Biodivers Conserv (2009) 18:1781–1791
DOI 10.1007/s10531-008-9558-2

ORIGINAL PAPER

Wind power plants and the conservation of birds and bats in Spain: a geographical assessment

José Luis Tellería

Received: 14 July 2008 / Accepted: 27 November 2008 / Published online: 17 December 2008

Abstract The number of wind power plants installed in Spain has increased dramatically, and many are located in important wildlife areas. This paper explores the geographical overlap of wind power plants with the ranges of flying vertebrate species. The list of animals studied includes bats, soaring birds, and other birds that may be killed by turbines. Results show that the 10 × 10 km UTM squares occupied by wind power plants fell within the range of more bat and bird species than squares free of these infrastructures. For species included in the Spanish Red List, there were more wind power plants than expected inside the range of two raptors (*Neophron percnopterus* and *Circus pygargus*) and less than expected in six species (*Ciconia nigra*, *Aquila adalberti, Hieraetus fasciatus Myotis capaccinii*, *Rhinolophus mehelyi* and *Myotis myotis*). The rest of endangered species (15) had a range occupation similar to that predicted by random sampling, a result that reflects a poor strategy to prevent the overlap. These patterns may be explained by the small amount of overlap of the range of many of these animals with the windiest areas in Spain, where wind power plants are concentrated today. However, this situation is changing rapidly with the densification and expansion of wind power plants promoted under the Spanish Plan of Renewable Energies. This may produce the occupation of many areas important to bird and bat conservation, and therefore preventive measures should be implemented to protect these species and their habitats.

Keywords Bats · Birds · Conservation · Geographical overlap · Spain · Wind power plants

Introduction

Wind power plants are expanding in Europe to satisfy increasing energy demand in a world ever more concerned with green-house effects (EWEA 2008). The expansion of wind power has environmental impacts that need to be evaluated (e.g. habitat removal,

J. L. Tellería (✉)
Departamento de Zoología y Antropología Física, Facultad de Ciencias Biológicas,
Universidad Complutense, 28040 Madrid, Spain
e-mail: telleria@bio.ucm.es

construction of roads and power lines, visual impact, etc.). In this context, the effects of wind power plants on flying animals is a matter of conservation concern because turbines and associated equipment can kill or disturb animals in their vicinity (Percival 2005; Drewitt and Langston 2006; De Lucas et al. 2007; Everaert and Stienen 2007).

Spain has seen a huge expansion of wind power plants and is today one of the leading countries in this field (EWEA 2008). In 2004, the Spanish wind power industry produced 8,000 MW but, according to the Spanish Plan of Renewable Energies, the aim is to reach 20,000 MW in 2010 (Ministerio de Industria, Turismo y Comercio 2005). As a result, the country is being rapidly occupied by these infrastructures, many of which are located in key wildlife conservation areas (mountain ridges, remote highlands, steppes, etc. Laiolo and Tella 2006). Although local impact assessments are routine, no large-scale evaluations of the potential effects of this industry on terrestrial habitats and species have been carried out. This is an important issue because, according to UE Directives (85/337/EEC amended by 97/11/EC, 2001/42/EC), all potential construction sites must be evaluated within the context of large-scale integral assessment frameworks. This guideline applies to wind power plants whose accumulative effects may disrupt animal migrations and/or the habitat integrity of endangered populations (Exo et al. 2003; Drewitt and Langston 2006; Fox et al. 2006, Tellería 2009).

This paper explores the overlap between wind power plants and the breeding sites of a set of flying vertebrates. This group includes bats, soaring birds (raptors, storks), aerial-plankton feeder birds (nightjars, swallows, swifts), and birds that perform aerial displays (larks, pranticoles, etc. Appendix 1). Wind power interferes with many animals in similar ways (habitat alteration, disturbance, etc.), but these flying vertebrates run the additional risk of colliding with turbines during displays or movements around breeding sites. In addition, as many of these species are endangered in Spain, it is important to prevent the potential effect wind power plant expansion on their populations.

Methods

The data

Distribution of wind power plants was recorded from the official web of the Spanish Wind Energy Association (www.aeeolica.org) in September 2007. Information on bat and bird distribution was provided by the National Biodiversity Databank of the Spanish Ministry of the Environment (http://www.mma.es). This facility provides the results of two studies carried out to elaborate the national bird and mammal atlases (Palomo and Gisbert 2002; Martí and Del Moral 2003). In these databanks, the presence or absence of individual species was reported in 10 × 10 km UTM squares. These data were managed by ArcGis-ArcMap® 9.1 (buffering, overlap, Kernel polygons, etc.). Analyses were restricted to peninsular Spain and the Balearic islands.

Analyses

Conservation interest of squares

The conservation interest of the 5,443 10 × 10 km UTM squares studied was scored according to three criteria: (a) *Species richness*, as determined by the number of bat and bird species occurring in each square; (b) *Hotspots*, squares with a number of species over the median (18 species for birds and 9 species for bats) of the full range of species recorded in the whole set of study squares; and (c) *Species spots*, squares with the presence of individual species included in the Spanish List of Endangered Species (http://www.mma.es; see Appendix 1). Two complementary approaches were used to study the overlap of wind power plants with the bird and bat sites.

Spatial coincidence

Species richness in squares occupied by wind power plants was compared with richness in squares free of these infrastructures. This approach was used to test (*t*-test for independent groups) if plants were located in areas of conservation interest on the basis of large numbers of bat and bird species (Scott and Schipper 2006).

In addition, a comparison was made of the number of wind power plants occupying hotspots and species spots to the number predicted by random sampling. Random sampling was performed by multiplying each set of squares (number of hotspots and species spots) by the proportion (0.0492) of squares occupied by wind power plants (269) in the whole of Spain (5,443 squares). Observed versus predicted figures were compared by $\chi 2$ analyses, with Yate's correction when necessary. Non significant differences will reflect a poor strategy to avoid the overlap, and a significant positive or negative selection will reveal the invasion or avoidance by wind power plants of interesting bird and bat sites.

Geographical proximity

The proximity of wind power plants to breeding sites of flying vertebrates may be harmful due to collision with turbines. In addition, proximity to plants may used to assess the risk of any eventual expansion of these infrastructures to nearby bird and bat sites. This was evaluated by counting the number of hotspots or species spots located inside concentric buffer areas delimited at increasing distances (5, 10, 20 and 30 km) from power plants (Margules and Pressey 2000).

Results

General patterns

Bird and bat richness showed a similar distribution, with the highest scores in the northern half of Spain (Fig. 1). Interestingly, the richness of the species under study here was positively correlated to the distribution of bird ($r = 0.85$, $P < 0.001$, $n = 5{,}443$) and mammal species richness in general ($r = 0.64$, $P < 0.001$, $n = 5{,}443$) in Spain. The number of hotspots was higher in birds (2,386) than in bats (189). In the case of individual species, the number of occupied squares ranged from 14 (*Pandion haliaetus*) to 2,196 (*Circus pygargus*) in birds, and from 29 (*Myotis bechsteini*) to 926 (*Rhinolophus ferrumequinum*) in bats.

The distribution of wind power plants was analysed by Kernel polygons. Each polygon represented 10% of the total number of plants and formed a series of concentric areas radiating outwards, with the densest distribution in the inner areas. This approach defined

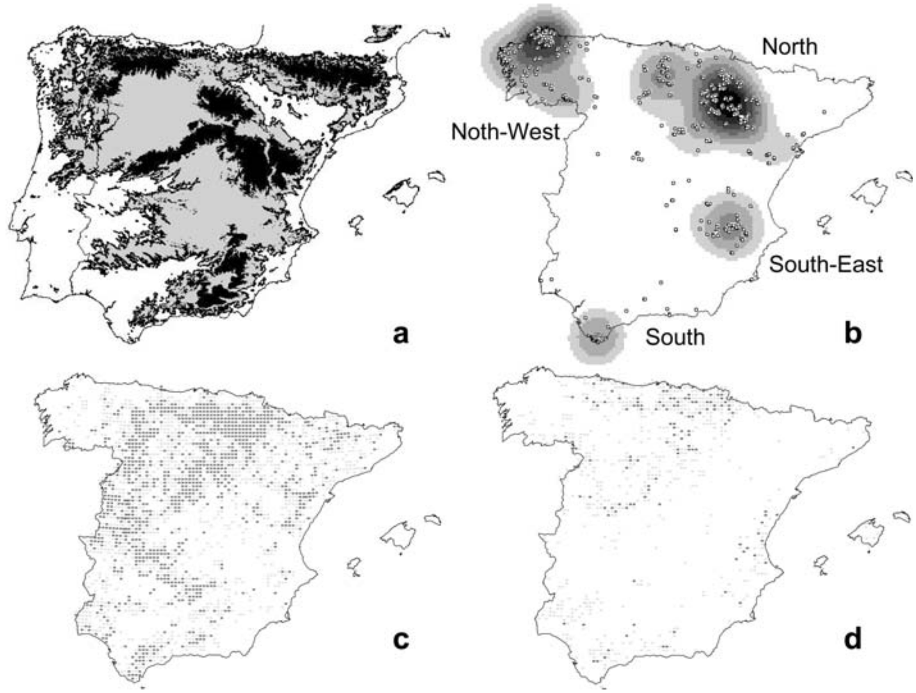

Fig. 1 **a** Main topographic features of the Iberian Peninsula; areas over 500 m are in grey and areas over 1,000 m are in black; **b** Distribution of wind power plants (points) and Kernel polygons depicting the areas with the highest densities (see text); **c** Bird hotspots. Distribution of squares with more than 18 (*grey*) and 22 (*black*) bird species; **d** Bat hotspots. Distribution of squares with more than 4 (*grey*) and 8 (*black*) species

four spatial clumps, with two large, dense clusters in northern Spain (Fig. 1). Central and south-western areas and the Mediterranean coasts (including the Balearic Islands) had less occupation by these infrastructures.

Spatial coincidence

The mean number (±SE) of bird species in squares occupied by wind power plants (18.55 ± 0.35, $n = 269$) was higher than in squares free of these infrastructures (17.47 ± 0.08, $n = 269$; *t*-test between groups $t_{5441} = 2.96$, $P = 0.003$). This difference was also observed in bats (1.73 ± 0.16 species in squares with plants and 1.50 ± 0.04 in squares without these infrastructures; $t_{5441} = 2.03$, $P = 0.043$). However, bird and bat hotspots were not over-sampled by wind power plants (Table 1).

In the case of individual species (Fig. 2), there were more wind power plants than expected in the range of two endangered birds (*Neophron percnopterus* and *C. pygargus*) and less than expected for three species (*Ciconia nigra*, *Aquila adalberti* and *Hieraetus faciatus*). Four endangered birds and nine bats had a range occupation similar to the observed in the whole country (Table 1). The range of three endangered bats (*Myotis capaccinii*, *Rhinolophus mehelyi* and *Myotis myotis*) was under-occupied by these infrastructures.

Table 1 (A) Number of hotspots and species spots; (B) observed versus predicted squares overlapping with wind farms; (C) *Chi*-square text to compare predicted versus observed overlapping squares

	(A) No. squares	(B) Overlap (observed/predicated)	(C) χ^2	*P*	(D) Squares (%) inside buffer areas			
					<5 km	<10 km	<20 km	<30 km
Birds								
Hotspots	2,386	134/117	2.60 (=)	NS	4.86	12.03	28.83	44.05
Ciconia nigra (Ex)	481	2/24	22.10(–)	<0.001	0.21	2.04	4.78	9.15
Gypaetus barbatus (Ex)	89	1/4	3.13(=)	NS	1.12	1.12	7.87	19.10
Aquila adalberti (Ex)	163	0/8	9.39(–)	<0.01	0	2.45	7.98	14.72
Neophron percnopterus (Vu)	939	60/46	4.48(+)	<0.01	5.64	14.48	32.16	46.54
Milvus milvus (Vu)	1,281	48/63	3.76(=)	NS	3.12	8.12	20.30	31.07
Hieraetus faciatus (Vu)	831	26/41	5.77(–)	<0.05	2.53	7.58	20.46	35.50
Circus pygargus (Vu)	2,196	154/106	22.84(+)	<0.001	5.83	14.71	32.06	45.81
Pandion haliaetus (Vu)	14	0/1	2.22(=)	NS	0	0	0	7.14
Chersophilus duponti (Vu)	235	16/11	2.38(=)	NS	6.38	17.87	45.53	62.55
Bats								
Hotspots	189	9/9	0(=)	NS	4.23	11.64	32.28	53.97
Myotis capaccinii (Ex)	57	0/3	4.20(–)	<0.05	0	5.26	15.79	29.82
Rhinolophus ferrumequinum (Vu)	926	50/46	0.37(=)	NS	4.64	11.23	28.19	47.30
Rhinolophus euryale (Vu)	337	10/17	3.04(=)	NS	2.67	8.01	23.74	42.43
Rhinolophus mehelyi (Vu)	154	3/8	3.92(–)	<0.05	1.30	3.25	9.09	23.38
Myotis mystacinus (Vu)	42	2/2	0(=)	NS	4.76	7.14	28.57	59.53
Myotis emarginatus (Vu)	160	7/8	0.28(=)	NS	4.38	12.5	34.38	57.50
Myotis bechsteini (Vu)	29	2/1	0.35(=)	NS	6.90	6.90	27.59	48.28
Myotis myotis (Vu)	561	16/28	5.41(–)	<0.05	2.50	9.09	25.31	42.25
Myotis blythi (Vu)	243	10/12	0.35(=)	NS	3.70	8.64	19.34	37.86
Nyctalus noctula (Vu)	57	3/3	0(=)	NS	5.26	17.54	38.60	45.61
Nyctalus lasiopterus (Vu)	68	3/3	0(=)	NS	4.41	11.76	27.94	41.18
Miniopterus schreibersi (Vu)	545	24/27	0.35(=)	NS	3.30	10.83	26.97	44.77

Results show significant positive (+) and negative (−) overlap, or no significant differences (=). The percentage of squares covered by buffer areas of different radius around wind farms is also shown. Ex: Extinction risk, Vu: Vulnerable

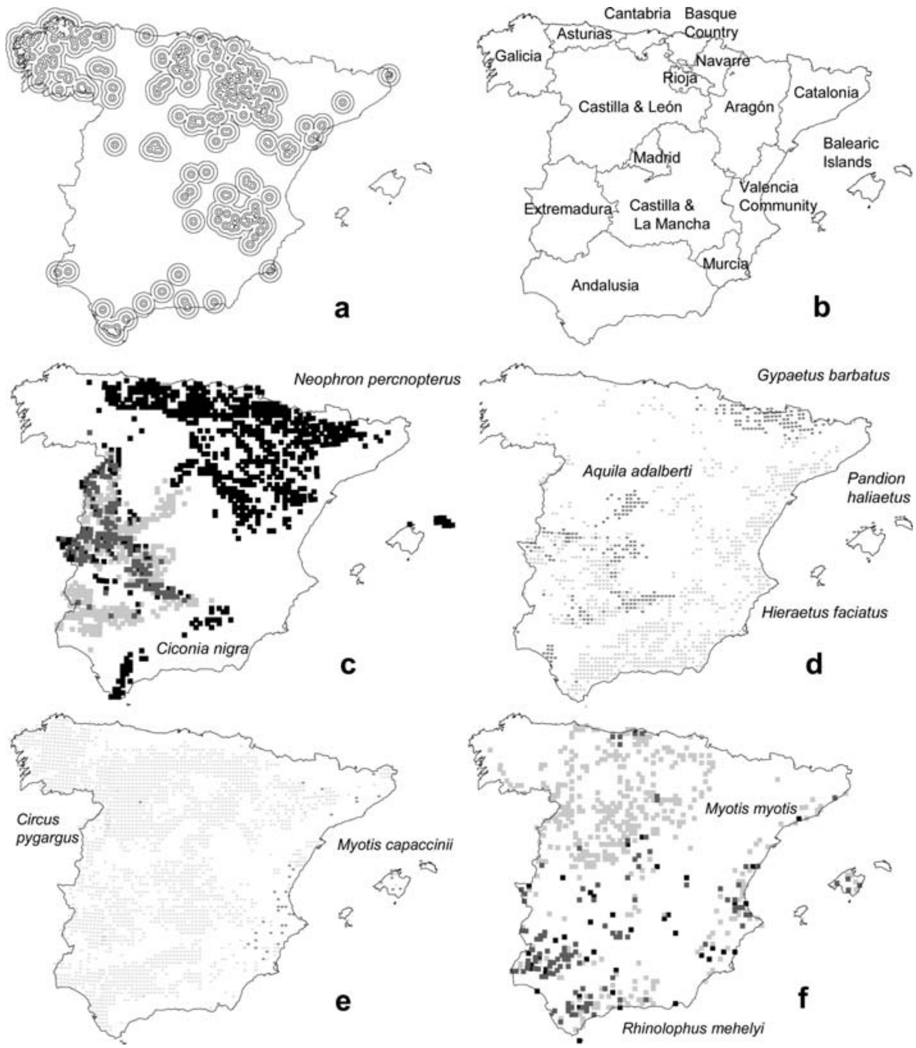

Fig. 2 **a** Distribution of 5, 10, 20 and 30 km buffer areas around wind farms; **b** Autonomous communities in Spain; **c** Distribution of *Neophron percnopterus* (*black squares*) and *Ciconia nigra* (*grey squares*); **d** Distribution of *Gypaetus barbatus* (*black squares* in the North), *Aquila adalberti* (*black squares* in the south-west), *Pandion haliaetus* (*black squares* in the Balearic Islands) and *Hieraetus fasciatus* (*grey squeares* in the South-Eastern half of Spain); **e** Distribution of *Circus pygargus* (*grey squeares*) and *Myotis capaccinii* (*black squares*); **f** Distribution of *Rhinolophus mehelyi* (*black squares*) and *Myotis myotis* (*grey squares*). Half tones represent overlap areas

Geographical proximity

There were an increasing number of bird and bat hotspots in the concentric buffer areas defined around wind power plants (Table 1). In fact, 44% of bird hotspots and 54% of bat hotspots were located inside the largest buffer area (30 km) around wind power plants. This pattern differed between species. Around 45% of squares occupied by Egyptian vultures (*Neophron percnopterus*) and Montagu's harriers (*Circus pygargus*) were inside this buffer ring, a proportion that increased in the case of the Dupont's larks (*Chersophilus duponti*; 63%). However, the main range of the black stork (*Ciconia nigra*) and the osprey (*Pandion. haliaetus*) was far from wind power plants, with <10% of the occupied spots inside the 30 km buffer zone. The patterns of range occupation were similar among bat species, with the highest occupation rates in the notch-eared bat (*Myotis emarginatus*; Table 1).

Discussion

Distribution patterns of flying vertebrates and wind power plants

It may be argued that the bat and bird species in this study comprise an odd assemblage that does not adequately reflect the geographical patterns of other species (Prendergast et al. 1993). However, high species richness in northern Spain has been described in vascular plants, butterflies, birds, and mammals (Martín and Gurrea 1990; Lobo et al. 2001; Ramírez and Tellería 2003; Carrascal and Lobo 2003; González-Taboada et al. 2007). In fact, we reported a significant correlation between the distribution of our particular set of flying vertebrates and the total number of bird and mammals species in Spain. This supports the view that the species richness of vertebrates considered in this study is a reasonable surrogate of the distribution patterns of a broader set of organisms. This high species richness in the northern half of Spain has been related with a set of bio-geographical and environmental traits: (a) the interspersion of moist Atlantic and dry Mediterranean habitats; (b) the presence of many species typical of the Atlantic realm that disappear to south and west (peninsular effect); (c) the existence of extensive woodlands and pasturelands suitable for species rare in agricultural and urban areas; and d) the abundance of limestone canyons and cliffs suitable to refuge many species (vultures, eagles, bats, etc.).

Wind power plants were clumped in the windiest areas of the Iberian Peninsula (Troen and Petersen 1989), which do not overlap with the richest areas in birds and bats. However, a main exception occurs around the north clump, where one of the most important areas for the Spanish wind power industry overlaps with one of the richest sectors in flying vertebrates (Fig. 1). This is the reason why the mean species richness in squares occupied by wind power plants was higher than in squares free of these infrastructures.

In the case of endangered birds and bats, the northern clump appears to be the main reason for the occupation by wind power plants of the range of the Egyptian vulture and the Montagu's harrier. However, the largest clumps of wind power plants were far from the Pyrenees Mountains, the main range of the lammergeier (*Gypaetus barbatus*), one of the most threatened birds in Spain (Fig. 2). The other species (Fig. 2) were distributed in the Balearic Islands (e.g. *Pandion haliaetus*), the forested hills of south-western Spain (*A. adalberti*, *C. nigra*; see also *R. melhyi*) and/or the eastern Mediterranean coasts (*Hieraetus fasciatus*, *Myotis capaccinii*; Martí and del Moral 2003; Palomo and Gisbert 2002). These areas are not yet covered by large concentrations of wind power plants (Fig. 1).

Potential impact of wind power plants on birds and bats

It is commonly accepted that flying vertebrates collide with wind turbines, but there is no agreement on the number of individuals killed per turbine and year. These figures vary according to the abundance of flying vertebrates, the location of plants and some aspects related to the arrangement and typology of turbines (Morrison et al. 2007). Some assessments have calculated mean losses of 2.3 birds (range 0.6–7.7) and 3.4 bats (0.1–47.5) per turbine and year in USA (National Wind Coordinating Committee 2002), and mean losses of 20.6 birds ($n = 11$ plants, range 1.34–64) in Europe (calculated form review in Everaert 2004). In the Spanish northern clump of power wind plants, these figures score around 23.8 birds (range 4–64, $n = 6$ plants) per turbine and year (Everaert 2004). Consequently, despite the variability of these estimates and the difficulties to get credible figures, particularly in the case of bats (Sterner et al. 2007), it is possible to presume losses of several thousand birds and bats killed per year in Spain, where there are nowadays around 13,000 turbines (Spanish Wind Energy Association, www.aeeolica.org).

The construction of plants in sensitive areas due to the presence of rare or endangered species (such as mountains and highlands in Spain) is a matter of conservation concern (Laiolo and Tella 2006), despite the alleged low significance of turbine-related mortality compared to other overspread infrastructures (roads, buildings, etc.; National Wind Coordinating Committee 2002). The reported losses may be particularly damaging to scarce animals with low reproductive rates and log life spans (e.g. some bats and large raptors) unable to replace an accumulative loss of individuals. In this context, the northern clump of plants may be observed today as a threat to the conservation of many flying vertebrates in Spain, particularly if power plants increase in number and expand to the west and south (Figs. 1, 2).

A large part of the range of bats and birds are inside the buffer areas around wind power plants (Fig. 2). It is obvious that the largest buffer area (30 km around plants) is excessive and not necessary to prevent the harmful effects of turbines on many small flying vertebrates, as bats and small birds' home ranges cover small areas (e.g. Garza et al. 2005; Goiti et al. 2006). Thus it may be accepted that the percentage of the species range included in this large area will not be a proper index of disturbance or collision risks. However, many large birds (e.g. eagles, vultures, storks, etc.) travel each day more than 30 km from their nesting sites in search of food (Newton 1979; Donázar 1993; Jiguet and Villarubias 2004). These animals will encounter wind power plants and face risk situations in which collision will depend on their ability or experience to avoid turbines. However, in the case of those plants in close proximity to sites occupied by vertebrates, it may be assumed a true risk of collision exists because the collisions rates are usually related to the number of flights per day across wind power plants (Everaert 2004). This may cause a serious conservation problem for some endangered species, despite the apparent low percentage of their range occupied by wind power plants. It is important to realize that many of them are located in a very small set of squares in which any impact will be detrimental to conservation (e.g. *Chersophilus duponti*, *Myotis mystacinus*, *Myotis bechsteini*, *Nyctalus noctula*, etc. Table 1).

Prospects

The reported mortality per turbine in sensitive areas should not be taken lightly, especially in relation to the extant high density of wind power plants in some sectors and the large number proposed in future construction plans. In fact, the pattern depicted in this paper is a fixed picture (September 2007) of the ongoing rapid expansion of the wind power industry in Spain. Future trends are difficult to evaluate despite the predictions of the Spanish Plan of Renewable Energies (Ministerio de Industria, Turismo y Comercio 2005), particularly because the numbers planned have increased in several autonomous communities

Table 2 Distribution of wind power plants in the Spanish autonomous communities

Autonomous community	Installed in 2004	Prediction for 2010 (SPRE)	Final aims (a.c.)
Andalusia	350	2,200	4,000
Aragon	1,154	2,400	4,000
Asturias	145	450	?
Balearic islands	3	50	?
Cantabria	0	300	?
Castilla-León	1,543	2,700	6,700
Castilla-La Mancha	1,534	2,600	4,450
Catalonia	94	1,000	3,000
Extremadura	0	225	?
Galicia	1,830	3,400	6,300
Madrid	0	50	?
Murcia	49	400	?
Navarre	854	1,400	?
La Rioja	356	500	?
Valencia Com.	21	1,600	2,359
Basque country	86	250	?

The installed power (MW) in 2004 and 2006, and the predictions for 2010 according to the Spanish Plan of Renewable Energies (SPRE) and the ultimate aims of some autonomous communities (a.c.) are shown (Ministerio de Industria, Turismo y Comercio 2005; Instituto para la Diversificación y el Ahorro de la Energía 2007)

(Table 2). But according to the available information it is possible to predict two main geographical trends in Spain: (a) the densification and regional expansion of these infrastructures from the existing clumps (see predictions for Galicia, Castilla-León or Aragón in Table 2) and (b) the expansion to areas where this industry is still poorly developed (southern half of Spain and the Mediterranean coastal areas; see Andalusia, Castilla-La Mancha, Extremadura, Catalonia, Table 2) where many endangered species are present today (Fig. 2).

The lack of any large-scale strategic evaluation to prevent the impact of this expanding industry on Spanish biodiversity is a matter of concern. The lack of study may be explained by inertia resulting from the early appearance of this industry in Spain (1980s), when the ecological impact of wind power plants was poorly understood. It may also be related to the decentralised management of licenses for plant construction and the almost exclusive focus on the local impact of these infrastructures. Fortunately, inter-regional coordination is the rule today in the case of projected offshore wind power plans, whose potential impact on the biodiversity of the coastlines and territorial waters of Spain (under the exclusive responsibility of the central government) has been already evaluated (Ministerio de Industria, Turismo y Comercio 2007).

This historical gap in the assessment of the potential effect of wind power plants on terrestrial biodiversity must be amended if Spain is to manage properly the expansion of this industry. It is important to establish some explicit guidelines to prevent or reduce the expansion of wind power plants in the range of the most endangered species. In this context, it seems crucial to restrict the occupation of protected areas where many of these species have found a final refuge. It is sad to note that the new Spanish Law on Environmental Impact Assessment (Real Decreto Legislativo 1/2008, 11 January) does not ban the construction of wind power plants inside protected areas, a decision that will be evaluated through “ad hoc” local or regional assessments. The time to prevent these problems is now because we are still in the first stages of addressing a new conservation issue that will affect many countries. The European Union, which aims to increase wind power production from 56,000 MW in 2007 to 300,000 MW in 2030 (EWEA 2008), must prevent negative effects on species and territories whose protection the EU has been actively promoting for the last several years (e.g. Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora).

Acknowledgments Alvaro Ramírez and Alma Román prepared the data on vertebrate and power plant distribution. Dr. Eduardo De Juana, Dr. Tomás Santos and Dr. Francisco Sánchez-Aguado improved an early version of this manuscript. Kevin Wood (Gabinete Linguístico de la Fundación UCM) reviewed and improved the English version of the article. This research, carried out to answer some of the author's questions on the potential impact of wind power plants on the Spanish wildlife, has been not funded by any public or private agency.

Appendix

List of species considered in this study. The conservation status of those species endangered in Spain is indicated. Ex: Extinction risk, Vu: Vulnerable.

Birds: *Accipiter gentilis, Acipiter nisus, Aegypius monachus, Alauda arvensis, Anthus campestris, Anthus trivialis, Anthus spinoletta, Apus apus, Apus caffer, Apus melba, Apus pallidus, Aquila adalberti*(Ex)*, Aquila chrysaetos, Buteo buteo, Calandrella brachydactyla, Calandrella rufescens, Caprimulgus europaeus, Caprimulgus ruficollis, Chersophilus duponti* (Vu)*, Ciconia ciconia, Ciconia nigra* (Ex)*, Circaetus gallicus, Circus aeruginosus, Circus cyaneus, Circus pygargus* (Vu)*, Cisticila juncidis, Corvus corax, Delichon urbicum, Elanus caeruleus, Falco eleonorae, Falco naumanni, Falco peregrinus, Falco subbuteo, Falco tinnunculus, Galerida cristata, Galerida theklae, Glareola pratincola, Gypaetus barbatus* (Ex)*, Gyps fulvus, Hieraaetus fasciatus* (Vu)*, Hieraaetus pennatus, Hirundo daurica, Hirundo rustica, Lullula arborea, Melanocorypha calandra, Merops apiaster, Milvus migrans, Milvus milvus* (Vu)*, Neophron percnopterus* (Vu)*, Pandion haliaetus* (Vu)*, Pernis apivorus, Ptyonoprogne rupestris, Riparia riparia, Scolopax rusticola.*

Bats: *Barbastella basbastellus, Eptesicus serotinus, Miniopterus schreibersi* (Vu)*, Myotis bechsteini* (Vu)*, Myotis capaccinii* (Ex)*, Myotis daubentoni, Myotis emarginatus* (Vu)*, Myotis myotis* (Vu)*, Myotis blythi* (Vu)*, Myotis mystacinus* (Vu)*, Myotis nattereri, Nyctalus lasiopterus* (Vu)*, Nyctalus noctula* (Vu)*, Pipistrellus kuhlii, Pipistrellus nathusii, Pipistrellus pipistrellus, Plecotus auritus, Plecotus austriacus, Rhinolophus euryale (Vu), Rhinolophus ferrumequinum* (Vu)*, Rhinolophus hipposideros, Rhinolophus mehelyi* (Vu)*, Tadarida teniotis.*

References

Carrascal LM, Lobo JM (2003) Respuestas a viejas preguntas con nuevos datos: estudio de los patrones de distribución de la avifauna española y consecuencias para su conservación. In: Martí R, del Moral J.C. (eds) Atlas de las aves reproductoras de España, Dirección General de Conservación de la Naturaleza-Sociedad Española de Ornitología, Madrid

De Lucas M, Janss GFE, Ferrer M (2007) Birds and wind farms risk assessment and mitigation. Quercus, Madrid

Donázar JA (1993) Los buitres ibéricos. Biología y conservación. J.M. Reyero Editor, Madrid

Drewitt AL, Langston RHW (2006) Assessing the impacts of wind farms on birds. Ibis 148:29–42. doi:10.1111/j.1474-919X.2006.00516.x

EWEA (2008) Pure power. Wind energy scenarios up to 2030. European Wind Energy Association, Brussels

Everaert J (2004) Wind turbines and birds in Flanders: preliminary study results and recommendations. Natuur Oriolus 69:145–155

Everaert J, Stienen EWM (2007) Impact of wind turbines on birds in Zeebrugge (Belgium). Biodivers Conserv 16:3345–3359. doi:10.1007/s10531-006-9082-1
Exo KM, Hüppop O, Garthe S (2003) Birds and offshore wind farms: a hot topic in marine ecology. Wader Stud Group Bull 100:50–53
Fox AD, Desholm M, Kahlert J, Christensen TK, Petersen IK (2006) Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds. Ibis 148:129–144. doi:10.1111/j.1474-919X.2006.00510.x
Garza V, Suárez F, Herranz J, Traba J, De la Morena E, Morales M, Gonzalez R, Castaneda M (2005) Home range, territoriality and habitat selection by the Dupont's lark *Chersophilus duponti* during the breeding and post-breeding periods. Ardeola 52:133–146
Goiti U, Aihartza J, Almenar D, Salsamendi E, Garin I (2006) Seasonal foraging by *Rhinolophus euryale* (Rhinolophidae) in an Atlantic rural landscape in northern Iberian Peninsula. Acta Chiropt 8:141–155. doi:10.3161/1733-5329(2006)8[141:SFBRER]2.0.CO;2
González-Taboada F, Nores C, Álvarez MA (2007) Breeding bird species richness in Spain: assessing diversity hypothesis at various scales. Ecography 30:241–250. doi:10.1111/j.0906-7590.2007.04824.x
Instituto para la Diversificación y el Ahorro de la Energía (2007) Situación de la Energía Eólica en España. Madrid. http://www.idae.es. Cited 20 May 2008
Jiguet F, Villarubias S (2004) Satellite tracking of breeding black storks *Ciconia nigra*: new incomes for spatial conservation issues. Biol Conserv 120:153–160. doi:10.1016/j.biocon.2004.02.007
Laiolo P, Tella JL (2006) Fate of unproductive and unattractive habitats: recent changes in Iberian steppes and their effects on endangered avifauna. Environ Conserv 33:223–232. doi:10.1017/S0376892906003146
Lobo JM, Castro I, Moreno JC (2001) Spatial and environmental determinants of vascular plant species richness distribution in the Iberian Peninsula and Balearic Islands. Biol J Linn Soc Lond 73:233–253. doi:10.1111/j.1095-8312.2001.tb01360.x
Margules CR, Pressey RL (2000) Systematic conservation planning. Nature 405:243–253. doi:10.1038/35012251
Martí R, del Moral JC (eds) (2003) Atlas de las aves reproductoras de España. Dirección General de Conservación de la Naturaleza. Sociedad Española de Ornitología/BirdLife, Madrid
Martín J, Gurrea P (1990) The peninsular effect in Iberian Butterflies (Lepidoptera: Papilionoidea and Hesperoidea). J Biogeogr 17:85–96. doi:10.2307/2845190
Ministerio de Industria Turismo y Comercio (2005) Plan de Energías Renovables en España 2005–2010. Ministerio de Industria, Turismo y Comercio/Instituto para la Diversificación y Ahorro de la Energía, Madrid
Ministerio de Industria Turismo y Comercio (2007) Informe de sostenibilidad ambiental y estudio estratégico ambiental del litoral espalo para la instalación de parques eólicos. Ministerio de Industria, Turismo, Instituto para la Diversificación y Ahorro de la Energía, Ministerio de Agricultura Pesca y Alimentación, Ministerio de Medio Ambiente, Madrid
Morrison ML, Sinclair KC, Thelander CG (2007) A sampling framework for conducting studies of the influence of wind energy developments on birds and other animals. In: De Lucas M, Janss GFE, Ferrer M (eds) Birds and wind farms. Risk assessment and mitigation, vol 101–115. Quercus, Madrid
National Wind Coordinating Committee (2002) Wind turbine interactions with birds and bats: a summary of research results and remaining questions. NWCC, Washington
Newton I (1979) Population ecology of raptors. T. & A. D Poyser, London
Palomo LJ, Gisbert J (2002) Atlas de los mamíferos terrestres de España. Dirección General de Conservación de la Naturaleza. SECEM—SECEMU, Madrid
Percival S (2005) Birds and wind farms: what are the real issues? Br Birds 98:194–204
Prendergast JR, Quinn MR, Lawton JH, Eversham BC, Gibbons DW (1993) Rare species, the coincidence of diversity hotspots and conservation strategies. Nature 365:335–337. doi:10.1038/365335a0
Ramírez A, Tellería JL (2003) Efectos geográficos y ambientales sobre la distribución de las aves forestales ibéricas. Graellsia 59:219–231
Scott JM, Schipper J (2006) Gap analysis: a spatial tool for conservation planning. In: Groom MJ, Meffe GK, Ronald Carroll C (eds) Principles of conservation biology. Sinauer, Sunderland
Sterner D, Orloff S, Spiegel L (2007) Wind turbine collision research in the United States. In: De Lucas M, Janss GFE, Ferrer M (eds) Birds and wind farms. Risk Assessment and Mitigation. Quercus, Madrid
Tellería JL (2009) Potential effects of wind farms on migratory birds in Spain. Bird Conserv Int 19:1–6
Troen I, Petersen EL (1989) European wind Atlas. Risø National Laboratory, Roskilde