systematic group | Individuals | Percentage | Occurrence in scan samples (%) | Species |
|---|---|---|---|---|
| Raptors (Accipitridae and Falconidae) | 272 | 36.6 | 51.2 | Honey buzzard *Pernis apivorus* *<br>Marsh harrier *Circus aeruginosus* *<br>Goshawk *Accipiter gentilis*<br>Sparrowhawk *Accipiter nisus*<br>Black kite *Milvus migrans* *<br>White-tailed eagle *Haliaeetus albicilla* *<br>Common buzzard *Buteo buteo*<br>Hobby *Falco subbuteo*<br>Common kestrel *Falco tinnunculus* |
| Gulls (Laridae) | 270 | 36.3 | 18.1 | Black-headed gull *Larus ridibundus*<br>Yellow-legged gull *Larus michahellis*<br>Caspian gull *Larus cachinnans* |
| Crows (Corvidae) | 106 | 14.2 | 18.4 | Carrion crow *Corvus corone* |
| Cormorants (Phalacrocoracidae) | 36 | 4.8 | 3.2 | Great cormorant *Phalacrocorax carbo* |
| Herons (Ardeidae) | 28 | 3.8 | 5.0 | Grey heron *Ardea cinerea* |
| Ducks and geese (Anatidae) | 19 | 2.6 | 1.7 | Greylag goose *Anser anser*<br>Mallard *Anas platyrhynchos* |
| Storks (Ciconiidae) | 7 | 0.9 | 1.3 | Black stork *Ciconia nigra* *<br>White stork *Ciconia ciconia* * |
| Others | 6 | 0.8 | 1.1 | Lapwing *Vanellus vanellus*<br>White-winged tern *Chlidonias leucopterus*<br>Common tern *Sterna hirundo* *<br>Black woodpecker *Dryocopus martius* *<br>Golden oriole *Oriolus oriolus* |

*Analysis*

For analysis, birds were divided into 3 categories: 'ALL SPECIES' summarizes all species observed; analyses were additionally performed for the 2 most abundant groups, birds of prey ('RAPTORS' hereafter) and 'GULLS' (Table 1).
To determine influences of air traffic on overall activity of birds, we compared periods with air traffic to undisturbed ones. For that purpose, scan samples were summed up for each day and divided through the number of disturbed or undisturbed periods on that day, respectively. To determine variation in the distribution of flying birds, the airspace on both sides of the centreline was divided into parallel sections of 400 m width. For each distance category (e.g. 0-400 m, 400-800 m, etc.) we calculated a 'bird flight activity' index for both disturbed and undisturbed periods according to the formula

a) $$\frac{\frac{\text{Number of birds}}{\text{Number of intervals}}}{\text{km}^2}$$

We applied general linear models (GLM) to examine effects of air traffic on vertical and horizontal distances to the aircraft's flight path maintained by flying birds. For analyses of lateral distances to the centreline, individuals were grouped into birds flying at altitudes ≤ 25 m and > 25 m. Cloud cover was categorized as < 50% or ≥ 50%. The variables temperature and wind direction did not improve the models and were thus excluded from the analyses. To meet the assumptions of normality of parametric tests, the variable 'lateral distance to the centreline' was square root transformed and 'flight altitude of birds' was log-transformed (Sokal and Rohlf, 1981). Results were considered significant if $p$ <0.05.

# 3. Results

*Influence of air traffic on activity of birds*

The 'bird flight activity' index did not vary between disturbed and undisturbed periods indicating that overall activity was not influenced by aircraft traffic (Mann-Whitney U-test, ALL SPECIES: *U*= 37, *p* = 0.76, n = 18; GULLS: *U* = 31, *p* = 0.84, n = 18; RAPTORS: *U* = 36, *p* = 0.69, n = 18). However, the spatial distribution of birds in the airspace differed between disturbed and undisturbed periods in ALL SPECIES and GULLS (Paired Wilcoxon test, n = 6; ALL SPECIES: $z = 2.2$, $p < 0.03$; GULLS: $z = 2.2$, $p < 0.03$; Figure 2). In both groups, the most distinct variation in terms of decreased flight activity at times of air traffic occurred in distances of 400-800 m to the centreline amounting to 40% in ALL SPECIES and 70% in GULLS. No such spatial variation was found in RAPTORS (Paired Wilcoxon test, n = 6; $z = 0.3$, $p = 0.7$; Figure 2).

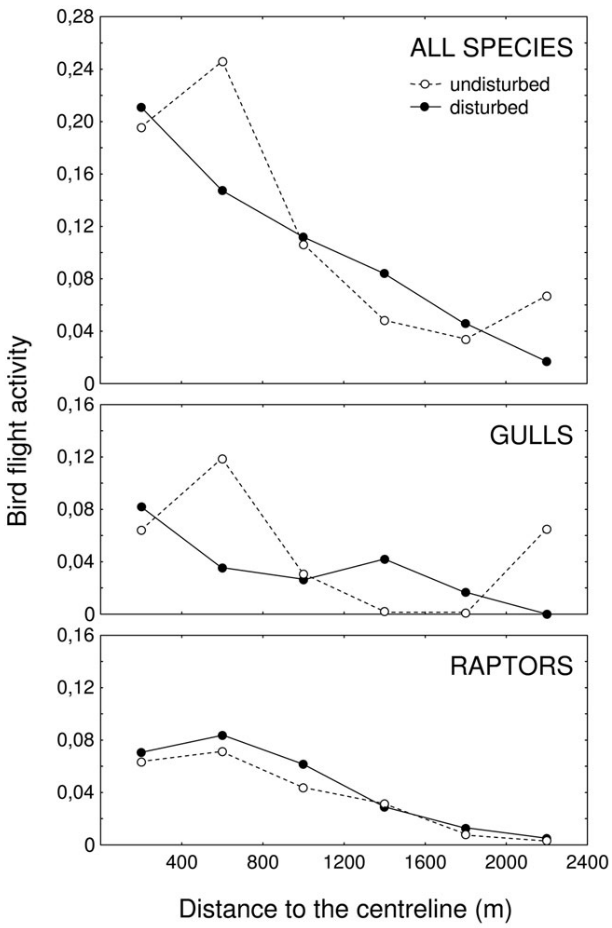



**Figure 2.** Spatial variation in bird flight activity during disturbed and undisturbed periods.

*Influence on vertical and horizontal distribution of birds*

Considering lateral distances to the aircraft flight line, we found a significant interaction effect 'flight level of bird × presence of air traffic' for ALL SPECIES and for GULLS (Table 2A). Among low (≤25 m altitude) flying birds, ALL SPECIES and GULLS thus clearly avoided the flight corridor in disturbed periods. Low-flying RAPTORS were not considered in the analysis due to the small sample size. The median lateral distance to the centreline increased by 52.5% in ALL SPECIES and by almost 162% in GULLS when air traffic was present (Figure 3). 'Flight level of bird' was a significant factor influencing lateral distance to the centreline of ALL SPECIES. High-flying birds generally kept larger distances than bird flying at altitudes ≤25 m (Figure 3). During undisturbed periods, the median distance to the centreline of high-flying birds exceeded those of low-flying ones by 40.5% (GULLS) to 43% (ALL SPECIES), respectively. Observed lateral distances to the centreline of birds flying at altitudes >25 m did not differ between disturbed and undisturbed periods in either group.

Flight altitudes of birds were related to a combination of total cloud cover and occurrence of air traffic in either group (Table 2B). During aircraft overflights, birds flew low at times of high cloud cover, but increased altitudes when the sky was clear (Figure 4).

**Table 2.** GLM analyses of (A) lateral distance to the centreline of the flight path of aircraft in relation to air traffic (present/absent) and flight level of birds (≤25 m vs. >25 m), (B) flight altitude of birds in relation to air traffic and cloud cover (<50% vs. ≥50%). Df = 1 for each factor. Number of scan samples: ALL SPECIES: n = 463; GULLS: n = 84; RAPTORS: n = 237. Missing values: not tested due to low sample size. Significant values are printed in bold.

| | ALL SPECIES | | GULLS | | RAPTORS | |
|---|---|---|---|---|---|---|
| A) y = LATERAL DISTANCE | $\chi^2$ | *p* | $\chi^2$ | *p* | $\chi^2$ | *p* |
| Air traffic | 0.93 | 0.34 | 0.03 | 0.87 | 2.27 | 0.13 |
| Flight level of bird | 10.26 | **< 0.002** | 0.91 | 0.34 | 0.06 | 0.79 |
| Flight level x air traffic | 6.60 | **< 0.02** | 9.17 | **< 0.003** | | |
| B) y = FLIGHT ALTITUDE | $\chi^2$ | *p* | $\chi^2$ | *p* | $\chi^2$ | *p* |
| Air traffic | 2.70 | 0.10 | 0.07 | 0.80 | 1.25 | 0.27 |
| Cloud cover | 0.93 | 0.33 | 0.02 | 0.89 | 6.20 | **< 0.02** |
| Cloud cover x air traffic | 18.71 | **< 0.0001** | 4.74 | **< 0.03** | 5.91 | **< 0.02** |

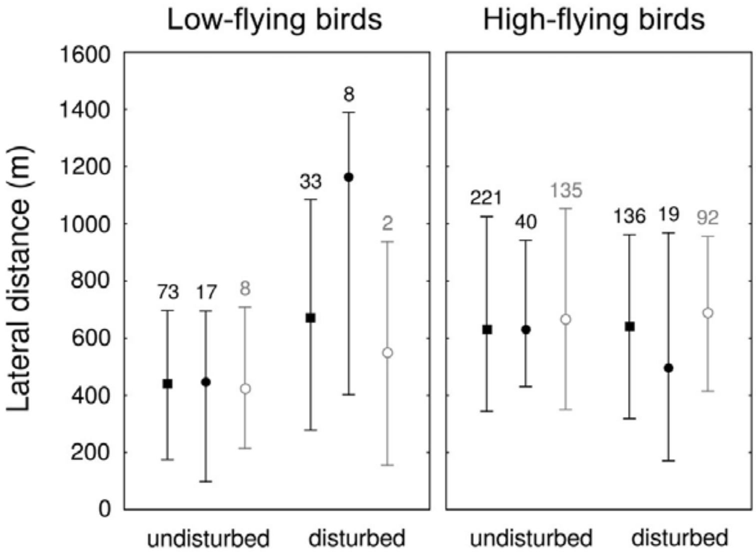



**Figure 3.** Influence of air traffic on horizontal distance of birds to the centreline of the aircraft's flight path for birds flying at altitudes ≤25 and >25 m. Plots display medians, interquartile ranges and sample sizes. Squares = ALL SPECIES; filled circles = GULLS. Effects on RAPTORS (open circles) were not tested due to low sample size and are shown only for the sake of comparison (in grey).

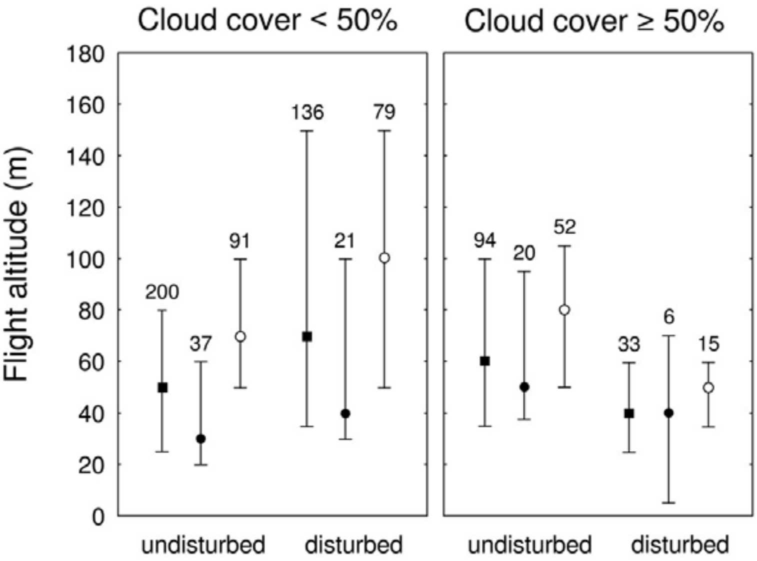



**Figure 4.** Influence of air traffic on flight altitudes of birds at times of low (<50%) and high (≥50%) cloud cover. Plots display medians, interquartile ranges and sample sizes. Squares = ALL SPECIES; filled circles = GULLS; open circles = RAPTORS.

# 4. Discussion

We examined immediate responses of flying birds to low-level flights of large commercial aircraft. The principal conclusions from our study were four-fold:

(i) overall bird flight activity was not influenced by aircraft traffic;

(ii) the spatial distribution of birds (except raptors) in the airspace differed between disturbed and undisturbed periods with a pronounced decrease in activity in distances of 400-800 m to the centreline at times of air traffic;

(iii) low-flying birds displayed horizontal avoidance behaviour of aircraft. Birds flying above tree-height maintained greater distances to the aircraft's flight trajectory in general;

(iv) birds vertically avoided aircraft by altering flight altitudes during disturbed periods depending on cloud cover (descending at times of high cloud cover, climbing when the sky was clear).

Large, fixed-winged planes are considered to hold the least disturbance potential compared to military jets, light planes and helicopters and the probability that wildlife habituate to this kind of aircraft type is generally assumed to be high, especially in areas frequently exposed to overflights (Komenda-Zehnder and Bruderer, 2002). Correspondingly, our data implies that air traffic did not influence overall bird flight activity at our study site. The spatial distribution of ALL SPECIES and GULLS in the airspace, however, was affected by aircraft flights as most impressively illustrated by a distinct activity decrease in distances of 400-800 m to the centreline of the aircraft's flight path. Even though the most conspicuous decrease should be expected to be close to the flight trajectory, bird flight activity in 0-400 m distance to the centreline was similar between disturbed and undisturbed periods in either group. Since flight movements noticeably increase in the 400-800 m distance category in the absence of aircraft, we suppose that activity around the centreline is generally low even during undisturbed periods.

This result is roughly consistent with lateral distances maintained of low-flying birds in response to the approach of an aircraft in our study. Lateral distance-to-disturbance has repeatedly been shown to be one of the primary factors influencing the extent of disturbance effects and resulting behavioural responses (e.g. Grubb and King, 1991; Ward et al., 1999). The sudden appearance of aircraft may be responsible for this short-term avoidance behaviour since the trees of the floodplain forest alongside the river Danube prevented low-flying individuals to visually detect approaching aircraft from afar. Birds flying above tree-top height maintained greater distances to the centreline in general, thus exhibiting permanent avoidance of the aircraft's trajectory even in the absence of air traffic.

During undisturbed periods, their median lateral distances to the centreline exceeded 600 m in either group. Our findings thus indicate that an area of about 600 m on both sides of the centreline is avoided by flying birds.

Birds of either group displayed vertical avoidance in response to an approaching aircraft by temporarily altering flight altitude. The vertical displacement of birds depended on the degree of total cloud cover at the time of air traffic. During disturbed periods, birds flew low at times of high cloud cover, but increased altitudes when the sky was clear. Flight altitudes of birds are strongly related to thermal convection (Shamoun-Baranes et al., 2006) which is greater on days with less cloud cover (Garratt 1992). Especially flight altitudes of soaring birds, such as larger raptors and storks, are strongly influenced by meteorological conditions. However, weather-related variation in flight altitude has also been found in black-headed gulls (*Larus ridibundus*) which flew lower during energetically more costly flapping flight than when soaring/gliding with maximum hourly flight altitudes significantly influenced by total cloud cover (Shamoun-Baranes et al., 2006). Our results indicate that birds tried to avoid air traffic by increasing flight altitude when thermal lift was good (i.e. low cloud cover) gaining height by means of thermal updrafts. Conversely, when cloud cover inhibited thermal convection, birds took evasive action by flying at lower altitudes.

Larkin et al. (1975) noticed that nocturnal migrants sometimes react to the approach of a small airplane with its landing lights continuously on by taking evasive maneuvers. Based on our findings, we presume that this also applies to resident individuals approached by large low-flying aircraft during local flights. Vertical and horizontal avoidance behaviour reduces collision risk but implies that air traffic might represent a barrier to movement to local flights between feeding, breeding, and roosting areas. In practical terms, the maintenance of 600 m distances on both sides of the flight line would result in about 480 ha of airspace being lost for flying birds at times of air traffic translating to 0.5% of the National Park area. The extent to which such avoidance constitutes a problem depends on (i) the frequency of disturbance, (ii) quantity and spacing of flight routes utilized by aircraft, (iii) the species under consideration as well as fluctuating levels of sensitivity depending on life stage and time of year and (iv) the amount of extra energetic cost incurred by the displacement of flying birds (relative to the normal flight costs) and their ability to compensate for increased energy expenditure. The flight trajectory runs across the so called ‘Lower Lobau’ area, a complex of former alluvial floodplains, riverine forest, meadows, oxbow lakes, sand and dry gravel ridges and reedbeds within the National Park. Interestingly, a recent survey of raptor eyries in the Donau-Auen National Park showed that the Lower Lobau holds conspicuously fewer nest sites compared to the rest of the National Park (Thoby, 2006). The author suggests that frequent air traffic may be an important factor, but evidence has not been provided.

In conclusion, our study shows that flying birds respond to air traffic by lateral and vertical avoidance behaviour. Based on experimental overflights over wintering waterfowl, Bruderer and Komenda-Zehnder (2005) recommend the implementation of 500 m buffer zones around defined sensitive areas – a value in accordance with our observations which should be taken into consideration when planning airports or new runways. However, it is hard to translate changes in behaviour, abundance, and distribution of local birds to the specific consequences for the lifetime fitness of an individual bird, or for the population as a whole (e.g. Gill et al., 2001). As aircraft movements are increasing, the determination of long-effects of aircraft on bird populations in areas with intense air traffic will be a future challenge for applied nature conservation research worldwide.

## 5. Acknowledgements

The study was supported by the Nationalpark Donau-Auen GmbH. We would like to express special thanks to G. Frank and C. Baumgartner (Danube floodplains National Park) for their manifold support during the whole study. P. Halwachs made easy access to the area possible. S. Farmer helped with the field work. We are grateful to G. Bieringer and H.P. Kollar for valuable contributions concerning study design and discussion. We thank Vienna International Airport for providing meteorological data in an unbureaucratic way.

## 6. References

Bélanger, L., Bédard, J., 1989. Responses of staging greater snow geese to disturbance. Journal of Wildlife Management 53, 713-719.

Bélanger, L., Bédard, J., 1990. Energetic cost of man-induced disturbance to staging snow geese. Journal of Wildlife Management 54, 36-41.

Bellrose, F.C., 1971. The distribution of nocturnal migrants in the air space. Auk 88, 397-424.

Bruderer, B., Komenda-Zehnder, S., 2005. Einfluss des Flugverkehrs auf die Avifauna – Schlussbericht mit Empfehlungen. Schriftenreihe Umwelt Nr. 376. Bundesamt für Umwelt, Wald und Landschaft, Bern.

Bunnell, F.L., Dunbar, D., Koza, L., Ryder, G., 1981. Effects of disturbance on the productivity and numbers of white pelicans in British Columbia – observations and models. Colonial Waterbirds 4, 2-11.

Burger, J., 1981a. Behavioural responses of herring gulls *Larus argentatus* to aircraft noise. Environmental Pollution Series A 24, 177-184.

Burger, J., 1981b. The effect of human activity on birds at a coastal bay. Biological Conservation 21, 231-241.

Delaney, D.K., Grubb, T.G., Beier, P., Pater, L.L., Reiser, M.H., 1999. Effects of helicopter noise on Mexican spotted owls. Journal of Wildlife Management 63, 60-76.

Garratt, J.R., 1992. The atmospheric boundary layer. Cambridge University Press, Cambridge, UK.

Gill, J.A., Norris, K., Sutherland, W.J., 2001. Why behavioural responses may not reflect the population consequences of human disturbance. Biological Conservation 97, 265-268.

Grubb, T.G., King, R.M., 1991. Assessing human disturbance of breeding bald eagles with classification tree models. The Journal of Wildlife Management 55, 500-511.

Komenda-Zehnder, S., Bruderer, B., 2002. Einfluss des Flugverkehrs auf die Avifauna – Literaturstudie. Schriftenreihe Umwelt Nr. 344. Bundesamt für Umwelt, Wald und Landschaft, Bern.

Küsters, E., van Raden, H., 1998. Zum Einfluss militärischen Schießbetriebs auf Vögel im Wattenmeer. Zeitschrift für Jagdwissenschaft 44, 221-236.

Larkin, R.P., Torre-Bueno, J.R., Griffin, D.R., Walcott, C., 1975. Reactions of migrating birds to lights and aircraft. Proceedings of the National Academy of Sciences of the United States of America 72, 1994-1996.

Owens, N.W., 1977. Responses of wintering brent geese to human disturbance. Wildfowl 28, 5-14.

Shamoun-Baranes, J., van Loon, E., van Gasteren, H., van Belle, J., Bouten, W., Buurma, L., 2006. A comparative analysis of the influence of weather on the flight altitude of birds. Bulletin of the American Meteorological Society 87, 47-61.

Sokal, R.R., Rohlf, F.J., 1981. Biometry. W.H. Freeman, New York.

Sossinka, R., Niemann, J., 1994. Störungen von Entenvögeln durch Hubschrauber nach Untersuchungen an der Weserstaustufe Schlüsselburg. Artenschutzreport 4, 19-21.

Stalmaster, M.V., Kaiser, J.L., 1997. Flushing responses of wintering bald eagles to military activity. Journal of Wildlife Management 61, 1307-1313.

Stock, M., Hofeditz, F., 1994. Beeinflussen Flugbetrieb und Freizeitaktivitäten das Aktivitätsmuster von Ringelgänsen (*Branta bernicla*) im Wattenmeer? Artenschutzreport 4, 13-19.

Teufelbauer, N., Frank, G. (in press). Donauauen östlich von Wien, in: Dvorak, M. (Ed.), Important Bird Areas in Österreich, 2nd Edition. BirdLife Austria, Vienna.

Thoby, A., 2006: Veränderungen der Greifvogelfauna in den Donau-Auen östlich von Wien, am Beispiel der Wälder im Gebiet des Nationalpark Donau-Auen. Diplomarbeit, Universität Wien.

Trimper, P.G., Standen, N.M., Lye, L.M., Lemon, D., Chubbs, T.E., Humphries, G.W., 1998. Effects of low-level jet aircraft noise on the behaviour of nesting osprey. Journal of Applied Ecology 35, 122-130.

Vienna International Airport, 2008. Flugbewegungsaufteilung im Linien- und Charterverkehr 2007 nach Pistenrichtung in Absolut und Prozent. http://www.vie-umwelt.at/jart/prj3/via/resources/uploads/Umwelt/LC_2007.pdf (accessed 01/06/2008).

Ward, D.H., Stehn, R.A., Erickson, W.P., Derksen, D.V., 1999. Response of fall-staging brant and canada geese to aircraft overflights in southwestern Alaska. Journal of Wildlife Management 63, 373-381.

# Zusätzliche Ergebnisse

Im Folgenden werden kurz Ergebnisse der Felderhebungen dargestellt, die in der Publikation nicht erwähnt werden. Eine Auflistung der erfassten Arten findet sich in Abb. 1. Es wurden eine ganze Reihe sensibler Arten, die im Anhang I der Vogelschutzrichtlinie gelistet sind, beobachtet (Weißstorch, Schwarzstorch, Schwarzmilan, Wespenbussard, Seeadler, Flussseeschwalbe, Schwarzspecht). Bei der statistischen Auswertung kamen Spearman-Rangkorrelationen ($r_s$) und $\chi^2$-Test zur Anwendung.

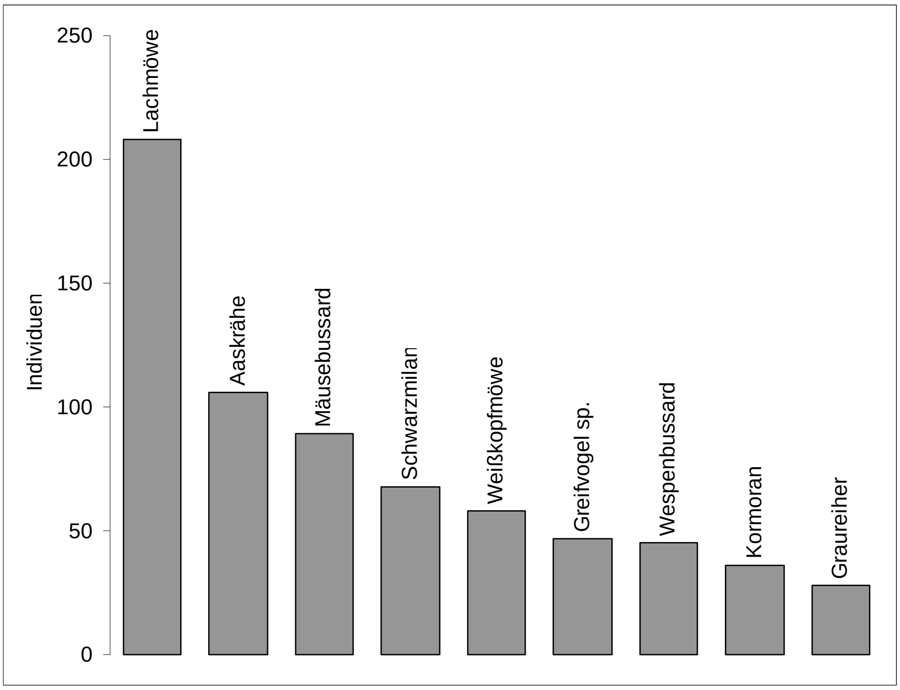



**Abb. 1.** Zahl der Sichtungen pro Art.

## 7. Zusätzliche Ergebnisse zur Aktivität

Zwischen Vogel- und Flugverkehrsaktivität im Tagesablauf wurden signifikante Zusammenhänge gefunden (ALLE ARTEN: $r_s$=0.83, $p$ < 0.05, GREIFVÖGEL: $r_s$ = 0.94, $p$ < 0.05, n jeweils 6; Abb. 2). Dieser Zusammenhang ist auf das Auftreten von Südwinden zurückzuführen, da sowohl der Flugverkehr als auch ALLE ARTEN und GREIFVÖGEL eine signifikante Bevorzugung von Südwinden aufweisen ($\chi^2$ = 22.98, $p$ < 0.001, $df$ = 3 resp. $\chi^2$ = 26.51, $p$ < 0.001, $df$ = 3). Flugzeuge müssen aus Sicherheitsgründen gegen den

Wind starten und landen (http://www.vie-umwelt.at/jart/prj3/via/umwelt.jart?rel=de&content-id=1174475986782&reserve-mode=active). Die für den Nationalpark relevante Piste 16/34 ist Nord-Süd ausgerichtet, wodurch das signifikant häufigere Auftreten von Flugzeugen während südlicher Winde erklärbar ist. Die Bevorzugung südlicher Windverhältnisse bei Vögeln ist für uns dagegen nicht nachvollziehbar. Da die Aktivität von Vögeln und der Flugbetrieb bei südlicher Windrichtung am höchsten waren, wurde kein Unterschied in der Anzahl der Vögel zwischen Windrichtungen gefunden bei einem Vergleich von Intervallen mit und ohne Flugbetrieb ($\chi^2 = 5.09$, $p > 0.05$, $df = 3$).

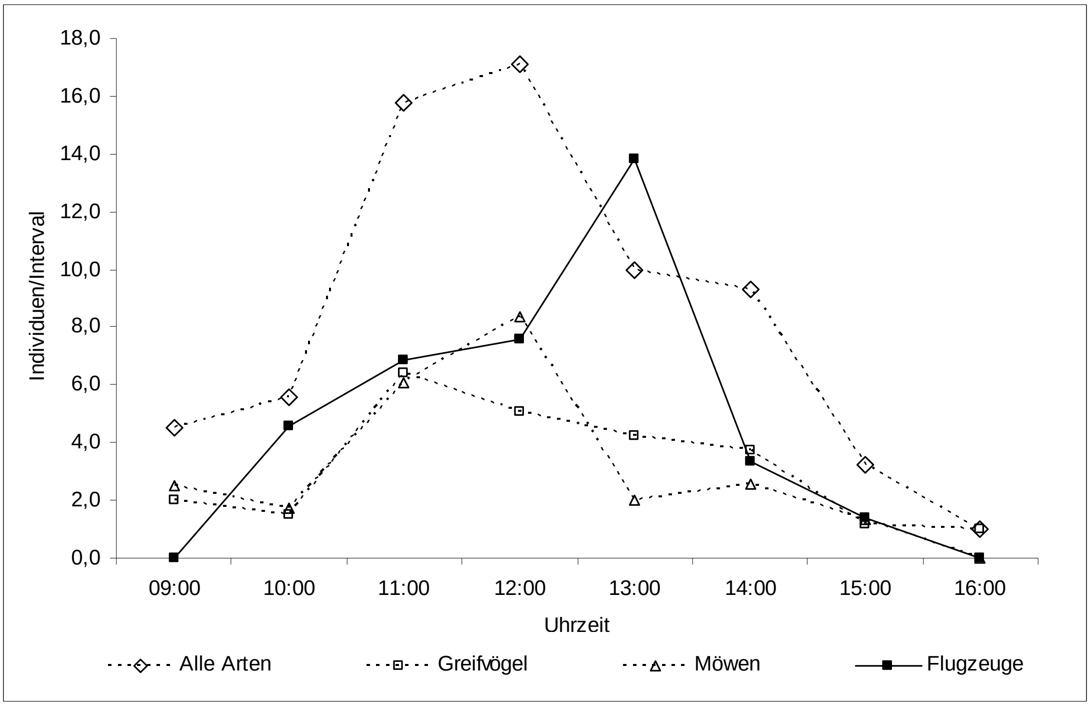



**Abb. 2.** Tageszeitliches Auftreten der untersuchten Vogelgruppen sowie tageszeitliche Entwicklung des Flugverkehrs.

# 8. Überprüfung direkter Effekte

Überfliegende Flugzeuge wirkten sich nicht auf das Verhalten der Tiere aus (Abb. 3). Da aber nur die Verhaltensweisen „kreisend“, „Streckenflug“ und „sitzend“ in ausreichender Stichprobe vorhanden waren, war eine messbare Auswirkung auf das Verhalten nicht zu erwarten.

Die Flugrichtung unterschied sich nicht zwischen Intervallen mit und ohne Flugbetrieb ($\chi^2 = 1.37$, $p > 0.05$, $df = 1$). Auch innerhalb eines 600 m Bereiches um die *centreline* (mittlere Fluglinie der Flugzeuge) war kein Unterschied ersichtlich ($\chi^2 = 1.19$, $p > 0.05$, $df = 1$). Unsere Auswertung zeigte eine Meidung des Flugkorridors bei Individuen in Flughöhen bis 25 m (s. Manuskript). Es wird vermutet, dass das Herannahen des Flugzeugs durch die an die Donau angrenzende Baumkulisse für die Vögel nicht ersichtlich ist (Überraschungseffekt). Eine derartige Unterteilung der Individuen in unter- und oberhalb des Baumhorizonts war jedoch für die Flugrichtungen nicht möglich. Daher kann nicht nachvollzogen werden, ob es einen ähnlichen Überraschungseffekt auch bei der Flugrichtung gibt.

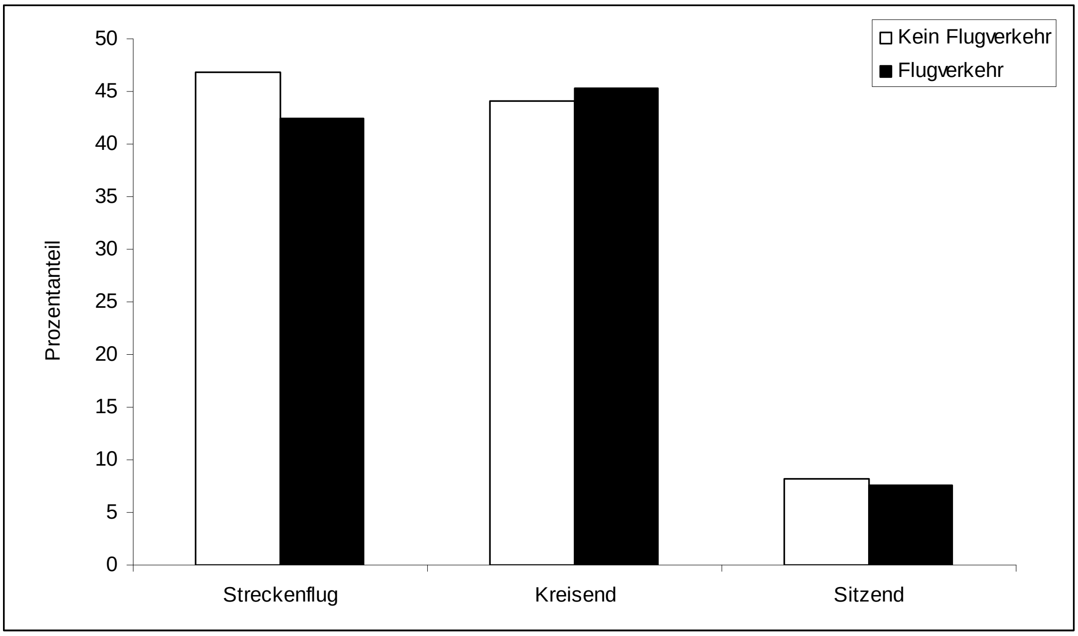



**Abb. 3.** Beobachtetes Verhalten in Abhängigkeit vom Flugverkehr.

# Zusammenfassung

In der vorliegenden Studie konzentrierten wir uns auf auffällige Muster in der Aktivität und der Raumnutzung von Großvögeln, die eine Meidung der Flugschneise vermuten ließen. Die beobachteten Großvögel umfassten sensible Arten wie Weiß- und Schwarzstorch, Schwarzmilan oder Wespenbussard. Wir führten regelmäßige Scans fliegender Vögel von einem Beobachtungspunkt unterhalb der Flugschneise aus. Für die Analyse wurden die erfassten Individuen in drei Gruppen eingeteilt: ALLE ARTEN, MÖWEN und GREIFVÖGEL.

Bei ALLEN ARTEN und MÖWEN wurde eine Reduktion der Flugaktivität in unmittelbarer Umgebung von der Flugschneise festgestellt. In einem Bereich von 400-800 m um die mittlere Fluglinie (*centreline*) kam es bei Flugbetrieb zu einer Reduktion der Flugaktivität um 40% bei ALLEN ARTEN bzw. 70% bei MÖWEN. GREIFVÖGEL zeigten keine offensichtliche Reduktion. Weiters zeigte sich, dass es zu einer Veränderung in der Raumnutzung sowohl in vertikaler wie auch horizontaler Richtung kam. Bei allen drei untersuchten Gruppen kam es zu einer Alteration der Flughöhe. Bei geringer Bewölkung (< 50%) wurde bei Flugverkehr eine Zunahme in der Flughöhe der beobachteten Individuen festgestellt, bei starker Bewölkung (≥ 50%) verringerten die Vögel ihre Flughöhe. Bei ALLEN ARTEN und bei den MÖWEN kam es über der Donau bei Flugverkehr zu einer Vergrößerung der lateralen Distanz zur *centreline*. Diese vergrößerte sich bei Flugbetrieb um 52,5% bei ALLEN ARTEN und um 162% bei MÖWEN. Dies war aber nur bei Individuen mit geringer Flughöhe (≤ 25 m) feststellbar. Wir vermuten hier einen Überraschungseffekt, da Vögel in niedrigen Flughöhen direkt über der Donau flogen und durch die Baumbestände am Ufer der Donau die Flugzeuge erst spät entdeckten. Weiters vermuten wir, dass eine prinzipielle Meidung des Flugkorridors über den Baumkronen vorherrscht. Die geringsten Distanzen zur *centreline* wurden unter 25 m bei fehlendem Flugverkehr gemessen. Über 25 m wurden hingegen, unabhängig vom Flugbetrieb, immer Entfernungen von etwa 600 m (Median) zur Mittellinie festgestellt.

# Folgerungen für den Nationalpark Donauauen

Die Wirkung eines Störereignisses durch Flugzeuge beruht auf dem Zusammenspiel zahlreicher Faktoren und einer damit einhergehenden wechselnden Handlungsbereitschaft eines Vogels, in einem bestimmten Ausmaß zu reagieren. Durch diese Komplexität ist eine Beantwortung der Frage, inwieweit die Flugschneise über dem Nationalpark negative Auswirkungen hat, ausgesprochen schwierig. Insbesondere die Auswirkungen auf den Brutbestand sensibler Arten und deren Entwicklung lässt sich nur im Rahmen aufwändiger Untersuchungen feststellen. Zusätzlich besteht die Problematik, dass eventuell bereits vorhandene Habituationseffekte nur schwer nachvollzogen und geprüft werden können.

Trotz der oben beschriebenen Problematiken konnte ein negativer Einfluss des Flugverkehrs festgestellt werden. Besonders sensibel reagierten die Vögel in einem Bereich von 400-800 m um die *centreline*. Nimmt man eine mittlere Entfernung von 600 m, wären 480 ha des Nationalparks betroffen. Hier ist zu betonen, dass es sich um besonders sensible Bereiche wie das Kühwörther Wasser oder das Mittelwasser handelt. Ein Überraschungseffekt wie über der Donau ist auch bei diesen Altarmen zu erwarten. Wie stark dieses Gebiet entwertet wird, kann jedoch nur schwer beurteilt werden. Mit Sicherheit nutzen Reiher, Enten- oder Möwenvögel die Gebiete unter der Flugschneise in dem oben dargestellten Bereich bei Flugverkehr nur in einem eingeschränkten Ausmaß. Falls die Vermutung zutrifft, dass Greifvögel schon eine Anpassung aufweisen und die Flugschneise prinzipiell meiden, würde dies auch für diese Gruppe zutreffen. Über mögliche Auswirkungen auf Populationsebene können aufgrund der durchgeführten Felduntersuchungen keine Aussagen getroffen werden. Einen Hinweis auf derartige Einflüsse vermutet Thoby (2006) aufgrund einer Lücke in der Verteilung von Greifvogel-Horsten unterhalb der Flugschneise. Das Verschwinden der Graureiherkolonie in Mühlleiten im Jahr 1983 wurde auf menschliche Störungen wie Schlägerungen vor Ort und das Errichten von Pumpwerken im Jahre 1966 zurückgeführt (Festetics 1970, Ranner 1991). In den Jahren 1976-1978 wurde die Piste 16/34 gebaut. Inwieweit die Inbetriebnahme eine zusätzliche Störungsquelle darstellte, kann nachträglich jedoch schwer nachvollzogen werden.

Um genauere Aussagen über die auf sensible Arten wirkende Belastung durch den Flugverkehr zu erhalten, wären Studien über die gesamte Länge der Flugschneise notwendig. Mögliche Ansätze wären Horstbeobachtungen z.B. von Schwarzmilanen, Nutzung der Altarme oder das Auswerten der Quantität von Stresshormonen in Kotproben.

# 9. Literatur

Festetics, A., 1970: Die Donaauen „Untere Lobau" – Vorschlag zur Errichtung eines Greifvogelreservates. Natur & Land 56: 73-81.

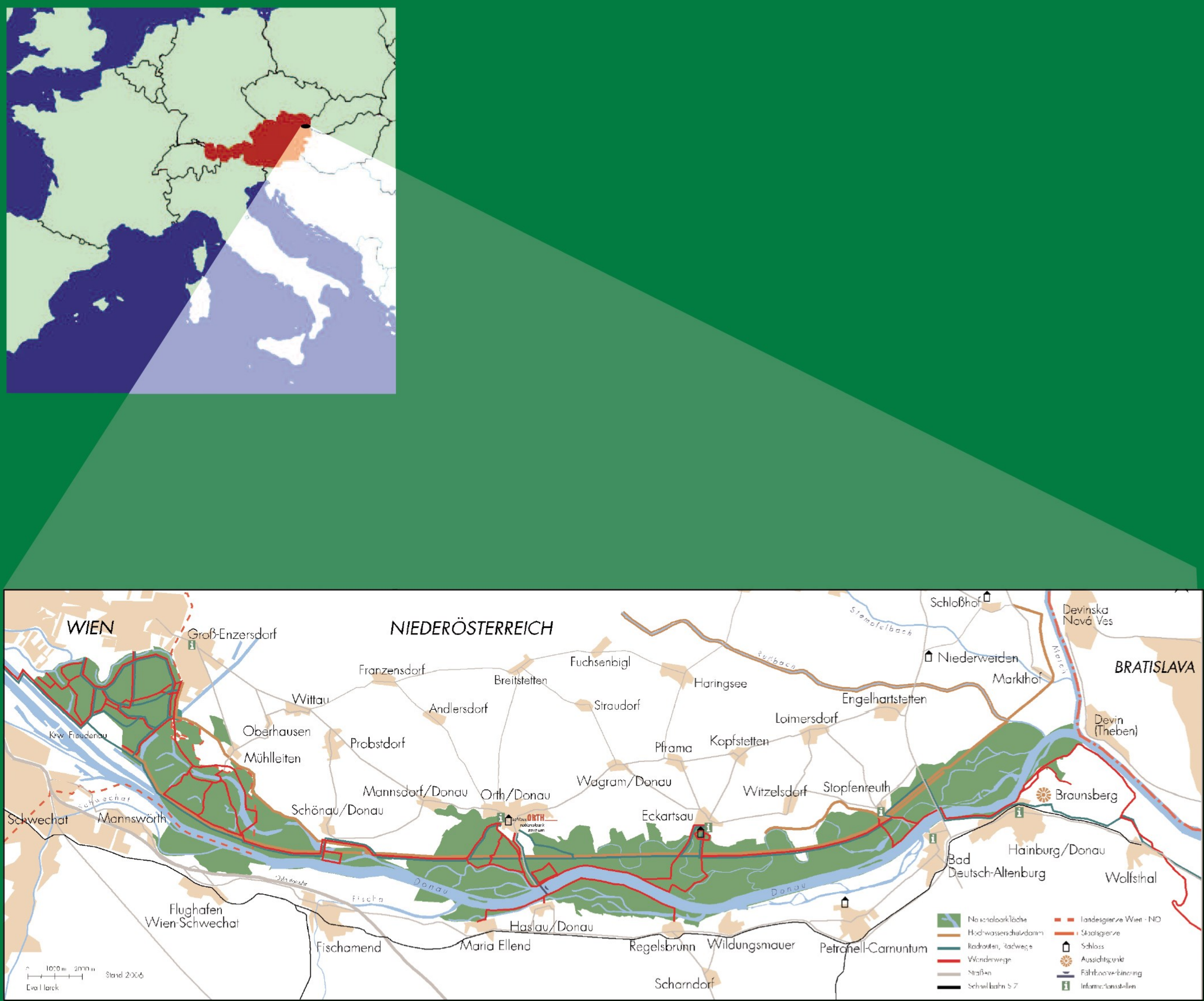
Ranner, A., 1991: Verbreitung und Bestand des Graureihers (*Ardea cinerea*) in Österreich. Vogelschutz 6. BirdLife Österreich. Wien: 31-40.

Thoby, A., 2006: Veränderungen der Greifvogelfauna in den Donau-Auen östlich von Wien, am Beispiel der Wälder im Gebiet des Nationalpark Donau-Auen. Diplomarbeit, Universität Wien.

- Herausgeber: Nationalpark Donau-Auen GmbH
- Titelbild: N. Teufelbauer
- Für den Inhalt sind die Autoren verantwortlich
- Für den privaten Gebrauch beliebig zu vervielfältigen
- Nutzungsrechte der wissenschaftlichen Daten verbleiben beim Rechtsinhaber
- Als pdf-Datei direkt zu beziehen unter www.donauauen.at



- Zitiervorschlag: MURAOKA, Y., TEUFELBAUER, N., WICHMANN, G. (2016) Auswirkungen von Flugzeug-Einflugschneisen auf die Vogelwelt unter besonderer Berücksichtigung von Großvögeln und Arten aus dem Anhang I der EU-Vogelschutzrichtlinie, Teil 2: Freilandstudie und Folgerungen für den Nationalpark Donau-Auen. Wissenschaftliche Reihe Nationalpark Donau-Auen, Heft 46



Nationalpark Donau-Auen GmbH
A-2304 Orth/Donau, Schloss Orth
Tel. 02212/3450, Fax DW 17
nationalpark@donauauen.at, www.donauauen.at


KOSTBARE NATUR FÜR GENERATIONEN