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Report of the IWG on Wind Turbines and Bat Populations

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Subgroups

To simplify the work, several sub-groups were created:

Sub-group	Coordinator (c) and members
Update/reorganizing of the list of references	Marie-Jo Dubourg-Savage (c) Laurent Biraschi
Compilation of data on bat mortality per country	Marie-Jo Dubourg-Savage (c) Lothar Bach
Updating of tables on monitoring studies done in Europe and on bats´ behaviour in relation to windfarms	Anna Nele Herdina (c) Laurent Biraschi Marie-Jo Dubourg-Savage
Mitigation and compensation measures	Joana Bernardino (c) Branko Karapandža Dino Scaravelli Lothar Bach Luisa Rodrigues Thierry Kervyn
Estimation of mortality rate taking into consideration predation, efficiency and controlled area; choose of best estimator for Europe	Lothar Bach (c) Dino Scaravelli Jasja Dekker Joana Bernardino Petra Bach

	Rita Bastos
Impact of mortality rate on populations	Christian Voigt (c) Jasja Dekker Lothar Bach Rita Bastos
Deterrents	Lothar Bach (c) Branko Karapandža Dino Scaravelli Luisa Rodrigues
Maximum foraging distances of species and Detectability coefficients to compare activity indices	Marie-Jo Dubourg-Savage (c) Eeva-Maria Kyheröinen Dina Rnjak Zuhair Amr Christine Harbusch
Collect national guidelines	Andrzej Kepel (c) Branko Mićevski Dina Rnjak Jan Collins
Use of dogs *vs* humans during carcass searches	Dina Rnjak (c) Fiona Mathews Jan Collins Joana Bernardino Petra Bach
Comparing measurement of activity at ground level and rotor height	Lothar Bach (c) Jan Collins Johanna Hurst Marie-Jo Dubourg-Savage Petra Bach Thierry Kervyn
Small Wind Turbines	Kirsty Park (c) Lothar Bach
Offshore windfarms	Lothar Bach (c)
Wind farms and forests	Christian Voigt (c) Andrzej Kepel Branko Karapandža Christine Harbusch Fiona Mathews Lothar Bach Thierry Kervyn Johanna Hurst
Implementation of mitigation and post-construction monitoring	Daniela Hamidović (c) Branko Micevski Per Ole Syvertsen Jasja Dekker
200m buffer distance to habitats particularly important for bats	Branko Karapandža (c)

Results

Results are presented by sub-group.

Update/reorganizing of the list of references

Annex 1 includes new references and is an addendum to the list of references which had been presented in AC20 (Doc.EUROBATS.AC20.5; http://www.eurobats.org/sites/default/files/documents/pdf/Advisory_Committee/EUROBATS.AC20.Record_0.pdf) and in EUROBATS Publication Series nº 6 (http://www.eurobats.org/sites/default/files/documents/publications/publication_series/pubseries_no6_english.pdf).

Compilation of data on bat mortality per country

The following table updates the data per species and per country regarding bat fatalities found both accidentally and during post-construction monitoring studies from 2003 to the end of December 2015. It reflects by no means the real extent of bat mortality at wind turbines as it is based only on reported fatalities to EUROBATS IWG members.

Available data show that at least 27 species have been killed by wind turbines in Europe.

In Lower Saxony from now on no carcass search will be done anymore in new post-construction monitoring projects, since new guidelines forbid this activity (Niedersächsisches Ministerium für Umwelt, Energie und Klimaschutz 2015).

Reported bat mortality in Europe (2003-2015) - State 13/04/2016

Species	AT	BE	CH	CR	CZ	DE	ES	EE	FI	FR	GR	IT	LV	NL	NO	PT	PL	RO	SE	UK	Total
Nyctalus noctula	46				31	973	1			31	10					1	16	5	1		**1115**
Nyctalus lasiopterus							21			6	1					9					**37**
N. leisleri			1	4	3	143	15			63	58	2				253	5				**547**
*Nyc.*spec */ V.murinus*				1			2			1						17					**21**
Eptesicus serotinus	1				11	56	2			23	1			1			3				**98**
E. isabellinus							117									1					**118**
E. serotinus / isabellinus							11									16					**27**
E. nilssonii	1				1	3		2	6				13		1		1		8		**36**
Vespertilio murinus	2			10	6	116				8	1		1				7	7	1		**159**
Myotis myotis						2	2			3											**7**
M. blythii							4			1											**5**
M. dasycneme						3															**3**
M. daubentonii						7										2					**9**
M. bechsteinii										1											**1**
M. emarginatus							1			2											**3**
M. brandtii						1															**1**
M. mystacinus						2					1										**3**
Myotis spec.						1	3														**4**
Pipistrellus pipistrellus	2	10		5	16	556	73			622		1		15		281	3	3	1		**1588**
P. nathusii	13	3		14	7	812				178	35	2	23	8			16	12	5		**1128**
P. pygmaeus	4			1	2	82				125			1			36	1	2	1	1	**256**
P. pipistrellus / pygmaeus	1		1			2	483			29	54					37	1	2			**610**
P. kuhlii				94			44			130						44		4			**316**
P.pipistrellus / kuhlii				12												19					**31**
Pipistrellus spec.*/ H.savii*	8			53	9	68	20			134	1		2			97	2	4		3	**401**
Hypsugo savii	1			136		1	50			36	26	12				47					**309**
Barbastella barbastellus						1	1			3											**5**
Plecotus austriacus	1					6															**7**
Plecotus auritus						7															**7**
Tadarida teniotis				6			23			1						27					**57**
Miniopterus schreibersii							2			5						4					**11**

Rhinolophus ferrumequinum							1														**1**
Rhinolophus mehelyi							1														**1**
Chiroptera spec.	1	1		45	1	63	320	1		192	6	1				110	3		30	8	**782**
Total	**81**	**14**	**2**	**381**	**87**	**2905**	**1197**	**3**	**6**	**1594**	**194**	**18**	**40**	**24**	**1**	**1001**	**58**	**39**	**47**	**12**	**7704**

AT = Austria, BE = Belgium, CH = Switzerland, CR = Croatia, CZ = Czech Rep., DE = Germany ES= Spain, EE = Estonia, FI = Finland, FR = France, GR = Greece, IT = Italy, LV = Latvia, NL = Netherlands, NO = Norway, PT = Portugal, PL = Poland, SE = Sweden, UK = United Kingdom

Niedersächsisches Ministerium für Umwelt, Energie und Klimaschutz (2015): Leitfaden – Umsetzung des Artenschutzes bei der Planung und Genehmigung von Windenergieanlagen in Niedersachsen (Fassung 23.11.2015): 38 pp.

Updating of tables on monitoring studies done in Europe

Annex 2 contains new data of studies done in Europe; this table is an addendum to Table 1 of EUROBATS Publication Series nº 3, Annex 3 of Doc.EUROBATS.AC14.9.Rev1, Annex 3 of Doc.EUROBATS.StC4-AC15.22.Rev.1, Annex 2 of Doc.EUROBATS.AC17.6, Annex 2 of Doc.EUROBATS.AC18.6, Annex 2 of Doc.EUROBATS.StC9-AC19.12, Annex 1 of EUROBATS Publication Series nº 6, and Annex 2 of Doc.EUROBATS.AC20.5.

Mitigation and compensation measures

Between 2015 and the beginning of 2016 several review articles have been published about the environmental impacts associated with wind energy developments (e.g. Dai et al. 2015, Schuster et al. 2015, Arnett et al. 2016). Most of them reinforced the need to actively implement effective mitigation measures in order to assure the conservation of wildlife species such as bats.

As pointed out in the previous reports, operational mitigation (curtailment) through the increase of wind turbines cut-in speed and/or feathering turbine blades, continues to be an important measure to reduce bat fatality at wind energy facilities. It has been so far successfully tested both in North American and some European countries (e.g. LEA 2010, Arnett et al. 2013). The implementation of such measures may be enhanced by the development of site-specific algorithms that adjust turbines operation based on temperature, wind speed, season, time of day and/or other parameters. Martin et al. (2015) reported on new tests performed in a US wind farm over 2 years (spring 2012 – fall 2013). From June through September of each year, half of the wind turbines (randomly selected each night) were cut-in at 6.0 m/s and the remaining at 4.0 m/s. This curtailment measures were implemented during night time whenever wind speeds were less than 6.0 m/s and temperatures were greater than 9.5° C. In 2012 bat fatality was 2.7 times (95% CI: 1.9-3.9) higher at fully operational turbines than at curtailed turbines. In 2013 it was 1.5 times higher, however the low number of bats found killed that year limited statistical power. According to authors, analyses still underway will identify the combinations of weather parameters (temperature and wind speed) most effective at reducing bat fatalities.

Another way to improve the operational mitigation is by using real-time data on bat activity itself to automatically inform a turbine shutdown on demand. An example of that methodological strategy is the ATOM system (Acoustic and Thermographic Offshore Monitoring) which combines thermal imaging with acoustic and ultrasound sensors to continuously monitor bird and bat abundance, flight height, direction, and speed (Robinson Willmott at al. 2015). The overall functioning of the system and its ability to record target species was tested mainly offshore, between 2011 and 2013. Concerning bats, data gathering by the ultrasound sensors was restricted by frequent failure due to the harsh marine environment. Furthermore, the short detection distance of some bat species (shorter than the blade length) and the inertia of the rotor may hamper the efficiency of a shutdown on demand. Thus, and although it seems promising, the system still needs further improvements and tests in order to be able to reduce bat collision risk at wind farms.

The prototype DTBat system is being tested in Switzerland (canton of Grisons) (Hanagasioglu *et al*., 2015). The prototype records real-time bat activity, functions unattended and records bat calls in the Data Analysis Platform on-line. Algorithms for stopping wind turbine in case of collision risk are still under development. The delay between when a bat is detected and the time required to stop the turbine is a particular difficulty with this system.

To the best of our knowledge, few new studies have been published regarding the development and test of compensation measures for bats affected by wind energy facilities. Since forestry practices play an important role on bat conservation, Pereira *et al*. (2016) tried to identify possible management actions that can be adopted in commercial pine forests to mitigate negative impacts of wind farms on bats. During one year data was collected on bat richness and activity, prey availability and vegetation structure within pine stands with distinct management histories. Based on the variables that best predicted bat richness and activity (e.g. canopy and dry branches cover) a set of management actions was identified for coniferous forests that could be incorporated in future mitigation strategies. However, the authors argue that the proposed measures still need to be tested in order to fully understand their effectiveness concerning the offset of wind farms negative impacts on bats (Pereira *et al*. 2015).

The sub-group prepared a draft questionnaire to be sent to focal points of Parties and non-party Range States. The draft questionnaire will be discussed during 21AC.

Arnett E.B., E.F. Baerwald, F. Mathews, L. Rodrigues, A. Rodríguez-Durán, J.Rydell, R. Villegas-Patraca& C.C. Voigt. 2016. *Impacts of Wind Energy Development on Bats: A Global Perspective*. *In* Voigt C.C. & Kingston T. (Eds.). 2016. *Bats in the Anthropocene: Conservation of Bats in a Changing World*. Springer. 1st ed. 2016. Pp. 295-323.

Arnett E.B., G.D. Johnson, W.P. Erickson & C.D. Hein. 2013. *A synthesis of operational mitigation studies to reduce bat fatalities at wind energy facilities in North America*. A report submitted to the National Renewable Energy Laboratory. Bat Conservation International. Austin, Texas, USA.

Dai K., A. Bergot, C. Liang, W. Xiang & Z. Huang. 2015. Environmental Issues Associated with Wind Energy - A Review. *RenewableEnergy*, 75, 911-921.

LEA (2010) Monitorização dos efeitos da Medida de Minimização de Mortalidade do Parque Eólico do Outeiro Relatório final. Laboratório de Ecologia Aplicada da Universidade de Trás-os-Montes e Alto Douro. Vila Real, 78 pp

Hanagasioglu M., Aschwanden J., Bontadina F., de la Puente Nilsson M. 2015. Investigation of the effectiveness of bat and bird detection of the DTBat and DTBird systems at Calandawind turbine. Swiss Federal Office of Energy SFOE & Federal Office for the Environment FOEN.

Martin C., E.B. Arnett & M. Wallace. 2015. *Operational mitigation reduces bat fatalities at the Sheffield wind facility, Vermont.* Conference on Wind Energy and Wildlife Impacts (CWW): Book of Abstracts. Berlin, Germany. March 10-12, 2015.

Pereira M.J.R., F. Peste, A. Paula, P. Pereira, J. Bernardino, J. Vieira, C. Bastos, M. Mascarenhas, H. Costa & C. Fonseca.2015. *Management of coniferous forests for bats affected by wind farms: Challenges and opportunities for mitigation strategies*. Conference on Wind Energy and Wildlife Impacts (CWW): Book of Abstracts. Berlin, Germany. March 10-12, 2015.

Pereira M.J.R., F. Peste, A. Paula, P. Pereira, J. Bernardino, J. Vieira, C. Bastos, M. Mascarenhas, H. Costa & C. Fonseca. 2016. Managing coniferous production forests towards bat conservation. *Wildlife Research*, 43: 80-92.

Robinson Willmott J., G.M. Forcey & L.A. Hooton. 2015. Developing an automated risk management tool to minimize bird and bat mortality at wind facilities. *Ambio* 2015, 44(Suppl. 4): S557–S571.

Schuster E., L. Bulling&J. Köppel. 2015. Consolidating the State of Knowledge: A Synoptical Review of Wind Energy's Wildlife Effects. *Environmental Management*, 56(2), 300–331.

Estimation of mortality rate taking into consideration predation, efficiency and controlled area; choice of best estimator for Europe

Not much has been published in 2015/ beginning of 2016 concerning the development of fatality estimators. Wolpert (2015) developed a refined estimator (ACME: acronym for Avian and Chiropteran Mortality Estimator), which takes the following factors into account: 1) unremoved (older) carcasses may be harder to find by human searchers,; 2) scavengers may reduce their interest in carcasses as they age; and 3) some of the carcasses overlooked in one search might be found in the following searches. These are assumptions that were also taken into account by some of the most recent estimators; and that are summarized in Korner-Nievergelt *et al*. (2015) (see also IWG report AC20 (Doc.EUROBATS.AC20.5). No evaluation is presented regarding the performance of the refined estimator compared to these last estimators published.

Korner-Nievergelt F., Behr O., Brinkmann R., Etterson, M.A., Huso M.M., Dalthorp D. & I. Niermann. 2015. Mortality estimation from carcass searches using the R-package carcass-a tutorial. Wildlife Biology, 21(1): 30-43.

Wolpert R.L. 2015. ACME: A Partially Periodic Estimator of Avian & Chiropteran Mortality at Wind Turbines. Cornell University Library. 22p. http://arxiv.org/abs/1507.00749

Impact of mortality rate on populations

A likely negative of wind turbine-related fatalities on bat population is often discussed among stakeholders of the wildlife-wind energy conflict in Europe. In theory, bat populations are particularly susceptible to increased mortality rates, given the low fecundity of bat species and thus recruitment of juveniles in populations (Jones *et al*. 2003). Therefore, even minor increases in mortality risks might have large-scale effects on bat populations. The major difficulty in any demographic study seems to be the lack of required baseline data, e.g. of population sizes, recruitment and dispersal rates in the absence and presence of wind turbines. Even when such demographic parameters have been established for local bat populations over many years, it is difficult to distinguish between effects caused by wind turbines and those triggered by other confounding factors, such as changes in the management of local habitats, losses of daytime roosts, annual climatic fluctuations (e.g. increased winter mortality caused by a sequence of harsh winters), global climate changes among others). The IWG is not aware of any recent (2015-2016) paper demonstrating specifically an effect of wind turbines on bat populations. Yet, several review papers highlight to various extents the discrepancy between empirical data and the urgent need for synthesis (Köppel *et al*. 2014, Tabassum-Abbasi *et al*. 2014, Dai *et al*. 2015, Schuster *et al*. 2015, Smales 2015, Voigt *et al*. 2015, Arnett *et al*. 2016). Giavi *et al*. (2014) suggested that natural mortality rates of migratory bat species, such as *N. leisleri*, are low during migration. Two papers highlight the difficulty in connecting individuals bats killed at wind turbines and the likely location of their local populations, particularly for migratory bats (Voigt *et al*. 2012, Lehnert *et al*. 2014). The higher percentage of females from distant places that were killed at German wind turbines suggest a potential large negative effect of the so-called German "Energiewende" on bat population in Northeastern Europe (Voigt *et al*. 2015, Lehnert *et al*. 2014). Using a spatial modelling approach, Roscioni *et al*. (2013, 2014) combined species distribution models for bats with the spatial distribution of wind turbines at an Italian site that undergoes intense wind farm development. They modelled the likely incidence of each wind farm in bat flight corridors by overlaying existing and planned turbine locations on potential commuting corridors (Roscioni *et al*. 2014). A similar modelling approach was followed by Santos *et al*. (2013) for *Hypsugo savii*, *Nyctalus leisleri*, *Pipistrellus kuhlii* and *Pipistrellus pipistrellus* in order to generate predictive models to determine areas of probable mortality. Hedenström & Rydell (2013) showed in another model, based on simple assumptions that the planned increase of wind turbines in Sweden will have a negative effect on Swedish populations of *Nyctalus noctula*, even when the current number of wind turbines remains constant, if no mitigation measures are taken. Ferreira *et al*. (2015) investigated the impact of windmills on bat species using a spatially explicit agent-based model. They found a clear relationship between mortality events and the proximity between roosts and the location of the wind turbines. Chauvenet *et al*. (2014) used capture-mark-recapture to describe demographic rates for *Eptesicus serotinus* at two sites in England, investigating the transition rates between three stages: juveniles, immatures and breeders. Using an individual-based population dynamics model, they investigated the expected trajectories for both populations. They demonstrate the presence and scale of temporal variation in this species' demography and show how site-specific variation in demographic rates can produce divergent population trajectories (Chauvenet *et al*. 2014). In conclusion, site or population specific difference in demographic parameters may question the validity of extrapolating patterns observed in local studies to a broader spatial scale. Recently, Diffendorfer *et al*. (2015) developed probabilistic, quantitative assessment methods to assess the impact of wind energy development on wildlife populations. Their approach is based on fatality information, populations estimates, species range maps, turbine location data, biological characteristics and generic population models. The model generates estimates of the relative risk and quantitative measures of the magnitude of the effect on species' populations trends and sizes, yet this model has not been validated for any bat species. The authors concur that this model is based on simplifying assumptions and that consequently the outcome may suffer from spares or unreliable empirical data. Indeed, the authors argue that bat fatality rates are influenced by multiple factors which may complicate any projections of models on the population level (page 16; Diffendorfer *et al*. 2015). Lastly, their model is not designed to implement management strategies regarding the wildlife-friendly development of wind energy, but rather for scientific purposes.

The IWG is convinced that the development of studies at regional or local (particularly important for rare species) levels is vital, e.g. the promotion of wind turbine facilities in forested areas may affect in particular non-migratory bat species, e.g. those of the genus *Myotis*, so that population effects may be easier to detect. Bat surveys for impact assessment of wind farm projects should take into account the connectivity between wind turbine sites and breeding sites. Also, it is important to take into account the cumulative impact of all wind farms in the home range of a population. Note that such a home range in migrating species may be the area from the UK to the Baltic States or from Russia to Greece.

Arnett, E. B., Baerwald, E. F., Mathews, F., Rodrigues, L., Rodríguez-Durán, A., Rydell, J., & Voigt, C. C. (2016). Impacts of wind energy development on bats: a global perspective. In *Bats in the Anthropocene: Conservation of Bats in a Changing World* (pp. 295-323). Springer International Publishing.

Chauvenet, ALM, Hutson, A.M., Smith, G.C., Aegerter, J.N. (2014) Demographic variation in the UK serotine bat: filling gaps in knowledge for management. Ecology and Evolution, 4(19): 3820-3829.

Dai, K.S., Bergot, A., Liang, C., Xiang, W.N., Huang, Z.H. (2015) Environmental issues associated with wind energy – A review. Renewable energy 75: 911-921.

Diffendorfer, J. E., Beston, J. A., Merrill, M. D., Stanton, J. C., Corum, M. D., Loss, S. R., ... & Heist, K. W. (2015). Preliminary methodology to assess the national and regional impact of US wind energy development on birds and bats.*US Geological Survey Scientific Investigations Report*, *506*.

Ferreira, D., Freixo, C., Cabral, J. A., Santos, R., & Santos, M. (2015). Do habitat characteristics determine mortality risk for bats at wind farms? Modelling susceptible species activity patterns and anticipating possible mortality events. *Ecological Informatics*, *28*, 7-18.

Giavi, S., Moretti, M., Bontadina, F., Zambelli, N,. Schaub, M., (2014) Seasonal surival probability suggest low migration mortality in migrating bats. PlosONE 9: e85628.

Hedenström A. & Rydell J. 2013. Effect of wind turbine mortality on bat populations in Sweden: predictions from a simple population model. – Talk at CWE2013, Stockholm, 5-7 February 2013, Naturvardsverket rapport 6546:58.

Jones KE, Purvis A, Gittleman JL (2003) Biological correlates of extinction risk in bats. Am Natural 161: 601–614

Köppel, J., Dahmen, M., Helfrich, J., Schuster, E., Bulling, L. (2014) Cautious but committed: moveing toward adaptive planning and operation strategies for renewable enregy's wildlife implications. Environmental Management 54: 744-755.

Lehnert L.S., Kramer-Schadt S., Schönborn S., Lindecke O., Niermann I., Voigt C.C. (2014) Wind Farm Facilities in Germany Kill Noctule Bats from Near and Far. PLoS ONE 9(8): e103106. doi : 10.1371/journal.pone.0103106

Roscioni F, Russo D, Di Febbraro M, Frate L, Carranza ML, Loy A (2013) Regional-scale modeling of the cumulative impact of wind farms on bats. Biodivers Conserv. doi 10.1007/s10531-013- 0515-3

Roscioni, F., Rebelo, H., Russo, D., Carranza, M.L., DiFebbraro, M., Loy, A. (2014) A modelling approach to infer the effects of wind farms on landscape connectivity for bats. Landscape ecology 29: 891-903.

Santos H., L. Rodrigues, G. Jones & H. Rebelo. 2013. Using species distribution modelling to predict bat fatality risk at wind farms. Biological Conservation, 157:178-186.

Schuster, E., Bulling, L., & Köppel, J. (2015). Consolidating the state of knowledge: A synoptical review of wind energy's wildlife effects. *Environmental management*, *56*(2), 300-331.

Smales, I. (2015). Fauna Collisions with Wind Turbines: Effects and Impacts, Individuals and Populations. What Are We Trying to Assess?. In *Wind and Wildlife* (pp. 23-40). Springer Netherlands.

Tabassum-Abbasi, P., M., Abbasi, T. Abbasi, S.A. (2014) wind energy: Increasing deployment, rising environmental concerns. Renwable and sustainable energy reviews. 31: 270-288.

Voigt C.C., Popa-Lisseanu A.G., Niermann, I. & Kramer-Schadt, S. 2012.: The catchment area of wind farms for European bats: A plea for international regulations. Biological Conservation 153:80- 86.

Voigt, C.C., Lehnert, L.S., G. Petersons, F. Adorf, L. Bach (2015) Bat fatalities at wind turbines: German politics cross migratory bats. European Journal of Wildlife Research. 61:213-219

Deterrents

There are no new results from acoustic deterrents since 2014. In a field test on Hawaii, Gorresen *et al.* (2015) tested whether it is possible to deter bats from trees by using ultraviolet light. Although UV illumination increased the number of insects and did not decrease bat activity completely, they found a significant reduction of bat activity compared with sites without UV illumination. However, they argue that more tests have to be done as means to reduce bat fatalities at wind turbines.

Gorresen, P.M., P.M. Cryan, D.C. Dalton, S. Wolf, J.A. Johnson, C.M. Todd & F. Bonaccorso (2015) Dim ultraviolet light as a means of deterring activity by the Hawaiian hoary bat *Lasiurus cinerus semotus*. Endangered Species Research, 28: 249-257.

Maximum foraging distances of species and Detectability coefficients to compare activity indices

The table on "maximum foraging distances of species" (included in *Doc.EUROBATS.AC17.6*; http://www.eurobats.org/sites/default/files/documents/pdf/Advisory_Committee/AC17_Doc_6_IWG_wind_turbines_inc%20Annex%20I-II.pdf) is still valid in the absence of new information.

The following table (after Barataud 2015) is an update of activity indices that were published in 2012. Activity indices (usually the number of contacts per time unit) result generally of preconstruction surveys and are required by wind energy promoters to evaluate the risks of their projects. But the number of bat contacts/hour can only be compared between species that have calls of similar intensity. The probability of contacting a species with a low intensity call (e.g. *R. hipposideros*) is smaller than a species with a very high intensity call (e.g. *Nyctalus* spp.). Range variations of a signal depend also on many parameters that make comparison even more difficult. To allow comparison, bats have therefore been sorted according to the increasing intensity of their sonar calls. A detectability coefficient, based on the maximum distance of detection, has been calculated for three different observer's locations (open habitat, open to semi-open habitats and woodlands). Applying this coefficient to the number of contacts or indices per species will then allow comparing the activity between species or groups of species. For more details see Barataud 2015. Dietz & Kiefer (2014) consider that when using an automatic bat detector the distance of detection is only half or 2/3 of the indicated distances.

Open habitat			
Intensity level of calls	**Species**	**Distance of detection (m)**	**Detectability coefficient**
Very low to low	*Rhinolophus hipposideros*	5	5,00
	Rhinolophus ferr/eur/meh.	10	2,50
	Myotis emarginatus	10	2,50
	Myotis alcathoe	10	2,50
	Myotis mystacinus	10	2,50
	Myotis brandtii	10	2,50
	Myotis daubentonii	15	1,67
	Myotis nattereri	15	1,67
	Myotis bechsteinii	15	1,67
	Barbastella barbastellus	15	1,67
Medium	*Myotis oxygnathus*	20	1,25
	Myotis myotis	20	1,25
	Pipistrellus pygmaeus	25	1,00
	Pipistrellus pipistrellus	30	0,83
	Pipistrellus kuhlii	30	0,83
	Pipistrellus nathusii	30	0,83
	Miniopterus schreibersii	30	0,83
High	*Hypsugo savii*	40	0,63
	Eptesicus serotinus	40	0,63
	Plecotus spp	40	0,63
Very high	*Eptesicus nilssonii*	50	0,50
	Eptesicus isabellinus	50	0,50
	Vespertilio murinus	50	0,50
	Nyctalus leisleri	80	0,31

	Nyctalus noctula	100	0,25
	Tadarida teniotis	150	0,17
	Nyctalus lasiopterus	150	0,17

Open and semi-open habitats			
Intensity level of calls	**Species**	**Distance of detection (m)**	**Detectability coefficient**
Very low to low	*Rhinolophus hipposideros*	5	5,00
	Rhinolophus ferr/eur/meh.	10	2,50
	Myotis emarginatus	10	2,50
	Myotis alcathoe	10	2,50
	Myotis mystacinus	10	2,50
	Myotis brandtii	10	2,50
	Myotis daubentonii	15	1,67
	Myotis nattereri	15	1,67
	Myotis bechsteinii	15	1,67
	Barbastella barbastellus	15	1,67
Medium	*Myotis oxygnathus*	20	1,25
	Myotis myotis	20	1,25
	Plecotus spp	20	1,25
	Pipistrellus pygmaeus	25	1,00
	Pipistrellus pipistrellus	25	1,00
	Pipistrellus kuhlii	25	1,00
	Pipistrellus nathusii	25	1,00
	Miniopterus schreibersii	30	0,83
High	*Hypsugo savii*	40	0,63
	Eptesicus serotinus	40	0,63
Very high	*Eptesicus nilssonii*	50	0,50
	Eptesicus isabellinus	50	0,50
	Vespertilio murinus	50	0,50
	Nyctalus leisleri	80	0,31
	Nyctalus noctula	100	0,25
	Tadarida teniotis	150	0,17
	Nyctalus lasiopterus	150	0,17

Underwood (clutter)			
Intensity level of calls	**Species**	**Distance of detection (m)**	**Detectability coefficient**
Very low to low	*Rhinolophus hipposideros*	5	5,00
	Plecotus spp	5	5,00
	Myotis emarginatus	8	3,13
	Myotis nattereri	8	3,13
	Rhinolophus ferr/eur/meh.	10	2,50
	Myotis alcathoe	10	2,50
	Myotis mystacinus	10	2,50
	Myotis brandtii	10	2,50
	Myotis daubentonii	10	2,50

	Myotis bechsteinii	10	2,50
	Barbastella barbastellus	15	1,67
	Myotis oxygnathus	15	1,67
	Myotis myotis	15	1,67
Medium	*Pipistrellus pygmaeus*	25	1,00
	Miniopterus schreibersii	25	1,00
	Pipistrellus pipistrellus	25	1,00
	Pipistrellus kuhlii	25	1,00
	Pipistrellus nathusii	25	1,00
High	*Hypsugo savii*	30	0,83
	Eptesicus serotinus	30	0,83
Very high	*Eptesicus nilssonii*	50	0,50
	Eptesicus isabellinus	50	0,50
	Vespertilio murinus	50	0,50
	Nyctalus leisleri	80	0,31
	Nyctalus noctula	100	0,25
	Tadarida teniotis	150	0,17
	Nyctalus lasiopterus	150	0,17

Barataud M. (2015). Acoustic Ecology of European Bats. Species Identification, Study of their Habitats and Foraging Behaviour. English translation. A. Cockle. Biotope Editions and Publications Scientifiques du Muséum. 340 pp. + DVD of sound sequences

Dietz C. & Kiefer A. (2014). Die Fledermäuse Europas: kennen, bestimmen, schützen. Kosmos Naturführer. 394 pp.

Collect national guidelines

No new information was received, so information on National guidelines may be found in *Doc.EUROBATS.StC9-AC19.12* (http://www.eurobats.org/sites/default/files/documents/pdf/Advisory_Committee/Doc_StC9_AC19_12_ReportIWG_WindTurbines%20incl_Annexes.pdf).

Use of dogs vs humans during carcass searches

Search dogs are used in a number of fields including police tracking, search and rescue, truffle searches, hunting and cadaver searches (Browne *et al*. 2006). In the recent years, dogs have also been used for locating bat roosts in trees and snags (Chambers *et al.* 2015). Trained search dogs are proved to be more accurate and effective in searching for bat carcasses under wind turbines in comparison to human observers. This is especially true for steep and heavily vegetated sites, large search plots and locations where specific threatened or endangered species are the biggest concern (Arnett *et al*. 2005, Arnett 2006, Paulding *et al*. 2011, Paula *et al*. 2011, Reed *et al*. 2011, Mathews *et al*. 2013, Bennett 2014).

In the latest Scientific Report (Therkildsen & Elmeros 2015) from Danish Centre for Environment and Energy, the results were presented of a first year post-construction bird and bat monitoring using search dogs at Wind Turbine Test Centre near Østerild in Thy (Denmark). The monitoring was conducted in 2013 by the Department of Bioscience from Aarhus University. The search efficiency trial showed that the search dogs found 82% of the test carcasses which is comparable to other evaluations at wind turbine sites with high to medium visibility, i.e. sites where the vegetation is < 50 cm high (Arnett 2006, Mathews *et al.* 2013). Inaccessible areas with very dense vegetation cover were not searched within search plots. No bats were recovered during the searches. Pre-construction and post-construction bat activity and mortality monitoring suggested that there have been no negative effects during the first year of operation. Bird fatalities were also not retrieved during the carcass searches, but the complete absence of bird collisions was considered highly unlikely. Therefore, it was suggested that some fatalities were missed by, or were not available to the dogs or they were removed by scavengers between searches.

The differences between human searchers and search dogs are caused by the differences between human vision and dog olfactory sense, which can be used in larger area and in higher and denser vegetation (Arnett *et al*. 2005). Still, carcass decomposition condition and weather conditions such as wind and temperature can play important roles in scenting conditions and affect the search accuracy and efficiency of the working dog (Paula *et al*. 2011). General findings and recommendations on using search dogs in bat and bird mortality monitoring were presented by Bennett (2014) based on her fieldwork experience since 2005, through 5,500 surveys using search dogs across six different wind facilities in Australia. To ensure that detection rates of dogs remained high, dog and handler teams were evaluated in detectability trials quarterly with detection rates never falling below 84%, and many dogs achieving 100% detection of carcasses. It was suggested that the key for successful search is to be flexible in search protocols and to understand the effect that various factors can have on dogs detection accuracy and efficiency, including the relationship between the handler and the dog, weather conditions, topography, vegetation and target species. The influence of these factors were presented, as well as observed interactions between temperature and wind speed on the search dog efficiency. Management techniques used to maintain maximum searcher efficiency were also described. It was suggested that survey transects should only be considered as a guide when using dogs, as it is essential to allow the dogs the freedom to follow scents. Low wind and extreme cold was observed to be poor weather conditions for scenting, however it was stated that reducing search intervals and extra encouragement from the handler can ensure that mortality detection is not impacted. Although precipitation could have a negative impact on searcher efficiency, it is also noted that scenting after a rain in good weather conditions can actually increase scenting capabilities as it washes away confounding scents from the survey site. Steep and undulating sites do not provide the same ease of detection so the handlers are advised to allow the dogs to search to the highest and lowest depressions and slopes in the survey area.

It is important to note that caution is necessary when conclusions are being made due to possible bad selections and trainings of the dogs as well as handlers (dog-handler teams).

To produce consistent results, bat workers are urged to make assessments of the accuracy and efficiency of the dog–handler team at each wind farm location (Mathews *et al*. 2013). Regular detection trials are important for both maintaining the dogs enthusiasm for the task and for calculating monitoring accuracy (Bennett 2014).

Arnett E.B., technical editor. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality, search protocols, patterns of fatality, and behavioural interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Arnett E.B. 2006. A preliminary evaluation on the use of dogs to recover bat fatalities at wind energy facilities. Wildlife Society Bulletin, 34(5): 1140 – 1145.

Bennett E. 2014. Observations from the use of dogs to undertake carcass searches at wind facilities in Australia. In: Hull C.L., E. Bennett, E. Stark, Elizabeth, I. Smales, J. Lau, M. Venosta, eds. 2014. Wind and Wildlife: Proceedings from the Conference on Wind Energy and Wildlife Impacts, Vol. Part II. October 2012, Melbourne, Australia. Dordrecht. p. 113 – 123.

Browne C., K. Stafford & R. Fordham. 2006. The use of scent-detection dogs. Irish Veterinary Journal, 59(2): 97 – 104.

Chambers C.L., C.D. Vojta, E.D. Mering & B. Davenport. 2015. Efficacy of scent-detection dogs for locating bat roosts in trees and snags using detection dogs to locate bat roosts. Wildlife Society Bulletin, 39(4): 780 – 787.

Mathews F., M. Swindells, R. Goodhead, T.A. August, P. Hardman, D.M. Linton & D.J. Hosken. 2013. Effectiveness of search dogs compared with human observers in locating bat carcasses at wind-turbine sites: A blinded randomized trial. Wildlife Society Bulletin, 37: 34 – 40.

Paula J., M.C. Leal, M.J. Silva, R. Mascarenhas, H. Costa & M. Mascarenhas. 2011. Dogs as a tool to improve bird-strike mortality estimates at wind farms. Journal for Nature Conservation, 19: 202 – 208.

Paulding E., J. Nowakowski & W. Grainger. 2011. The use of dogs to perform mortality searches: cost effective and efficient. Conference on Wind Energy and Wildlife Impacts, 2 – 5 May 2011, Trondheim, Norway, NINA Report 693, poster abstract p.114.

Reed S.E., A.L. Bidlack, A. Hurt & W.M. Getz. 2011. Detection distance and environmental factors in conservation detection dog surveys. Journal of Wildlife Management*,* 75(1): 243 – 251.

Therkildsen O.R. & M. Elmeros, eds. 2015. First year post-construction monitoring of bats and birds at Wind Turbine Test Centre Østerild. Aarhus University, DCE – Danish Centre for Environment and Energy, 126 pp. Scientific Report from DCE – Danish Centre for Environment and Energy No. 133.

Comparing measurement of activity at ground level and rotor height

As pointed out in the EUROBATS Guidelines (Rodrigues *et al*. 2014), it is generally assumed that ground data on bat activity can be used to assess the activity at nacelle height because there are several studies showing a correlation between the two data sets (e.g. Behr *et al*. 2011). However, the correlation seems to differ between species (groups): Nyctaloids are more frequent at rotor height than at ground level, *P. pipistrellus* is less frequent at rotor height than at ground level and the activity levels of *P. nathusius* are similar at all heights (Behr *et al*. 2011). In some situations, no strict correlation was found (Collins & Jones 2009, Limpens *et al.* 2013). Therefore, it is often recommended to use results from measurements at ground level only to predict species composition and phenology at rotor height (e.g. Hurst *et al*. 2015). For quantitative analysis, measurements at rotor height are still highly recommended.

Conducting environmental impact studies with automated bat calls recorders simultaneously at ground level and blade height provides new insights on the use of vertical space by bats.

A large number of sites all over Europe have now hosted automatic recordings of bats at the height of the collision risk zone, e.g. at the bottom of the blade swept zone of future wind turbines, or at the nacelle of existing wind turbines (e.g. in Belgium: CSD 2013, Sertius-Biotope 2014, Rico 2016).

The number of bat calls recorded at 50 meters or above is strongly affected by the study site environment and the period in the activity season of bats.

Three major trends are detected among these studies:

1. In open areas (landscape dominated by grassland or arable fields), bat calls are more numerous near the ground than (below 10 meters) than at 50 meters, by a factor 3 to 8 in open areas.
2. In forest or in its vicinity (< 200 meters), the number of bat calls at 50 meters is much higher and is usually similar to the number of bat calls near the ground.
3. The number of bat calls at 50 meters or above is proportionally higher in August and September than during the other months of the activity season, as a result of an increased activity of migrating species (mainly *N. noctula, N. leisleri, P. nathusii*), but also resident *P. pipistrellus*.

However, another study from Germany, that analyzed activity data from wind masts at prospected wind parks, found that also at forest clearings activity at ground level was much higher than at 50 and 100 m (Hurst *et al*. 2014). This underlines that more data should be collected to detect general patterns of activity differences between ground level and different heights.

Since bat activity tends to decrease with altitude (measured from the ground in open areas or measured from the canopy in forest, e.g. Hurst *et al*. 2014), increasing significantly the bottom of the blade swept zone[1] may be regarded as a complementary mitigation measure, in combination with blade feathering.

More recently, trajectography developed as a new and promising discipline in bat studies, thanks to the development of recorders using synchronized acoustic or thermographic

[1] for instance above 70 meters in place of 50 meters, thanks to higher tower

sensors. When applied at existing wind turbines, trajectography shows that bat typically approached turbines on the leeward (downwind) side (Cryan *et al.* 2014, Rico 2016). This suggests that the mast or the nacelle of a wind turbine may be attractive to bats for different reasons. More researches need to be conducted on this topic.

Behr, O., R. Brinkmann, Niermann, I. & Korner-Nievergelt, F. 2011: Akustische Erfassung der Fledermausaktivität an Windenergieanlagen. – In: Brinkmann, R., Behr, O., Niermann, I. & Reich, M. (Hrsg.): Entwicklung von Methoden zur Untersuchung und Reduktion des Kollisionsrisikos von Fledermäusen an Onshore-Windenergieanlagen. Umwelt und Raum Bd. 4, 177-286, Cuvillier Verlag, Göttingen.

Collins, J. & Jones, G. (2009): Differences in bat activity in relation to bat detector height: implications for bat surveys at proposed windfarm sites. Acta Chiropterologica 11(2): 343-350.

Cryan, P.M., Gorresen, P.M., Hein, C.D., Schirmacher, M.R., Diehl, R.H., Huso, M.M., Hayman, D.T., Fricker, P.D., Bonaccorso, F.J., Johnson, D.H. and Heist, K., 2014. Behavior of bats at wind turbines. Proceedings of the National Academy of Sciences, 111(42), pp.15126-15131.

CSD. 2013. Suivi de mortalité des chauves-souris et bat monitoring sur le parc éolien de Perwez. Rapport final. CSD Ingénieurs Conseils Namur. 94 pp.

Hurst, J., H. Schauer-Weisshahn, M. Dietz, E. Höhne, M. Biedermann, W. Schorcht, I. Karst und R. Brinkmann (2014). When are bats active in high altitudes above the forest canopy? - Activity data from wind masts allows the prediction of times with high collision risks. 13th European Bat Research Symposium, 1-5 September 2014, Sibenik, Croatia.

Hurst, J., Balzer S., Biedermann, M., Dietz, C., Dietz, M., Höhne, E., Karst, I., Petermann, R., Schorcht, W., Steck, C. & Brinkmann, R. (2015). Erfassungsstandards für Fledermäuse bei Windkraftprojekten in Wäldern - Diskussion aktueller Empfehlungen der Bundesländer. Natur und Landschaft, 90: 157-169.

Limpens, H.J.G.A., M. Boonman, F. Korner-Nievergelt, E.A. Jansen, M. van der Valk, M.J.J. La Haye, S. Dirksen & S.J. Vreugdenhil, 2013. Wind turbines and bats in the Netherlands - Measuring and predicting. Report 2013.12, Zoogdiervereniging & Bureau Waardenburg.

Rico P. 2016 Etude de l'activité et de la mortalité des chiroptères sur des parcs éoliens au moyen de la trajectographie acoustique et de la recherche de cadavres au sol – Contributions aux évaluations des incidences sur l'environnement. Draft report. Marché public de services N°03.05.0.-14D454 – Sens of Life – Service public de Wallonie-DGO3.

Rodrigues, L., Bach, L., Duborg-Savage, M.J., Karapandza, B., Kovac, D., Kervyin, T., Dekker, J., Kepel, A., Bach, P., Collins, J. and Harbusch, C., 2014. Guidelines for consideration of bats in wind farm projects—Revision 2014. EUROBATS Publication Series.

Sertius-Biotope. 2014. Projet éolien de Trois-Ponts – Etude de l'activité des chauves-souris en altitude. Décembre 2014. 34 pp.

Small Wind Turbines

Small wind turbines (SWT, now defined as < 100kW; Worldwide Energy Association) are now routinely installed in many European countries and the USA and, in spite of the rapid growth in numbers, there has been little study of their impact on wildlife. Consequently, the evidence-base upon which to establish planning guidance is very limited. Research in the UK has examined the evidence for possible effects of micro-turbines and the magnitude of impact that they may have upon birds and bats. Available evidence to date indicates that in close proximity to operating SWT (< 18 m hub height / < 15kW) bat activity is substantially reduced, suggesting their use of habitat adjacent to SWT may be affected (Minderman *et al.*

2012, Tatchley 2015), but that mortality rates at many sites appear to be relatively low (Minderman *et al*. 2015).

Tatchley *et al*. (in press) conducted a UK-wide mail survey investigating public attitudes towards SWTs. Just over half of the respondents felt that SWTs were acceptable across a range of settings, with those on road signs being most accepted and least accepted in hedgerows and gardens, the latter in part because of concerns for wildlife including bats. Concern about climate change positively influenced how respondents felt about SWTs. The avoidance of locating SWTs in contentious settings such as hedgerows and gardens may help to minimise public opposition to proposed installations.

In northern Germany two studies about bats and SWT have started during the last two years, but no data are published yet.

Minderman J, Fuentes-Montemayor E, Pearce-Higgins JW, Pendlebury CJ, Park KJ. (2015). Levels and correlates of bird and bat mortality at small wind turbine sites. Biodiversity & Conservation 24, 467-482.

Tatchley, C. (2015). Wildlife impacts of and public attitudes towards small wind turbines. Unpublished PhD thesis, University of Stirling. Available at UoS Online Research Repository: http://dspace.stir.ac.uk/handle/1893/22894#.VuhGnNKLRpg

Tatchley C, Paton H, Robertson E, Minderman J, Hanley N & Park, KJ. (in press). Drivers of public attitudes towards small wind turbines in the UK. PloS ONE.

Offshore windfarms

Lagerveld *et al*. (2014) did the first bat survey at two off-shore wind farms in the Southern North Sea (15 and 23 km from the coastline). They got more than 200 bat contacts, 98% belonging to *P. nathusii* and 2% belonging to *Nyctalus noctula*. In the following years they continued the survey and included a new site about 80km away from the coast (Lagerveld *et al*. 2015). Bats were recorded at all sites (0, 15, 23 and 80 km away from the coast). *Pipistrellus nathusii* was the most frequently recorded species at each site and the only one recorded at the site 80 km far out. Nyctaloid (including *Nyctalus*, *Vespertilio* and *Eptesicus* species) was the second-most common species group, recorded at the coast and 15 and 23km far out. *Pipistrellus pipistrellus* were only recorded at the coast site and 15 km far out. The fact that bats were recorded shortly after sunset at the coastline and 80 km far out led to their conclusion that bats might have roosted in the wind turbines.

Rydell & Wickmann (2015) published a study done in a wind farm 4 km off from Gotland in the Baltic Sea. They studied bat activity 5 m above the sea level between 14th of August and 20th of October 2013. During that time they only recorded six echolocation sequences of *Nyctalus noctula* between 26th and 27th of August.

Bach *et al*. (2015) continued their acoustical studies at Falsterbo (Sweden), where bats regularly leave the Swedish mainland towards Denmark, crossing the Öresund or Western Baltic. *Pipistrellus nathusii* was the most frequently migrating species; however *P. pygmaeus*, *N. leisleri* and *Vespertilio murinus* appeared also at the study site during migration periods and less during June/July. For *Nyctalus noctula* the situation is unclear. They found high variation of migration activity between the years for *Pipistrellus nathusii* and *P. pygmaeus*.

Bach, L. P. Bach, S. Ehnbom, & M. Karlsson (2015) Bat migration at Måkläppen (Falsterbo) 2010-2014. Falsterbo Report number 292: 7pp. http://www.falsterbofagelstation.se/arkiv/pdf/292.pdf

Lagerveld, S., B. Jonge Poerink, H. Verdaat & R. Haselager (2014) Bat Activity in Dutch offshore wind farms in autumn 2012. Lutra 57(2): 61-69. http://www.zoogdierwinkel.nl/sites/default/files/imce/nieuwesite/Winkel/pdf%20download/Lutra%2057(2)_Lagerveld%20et%20al_2014.pdf

Lagerveld, S., B. Jonge Poerink & P. de Vries (2015) Monitoring bat activity at Dutch EEZ in 2012. IMARES Report number C094/15: 33 pp. https://www.noordzeeloket.nl/images/Monitoring%20bat%20activity%20at%20the%20Dutch%20EEZ%20in%202014%20-%20IMARES_4701.pdf

Rydell, J. & A. Wickmann (2015) Bat activity at a small wind turbine in the Baltic. Acta Chiropterologica 17(2): 359-364.

Wind farms and forests

Many recent studies have shown that European forests are refuges for bats. Forest habitats supply roosts and foraging grounds for many bat species, resulting in higher bat activity in forests than in open areas. When wind farms are constructed within woodlands, the impacts may include the following: (i) loss of roosts when trees are felled to make way for turbines and related infrustructure, (ii) loss of foraging habitat due to tree felling, (iii) disturbance effects from the operational turbines and roads, and (iv) potential collision with turbine blades.

Roosts: Several studies show that tree-dwelling bats preferentially choose high cavities in trees for roosting (Russo *et al*. 2004; Ruczyński & Bogdanowicz 2005; Tillon & Aulagnier 2014). These may be difficult to detect from ground-level, and acoustic detectors may need to be elevated if they are to be used to assist emergence counts. There is also evidence that the roosting ranges of adjacent social groups of woodland bats do not overlap (August *et al*. 2014). Therefore when roosting sites are lost through felling, it may be difficult for the colony to relocate.

Commuting and migratory behaviour: Some bat species fly high above ground/canopy during commuting and migration flights. This is especially the case of *Nyctalus noctula* and *Nyctalus leisleri*. Several other species commute high above ground even if their foraging behaviour occurs at low levels. This is for instance the case of the ground-gleaning *M. myotis* which has already been observed commuting at a speed of 50 km/h (Arlettaz 1996) and above 32 meters (Sertius-Biotope 2014). Forests stands often reach more than 30 meters above the ground level. When the lowest point of blade movement is equal or less than 50 meters, the safe operating space is dangerously restricted for bats flying above the canopy, even if the direct surroundings of the turbine have been clear-cut

Detectability and forest strata: The activity of bats has been observed to be highest in (Rieger & Nagel 2007; Collins & Jones 2009; Müller *et al*. 2012, 2013; Plank *et al*. 2012;

Schuster *et al*. 2015) and above canopies (Bach *et al*. 2012; Müller *et al*. 2013; Schuster *et al*. 2015). In France, Fauvel & Bécu (2005) and then Barataud & Giosa (2012) demonstrated that although it is possible to detect bats in forest from the ground, the species diversity identified at ground level may be different from that recorded at the canopy. A recent study in France (Tillon pers. com.) showed that certain bat species which are found in forests, such as gleaning *Plecotus auritus* and *Myotis bechsteinii*, are detected at ground-level, yet the recorded activity is lower than their actual abundance. Even *Pipistrellus* and *Nyctalus* species foraging above the canopy are usually not detectable from ground (Bach *et al*. 2012; Müller *et al*. 2013). Therefore the absence of ultrasonic evidence or very few contacts on the ground do not necessarily mean that a species is absent or that it occurs rarely. In the UK, a recent study has investigated the number of repeated surveys required to detect woodland species occupancy using walked transect surveys (Scott & Altringham 2014). To provide a 95% probability of species detection, 2 surveys were required for *Myotis brandtii, M. mystacinus* and *Barbastella barbastellus*, 4 for *Rhinolophus hipposideros*, 5 for *Myotis nattereri*, and 9 for *P. auritus*, though the authors point out that surveys can be stopped as soon as occupancy is detected. *Myotis alcathoe* and *M. bechsteinii* have not been detected during the study, but it is suggested that 2-3 surveys for *M. alcathoe* and 4-6 for *M. bechsteinii* would be required based on their call characteristics. Furthermore, it is difficult to definitely identify these species based on acoustic records due to very similar call characteristics.

The results of the studies above indicate two main conclusions:

- Bat activity is distributed according to the stratification of the forest habitat with some species keeping to the undergrowth, others foraging within the canopy and understory (mainly *Plecotus* and *Myotis* species), and others foraging above the trees, sometimes quite high (*Nyctalus, Eptesicus, B. barbastellus, Miniopterus schreibersii* and some *Pipistrellus*);
- Not all bat species in the forest can be detected acoustically from the ground, particularly true forest species with very high conservation values and species foraging above the canopy. Their activity can very rarely be accurately assessed from the ground even by increasing the number of recording points and sites within the forest.

Since traditional acoustic survey from the ground shows a very low detection rate for some species, additional methods such as acoustic surveys at height and non-acoustic methods (e.g. mist-netting, trapping, radio-tracking) should be utilised for impact assessment studies in forests, especially for wind farm projects (Hayes 2000, Duchamp *et al*. 2006, Gorresen *et al*. 2008, Bach *et al*. 2012, Barataud 2012, Skalak *et al*. 2012, Britzke *et al*. 2013). Lastly, a recent paper suggested that extensive mistnetting has to be practiced (over at least 4 nights per site) and variable sites included, such as sites with high vegetation coverage, sites covering ground to subcanopy level, and others, to detect all bat species of a local forest bat ensemble (Angetter 2016). Also, acoustic surveys and any other methods used should take into account the species-specific behaviour and surveys should be carried out on the ground as well as in the canopy and above the canopy (Schuster *et al*. 2015). The thermal/infrared recording of bats around the nacelle should also be considered, as suggested by Mathews *et al*. (2015) since there were situations were bats were not recorded with ultrasound detectors placed in the nacelle although their activity might be recorded via cameras. In conclusion, a combination of methods such as conventional mistnetting effort and acoustical surveys should be practiced to detect all local bat species.

Post construction attractiveness of wind farms in forest for bats: Bats may be attracted towards wind turbines after their constructions in forests for two reasons. First, the construction usually increases the proportion of forest edges within forests, because of road expansions required for the safe operation of large trucks or clear-cutting at the specific location of WT. These forest gaps increase the sunlight on the ground, which ultimately will boost vegetation and insect activity in the close vicinity of wind turbines. Secondly, wind turbines may resemble tall trees, and therefore be attractive to bats as roosting or mating sites (Cryan *et al*. 2014). For all these reasons, a precautionary approach is adopted by an increasing number of European countries (Germany, Belgium, France, Sweden) when wind turbines are planned in forests. Some countries or regions allow WT projects only in biologically depleted forests (intensive spruce plantations for instance), but refuse them in forests harbouring high biodiversity (broad-leaved forests, ancient forests, ...). Recording bat activity above the canopy or at the lowest blade level has become a standard in an increasing number of EIA related to WT projects in forests.

Fragments, edges and hedges: Even small forest fragments and hedges in otherwise open agricultural landscape have large positive impact on local bat activity and diversity (e.g. Brandt *et al*. 2007; Řehák *et al*. 2010; Kelm *et al*. 2014, Heim *et al*. 2015), but also on bat diversity on regional scale (Mehr *et al*. 2011). Therefore, bat surveys for impact assessment of wind farm projects should especially consider forest fragments and hedges and, if needed, to employ same methods as recommended for wind farms in forests (see also IWG report on '200 m buffer distance to habitats particularly important for bats'). Also, Kelm *et al*. (2014) studied bat activity in relation to distance to hedgerows in an agricultural landscape. They found that activity of all bat species was concentrated near the hedges and decreasing with distance, at species-specific and season-specific intensities and rates. For most of the species (except for only *Nyctalus noctula* during summer) activity is significantly lower at 200 m distance from hedges, which strongly supports threshold distance of wind turbines from forest edges, hedges and other habitat elements specifically important for bats set up by EUROBATS Guidelines.

Angetter L.-S. (2016) Fledermausfang im Rahmen der Eingriffsplaning von Windkraftanalgen in Wäldern. Naturschutz und Landschaftspanung 48:73-79.

Arlettaz R. 1996. Feeding behaviour and foraging strategy of free-living mouse-eared bats, Myotis myotis and Myotis blythii. Animal behaviour 51(1): 1-11.

August T. A., M. A. Nunn, A. G. Fensome, D. M. Linton, & F. Mathews. 2014. Sympatric Woodland Myotis Bats Form Tight-Knit Social Groups with Exclusive Roost Home Ranges. PLoS One 9:e112225.

Bach L., Bach P., Tillmann M. & Zucchi H. (2012): Fledermausaktivität in verschiedenen Straten eines Buchenwaldes in Nordwestdeutschland und Konsequenzen für Windenergieplanungen. – Naturschutz & Biologische Vielfalt 128: 147-158.

Barataud M. 2012. Ecologie acoustique des Chiroptères d'Europe: Identification des espèces, étude de leurs habitats et comportements de chasse. Biotope, Mèze & Muséum national d'histoire naturelle, Paris.

Barataud M. & S. Giosa. 2012. Biodiversité Des Chiroptères et Gestions Forestières En Limousin. Limoges. LT-BAR25.pdf.

Brandt G., Blows L., Linton D., Paling N. & Prescott C. 2007. Habitat associations of British bat species on lowland farmland within the Upper Thames catchment area. Habitat Associations of British bats. Centre for Wildlife Assessment & Conservation E-Journal 1: 10-19.

Britzke E.R., E.H. Gillam & K.L. Murray. 2013. "Current State of Understanding of Ultrasonic Detectors for the Study of Bat Ecology." Acta Theriologica 58 (2): 109–17.

Collins J. & G. Jones. 2009. "Differences in Bat Activity in Relation to Bat Detector Height: Implications for Bat Surveys at Proposed Windfarm Sites." Acta Chiropterologica 11 (2): 343–50.

Cryan P.M., Gorresen P.M., Hein C.D., Schirmacher M.R., Diehl R.H., Huso M.M., D.T.S. Hayman, P.D. Fricker,F.J. Bonaccorso, D.H. Johnson, K. Heist & Dalton, D.C. (2014). Behavior of bats at wind turbines. Proceedings of the National Academy of Sciences, 111(42), 15126-15131.

Duchamp J.E., M. Yates, R-M Muzika & R.K. Swihart. 2006. "Estimating Probabilities of Detection for Bat Echolocation Calls: An Application of the Double-Observer Method." Wildlife Society Bulletin 34 (2): 408–12. doi:10.2193/0091-7648(2006)34[408:EPODFB]2.0.CO;2.

Fauvel B. & D. Bécu. 2005. Développement d'une méthodologie pour mesurer l'activité des chauvessouris : Diverses applications et définition d'un protocole pour le suivi des Réserves de l'ONF. In Les Mammifères Forestiers, Actes Du XXVIIIème Colloque Francophone de Mammalogie de La SFEPM, edited by L. Tillon, 18:63–70.

Gorresen P.M., A.C. Miles, C.M. Todd, F.J. Bonaccorso & T.J. Weller. 2008. Assessing Bat Detectability and Occupancy with Multiple Automated Echolocation Detectors. Journal of Mammalogy 89 (1): 11–17.

Hayes J.P. 2000. Assumptions and Practical Considerations in the Design and Interpretation of Echolocation-Monitoring Studies. Acta Chiropterologica 2 (2): 225–36.

Heim O., Treitler J.T., Tschapka M., Knörnschild M. & Jung, K. (2015). The Importance of Landscape Elements for Bat Activity and Species Richness in Agricultural Areas. PloS one, 10(7), e0134443

Kelm D.H., Lenski J., Kelm V., Toelch U. & Dziock F. (2014) Seasonal bat activity in relation to distance hedgerows in an agricultural landscape in central Europe and implications for wind energy development. Acta Chiropterologica 16(1): 65-73.

Mathews F., Richardson S. & Hosken D. (2015): A nationwide assessment of the impacts of wind turbines on bats - What have we learnt so far? In: Köppel J. & Schuster E.: Book of Abstracts. Conference on Wind energy and Wildlife impacts (CWW 2015), March 10-12, 2015. Berlin, Germany, p. 46.

Mehr M., R. Brandl, T. Hothorn, F. Dziock, B. Förster & J. Müller. 2011. Land use is more important than climate for species richness and composition of bat assemblages on a regional scale. Mammalian Biology - Zeitschrift für Säugetierkunde, 76 (4): 451-460.

Müller J., M. Mehr, C. Bässler, M.B. Fenton, T. Hothorn, H. Pretzsch, H.-J. Klemmt & R. Brandl. 2012. Aggregative Response in Bats: Prey Abundance versus Habitat. Oecologia 169: 673–84.

Müller J., R. Brandl, J. Buchner, H. Pretzsch, S. Seifert, C. Strätz, M. Veith & B. Fenton. 2013. From ground to above canopy — Bat activity in mature forests is driven by vegetation density and height, Forest Ecology and Management 306: 179-184

Plank M., K. Fiedler & G. Reiter. 2012. Use of Forest Strata by Bats in Temperate Forests. Journal of Zoology 286: 154–62.

Řehák Z., Ž. Horáčková, J. Zukal & T. Bartonička 2010. Importance of forest fragments in agricultural landscape to bats. 15 International Bat research conference, Prague, 23-27 august 2010. Programme, Abstract. List of Participants: 262

Rieger I. & P. Nagel. 2007. "Vertical Stratification of Bat Activity in a Deciduous Forest." In The Canopy of a Temperate Floodplain Forest - Results from Five Years of Research at the Leipzig Canopy Crane, edited by M. Unterseher, W. Morawetz, S. Klotz, and E. Arndt, The Leipzig Canopy Crane Project, 141–49. Leipzig (Germany): Universität Leipzig.

Ruczyński I., and W. Bogdanowicz. 2005. Roost cavity selection by *Nyctalus noctula* and *N. leisleri* (Vespertilionidae, Chiroptera) in Białowieża primeval forest, Eastern Poland. Journal of Mammalogy 86:921-930. Russo, D., L. Cistrone, G. Jones, and S.

Russo D., L. Cistrone, G. Jones & S. Mazzoleni. 2004. Roost selection by barbastelle bats (*Barbastella barbastellus*, Chiroptera: Vespertilionidae) in beech woodlands of central Italy: consequences for conservation. Biological Conservation 117:73-81.

Scott C. & Altringham J. 2014. WC1015 Developing effective methods for the systematic surveillance of bats in woodland habitats in the UK. Report,University ofLeeds, 62pp.

Sertius-Biotope (2014) – Projet éolien de Trois-Ponts – Etude de l'activité des chauves-souris en altitude. Décembre 2014. 34 pp.

Schuster E., L. Bulling & J. Köppel. 2015. Consolidating the State of Knowledge: A Synoptical Review of Wind Energy's Wildlife Effects. Environmental Management, 56(2): 300–331.

Skalak S.L., R.E. Sherwin & R.M. Brigham. 2012. Sampling Period, Size and Duration Influence Measures of Bat Species Richness from Acoustic Surveys. Methods in Ecology and Evolution 3: 490–502.

Tillon L. & S. Aulagnier. 2014. Tree cavities used as bat roosts in a European temperate lowland subatlantic forest. Acta Chiropterologica 16 (2): 359–68. doi:10.3161/150811014X687314.

Implementation of mitigation and post-construction monitoring

The sub-group prepared a draft questionnaire to be sent to focal points of Parties and non-party Range States. The draft questionnaire will be discussed during 21AC.

200m buffer distance to habitats particularly important for bats

Using different methodological approach than Kelm *et al.* (2014), whose publication was available at the moment of the Guidelines update, Heim *et al.* (2015) have come to conclusions that further support Guidelines' recommendation of 200m buffer for WGs from forests. They have monitored bat activity and species richness at 50 grassland sites in the Biosphere Reserve Schorfheide-Chorin (NE Germany), from May to September in 2010, and tested significance of the distance to and the land cover share of forest remnants and urban areas in a 200m buffer around the recording sites as well as a distance to potentially connecting landscape elements e.g. trees, linear vegetation, groves, running and standing water) for species richness and higher bat activity. Overall species richness and bat activity increased significantly with higher share of forest land cover in the 200m buffer and at smaller distance to forested areas. Moreover, species richness increased in proximity to tree groves. Higher share of forest land cover and smaller distance to forest also resulted in a higher activity of bats on grassland sites during May, June and July. Landscape elements near grassland sites also influenced species composition of bats and species richness of functional groups (open, edge and narrow space foragers), however, species richness of all functional groups was highest at sites with higher share of forest land cover in their direct surroundings and at closer proximity to forest patches.

Heim, O., Treitler, J.T,, Tschapka, M., Knörnschild, M., Jung, K. (2015) The Importance of Landscape Elements for Bat Activity and Species Richness in Agricultural Areas. PLoS ONE 10(7): e0134443. doi:10.1371/journal.pone.0134443.

Kelm, D.H., J. Lenski, V. Kelm, U. Toelch & F. Dziock (2014) Seasonal Bat Activity in Relation to Distance to Hedgerows in an Agricultural Landscape in Central Europe and Implications for Wind Energy Development. Acta Chiropterologica 16 (1): 65-73. doi: http://dx.doi.org/10.3161/150811014X683273.

Final remarks

Available results continue to show that mortality is highly variable between different sites and between different wind turbines within one wind farm. Besides that, mortality varies between years and this is why we advise for a 3-year mortality monitoring to get a better idea of the impact and to avoid biases unrelated to the wind farm. Furthermore monitoring of mortality rarely follows the same method. Monitoring schedule, time interval between controls and estimator for mortality rate differ from one wind farm to the other and make comparisons impossible. Tests for predation and searcher's efficiency are not always performed, not to mention the correction for the % of area not sampled.

It is not possible to evaluate the impacts of wind farms without mortality data; yet very few governments sent the results of their monitoring programmes. This is essential if we want to assess the cumulative impacts of wind farms on local or regional bat populations. Therefore the IWG urges the Eurobats range states again to send data on observed mortality, monitoring programmes and research projects, papers references, National guidelines, and all relevant information (mitigation measures, compensation measures, deterrents, etc).

Annex 1 – New references
(addendum to the list presented in 20AC (Doc.EUROBATS.AC20.5) and in EUROBATS Publication Series nº 6)

Adams, A.M., M.K. Jantzen, R.M. Hamilton & M.B. Fenton (2012): Do you hear what I hear? Implications of detector selection for acoustic monitoring of bats. *Methods in Ecology and Evolution*, 3: 992-998.

Adorf F. 2015. Bats at Risk! How informative are results from high-altitude surveys of bat activity at wind turbines? Practical applications 4th International Berlin Bat Meeting: Movement Ecology of Bats, Poster, Book of abstracts, p.108

Alvarez-Castañeda S.T. & W. Z. Lidicker Jr., 2015. Managing coexistence for bats and wind turbines *THERYA, 2015, Vol. 6 (3): 505-513* DOI: 10.12933/therya-15-330

Angetter, L.-S. (2016) Fledermausfang im Rahmen der Eingriffsplanung von Windkraftanlagen in Wäldern. Naturschutz und Landschaftsplanung 48:73-79.

Arnett E. B., Baerwald E.F., Mathews F., Rodrigues L., Rodríguez-Durán A., Rydell J., Villegas-Patraca R. & Voigt C.C., 2016 Impacts of Wind Energy Development on Bats: A Global Perspective. C.C. Voigt and T. Kingston (eds.), *Bats in the Anthropocene: Conservation of Bats in a Changing World*, DOI 10.1007/978-3-319-25220-9_11

Bach, L. P. Bach, S. Ehnbom, & M. Karlsson (2015) Bat migration at Måkläppen (Falsterbo) 2010-2014. Falsterbo Report number 292: 7pp. http://www.falsterbofagelstation.se/arkiv/pdf/292.pdf

Bach & Bach (2016) Fledermausmonitoring im Windpark Dornum, Gondelmonitoring und Schlagopfersuche - Zwischenbericht 2015 - unpubl. Report to Windpark Dornum GmbH & Co. KG, 37 p.

Bach & Bach (2016) Fledermausmonitoring im Windpark Spolsen Gondelmonitoring und Schlagopfersuche - Endbericht 2015 - unpubl. Report to Planungsbüro Diekmann & Mosebach, 41 p.

Bach & Bach (2016) Fledermausmonitoring im Windpark Ostermarsch Gondelmonitoring und Schlagopfersuche - Zwischenbericht 2015 - unpubl. Report to Norderland Energie GmbH

Bach & Bach (2016) Fledermausmonitoring im Windpark Holtriem Gondelmonitoring und Schlagopfersuche - Zwischenbericht 2015 - unpubl. Report to Norderland Energie GmbH.

Bio3. 2015. Monitorização das comunidades de aves e quirópteros no Parque Eólico do Malhanito. Relatório 4 (Fase de exploração –2013/2014). 139pp.

Bio3. 2015. Parque Eólico de Mosqueiros II. Monitorização da Comunidade de Quirópteros. Relatório 5 (Fase de exploração - 2014). 88 pp.

Bontadina F., Beck A., Biollaz F., Brossard C., Dietrich A., Dobner M., Eicher C., Frey-Ehrenbold A., Krainer K., Loercher F., Maerki K., Mattei-Roesli M., Mixanig H., Plank M., Vorauer A., Wegleitner S., Widerin K., Wieser D., Wimmer B. & Reiter G. (2015). Massive bat migration across the Alps: implications for wind energy development. 4th International Berlin Bat Meeting: Movement Ecology of Bats, Book of abstracts, p. 34

Diffendorfer, J. E., Beston, J. A., Merrill, M. D., Stanton, J. C., Corum, M. D., Loss, S. R., ... & Heist, K. W. (2015). Preliminary methodology to assess the national and regional impact of US wind energy development on birds and bats.*US Geological Survey Scientific Investigations Report*, *506*.

Erickson, R. A., E. A. Eager, J. C. Stanton, J. A. Beston, J. E. Diffendorfer, and W. E. Thogmartin. 2015. Assessing local population vulnerability with branching process models: an application to wind energy development. Ecosphere 6(12):254. http://dx.doi.org/10.1890/ES15-00103.1

Ferreira D., C. Freixo, J.A. Cabral, R. Santos & M. Santos. 2015. Do habitat characteristics determine mortality risk for bats at wind farms? Modelling susceptible species activity patterns and anticipating possible mortality events. Ecological Informatics, 28: 7–18.

Ferri V., C. Battisti & C.Soccini. 2016. Bats in a Mediterranean Mountainous Landscape: Does Wind Farm Repowering Induce Changes at Assemblage and Species Level? Environmental Management. DOI 10.1007/s00267-016-0686-2.

Frey, Bach & Bach (2016) Monitoring der Fledermausaktivität im Windpark Krögershamm - Endbericht 2015 - unpubl. Report to Planungsbüro Diekmann & Mosebach, 52 p.

Geonatura Ltd. (2015) Bat fauna monitoring at wind farm Danilo in Croatia (Annual report 2014-2015)

Hanagasioglu M., Aschwanden J., Bontadina F., de la Puente Nilsson M. 2015. Investigation of the effectiveness of bat and bird detection of the DTBat and DTBird systems at Calandawind turbine. Swiss Federal Office of Energy SFOE & Federal Office for the Environment FOEN.

Hayes MA, Cryan PM, Wunder MB (2015) Seasonally-Dynamic Presence-Only Species Distribution Models for a Cryptic Migratory Bat Impacted by Wind Energy Development. PLoS ONE. 10(7): e0132599. doi:10.1371/journal.pone.0132599

Heim, O., Treitler, J.T., Tschapka, M., Knörnschild, M., Jung, K. (2015) the importance of landscape elemnets for bat activity and species richness in agricultural areas. PLoS ONE 10(7): e0134443. doi:10.1371/journal.pone.0134443

Hillen J. & Adorf F. (2015). Bats at Risk! Reality versus statistical model: Do systematic fatality searches yield a realistic picture of species-specific threats to bats from wind turbines? 4th International Berlin Bat Meeting: Movement Ecology of Bats, Poster, Book of abstracts, p. 109

Hurst J., Balzer S., Biedermann M., Dietz C., Dietz M., Höhne E., Karst I., Petermann R., Schorcht W., Steck C. & Brinkmann, R. (2015). Erfassungsstandards für Fledermäuse bei Windkraftprojekten in Wäldern. Natur und Landschaft 90: 157-170.

Huso M.M.P., D.H. Dalthorp, D.A. Dail & L.J. Madsen. 2014. Estimating wind-turbine caused bird and bat fatality when zero carcasses are observed. Ecological Applications. DOI: 10.1890/14-0764.1.

Ijäs A., Inberg E., Vasko V., Lilley T. & Hagner-Wahlstein N. (2015). Aggregation of migratory bats to the coastline of the Northern Baltic Sea. 4th International Berlin Bat Meeting: Movement Ecology of Bats, Book of abstracts, p.33

Kelm D., Lenski J., Kelm V., Toelch U. & Dziock F. (2015). Seasonal bat activity near hedgerows in north-eastern Germany. 4th International Berlin Bat Meeting: Movement Ecology of Bats, Poster, Book of abstracts, p. 115

Lagerveld, S., B. Jonge Poerink, H. Verdaat & R. Haselager (2014) Bat Activity in Dutch offshore wind farms in autumn 2012. Lutra 57(2): 61-69. http://www.zoogdierwinkel.nl/sites/default/files/imce/nieuwesite/Winkel/pdf%20download/Lutra%2057(2)_Lagerveld%20et%20al_2014.pdf

Lagerveld, S., B. Jonge Poerink & P. de Vries (2015) Monitoring bat activity at Dutch EEZ in 2012. IMARES Report number C094/15: 33 pp. https://www.noordzeeloket.nl/images/Monitoring%20bat%20activity%20at%20the%20Dutch%20EEZ%20in%202014%20-%20IMARES_4701.pdf

LEA. 2015. Monitorização da Atividade e Mortalidade de Quirópteros no Parque Eólico de Negrelo e Guilhado. Relatório do 4º ano (2012) e final da fase de exploração. Revisão da sua versão original de 2012. Laboratório de Ecologia Aplicada da Universidade de Trás-os-Montes e Alto Douro. Estudo coordenado por Ecosfera, consultoria ambiental Lda. para EDP Renováveis Portugal, S.A.. Porto. 54 pp + Anexos.

Măntoiu D.S., Chişamera G., Chachula O.M., Mărginean G., Pocora I., Pocora V., Hodor C., Stanciu C.R., Popescu-Mirceni R., Telea A., Bălăşoiu D.. & Şandric I.C. (2015). A bat fatality risk model at wind farms in Dobrogea, Romania, using a GIS approach. 4th International Berlin Bat Meeting: Movement Ecology of Bats, Poster, Book of abstracts, p. 116

Mascarenhas, M.; Bernardino, J.; Paula, A.; Costa, H.; Bastos, C.; Cordeiro, A.; Marques, A.; Marqués, J.; Mesquita, S.; Paula, J.; Pereira, M.; Peste, F.; Ramalho, R.; Rodrigues, S.; Santos, J.; Veira, J.; Fonseca, C. (2015). Biodiversity & Wind Energy: A Bird's and Bat's Perspective. Bio3 and University of Aveiro, Aveiro, Portugal, 98pp.

Mathews F., Richardson S. & Hosken D. (2015): A nationwide assessment of the impacts of wind turbines on bats - What have we learnt so far? In: Köppel J. & Schuster E.: Book of Abstracts. Conference on Wind energy and Wildlife impacts (CWW 2015), March 10-12, 2015. Berlin, Germany, p. 46.

Minderman J, Fuentes-Montemayor E, Pearce-Higgins JW, Pendlebury CJ, Park KJ. (2015). Levels and correlates of bird and bat mortality at small wind turbine sites. Biodiversity & Conservation 24, 467-482.

Nealon U., Montgomery I. & Teeling E. (2015). Using species distribution modelling to predict the risk to non-migrating bats at current and future wind energy facilities in Ireland. 4th International Berlin Bat Meeting: Movement Ecology of Bats, Poster, Book of abstracts, p. 118

Niedersächsisches Ministerium für Umwelt, Energie und Klimaschutz (2015): Leitfaden – Umsetzung des Artenschutzes bei der Planung und Genehmigung von Windenergieanlagen in Niedersachsen (Fassung 23.11.2015): 38 pp.

NOCTULA. 2015. Relatório intercalar de monitorização de avifauna e quirópteros do Parque Eólico ENERFER I (Fase de exploração - Ano II – Março 2015). Noctula – Modelação e Ambiente. Viseu. 42 pp.

NOCTULA. 2015. Relatório intercalar de monitorização de avifauna e quirópteros do Parque Eólico ENERFER I (Fase de exploração - Ano II – Maio 2015). Noctula – Modelação e Ambiente. Viseu. 48 pp.

NOCTULA. 2015. Relatório intercalar de monitorização de avifauna e quirópteros do Parque Eólico ENERFER I (Fase de exploração - Ano II – Julho 2015). Noctula – Modelação e Ambiente. Viseu. 54 pp.

NOCTULA. 2015. Relatório intercalar de monitorização de avifauna e quirópteros do Parque Eólico ENERFER I (Fase de exploração - Ano II – Setembro 2015). Noctula – Modelação e Ambiente. Viseu. 44 pp.

NOCTULA. 2015. Relatório Final de Monitorização da Atividade e Mortalidade de Aves e Quirópteros do Parque Eólico da Tocha (Fase de Exploração – Ano III). NOCTULA – Consultores em Ambiente. Viseu. 71 pp.

NOCTULA. 2015. Relatório de Monitorização da Mortalidade de Avifauna e Quirópteros no âmbito da extensão das pás dos aerogeradores do Parque Eólico da Lameira (Situação de Referência). NOCTULA – Consultores em Ambiente. Viseu. 37 pp.

O'Shea T. J. Cryan P. M., Hayman D.T.S., Plowright R. K. & Streicker D. G., 2016. Multiple mortality events in bats: a global review, 2015. Editor: KH, Mammal Review. doi:10.1111/mam.12064

Pereira M.J.R., F. Peste, A. Paula, P. Pereira, J. Bernardino, J. Vieira, C. Bastos, M. Mascarenhas, H. Costa & C. Fonseca.2015. Management of coniferous forests for bats affected by wind farms: Challenges and opportunities for mitigation strategies. Conference on Wind Energy and Wildlife Impacts (CWW): Book of Abstracts. Berlin, Germany. March 10-12, 2015.

Pereira M.J.R., F. Peste, A. Paula, P. Pereira, J. Bernardino, J. Vieira, C. Bastos, M. Mascarenhas, H. Costa & C. Fonseca. 2016. Managing coniferous production forests towards bat conservation. Wildlife Research, 43: 80-92.

PROCESL. 2015. Monitorização de quirópteros do Parque Eólico de Alvaiázere. Relatório anual 2014 (ano 4 da fase de exploração).

PROCESL. 2015. Parque Eólico da Raia - reforço de potência. Monitorização de Quirópteros. Relatório 6 (4º ano da fase de exploração - 2014).

Pylant C. L., Nelson D. M. *, Fitzpatrick M. C., Gates J. E., Keller S. R., 2016. Geographic origins and population genetics of bats killed at wind-energy facilities. Ecol. Appli. doi: 10.1890/15-0541

Rico P. 2016 Etude de l'activité et de la mortalité des chiroptères sur des parcs éoliens au moyen de la trajectographie acoustique et de la recherche de cadavres au sol – Contributions aux évaluations des incidences sur l'environnement. Draft report. Marché public de services N°03.05.0.-14D454 – Sens of Life – Service public de Wallonie-DGO3.

Robinson Willmott J., G.M. Forcey& L.A. Hooton. 2015. Developing an automated risk management tool to minimize bird and bat mortality at wind facilities. Ambio2015, 44(Suppl. 4):S557–S571.

Rydell, J., Wickman, A., 2015. Bat activity at a small wind turbine in the Baltic Sea. Acta Chiropterol. 17(2): 359–364.

Rydell J., W. Bogdanowicz, A. Boonman, S. Pettersson, E. Suchecka & J.J. Pomorski. 2016. Bats may eat diurnal flies that rest on wind turbines. Mammalian Biology-Zeitschrift für Säugetierkunde, 81(3): 331-339.

Strix. 2015. Monitorização de Quirópteros na área do Parque Eólico do Barão de São João. Relatório Ano 8 – 2014. Revisão 1.

Schuster E., Bulling L. & Köppel J., 2015. Consolidating the State of Knowledge: A Synoptical Review of Wind Energy's Wildlife Effects. Environmental Management (2015) 56:300–331. © Springer Science+Business Media New York; DOI 10.1007/s00267-015-0501-5

Smales, I. (2015). Fauna Collisions with Wind Turbines: Effects and Impacts, Individuals and Populations. What Are We Trying to Assess?. In *Wind and Wildlife* (pp. 23-40). Springer Netherlands.

Tatchley, C. (2015). Wildlife impacts of and public attitudes towards small wind turbines. Unpublished PhD thesis, University of Stirling. Available at UoS Online Research. http://dspace.stir.ac.uk/handle/1893/22894#.VuhGnNKLRpg

Tatchley C, Paton H, Robertson E, Minderman J, Hanley N & Park, KJ. (in press). Drivers of public attitudes towards small wind turbines in the UK. PloS ONE.

Therkildsen, O.R. & Elmeros, M. (eds.) 2015. First year post-construction monitoring of bats and birds at Wind Turbine Test Centre Østerild. Aarhus University, DCE – Danish Centre for Environment and Energy, 126 pp. Scientific Report from DCE – Danish Centre for Environment and Energy No. 133. http://dce2.au.dk/pub/SR133.pdf.

TPF Planege. 2015. Parque Eólico de Falperra-Rechãzinha. Monitorização de quirópteros. Fase de exploração (Fase III) – 2º ano. Relatório nº 3.

Voigt C.C., Lehnert L. S., Petersons G., Adorf F. & Bach L. (2015) Wildlife and renewable energy : German politics cross migratory bats. Eur J Wildl Res., 61:213-219.

Wolpert R.L. 2015. ACME: A Partially Periodic Estimator of Avian & Chiropteran Mortality at Wind Turbines. Cornell University Library. 22p. http://arxiv.org/abs/1507.00749

YME. 2011. Monitorização Ambiental do Parque Eólico de Alto da Folgorosa – Fase de exploração. Avifauna, Morcegos, Flora e Vegetação.

YME. 2012. Monitorização Ambiental do Parque Eólico de Alto da Folgorosa – Fase de exploração. Avifauna, Morcegos, Flora e Vegetação. Adenda ao relatório anual 2011.

Previous unlisted papers

Alves P., B Silva & S Barreiro. 2013. Parque Eólico de Chão Falcão I. Monitorização de quirópteros. Relatório 6 – Ano 2009 (relatório final). Plecotus, Lda.

Bat Conservation Ireland (2012) Wind turbine/wind development bat survey guidelines - version 2.8. Bat conservation Ireland. http://www.batconservationireland.org/pubs/reports/BCIreland%20Wind%20Farm%20Turbine%20Survey%20Guidelines%20Version%202%208.pdf

Bio3. 2013. Monitorização das comunidades de aves e quirópteros no Parque Eólico da Terra Fria. Relatório V (Fase de exploração de Montalegre), Relatório Final de Contim (Ano 2012). Relatório elaborado para ENEOP2. Bio3, Lda. Almada, Abril de 2013.

Cryan P.M., Gorresen P.M., Hein C.D., Schirmacher M.R., Diehl R.H., Huso M.M., D.T.S. Hayman, P.D. Fricker,F.J. Bonaccorso, D.H. Johnson, K. Heist & Dalton, D.C. (2014).

Behavior of bats at wind turbines. Proceedings of the National Academy of Sciences, 111(42), 15126-15131.

CSD (2013) : Suivi de mortalité des chauves-souris et bat monitoring sur le parc éolien de Perwez. Rapport final. CSD Ingénieurs Conseils Namur. 94 pp.

Ecosativa. 2013. Plano de Monitorização de avifauna e quirópteros do Parque Eólico de Alto da Coutada. Fase de exploração. Relatório Final. São Teotónio, Portugal.

Ecosativa. 2013. Plano de Monitorização de avifauna e quirópteros. Ampliação do Parque Eólico do Açor. Fase de exploração.São Teotónio, Portugal.

Ecosativa. 2014. Plano de Monitorização de avifauna e quirópteros. Ampliação do Parque Eólico do Açor. Fase de exploração.2º Relatório anual da fase exploração para a empresa EDP renováveis Portugal S.A. São Teotónio, Portugal.

LEA. 2007. Monitorização da mortalidade de aves e quirópteros no Parque Eólico da Lameira. Relatório Final 2006/2007.

Naturibérica. 2009.Monitorização do Parque Eólico de Alto da Folgorosa. Avifauna e Quirópteros. Relatório Anual.

NOCTULA. 2013. Relatório de monitorização dos sistemas ecológicos na área do Parque Eólico de São Macário II (Fase de exploração (ano I) – 2011/2012). NOCTULA – Modelação e Ambiente. Viseu. 144 pp.

NOCTULA. 2013. Relatório de monitorização da mortalidade de avifauna e de quirópteros na área do Parque Eólico da Serra d'El Rei (Fase de exploração - 2012/2013). NOCTULA – Modelação e Ambiente. Viseu. 17 pp.

NOCTULA. 2014. Relatório de monitorização dos sistemas ecológicos na área do Parque Eólico de São Macário II (Fase de exploração (ano III) – Novembro de 2014. NOCTULA – Consultores em Ambiente. Viseu. 127 pp.

NOCTULA. 2014. Relatório de monitorização da mortalidade de avifauna e de quirópteros na área do Parque Eólico da Serra d'El Rei (Fase de exploração - 2013/2014). NOCTULA – Consultores em Ambiente. Viseu. 16 pp.

NOCTULA. 2014. Relatório de monitorização da atividade e mortalidade de quirópteros na área do Parque Eólico do Sobrado (Fase de exploração – ano de 2014) – Janeiro de 2015. NOCTULA – Consultores em Ambiente. Viseu. 37 pp.

NOCTULA. 2014. Relatório de monitorização dos sistemas ecológicos na área do Parque Eólico de Testos II (Fase de exploração (ano II) – 2012/2013). NOCTULA – Consultores em Ambiente. Viseu. 100 pp.

NOCTULA. 2014. Relatório de monitorização dos sistemas ecológicos na área do Parque Eólico de São Macário II (Fase de exploração - ano II) – 2012/2013. NOCTULA – Consultores em Ambiente. Viseu. 117 pp.

Piorkowski M.D. & O'Connell T. (2010). Spatial Pattern of Summer Bat Mortality from Collisions with Wind Turbines in Mixed-grass Prairie. Am. Midl. Nat. 164:260–269.

PROCESL. 2014. Monitorização de quirópteros do Parque Eólico de Alvaiázere. Relatório anual (ano 3 da fase de exploração – 2013).

ProSistemas. 2013. Parque Eólico de Chão Falcão. Monitorização de quirópteros. Relatório nº 5 - 2008.

Sertius-Biotope (2014) Projet éolien de Trois-Ponts – Etude de l'activité des chauves-souris en altitude. Décembre 2014. 34 pp.

Strix. 2014. Monitorização de Quirópteros na área do Parque Eólico do Barão de São João. Relatório Ano 7 – 2013. Revisão 1.

TPF Planege. 2013. Parque Eólico de Gevancas II. Monitorização de quirópteros. Fase de exploração (Fase II) – 1º ano. Relatório nº 4.

TPF Planege. 2014. Parque Eólico de Falperra-Rechãzinha. Monitorização de quirópteros. Fase de exploração (Fase II) – 1º ano. Relatório nº 2.

Weller TJ, Baldwin JA (2012) Using echolocation monitoring to model bat occupancy andinform mitigations at wind energy facilities. J Wildlife Management 76: 619–631. DOI: 10.1002.jwmg.206

Willis, K. R. C., R. M. R. Barclay, J. G. Boyles, R. m. Brigham, V. Brack Jr., D. Waldien, and J. Reichard. (2010). Bats are not birds and other problems with Sovacool's (2009) analysis of animal fatalities due to electricity generation. Energy Policy 38: 2067–2069.

Young DP, Bay K, Nomani S, Tidhar WL (2011) Nedpower mount storm wind energy facility post-construction avian and bat monitoring: July–October 2010. Western EcoSystems Technology, Inc, Cheyenne, Wyoming.

Annex 2 - New studies done in Europe

(addendum to Table 1 of *EUROBATS Publication Series nº 3*, Annex 3 of *Doc.EUROBATS.AC14.9.Rev1,* Annex 3 of *Doc.EUROBATS.StC4-AC15.22.Rev.1,* Annex 2 of *Doc.EUROBATS.AC17.6,* Annex 2 of *Doc.EUROBATS.AC18.6,* Annex 2 of *Doc.EUROBATS.StC9-AC19.12,* Annex 1 of *EUROBATS Publication Series nº 6,* and Annex 2 of *Doc.EUROBATS.AC20.5*)

Study (author, year, area)	Time	Habitat types	Data on WTs	Methods	Results
Bach & Bach, 2016a	15.4.-15.10.2015	agrarian habitat, mainly meadows	2 Enercon E70/E4 (rotor radius 35m total height 148m); 1 Enercon E70 (rotor radius 35m total height 120m); 5 Enercon E92 (rotor radius 46m, total height 184m)	carcass search every 3 days; acoustic monitoring (Avisoft); search efficency trial and carcass removal trial	one *Pipistrellus nathusii* (23.9.2015)
Bach & Bach, 2016b	1.6.-15.10.2016	agrarian habitat, mainly meadows	2 Vestas V112 (rotor radius 56m; total height 145m) one with shut down algorithm at 7,5m/s and 15°C (20.7-20.9.2015)	carcass search every 3 days; acoustic monitoring (Avisoft); search efficency trial and carcass removal trial	WT with shut down algorithm 3 Ppipstrellus nathusii (10.9.; 13.9.;10.10.2015)WT without shut down algorithm 1 Pipistrellus nathusii (23.8.2015)
Bach & Bach, 2016c	one WT: 15.4.-31.10.2015 two WT: 1.6.-31.10.2015 one WT: 1.7.-31.10.2015	agrarian habitat, mainly meadows and corn fields	4 Enercon E70/E4 (rotor radius 35m total height 99m)	carcass search every 3 days; acoustic monitoring (Avisoft); search efficency trial and carcass removal trial	one *Pipistrellus nathusii* (4.5.2015)
Bach & Bach, 2016d	1.7-31.10.2015	agrarian habitat, mainly meadows	6 Enercon E82 (rotor radius 41m total height 149m)	carcass search every 3 days; acoustic monitoring (Avisoft); search efficency trial and carcass removal trial	one *Eptesicus serotinus* (25.8.2015)
Eurus, 2014	1.7. - 30.9.2014.	Meadows, agrarian habitat, shrubs and roads	20 WT (tower height : 76,9 m, rotor diameter : 82 m)	Research was conducted on 9 WT. Three to four researchers went out on field from 6:00 to 14:00 h, 70 days in total. Used methods: GPS trails tracking, visual monitoring. Found carcasses were photographed and determined. Exact coordinates, carcasses conditions and morphological characteristics were immediately recorded.	A total of 40 bat fatalities were found. *Hypsugo savii* (18), *Vespertilio murinus* (2), *Tadarida teniotis* (2) and *Pipistrellus* sp. (5), *Pipistrellus pipistrellus* / *kuhlii* (12) and *Pipistrellus* spec. / *Hypsugo savii* (1) for which species could not be identified due to the state of the carcass.

Fokus - center for research and conservation of nature, 2014 and 2015	23.4.2013. - 26.3.2014. 18.3.2014. - 30.9.2014.	Low shrubs, agrarian habitat and meadows.	16 WT (tower height : 63 - 85 m, rotor diameter : 70 m)	Research was conducted on 16 WT (70 m around each WT). Used methods: continuous monitoring with batcorder, catching with nets, visual monitoring, using trained dogs in carcasses detection. Found carcasses were determined. Exact coordinates, carcasses conditions and morphological characteristics were immediately recorded.	A total of 27 fatalities were found in the first period of research (23.4.2013. - 26.3.2014.). *Hypsugo savii* (14), *Pipistrellus kuhlii* (4), *P. pipistrellus* (2), *Tadarida teniotis* (1) and Chiroptera sp. (6) for which species could not be identified due to the state of the carcass. A total of 60 fatalities were found in the second period of research (18.3.2014. - 30.9.2014.). *Hypsugo savii* (34), *Pipistrellus kuhlii* (3) and Chiroptera sp. (23) for which species could not be identified due to the state of the carcass.
Frey, Bach & Bach, 2016	1.5.-15.10.2015	agrarian habitat, mainly pastures and corn fields	1 Senvion REpower MM92 (rotor radius 41m, total height 125m); 2 SenvionREpower 3.2M114 (rotor radius 57, total height 150m) with shut down algorithm (only two WT) at 6m resp. 6,9m/sec and 12,7°C (1.6.-15.9.2015)	carcass search every 3 days; acoustic monitoring (Avisoft); search efficency trial and carcass removal trial	no dead bats at turbines with shut down algorithm; one *Pipstrellus nathusii* (22.8.2015) at the WT without shut down algorithm
Geonatura Ltd. 2015	1.4.-30.11.2014 ; 1.2.-31.3.2015	dry pastures and low shrubs	19 WT (tower height :78 m, rotor diameter : 82 m)	Monthly bat activity monitoring along linear transects and continuous monitoring on a weather mast, carcass removal trial and bat mortality monitoring with search intervals of approx. 8-12 days, 70 m around WT in the area of maximum visibility (plateaus, roads and slopes) due to the very poor visibility in high grass and shrubs.	A total of 68 bat fatalities were found. *Hypsugo savii (*20), *Nyctalus leisleri* (4), *Pipistrellus kuhlii* (24), *P. pipistrellus* (1), *P. pygmaeus* (1), *Pipistrellus* sp. (6), *Tadarida teniotis* (1), *Vespertilio murinus* (1) and Chiroptera sp. (1) for which species could not be identified due to the state of the carcass .
Minderman et al. 2014, UK	30.4.-9.9.2010 (carcass removal trials: 24.5.-3.8.2011)	urban areas, semi-natural habitats, woodland	21 SWT (mean tower height 10.2 m [range 4.0–26.4 m], mean rotor diameter 4.0 m [range 0.9–15.0 m], for both free-standing and building mounted turbines)	Carcass searches for 2-5 consecutive days (3-15 searches per site) of a square area equal to twice the hub height of the turbine squared, along parallel transects 2 m apart; carcass removal trials; survey for owners of small wind turbines (questionnaire about make, size and operating age of the turbine, and bird or bat casualties).	0 carcasses found (3 unidentified bat fatalities from 2 sites reported in survey)

Oikon, 2014	March - September 2013. March - August 2014.	Meadows, agrarian habitat, shrubs and roads	20 WT (tower height : 76,9 m, rotor diameter : 82 m)	Research was conducted on 20 WT (70 m around each WT), two times a month. Used methods: ultrasonic detector along linear transects, GPS trails tracking, visual monitoring. Found carcasses were photographed and determined. Exact coordinates, carcasses conditions and morphological characteristics were immediately recorded.	A total of 178 fatalities were found. *Hypsugo savii* (46), *Pipistrellus kuhlii* (59), *P. nathusii* (5), *P. pipistrellus* (2), *Vespertilio murinus* (7), *Tadarida teniotis* (2) and *Pipistrellus* sp. (23), *Pipistrellus* sp. / *Hypsugo savii* (11), *Hypsugo* / *Pipistrellus* sp. (2), *P. kuhlii* / *P. nathusii* / *Hypsugo savii* (4), *P. kuhlii* / *P. nathusii* (1), *Nyctalus leisleri* / *Vespertilio murinus* (1) and Chiroptera sp. (15) for which species could not be identified due to the state of the carcass. 2 of total 178 bats were found injured and were later released.
Rydell et al. 2016, Sweden	July-September in 2012–2014	boreal or hemi-boreal forest at 100–200 m altitude, one site agricultural area on island near sea level	46 WT in 7 wind parks (tower height: 90-125m)	Carcasses from searchen for post construction surveys	18 fatalities with intact stomaches (may not be total number of fatalities). *Nyctalus noctula* (9), *Pipistrellus pygmaeus* (6), *Eptesicus nilssonii* (3), *Vespertilio murinus* (1).

References

Bach & Bach (2016a):Fledermausmonitoring im Windpark Dornum, Gondelmonitoring und Schlagopfersuche - Zwischenbericht 2015 - unpubl. Report to Windpark Dornum GmbH & Co. KG, 37 p.

Bach & Bach (2016b):Fledermausmonitoring im Windpark Spolsen Gondelmonitoring und Schlagopfersuche - Endbericht 2015 - unpubl. Report to Planungsbüro Diekmann & Mosebach, 41 p.

Bach & Bach (2016c):Fledermausmonitoring im Windpark Ostermarsch Gondelmonitoring und Schlagopfersuche - Zwischenbericht 2015 - unpubl. Report to Norderland Energie GmbH

Bach & Bach (2016d):Fledermausmonitoring im Windpark Holtriem Gondelmonitoring und Schlagopfersuche - Zwischenbericht 2015 - unpubl. Report to Norderland Energie GmbH

Eurus d.o.o. (2014): Complementary bat monitoring at wind farm Jelinak in Croatia (1.7.2014. - 30.9.2014.)

Fokus - center for research and preservation of nature (2015): The results of bat monitoring in second year after construction of wind farm Ponikve in Croatia

Frey, Bach & Bach (2016): Monitoring der Fledermausaktivität im Windpark Krögershamm - Endbericht 2015 - unpubl. Report to Planungsbüro Diekmann & Mosebach, 52 p.

Geonatura Ltd. (2015): Bat fauna monitoring at wind farm Danilo in Croatia (Annual report 2014-2015)

Minderman, Fuentes-Montemayor, Pearce-Higgins, Pendlebury, Park (2014): Estimates and correlates of bird and bat mortality at small wind turbine sites, Biodivers Conserv 24(3): 467-482

Oikon d.o.o. (2014): Monitoring of the effects on the bat population during the use of the Jelinak wind farm in Croatia

Rydell, Bogdanowicz, Boonman, Pettersson, Suchecka, Pomorski (2016): Bats may eat diurnal flies that rest on wind turbines, Mammalian Biology 81: 331–339