Comments on the report “Wind Energy Developments and Natura 2000”, edited by the European Commission in October 2010

(http://ec.europa.eu/environment/nature/natura2000/management/docs/Wind_farms.pdf).

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(1) The EU guidance ANNEX II: Bird species considered to be particularly vulnerable to wind farms- Bird strike / collision

Introduction

The EU Guidance on wind energy development in accordance with the EU nature legislation (thereafter called EU Guidance) listed several bird species which are subject to different types of detrimental effects by wind farms. The explanations below should clarify that the following summary statement of the EU Guidance (p. 102) on onshore collision fatalities of birds doesn´t match the current state of research: "*Collision rates are overall very low, but with the noteworthy exception of high frequency of fatalities involving raptors. Special concern has to be raised for e.g. Eurasian Griffon Vulture (Gyps fulvus), Egyptian Vulture (Neophron percnopterus), White-tailed Eagle (Haliaeetus albicilla), Golden Eagle (Aquila chrysaetos), Red Kite (Milvus milvus) and Common Kestrel (Falco tinnunculus). Single cases with high number of fatalities at various locations in e.g. California, Spain and Norway have attracted wide-spread publicity, but risks are highly site-specific*.” A thorough examination of the German list of wind turbine fatalities shows that EU-list is incomplete regarding especially the bird strike / collision risk of several species.

To my knowledge no long-term, wide-ranging, systematic and all-species-covering bird fatality searches like those in California (Smallwood 2010) were done until now in European wind farms. An exception is the study on Smola in Norway (Bevanger et al. 2009b). However, this is not a typical site for a European windfarm and the number of bird species living there is small, especially in the strong snowy winters. Furthermore, no representative sampling or comprehensive recording of wind turbine fatalities even of single species exists in any European country to my knowledge. Apart from some vulture and eagle species and the Red kite (Camiña 2008, Carrete etal. 2009, Dürr 2009, Nygård et al. 2010), there is a apparent lack of comprehensive data which prevents scientifically sound extrapolations of wind turbine casualties for bird populations of greater areas or whole countries.

Extrapolations using the collision risk model proposed by the so-called “Band model” which largely depend on the precise estimation of avoidance rates (Chamberlain et al. 2006) or better called correction factor (which encompass different sources of error, May et al. 2010) are not reliable currently because “avoidance rates” are calculated indirectly by dividing the estimated actual mortality rate by the number of birds flying through the rotor disc area instead of using direct behavioural observations. That calculation procedure is subject to substantial observer, stochastic and systematic error (Chamberlain et al. 2006, May et al. 2010). One main source of error is the mortality estimation, which depends on the same poor data basis - as shown above - for almost all European bird species.

Summing up, the knowledge of the specific collision vulnerability or risk of European bird species is poor. This makes it even more important to use all the available information. However, the EU Guidance document missed several studies available in 2010, especially from non-English speaking countries; for example, the German wind turbine fatality data base compiled by the bird conservation agency of the federal state of Brandenburg which has been available on the internet for several years (http://www.mugv.brandenburg.de/cms/media.php/lbm1.a.2334.de/wka_vogel.xls).

Deduction of collision vulnerabilities of bird species at wind turbines from the German fatality list

Wind turbines in Germany

Since 1990, most German wind turbines have been erected on the mainland. In 2010 the first offshore windfarm began operating in Germany near the island Borkum. In the first decade most wind turbines were installed in coastal (onshore) areas, in the second decade wind farms expanded into mainland areas in northern Germany. So the actual distribution of wind turbines shows much more wind turbines in northern Germany than in southern (http://windmonitor.iwes.fraunhofer.de/windwebdad/www_reisi_page_new.show_page?page_nr=20&lang=en).

The number of German wind turbines increased from 228 in 1990 to 21,315 in 2010 (30 June). The mean size of wind turbines, expressed as the installed (rated) power increased continuously from an average of about 0.16 MW in 1991 to 2.01 MW in 2009 (http://www.dewi.de/dewi/fileadmin/pdf/publications/Statistics%20Pressemitteilungen/30.06.10/Statistik_1HJ_2010.pdf).

To my knowledge, the vast majority of German wind turbines were installed in agricultural areas avoiding wetlands, woods and Important Bird Areas.

The German fatality list

The German list of bird casualties was compiled by Tobias Dürr (LUGV, federal state Brandenburg) from 1989 through to January 2011. The list contains casualties which were accidently found by the general public and casualties from special fatality searches (e.g. 55% for the Red Kite, Dürr 2009). Only fatalities which were reported to Tobias Dürr (there is no commitment to report) or casualties found by him in the field and in published and unpublished (grey) literature (so far as known and accessible) are included in the list. Only a small fraction of reported casualties are from the period 1989-2003 when the public awareness of the collision problem was not yet established and fatality searches for collision victims were very rare, especially before 2001. Fatality searches, e.g. from impact studies with attendant monitoring, were added to the list mainly from 2004 onwards.

Only a very small fraction of collision victims can be found accidently by the general public and an unknown (I assume a substantial) proportion of these finds will not even be reported to the compiler for varying reasons, e.g. lack of knowledge, convenience and fear of official constraints on wind turbine operation. Furthermore fatality searches were done only in a small portion of all wind turbines. Therefore, it must be concluded that only a very small proportion of bird strikes at German wind turbines are included in the German list.

Deduction procedure

First, the total number of wind turbine casualties (**no. 1 in the attached table**) was divided by the number of individuals in the breeding population to roughly estimate the percentage of collisions (**no. 2 in the table**). The number of breeding individuals was calculated from the number of breeding pairs in Germany (mean of estimated population ranges in 2005, Südbeck et al. 2007) multiplied by two.

Several bird species with high breeding populations from which only one fatality was found and reported (mainly Passerines) were excluded from further examination, while some Non-Passerines (e.g. owls) without reported fatalities detection were added. Altogether 91 bird (64 Non-Passeriformes, 27 Passeriformes) species were considered.

Single absolute numbers of collision rate percentages are of little informative value because only a very small fraction of casualties are known and because the casualties are coming from a 22-year period but the breeding numbers from only one year. Furthermore, the base year 2005 may not represent the average population level of the 22-year-period. Also, the increasing numbers of wind turbines in the period 1989-2010 hinder an interpretation of the calculated mean collision rates of single species.

However useful information for single species could be derived by relating the calculated collision rate of a species to the calculated rate of species with a well known high collision vulnerability at wind turbines like Red Kite and White-tailed eagle (Dürr 2009, Mammen et al. 2009, Nygard et al. 2010; May et al. 2010).

As expected, White-tailed eagle and Red kite are the species with highest calculated collision rates (table). The great majority of species with a higher collision ranking belong to the Non-Passeriformes which are on average bigger and longer-lived than the Passeriformes. Nine diurnal and nocturnal raptor species and the White stork show highest fatality rates from 5.734% (White tailed eagle) to 0.144% (Black kite) whereas the 13 species with collision rates smaller than 0.001% are 11 small Passeriformes and 2 small Non-Passeriformes (1 dove, 1 woodpecker) species. There are some outliers (only species with at least 3 casualties were considered here): Corn bunting (0.044%) and Wheatear (0.032%) are the only small Passeriformes species with calculated collision rates higher than 0.006% and Grey heron (0.005%), Greylag goose (0.008%) and Crane (0.028%) show the lowest collision rates for big Non-Passeriformes species.

In a second step, I give a rough classification of biological characteristics of the bird species which might influence the collision and corpse recovery rate and therefore affect the interpretation of the relative collision rates.

The collision rate of migrant species (**column a) in the table**) which live only 3-6 months a year in Germany is likely to be underestimated compared to species living the whole year in Germany because the corpse recovery rate is probably lower in the breeding season with green vegetation preventing the location of dead bird corpses, especially in dense agricultural vegetation where most wind turbines are located. Furthermore, migrating species could collide with wind turbines on migration outside Germany which is not represented in the German list.

When calculating collision rates, breeding birds are not the appropriate reference base for bird species with high non-breeding populations (non-breeding floaters, staging/wintering birds). In a rough estimate I identified bird species where the non-breeding population - living at least for 4-6 months a year in Germany- is much greater than the German breeding population (**column b) in the table**).

It is evident that the recovery rate of dead corpses depends heavily on body size of the species, i.e. smaller birds will be overlooked more frequently than bigger ones. Furthermore, bigger corpses will decay more slowly than smaller ones and scavengers will remove smaller corpses more quickly than bigger ones. In **column c) in the table** I roughly distinguished 5 bird size classes from very small to very big.

Habitat is another factor with possible effects on collision rate and reporting probability (**column d) in the table**). Birds breeding in woodlands, in particular, have to be considered separately because finding a dead bird after collision with a wind turbine in woodland will be more difficult than finding a corpse in agricultural fields, especially in the winter period. It is also conceivable that corpses are caught by the foliage and cannot be found on the ground. This methodological bias is likely to be highest for those species that live exclusively in woodland like some woodpecker and owl species and lowest for those species which only breed in woodland but hunted mainly outside woodland like Hobby or Grey heron. Therefore, it is reasonable to conclude that the calculated collision rates of woodland bird species are underestimated in relation to those of other bird species. In this context, it is important to know that until now only a very small proportion of German wind turbines are situated in woodland and special bird fatality searches are missing there to my knowledge. Therefore, some differences in collision rates of woodland birds and of birds of open habitats should be real, resulting from this very unequal current distribution of German wind turbines. A typical example is the Golden eagle which breeds in the higher wooded parts of south Germany where wind turbines are absent at all, in woodland and open land.

I tried to integrate the four aspects a), b), c) and d) in one aspect e) which I called the probability of finding casualties in the time period 1989-2010 (**column e) in the table**). I divided the roughly estimated corpse recovery probabilities into four classes from a very low to a very high probability.

Collision risk assessment

Then I estimated the collision risk of the species, which was based primarily on the collision rate in relation to the finding probability and the collision rate of the Red kite and White-tailed eagle (**column f) in the table**). I distinguished qualitatively five risk classes from very low/none (equals 1) to very high (equals 5) with some classifications in-between. My risk assessment does not take into account the possible consequences of collision rates on population levels and population structure (see below). Where the data basis was deficient, collision rates of species with similar morphology and ecology (an important behavioural aspect was flight/hunting altitudes) and/or collision data from published studies (e.g. Barrios & Rodrígues 2004, Bevanger et al. 2009b, Everaert 2008, Lekuona & Ursúa 2007) were considered. For example, no Hen harrier was found and reported killed under German wind turbines until now but the flight behaviour of this harrier species is very similar to that of the Montagu's and Marsh harrier (both are classified with high collision risk). Additionally, there are some documented Hen harrier fatalities from wind farms in Spain and Northern Ireland. Since the breeding population of hen harriers in Germany is very small and nearly restricted to the North Sea islands where wind turbines are rare, the probability of finding a Hen harrier as a wind turbine fatality is very low. On the other hand, there is a substantial number of hen harriers over-wintering in Germany and some avoidance of wind farm areas was found in uplands (Pearce-Higgins et al. 2009). Combining all that information, the Hen harrier was ranked in the second highest collision risk class with a question mark.

In the **column g) in the table** I qualitatively distinguished 3 classes of data coverage (good, medium, deficient) which gives an estimate of the reliability of the collision risk assessments. When I assumed a low reliability for a collision risk indexing I put a question mark in the column f), if possible with the indication of the presumed direction (lower or higher assessment).

The final assessment assigns 31 species (16 species with a question mark) to the two classes of **high and very high collision risk**. These classes contain 20 raptor and owl species, 8 further Non-Passeriformes and only 3 Passeriformes (Great grey shrike, Raven and Corn bunting). The classes of **medium and small collision risk** comprise 30 Non-Passeriformes and 6 Passeriformes species (32 species with a question mark), which are mostly medium and smaller sized species. 22 medium and smaller sized species (9 with a question mark for higher risk) represent the last **class of very small collision risk** with 18 Passeriformes and 6 Non-Passeriformes (3 dove species, 2 woodpecker species, Little owl). The predominance of bigger bird species (mainly Non-Passeriformes) and raptors in the list of bird species of high collision risk at wind turbines was also described in a review by Drewitt & Langston (2008). Some outliers from this trend like Greylag goose and Crane could be explained by the far reaching avoidance reaction to wind turbines which was found in some resting geese species and migrating Cranes.

Finally I translated the 5 collision risk classes from column f) into the classification system of the EU Guidance (**column h) in the table)** which distinguished qualitatively 5 classes of bird strike / collision risk (with some classifications in between).

I equalised

- **evidence of substantial risk** (XXX, EU Guidance) with very high risk (my class 5),
- **evidence or indication of risk** (XX, EU Guidance) with high risk (my class 4),
- **potential risk** (X, EU Guidance) with medium risk (my class 3),
- **small or non-significant risk** (x, EU Guidance) with low risk (my class 2),
- **no risk** [my addition] (no entry, EU Guidance) with very low risk (my class 1).

In the last **column i) in the table** I listed the risk assessment of the EU Guidance document using a comparable numerical classification system.

That way the two assessment systems (**column h and I**) could be compared. The EU Guidance misses 9 species of the 31 species, which I assessed with a high or very high collision risk and classifies a further 16 species in lower risk classes and only 6 species in the same risk class.

From the 36 species which I assessed with a medium or small collision risk, the EU Guidance misses 24 species, classifies a further 3 species in lower risk classes and 8 species in the same risk class, but only 1 species (Lapwing) in a higher risk class.

The assessments of the remaining 22 species of low or missing collision risk were very similar.

Conclusion

The presented risk assessment of 91 bird species is based on 1148 wind turbine fatalities of 83 bird species from the German wind turbine fatality database and takes into account methodological constraints, the biology of species and published results (mainly from Europe, not cited in detail here). This additional information and the detailed explanation of the assessment procedure should considerably enhance the coverage and reliability to the assessment made by the EU Guidance document in Annex II. In this document, several risk assessments were made on a poor data basis: 57 out of 91 species got a question mark in column f) of the table. But in 24 of those cases I assumed a higher risk class might be more likely and in all 8 cases where I assumed a lower risk class might be more likely the next lower risk class was still high or medium.

The EU Guidance recognizes the internationally accepted precautionary principle (IUCN 2007) e.g. on page 67: "*The emphasis should be on objectively demonstrating, with reliable supporting evidence, that there will be no adverse effects on the Natura 2000 site. For this reason, the lack of scientific data or information on the potential risk or significance of impacts cannot be a reason to proceed with the plan or project*." Carrete et al. (2010) re-affirmed the need for applying this principle to minimize the impact of wind-farms on populations, especially of long-lived species.

Therefore, a revision of Annex II of the EU Guidance is required which considers also the new information derived from the German fatality list. The application of the precautionary principle needs to incorporate also collision risk assessments which are based on a poor data basis but give plausible arguments for a potential significant risk.

Certainly a revision of Annex II should add further bird species with collision risk which are not in the focus of the German fatality list and further species should get a higher collision risk ranking which the EU Guidance classified carrying a low risk. Some relevant raptor, wetland and grouse species can be found e.g. in Vasilikas et al. (2009), Lekuona & Ursúa (2007), Bevanger et al. (2009b), Everaert (2008) and Zeiler et al. (2009).

Further aspects of collision mortality in wind farms

The EU Guidance mentioned the collision with **turbine towers** only for bat species. However, a few studies show that some bird species were frequently found dead immediately at the tower base, especially species with a high wing loading like grouse species (Bevanger et al. 2009b, 2010, Zeiler et al. 2009). Most Corn buntings and Red-backed shrikes of the German fatality list were also found at the base of white painted towers; these towers are possibly poorly visible under special light conditions (T. Dürr personal comm.). Colliding with wind turbine towers is possibly a major risk for woodland species with straight flight and high wing loading like grouse and woodpecker species, for nocturnal woodland species like owls and Nightjars and for raptors hunting inside woods like Goshawk and Sparrowhawk. However there is general paucity of studies on the collision risk at wind turbines in woodland. Such data are urgently required because more wind turbines are planned in woodland e.g. in some regions of Germany (for a pilot study on the Tengmalm´s owl see Loose 2009). As long as no sound results are produced the precautionary principle has to be applied.

Although some studies have been done on the first European **off shore wind farms**, the actual number and species composition of bird fatalities at offshore wind farms is not known. Fatality searches are exceptionally difficult in open water and were replaced by modelling using collision risk models and radar studies. As shown above, all models depend heavily on the input of an "avoidance rate" which is unknown e.g. for night migrating bird species in the Baltic Sea (Bellebaum et al. 2010). Fatality studies at Danish lighthouses show that some night migrating species are attracted to lights, which are also present on offshore wind turbines in order to warn ships and aircraft. On an unmanned research platform in the North Sea with a 80 m high pylon several hundreds bird casualties were found during 159 visits, more than 50% in two nights (Hüppop et al. 2009). Therefore, it is possible that some night migrating species would suffer heavy strike losses in offshore wind farms at least under special weather/moonlight conditions (Hüppop et al. 2009, Bellebaum et al. 2010) with possible detrimental effects on raptor and waterbird populations (Desholm 2009). There is some indication that some wetland species (mainly Non-Passeriformes) and thermal soaring raptors succumb to collision risk especially with offshore wind turbines installed near the coast (Everaert 2008, Baisner et al. 2010). Therefore the following summary statement of the EU Guidance (p. 102) on offshore collision fatalities of birds needs a revision: "*For offshore locations information about collision fatalities are still limited, but direct observations and radar studies as well as modelling indicate very low risks, as has been shown e.g. for Eider (Somateria mollissima).*"

In chapter 3.4.3 **Repowering of wind farms** the EU-guidance cited only one paper on bat mortality. A revision should add publications on birds and dealing with mitigation measures like these: Länder-Arbeitsgemeinschaft der Vogelschutzwarten (2007), Smallwood (2008), Smallwood et al. (2009), Alameda County SRC (2010), Baisner et al. (2010).

(2) The EU guidance chapter 3.6 Cumulative effects

The following citations are from p. 45-46 of the EU Guidance document:

"*Cumulative effects may arise when several wind farms and their associated structures are present within an area or along a flyway corridor, or as the result of the combined impacts of wind farms and other types of activity (e.g. forestry or other industrial developments). The cumulative effect is the combined effect of all developments taken together but this does not mean that it is simply a sum of the effect of one wind farm plus the effect of a second wind farm. It may be more, it may be less… The key is to determine at what point do accumulated habitat loss (including effective habitat loss due to exclusion), barrier-effect induced increases in energy costs and collision mortality, acting in concert, pose a significant impact.*"

The EU Guidance document stresses the consideration of cumulative effects in the context of wind farms (for a framework see Masden et al. 2010). A revision of this short but very important chapter should include some recent studies illustrating spatiotemporal cumulative mortality effects on raptor population and their demography (Hunt 2002, Carrete et al. 2009, Dürr 2009, Nygård et al. 2010) as well as possible spatiotemporal cumulative disturbance and collision mortality effects on breeding, resting and migrating birds (Desholm M 2003, Pearce-Higgins et al. 2008, Masden et al. 2009, Mendel & Garthe 2010, Bellebaum et al. 2010). Potential cumulative effects were studied e.g. by Tapia et al. (2009), Tellería (2009a,b), Martínez et al. (2010) and Eichhorn & Drechsler (2010) by overlapping current and future distributions of wind turbines and raptors on greater areas.

It is also important to show that population trends are not the only parameter indicating detrimental cumulative effects on bird populations. See p. 34 of the EU Guidance. "*Even if current studies indicate that mortality due to wind farm fatalities is low compared to other factors and may not have affected general population trends so far, the potential collision risk still needs to be studied on a case by case basis and future risks should also take account of the potential cumulative impact of the expected large expansion of wind farm establishments during the next 10-20 years*." In addition to population levels and trends, the demographic structure is also important. Collision mortality could heavily affect the survival of the non-breeding segment (floaters) without primarily recognisable effect on breeding numbers (Hunt 2002). The collision rate of breeding birds could be sex-biased (Stienen et al. 2008) which should also be more detrimental for the long term breeding population trend than a natural sex-ratio. Collision mortality can also transform a self-sustaining population into a sink population which depends on net inputs of immigrants from other populations to maintain its population level (Schaub et al. 2010). Therefore a stable population is not always a healthy population.

In the chapter on cumulative aspects overhead wires should be expressly mentioned in a revision of the EU Guidance because new wind farms need electricity grid connections (see p. 64 of the EU Guidance) at least to the next electric connecting point or to distant points of electric consumption. If cables are installed overhead they represent a significant collision risk for many bird species (e.g. Bevanger et al. 2009a, Rollan et al. 2010, Schaub et. al 2010) which succumb to significant collision risk also at wind turbines. New studies by Martin (2010) and Martin & Shaw (2010) show that collision risks of some bird species at overhead wires could probably not be reduced by attaching optical markers to the cables. Consideration of cumulative population effects is especially important for installations of new long overhead wires connecting onshore and offshore wind farms to distant agglomerations. For example, about 3.500 km of new maximum voltage cables are necessary to effectively distribute and integrate renewable electricity in Germany if renewable electricity production (mainly wind power) increases substantially until 2020 (Deutsche Energie-Agentur 2010).

(3) ANNEX II: Bird species considered to be particularly vulnerable to wind farms- Habitat displacement

Without considering the habitat displacement issue in detail here, I would like to add information for the Corncrake and Quail. Long-term systematic counting of Corncrakes and Quails in a cereal farmland area where the Corncrake exhibit the greatest breeding population in North-Rhine Westphalia (Müller & Illner 2001a) showed that almost all birds of both species avoided the areas around wind turbines in a radius of about 300m (Müller & Illner 2001b). Further studies on the Corncrake in the same region support these findings (Joest 2008). Therefore, I suppose that Corncrake and Quail should classified with "evidence or indication of risk (XX, EU Guidance) or "evidence of substantial risk" for the vulnerability to wind farm- habitat displacement.

Literature

ALAMEDA COUNTY SRC (ESTEP J & SMALLWOOD S) 2010. Guidelines for siting wind turbines recommended for relocation to minimize potential collision-related mortality of four focal raptor species in the Altamont Pass Wind Resource Area. Report, 24 pp. (http://www.altamontsrc.org/alt_doc/p70_src_relocation_guidelines.pdf).

BAISNER A, ANDERSEN J, FINDSEN A, GRANATH S, MADSEN K & DESHOLM M 2010: Minimizing collision risk between migrating raptors and marine wind farms: Development of a spatial planning tool. Environmental Management 46: 801-808.

BARRIOS L & RODRÍGUES A 2004: Behavioural and environmental correlates of soaring-bird mortality at onshore wind turbines. J. Animal Ecology 41: 72-81.

BELLEBAUM J, GRIEGER C, KLEIN R, KÖPPEN U, KUBE J, NEUMANN R, SCHULZ A, SORDYL H & WENDELN H 2010: Ermittlung artbezogener Erheblichkeitsschwellen von Zugvögeln für das Seegebiet der südwestlichen Ostsee bezüglich der Gefährdung des Vogelzuges im Zusammenhang mit dem Kollisionsrisiko an Windenergieanlagen. Final report in German. Actual version March 2010. 333 pp. Forschungsvorhaben des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit, FKZ 0329948 (http://edok01.tib.uni-hannover.de/edoks/e01fb10/624406555.pdf).

BEVANGER K, BARTZKE G, BRØSETH H., GJERSHAUG JO, HANSSEN F, JACOBSEN KO, KVALØY P, MAY R, NYGÅRD T, PEDERSEN HC, REITAN O, REFSNÆS S, STOKKE S & VANG R 2009a: "Optimal design and routing of power lines; ecological, technical and economic perspectives" (OPTIPOL). Progress Report 2009. NINA report 504. 46 pp. (http://www.nina.no/archive/nina/PppBasePdf/rapport/2009/504.pdf).

BEVANGER K, BERNTSEN F., CLAUSEN S, DAHL EL, FLAGSTAD Ø, FOLLESTAD A, HALLEY D, HANSSEN F, HOEL PL, JOHNSEN L, KVALØY P, MAY R, NYGÅRD T, PEDERSEN HC, REITAN O, STEINHEIM Y & VANG R 2009b. "Pre- and post-construction studies of conflicts between birds and wind turbines in coastal Norway" (BirdWind). Progress Report 2009. – NINA REPORT 505. 70 PP. (http://www.nina.no/archive/nina/PppBasePdf/rapport/2009/505.pdf).

BEVANGER K, DAHL EL, GJERSHAUG JO, HALLEY D, HANSSEN F, NYGÅRD T, PEARSON M, PEDERSEN HC & REITAN O 2010: [Avian post-construction studies and EIA for planned ex-tension of the Hitra wind-power plant.]. NINA report 503. 68 pp. Norwegian with English summary (www.nina.no/archive/nina/PppBasePdf/rapport/2010/503.pdf).

CAMIÑA, A 2008: [Renewable energies and conservation of carrion eating birds: The case of the Eurasian Griffon vulture *Gyps fulvus* in northern Spain]. p. 171-180 in: Mayol J & Viada C (ED): Proceedings Congreso Técnico de Conservación de Fauna y Flora Silvestres: Palma de Mallorca, September 2006. Spanish with English summary (http://www.scribd.com/doc/20865239/Camina-2008-Las-energias-renovables-y-las-aves-carroneras-RUMBO-DEL-ARCA).

CARRETE M, SÁNCHEZ-ZAPATA JA, BENÍTEZ JR, LOBÓN M & DONÁZAR JA 2009: Large scale risk-assessment of wind-farms on population viability of a globally endangered long-lived raptor. Biological Conservation 142: 2954-2961 (http://www.ebd.csic.es/carnivoros/personal/carrete/martina/recursos/39.%202009%20Carrete%20et%20al%20(2009c)%20Biol%20Cons.pdf).

CARRETE M, SÁNCHEZ-ZAPATA JA, BENÍTEZ JR, LOBÓN M, CAMIÑA A, LEKUONA JM, MONTELÍO E & DONÁZAR JA 2010: The precautionary principle and wind-farm planning: Data scarcity does not imply absence of effects. Biological Conservation 143: 1829-1830.

CHAMBERLAIN DE, REHFISCH MM, FOX AD, DESHOLM M & ANTHONY SJ 2006: The effect of avoidance rates on bird mortality predictions made by wind turbine collision risk models. Ibis 148 (Suppl 1): 198–202.

DESHOLM M 2003: How much do small-scale changes in flight direction increase overall migration distance? Journal of Avian Biology 34: 155-158.

DESHOLM M 2009: Avian sensitivity to mortality: prioritising migratory bird species for assessment at proposed wind farms. Journal of Environmental Management 46: 801-808.

DEUTSCHE ENERGIE-AGENTUR (ED.) 2010: DENa-Netzstudie II - Integration erneuerbarer Energien in die deutsche Stromversorgung im Zeitraum 2015-2020 mit Ausblick 2025. German summary of the report. 28 pp. (http://www.dena.de/fileadmin/user_upload/Download/Dokumente/Studien___Umfragen/Ergebniszusammenfassung_dena-Netzstudie.pdf).

DREWITT AL & LANGSTON RHW 2008: Collision effects of wind-power generators and other obstacles on birds. Ann. N.Y. Acad. Sci. 1134: 233–266.

DÜRR T 2009: Zur Gefährdung des Rotmilans *Milvus milvus* durch Windenergieanlagen in Deutschland. Informationsdienst Naturschutz Niedersachsen Heft 3: 185-191.

EICHHORN M & DRECHSLER M 2010: Spatial trade-offs between wind power production and bird collision avoidance in agricultural landscapes. Ecology and Society 15: 10 [online] (http://www.ecologyandsociety.org/vol15/iss2/art10).

EUROPEAN COMMISSION (ed) 2010: Guidance Document. Wind energy developments and NATURA 2000. Report, October 2010. 116 pp. (http://ec.europa.eu/environment/nature/natura2000/management/docs/Wind_farms.pdf).

EVERAERT J 2008. [Effects of wind turbines on fauna in Flanders: Study results, discussion and recommendations]. Rapporten van het Instituut voor Natuur- en Bosonderzoek 2008 (rapportnr. INBO.R.2008.44). 174 pp. Dutch with English summary (http://publicaties.vlaanderen.be/ebl-web/do/publicatieSessionFacade/publicatieDownloadAction/downloadVanDetail?method=downloadVanDetail&id=12563).

HÜPPOP O, HILL R, HÜPPOP K & JACHMANN F 2009: Auswirkungen auf den Vogelzug. Begleitforschung im Offshore-Bereich auf Forschungsplattformen in der Nordsee FINOBIRD. Abschlussbericht (Förderkennzeichen 0329983, Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit). 278 pp. (http://www.ifv-vogelwarte.de/files/offshore/FKZ0329983_FINOBIRD_Abschlussbericht.pdf).

HUNT WG 2002:Golden eagles in a perilous landscape: Predicting the effects of mitigation for wind turbine blade-strike mortality. Report P500-02-043F (www.energy.ca.gov/reports/2002-11-04_500-02-043F.PDF).

IUCN (ed) 2007: Guidelines for applying the precautionary principle to biodiversity conservation and natural resource management. As approved by the 67th meeting of the IUCN Council 4-16 May 2007 (http://cmsdata.iucn.org/downloads/ln250507_ppguidelines.pdf).

JOEST R 2008: Bestand, Habitatwahl und Schutz des Wachtelkönigs im Europäischen Vogelschutzgebiet Hellwegbörde in den Jahren 2007 und 2008. Report, 40 pp. Bad Sassendorf Lohne.

LÄNDER-ARBEITSGEMEINSCHAFT DER VOGELSCHUTZWARTEN 2007: [Recommendations for distances of wind turbines to important areas for birds and breeding sites of selected species]. German mit English summary. Berichte zum Vogelschutz 44: 151-153 (http://www.drv-web.de/Downloads/BzV44/BzV_151-153-LAG-VSW-Abstand.pdf).

LEKUONA JM & URSÚA C 2007: Avian mortality in wind power plants of Navarra (northern Spain). P. 177-192 in: De Lucas M, Janss GFE & Ferrer N (eds): Birds and wind farms. Risk assessment and mitigation. Quercus, Madrid.

LOOSE T 2009: Der Rauhfußkauz (*Aegolius funereus*) im Windpark Hartenfelser Kopf - erste Ergebnisse eines Monitorings. Eulen-Rundblick Nr. 59: 18.

MAMMEN U, MAMMEN K, KRATZSCH L, RESETARITZ A & SIANO R 2009: Interactions of Red kites and wind farms: results of radio telemetry and field observations. P. 14-25 in: Hötker H (ed): Birds of Prey and Wind Farms: Analysis of Problems and Possible Solutions. Documentation of an international workshop in Berlin, 21st and 22nd October 2008 (http://bergenhusen.nabu.de/imperia/md/images/bergenhusen/bmuwindkraftundgreifwebsite/birds_of_prey_and_windfarms_documentation_2009.pdf)

MARTIN GR 2010: Bird collisions: a visual or a perceptual problem? BOU Proceedings-Climate Change and Birds. 4 pp. (http://www.bou.org.uk/bouproc-net/ccb/martin.pdf).

MARTIN GR & SHAW JM 2010: Bird collisions with power lines: Failing to see the way ahead? Biological Conservation 143: 2695-2702.

MARTÍNEZ JE, CALVO JF, MARTÍNEZ JA, ZUBEROGOITIA I, CEREZO E, MANRIQUE J, GÓMEZ GJ, NEVADO JC, SÁNCHEZ M, SÁNCHEZ R, BAYO J, PALLARE´S A, GONZÁLEZ C, GÓMEZ JM, PÉREZ P & MOTOS J 2010: Potential impact of wind farms on territories of large eagles in southeastern Spain. Biodivers. Conserv.19: 3757–3767.

MASDEN EA, HAYDON DT, FOX AD, FURNESS RW, BULLMAN R & DESHOLM M 2009: Barriers to movement: impacts of wind farms on migrating birds. ICES Journal of marine Science 66:746–753.

MASDEN EA, FOX AD, FURNESS RW, BULLMAN R & HAYDON DT 2010: Cumulative impact assessments and bird/wind farm interactions: Developing a conceptual framework. Environmental Impact Assessment Review 30: 1-7 (http://www.seaturtle.org/PDF/MasdenEA_2009_EnvironImpactAssessRev.pdf).

MAY R, HOEL PL, LANGSTON R, DAHL EL, BEVANGER K, REITAN O, NYGÅRD T, PEDERSEN HC, RØSKAFT E & STOKKE BG 2010: Collision risk in White-tailed eagles. Modelling collision risk using vantage point observations in Smøla wind-power plant. – NINA Report 639. 25 pp. (http://www.nina.no/Publikasjoner/Publikasjon.aspx?pubid=6204).

NYGÅRD T, BEVANGER K, DAHL EL, FLAGSTAD Ø, FOLLESTAD A, LUND HOEL P, MAY R & REITAN O 2010: A study of White-tailed eagle *Haliaeetus albicilla* movements and mortality at a wind farm in Norway. BOU Proceedings-Climate Change and Birds. 4 pp. (http://www.bou.org.uk/bouproc-net/ccb/nygard-etal.pdf).

MENDEL B & GARTHE S 2010: Kumulative Auswirkungen von Offshore-Windkraftnutzung und Schiffsverkehr am Beispiel der Seetaucher in der Deutschen Bucht. Coastline reports 15: 31-44 (http://databases.eucc-d.de/files/documents/00000954_31-44.pdf).

MÜLLER A. & ILLNER H 2001a: Erfassung des Wachtelkönigs in Nordrhein-Westfalen 1998 bis 2000. LÖBF-Mitteilungen 26: 36-51.

MÜLLER A & ILLNER H 2001b: Beeinfl ussen Windenergieanlagen die Verteilung rufender Wachtelkönige und Wachteln? German presentation on the conference: „Windenergie und Vögel - Ausmaß und Bewältigung eines Konfliktes“, Technische Universität Berlin, 29./30.November 2001.

PEARCE-HIGGINS JW, STEPHEN L, LANGSTON RHW & BRIGHT JA 2008: Assessing the cumulative impacts of wind farms on peatland birds: a case study of Golden plover *Pluvialis apricaria* in Scotland. Mires and Peat 4: 1–13 (http://www.mires-and-peat.net/map04/map_04_01.pdf).

PEARCE-HIGGINS JW, STEPHEN L, LANGSTON RHW, BAIBRIDGE IP & BULLMAN R. 2009: The distribution of breeding birds around upland wind farms. Journal of Applied Ecology 46: 1323-1331.

ROLLAN A, REAL J, BOSCH R, TINTO A & HERNÁNDEZ-MATÍAS A 2010: Modelling the risk of collision with power lines in Bonelli’s eagle *Hieraaetus fasciatus* and its conservation implications. Bird Conservation International 20: 279-294.

SCHAUB M, AEBISCHER A, GIMENEZ O, BERGER S & ARLETTAZ R 2010: Massive immigration balances high anthropogenic mortality in a stable eagle owl population: Lessons for conservation. Biol. Conserv. 143: 1911-1918 (http://xa.yimg.com/kq/groups/4619000/578488749/name/Schaub_BiolCons2010-Bubo.pdf).

SMALLWOOD KS 2008: Assessment of relocation/removal of Altamont Pass wind turbines rated as hazardous by the Alameda County SRC. Alameda County SRC document P-103. 10 pp. (http://www.altamontsrc.org/alt_doc/p103_assessment_of_src_recommendations_to_ relocate_rated_turbines.pdf).

Smallwood KS 2010. Fatality rates in the Altamont Pass Wind Resource Area 1998-2009. Report, 55 pp. (http://www.altamontsrc.org/alt_doc/p145_smallwood_fatality_monitoring_results_12_31_09.pdf).

SMALLWOOD KS; THELANDER CG; MORRISON ML; RUGGE LM 2007: Burrowing owl mortality in the Altamont Pass Wind Resource Area. Journal of Wildlife Management 71: 1513–1524.

Smallwood KS, Neher & Bell DA 2009: Map-based repowering and reorganization of a wind resource area to minimize burrowing owl and other bird fatalities. Energies 2009(2):915-943 (http://www.mdpi.com/1996-1073/2/4/915).

SMALLWOOD KS, BELL DA, SNYDER SA & DIDONATO JE 2010: Novel scavenger removal trials increase wind turbine–caused avian fatality estimates. Journal of Wildlife Management 74: 1089-1097.

Stienen E, Courtens W, Everaert J & Van de Walle M 2008: Sex-biased mortality of Common Terns in wind farm collisions. The Condor 110:154-157.

Südbeck P, Bauer HG, Boschert M, Boye P & Knief W 2007: [The Red List of breeding birds of Germany, 4th edition, 30 November 2007]. Ber. Vogelschutz 44: 23–81. German with English summary (http://www.dda-web.de/downloads/texts/publications/suedbeck_et_al_2007_rote_liste_brutvoegel.pdf).

Tapia L, Domínguez J & Rodríguez L 2009: Using probability of occurrence to assess potential interaction between wind farms and a residual population of golden eagle Aquila chrysaetos in NW Spain. Biodivers Conserv 18:2033–2041.

Tellería JL 2009a: Overlap between wind power plants and Griffon vultures *Gyps fulvus* in Spain. Bird Study 56: 268-271 (http://www.ucm.es/info/zoo/bcv/pdf/2009_BirdStudy_56_268.pdf).

Tellería JL 2009b: Wind power plants and the conservation of birds and bats in Spain: A geographical assessment. Biodiversity and Conservation 18:1781–1791 (http://www.ucm.es/info/zoo/bcv/pdf/2009_BiodivCons_18_1781.pdf).

Vasilakis D, Akriotis T, Schindler S 2009: Flight height and range use of the Eurasian Black vulture (*Aegypius monachus*) in Thrace, Greece: Implications for wildlife management and proposed wind farms. Poster EOU Conference.

Zeiler HP & Grünschachner-Berger V 2009: Impact of wind power plants on black grouse, *Lyrurus tetrix*, in Alpine regions. Folia Zool. 58: 173–182 (http://www.ivb.cz/folia/58/2/173-182_MS1449.pdf).

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Following

Table a) Species in risk order
Table b) Species in alphabetical order

Wind turbine collision casualties in Germany (1989) 2004 - 3 January 2011

Collision data compiled by Tobias Dürr (LUGV Brandenburg)

Zentrale Fundkartei der Staatlichen Vogelschutzwarte im Landesamt für Umweltamt, Gesundheit und Verbraucherschutz (LUGV) Brandenburg

Further compilation and estimations
by Hubertus Illner
15 February 2011

Legend – Collision rate: > 0.2% / > 0.02% / > 0.002%

Legend – c) body size: very big / big / medium / small / very small

Legend – e) probability of finding casualties: 1 high / 2 medium / 3 low / 4 very low

Legend – f) derived collision risk: very high 5 / high 4 / medium 3 / small 2 / very small/none 1

Legend – g) data basis in Germany: 1 good / 2 medium / 3 deficient

Legend – h): XXX = 3 / XX = 2 / X = 1 / x = 0.5

Legend – i): XXX = 3 / XX = 2 / X = 1 / x = 0.5 / no = 0

	(1) number of casualties	(2) breeding individuals 2005 in Germany*	Collision rate (1/2 x 100)	a) migrant species in Germany	b) non-breeding population much greater than breeding population**	c) body size	d) mainly breeding in woodland in Germany	e) probability of finding casualties	f) derived collision risk ***		g) data basis in Germany	h) proposal for a revision of the collision risk index ****	i) collision risk index according EU Commission 2010****
Haliaeetus albicilla	**57**	994	5.734%				x	1 high		5	1 good	**3**	**3**
Asio flammeus	**2**	243	0.823%	(x)	(x)			2 middle	**lower?**	5	3 deficient	**3 (2)**	missing
Milvus milvus	**146**	24,000	0.608%	x			x	2 middle		5	1 good	**3**	**3**
Pandion haliaetus	**6**	1,003	0.598%	x			x	2 middle		5	2 middle	**3**	missing
Aquila pomarina	**1**	222	0.450%	x			x	2 middle	**lower?**	5	3 deficient	**3 (2)**	**2**
Bubo bubo	**11**	2,900	0.379%				x	2 middle		5	2 middle	**3**	**1**
Ciconia ciconia	**21**	8,500	0.247%	x				1 high		5	1 good	**3**	**2**
Falco peregrinus	**4**	1,650	0.242%				x	2 middle		5	3 deficient	**3**	**1**
Circus pygargus	**2**	880	0.227%	x				3 low		5	3 deficient	**3 *******	**2**
Milvus migrans	**18**	12,500	0.144%	x			x	2 middle		5	1 good	**3**	**1**
Falco subbuteo	**5**	6,000	0.083%	x			x	3 low		5	3 deficient	**3**	**0**
Aquila chrysaetos		92					(x)	2 middle	**lower?**	5	3 deficient	**3 (2)**	**3**
Falco columbarius	**2**	no breeding bird		x				3 low	**lower?**	5	3 deficient	**3 (2)**	**0**
Ciconia nigra	**1**	1,030	0.097%	x			x	3 low	**higher?**	4	3 deficient	**2 (3)**	**0**
Buteo buteo	**162**	187,000	0.087%				x	2 middle		4	1 good	**2**	**2**
Corvus corax	**17**	22,000	0.077%	x			x	2 middle		4	2 middle	**2**	missing
Circus aeruginosus	**9**	13,800	0.065%	x				3 low		4	3 deficient	**2**	**0.5**
Chlidonias niger	**1**	1,550	0.065%	x				3 low	**higher?**	4	3 deficient	**2 (3)**	missing
Larus canus	**26**	45,000	0.058%	x	x			2 middle	**lower?**	4	3 deficient	**2 (1)**	missing
Cygnus olor	**12**	21,500	0.056%					1 high		4	1 good	**2**	missing
Emberiza calandra	**23**	52,000	0.044%	(x)				4 very low		4	2 middle	**2**	missing
Larus argentatus	**38**	89,000	0.043%		x			2 middle	**lower?**	4	3 deficient	**2 (1)**	**0.5**
Falco tinnunculus	**42**	108,000	0.039%	(x)			(x)	2 middle		4	1 good	**2**	**2**
Lanius excubitor	**1**	4,300	0.023%		(x)			3 low	**lower?**	4	3 deficient	**2 (1)**	missing
Larus ridibundus	**66**	290,000	0.023%		x			2 middle	**lower?**	4	3 deficient	**2 (1)**	missing
Accipiter nisus	**7**	36,000	0.019%				x	3 low	**higher?**	4	3 deficient	**2 (3)**	**0.5**
Accipiter gentilis	**3**	24,000	0.013%				x	2 middle	**higher?**	4	3 deficient	**2 (3)**	**0**
Pernis apivorus	**1**	8,800	0.011%	x			x	2 middle	**higher?**	4	3 deficient	**2 (3)**	**0**
Sterna hirundo	**1**	22,000	0.005%	x				2 middle	**higher?**	4	3 deficient	**2 (3)**	**2**
Buteo lagopus	**2**	no breeding bird		x				2 middle	**?**	4	3 deficient	**2**	**0**
Circus cyaneus		118			x			3 low	**?**	4	3 deficient	**2**	**1**
Apus tachymarptis (melba)	**1**	270	0.370%	x				4 very low	**?**	3	3 deficient	**1**	**1**
Somateria molissima	**1**	2,400	0.042%		(x)			1 high	**?**	3	3 deficient	**1**	**1**
Oenanthe oenanthe	**3**	9,400	0.032%	x	(x)			3 low	**?**	3	3 deficient	**1 (2)**	**0**
Grus grus	**3**	10,600	0.028%	x			x	1 high	**higher?**	3	3 deficient	**1 (2)**	**1**
Anas clypeata	**1**	4,800	0.021%	x				3 low	**higher?**	3	3 deficient	**1 (2)**	missing
Anas crecca	**2**	10,100	0.020%	x				3 low	**higher?**	3	3 deficient	**1 (2)**	missing
Tyto alba	**4**	31,000	0.013%					2 middle	**higher?**	3	3 deficient	**1 (2)**	missing
Charadrius dubius	**1**	10,200	0.010%	x				3 low	**?**	3	3 deficient	**1**	missing
Asio otus	**5**	58,000	0.009%	(x)	(x)		x	2 middle	**higher?**	3	3 deficient	**1 (2)**	**0.5**
Gallinago gallinago	**1**	12,300	0.008%	x				4 very low	**higher?**	3	3 deficient	**1 (2)**	**1**
Apus apus	**42**	720,000	0.006%	x				4 very low	**higher?**	3	2 middle	**1 (2)**	**0.5**
Pluvialis apricaria	**14**	16		x	x			3 low	**?**	3	3 deficient	**1**	**1**
Ardea cinerea	**3**	55,000	0.005%				x	2 middle	**higher?**	2.5	3 deficient	**1 (2)**	missing
Rallus aquaticus	**1**	24,000	0.004%	x				4 very low	**?**	2.5	3 deficient	**1**	missing
Scolopax rusticula	**1**	50,000	0.002%	x	(x)		x	4 very low	**?**	2.5	3 deficient	**1**	missing
Otus scops		2		x				4 very low	**?**	2.5	3 deficient	**1**	missing
Strix aluco	**1**	134,000	0.001%				x	3 low	**?**	2.5	3 deficient	**1**	missing
Aegolius funereus		4,400					x	3 low	**?**	2.5	3 deficient	**1**	missing
Glaucidium passerinum		5,000					x	3 low	**?**	2.5	3 deficient	**1**	missing
Anser anser	**3**	37,000	0.008%		(x)			2 middle	**?**	2	3 deficient	**0.5**	missing
Tadorna tadorna	**1**	12,600	0.008%					2 middle	**?**	2	3 deficient	**0.5**	missing
Lanius collurio	**15**	270,000	0.006%	x				4 very low		2	2 middle	**0.5**	missing
Anas platyrhynchos	**30**	620,000	0.005%					2 middle	**?**	2	1 good	**0.5**	missing
Haematopus ostralegus	**3**	62,000	0.005%					3 low	**?**	2	3 deficient	**0.5**	missing
Lullula arborea	**4**	104,000	0.004%	x			(x)	4 very low	**?**	2	3 deficient	**0.5**	missing
Aythya fuligula	**1**	27,000	0.004%	x	(x)			3 low	**?**	2	3 deficient	**0.5**	missing
Corvus frugilegus	**4**	138,000	0.003%		x		(x)	2 middle	**?**	2	3 deficient	**0.5**	missing
Fulica atra	**6**	208,000	0.003%					3 low	**?**	2	3 deficient	**0.5**	missing
Corvus corone/cornix	**20**	867,000	0.002%				(x)	2 middle		2	3 deficient	**0.5**	missing
Columba oenas	**3**	124,000	0.002%	x	(x)		x	3 low	**?**	2	3 deficient	**0.5**	**0.5**
Phasianus colchicus	**8**	370,000	0.002%					2 middle		2	2 middle	**0.5**	**0.5**
Vanellus vanellus	**3**	151,000	0.002%	x	(x)			2 middle		2	3 deficient	**0.5**	**1**
Cuculus canorus	**3**	157,000	0.002%	x				4 very low	**?**	2	3 deficient	**0.5**	**0.5**
Motacilla flava	**5**	270,000	0.002%	x				4 very low	**higher?**	2	3 deficient	**0.5**	missing
Gallinula chloropus	**1**	74,000	0.001%	x				2 middle	**?**	2	3 deficient	**0.5**	missing
Perdix perdix	**2**	179,000	0.001%					2 middle	**?**	2	3 deficient	**0.5**	missing
Riparia riparia	**3**	268,000	0.001%	x				4 very low	**higher?**	1.5	3 deficient	**0.5**	missing
Picus viridis	**1**	91,000	0.001%				(x)	4 very low	**higher?**	1.5	3 deficient	**0.5**	missing
Alauda arvensis	**51**	5,300,000	0.001%					4 very low	**higher?**	1.5	2 middle	**0.5**	**0** (winter)
Delichon urbica	**18**	2,030,000	0.001%	x				4 very low	**higher?**	1.5	2 middle	**0.5**	missing
Emberiza citrinella	**20**	3,200,000	0.001%					4 very low		1.5	2 middle	**0.5**	missing
Hirundo rustica	**13**	2,400,000	0.001%	x				4 very low	**higher?**	1.5	2 middle	**0.5**	missing
Anthus trivalis	**3**	1,200,000	0.000%	x			x	4 very low	**higher?**	1.5	3 deficient	**0.5**	missing
Athene noctua		16,600						3 low	**higher?**	1.5	3 deficient	**0.5**	missing
Streptopelia turtur		128,000		x				3 low	**higher?**	1.5	3 deficient	**0.5**	**0.5**
Regulus regulus	**25**	2,120,000	0.001%		(x)		x	4 very low		1	2 middle	**0**	missing
Columba palumbus	**50**	4,800,000	0.001%		(x)		(x)	2 middle		1	1 good	**0**	**0.5**
Ficedula hypoleuca	**4**	430,000	0.001%				x	4 very low		1	3 deficient	**0**	missing
Sturnus vulgaris	**23**	5,100,000	0.000%	(x)				4 very low		1	2 middle	**0**	**0** (non-breeding)
Turdus pilaris	**3**	770,000	0.000%	(x)	(x)		(x)	4 very low		1	3 deficient	**0**	missing
Passer montanus	**9**	2,600,000	0.000%					4 very low		1	2 middle	**0**	missing
Streptopelia decaoctao	**2**	600,000	0.000%					3 low		1	3 deficient	**0**	**0.5**
Garrulus glandarius	**3**	1,000,000	0.000%		(x)			3 low		1	3 deficient	**0**	missing
Turdus philomelos	**7**	3,400,000	0.000%	x			x	4 very low		1	3 deficient	**0**	missing
Motacilla alba	**3**	1,520,000	0.000%	x				4 very low		1	3 deficient	**0**	missing
Erithacus rubecula	**12**	6,200,000	0.000%	(x)			x	4 very low		1	2 middle	**0**	missing
Emberiza schoeniclus	**1**	680,000	0.000%	x				4 very low		1	3 deficient	**0**	**0**
Dendrocopus major	**1**	1,290,000	0.000%				x	4 very low	**higher?**	1	3 deficient	**0 (0,5)**	missing
Fringilla coelebs	**8**	20,200,000	0.000%	(x)			x	4 very low		1	2 middle	**0**	missing
Turdus merula	**5**	14,900,000	0.000%				(x)	4 very low		1	3 deficient	**0**	missing
Total	1,148												

Explanations

(x) means uncertain rating

* average estimate of pair numbers multiplied by 2 (Südbeck et al. 2007, Ber. Vogelschutz 44: 23–81)

** nonbreeding (breeding time floaters, resting/overwintering birds) population at least 4-6 months present

*** **?** means estimation is very uncertain because casualty data is very small or large nonbreeding/resting/overwintering numbers exceed the breeding population by far

**** transformation of the EU Guidance letter "X" into numbers for better readability:

- **XXX = 3** (evidence substantial risk)
- **XX = 2** (evidence or indication of risk)
- **X = 1** (potential risk)
- **x = 0.5** (small or non-significant risk)
- **no entry = 0** (no risk, addition H. Illner)

missing means that the species is missing at all in the Annex II of the EU Guidance

***** for further 3 possibly strike cases in Germany see: http://www.mugv.brandenburg.de/cms/media.php/lbm1.a.2334.de/wka_weihe.pdf

Remarks:

When the data basis was deficient collision rates of similar species and/or collision data from published studies were considered (for further details see text)

No collision rate calculated for Pluvialis apricaria because fatalities were found far from the single small breeding area

Most Skylarks were found in the breeding season (T. Dürr, personal comm.)

Wind turbine collision casualties in Germany (1989) 2004 - 3 January 2011

Collision data compiled by Tobias Dürr (LUGV Brandenburg)

Zentrale Fundkartei der Staatlichen Vogelschutzwarte im Landesamt für Umweltamt, Gesundheit und Verbraucherschutz (LUGV) Brandenburg

Further compilation and estimations
by Hubertus Illner
15 February 2011

Legend:

- Collision rate: > 0.2% / > 0.02% / > 0.002%
- c) body size: very big / big / medium / small / very small
- e) probability of finding casualties: 1 high / 2 medium / 3 low / 4 very low
- f) derived collision risk: very high 5 / high 4 / medium 3 / small 2 / very small/none 1
- g) data basis in Germany: 1 good / 2 medium / 3 deficient
- h): XXX = 3 / XX = 2 / X = 1 / x = 0.5
- i): XXX = 3 / XX = 2 / X = 1 / x = 0.5 / no = 0

	(1) number of casualties	(2) breeding individuals 2005 in Germany*	Collision rate (1/2 x 100)	a) migrant species in Germany	b) non-breeding population much greater than breeding population**	c) body size	d) mainly breeding in woodland in Germany	e) probability of finding casualties	f) derived collision risk ***		g) data basis in Germany	h) proposal for a revision of the collision risk index ****	i) collision risk index according EU Commission 2010****
Accipiter gentilis	3	24,000	0.013%				x	2 middle	higher?	4	3 deficient	2 (3)	0
Accipiter nisus	7	36,000	0.019%				x	3 low	higher?	4	3 deficient	2 (3)	0.5
Aegolius funereus		4,400					x	3 low	?	2.5	3 deficient	1	missing
Alauda arvensis	51	5,300,000	0.001%					4 very low	higher?	1.5	2 middle	0.5	0 (winter)
Anas clypeata	1	4,800	0.021%	x				3 low	higher?	3	3 deficient	1 (2)	missing
Anas crecca	2	10,100	0.020%	x				3 low	higher?	3	3 deficient	1 (2)	missing
Anas platyrhynchos	30	620,000	0.005%					2 middle	?	2	1 good	0.5	missing
Anser anser	3	37,000	0.008%		(x)			2 middle	?	2	3 deficient	0.5	missing
Anthus trivalis	3	1,200,000	0.000%	x			x	4 very low	higher?	1.5	3 deficient	0.5	missing
Apus tachymarptis (melba)	1	270	0.370%	x				4 very low	?	3	3 deficient	1	1
Apus apus	42	720,000	0.006%	x				4 very low	higher?	3	2 middle	1 (2)	0.5
Aquila chrysaetos		92					(x)	2 middle	lower?	5	3 deficient	3 (2)	3
Aquila pomarina	1	222	0.450%	x			x	2 middle	lower?	5	3 deficient	3 (2)	2
Ardea cinerea	3	55,000	0.005%				x	2 middle	higher?	2.5	3 deficient	1 (2)	missing
Asio flammeus	2	243	0.823%	(x)	(x)			2 middle	lower?	5	3 deficient	3 (2)	missing
Asio otus	5	58,000	0.009%	(x)	(x)		x	2 middle	higher?	3	3 deficient	1 (2)	0.5
Athene noctua		16,600						3 low	higher?	1.5	3 deficient	0.5	missing
Aythya fuligula	1	27,000	0.004%	x	(x)			3 low	?	2	3 deficient	0.5	missing
Bubo bubo	11	2,900	0.379%				x	2 middle		5	2 middle	3	1
Buteo buteo	162	187,000	0.087%				x	2 middle		4	1 good	2	2
Buteo lagopus	2	no breeding bird		x				2 middle	?	4	3 deficient	2	0
Charadrius dubius	1	10,200	0.010%	x				3 low	?	3	3 deficient	1	missing
Chlidonias niger	1	1,550	0.065%	x				3 low	higher?	4	3 deficient	2 (3)	missing
Ciconia ciconia	21	8,500	0.247%	x				1 high		5	1 good	3	2
Ciconia nigra	1	1,030	0.097%	x			x	3 low	higher?	4	3 deficient	2 (3)	0
Circus aeruginosus	9	13,800	0.065%	x				3 low		4	3 deficient	2	0.5
Circus cyaneus		118			x			3 low	?	4	3 deficient	2	1
Circus pygargus	2	880	0.227%	x				3 low		5	3 deficient	3 *****	2
Columba oenas	3	124,000	0.002%	x	(x)		x	3 low	?	2	3 deficient	0.5	0.5
Columba palumbus	50	4,800,000	0.001%		(x)		(x)	2 middle		1	1 good	0	0.5
Corvus corax	17	22,000	0.077%	x			x	2 middle		4	2 middle	2	missing
Corvus corone/cornix	20	867,000	0.002%				(x)	2 middle		2	3 deficient	0.5	missing
Corvus frugilegus	4	138,000	0.003%		x		(x)	2 middle	?	2	3 deficient	0.5	missing
Cuculus canorus	3	157,000	0.002%	x				4 very low	?	2	3 deficient	0.5	0.5
Cygnus olor	12	21,500	0.056%					1 high		4	1 good	2	missing
Delichon urbica	18	2,030,000	0.001%	x				4 very low	higher?	1.5	2 middle	0.5	missing
Dendrocopus major	1	1,290,000	0.000%				x	4 very low	higher?	1	3 deficient	0 (0,5)	missing
Emberiza calandra	23	52,000	0.044%	(x)				4 very low		4	2 middle	2	missing
Emberiza citrinella	20	3,200,000	0.001%					4 very low		1.5	2 middle	0.5	missing
Emberiza schoeniclus	1	680,000	0.000%	x				4 very low		1	3 deficient	0	0
Erithacus rubecula	12	6,200,000	0.000%	(x)			x	4 very low		1	2 middle	0	missing
Falco columbarius	2	no breeding bird		x				3 low	lower?	5	3 deficient	3 (2)	0
Falco peregrinus	4	1,650	0.242%				x	2 middle		5	3 deficient	3	1
Falco subbuteo	5	6,000	0.083%	x			x	3 low		5	3 deficient	3	0
Falco tinnunculus	42	108,000	0.039%	(x)			(x)	2 middle		4	1 good	2	2
Ficedula hypoleuca	4	430,000	0.001%				x	4 very low		1	3 deficient	0	missing
Fringilla coelebs	8	20,200,000	0.000%	(x)			x	4 very low		1	2 middle	0	missing
Fulica atra	6	208,000	0.003%					3 low	?	2	3 deficient	0.5	missing
Gallinago gallinago	1	12,300	0.008%	x				4 very low	higher?	3	3 deficient	1 (2)	1
Gallinula chloropus	1	74,000	0.001%	x				2 middle	?	2	3 deficient	0.5	missing
Garrulus glandarius	3	1,000,000	0.000%		(x)			3 low		1	3 deficient	0	missing
Glaucidium passerinum		5,000					x	3 low	?	2.5	3 deficient	1	missing
Grus grus	3	10,600	0.028%	x			x	1 high	higher?	3	3 deficient	1 (2)	1
Haematopus ostralegus	3	62,000	0.005%					3 low	?	2	3 deficient	0.5	missing
Haliaeetus albicilla	57	994	5.734%				x	1 high		5	1 good	3	3
Hirundo rustica	13	2,400,000	0.001%	x				4 very low	higher?	1.5	2 middle	0.5	missing
Lanius collurio	15	270,000	0.006%	x				4 very low		2	2 middle	0.5	missing
Lanius excubitor	1	4,300	0.023%		(x)			3 low	lower?	4	3 deficient	2 (1)	missing
Larus argentatus	38	89,000	0.043%		x			2 middle	lower?	4	3 deficient	2 (1)	0.5
Larus canus	26	45,000	0.058%	x	x			2 middle	lower?	4	3 deficient	2 (1)	missing
Larus ridibundus	66	290,000	0.023%		x			2 middle	lower?	4	3 deficient	2 (1)	missing
Lullula arborea	4	104,000	0.004%	x			(x)	4 very low	?	2	3 deficient	0.5	missing
Milvus migrans	18	12,500	0.144%	x			x	2 middle		5	1 good	3	1
Milvus milvus	146	24,000	0.608%	x			x	2 middle		5	1 good	3	3
Motacilla alba	3	1,520,000	0.000%	x				4 very low		1	3 deficient	0	missing
Motacilla flava	5	270,000	0.002%	x				4 very low	higher?	2	3 deficient	0.5	missing
Oenanthe oenanthe	3	9,400	0.032%	x	(x)			3 low	?	3	3 deficient	1 (2)	0
Otus scops		2		x				4 very low	?	2.5	3 deficient	1	missing
Pandion haliaetus	6	1,003	0.598%	x			x	2 middle		5	2 middle	3	missing
Passer montanus	9	2,600,000	0.000%					4 very low		1	2 middle	0	missing
Perdix perdix	2	179,000	0.001%					2 middle	?	2	3 deficient	0.5	missing
Pernis apivorus	1	8,800	0.011%	x			x	2 middle	higher?	4	3 deficient	2 (3)	0
Phasianus colchicus	8	370,000	0.002%					2 middle		2	2 middle	0.5	0.5
Picus viridis	1	91,000	0.001%				(x)	4 very low	higher?	1.5	3 deficient	0.5	missing
Pluvialis apricaria	14	16		x	x			3 low	?	3	3 deficient	1	1
Rallus aquaticus	1	24,000	0.004%	x				4 very low	?	2.5	3 deficient	1	missing
Regulus regulus	25	2,120,000	0.001%		(x)		x	4 very low		1	2 middle	0	missing
Riparia riparia	3	268,000	0.001%	x				4 very low	higher?	1.5	3 deficient	0.5	missing
Scolopax rusticula	1	50,000	0.002%	x	(x)		x	4 very low	?	2.5	3 deficient	1	missing
Somateria molissima	1	2,400	0.042%		(x)			1 high	?	3	3 deficient	1	1
Sterna hirundo	1	22,000	0.005%	x				2 middle	higher?	4	3 deficient	2 (3)	2
Streptopelia decaoctao	2	600,000	0.000%					3 low		1	3 deficient	0	0.5
Streptopelia turtur		128,000		x				3 low	higher?	1.5	3 deficient	0.5	0.5
Strix aluco	1	134,000	0.001%				x	3 low	?	2.5	3 deficient	1	missing
Sturnus vulgaris	23	5,100,000	0.000%	(x)				4 very low		1	2 middle	0	0 (non-breeding)
Tadorna tadorna	1	12,600	0.008%					2 middle	?	2	3 deficient	0.5	missing
Turdus merula	5	14,900,000	0.000%				(x)	4 very low		1	3 deficient	0	missing
Turdus philomelos	7	3,400,000	0.000%	x			x	4 very low		1	3 deficient	0	missing
Turdus pilaris	3	770,000	0.000%	(x)	(x)		(x)	4 very low		1	3 deficient	0	missing
Tyto alba	4	31,000	0.013%					2 middle	higher?	3	3 deficient	1 (2)	missing
Vanellus vanellus	3	151,000	0.002%	x	(x)			2 middle		2	3 deficient	0.5	1
Total	1,148												

Explanations

(x) means uncertain rating

* average estimate of pair numbers multiplied by 2 (Südbeck et al. 2007, Ber. Vogelschutz 44: 23–81)

** nonbreeding (breeding time floaters, resting/overwintering birds) population at least 4-6 months present

*** **?** means estimation is very uncertain because casualty data is very small or large nonbreeding/resting/overwintering numbers exceed the breeding population by far

**** transformation of the EU Guidance letter "X" into numbers for better readability:

- **XXX = 3** (evidence substantial risk)
- **XX = 2** (evidence or indication of risk)
- **X = 1** (potential risk)
- **x = 0.5** (small or non-significant risk)
- **no entry = 0** (no risk, addition H. Illner)
- **missing** means that the species is missing at all in the Annex II of the EU Guidance

***** for further 3 possibly strike cases in Germany see: http://www.mugv.brandenburg.de/cms/media.php/lbm1.a.2334.de/wka_weihe.pdf

Remarks:

When the data basis was deficient collision rates of similar species and/or collision data from published studies were considered (for further details see text)

No collision rate calculated for Pluvialis apricaria because fatalities were found far from the single small breeding area

Most Skylarks were found in the breeding season (T. Dürr, personal comm.)