Animal Conservation

Animal Conservation. Print ISSN 1367-9430

Reconciling the conservation of endangered species with economically important anthropogenic activities: interactions between cork exploitation and the cinereous vulture in Spain

A. Margalida[1], R. Moreno-Opo[2], B. E. Arroyo[3] & A. Arredondo[2]

1 Bearded Vulture Study and Protection Group, El Pont de Suert, Lleida, Spain
2 Fundación CBD-Hábitat, C/Gustavo Fernández Balbuena, Madrid, Spain
3 Instituto de Investigación en Recursos Cinegéticos (CSIC-UCLM-JCCM), Ciudad Real, Spain

Keywords
buffer zone; cork harvesting; economic anthropogenic activity; human disturbance; vulture conservation.

Correspondence
Antoni Margalida, Bearded Vulture Study and Protection Group, Apdo. 45, E-25520, El Pont de Suert, Lleida, Spain.
Email: margalida@inf.entorno.es

Editor: Todd Katzner

Received 5 March 2010; accepted 20 September 2010

doi:10.1111/j.1469-1795.2010.00412.x

Abstract

Limitation of disturbing activities around the breeding areas of protected species is not always possible, if these activities are economically important and have, in addition, positive effects on protecting the habitats of those protected species. Searching for optimal solutions making commercial exploitation of natural resources compatible with biodiversity conservation is thus of concern to managers and policy makers. This is the case of the cinereous vulture *Aegypius monachus*, breeding primarily in cork-oak woodland, and cork exploitation, a traditional socio-economic activity carried out in several Mediterranean countries, and critical for the maintenance of this important habitat. We studied the effects of this anthropogenic activity on the behaviour and breeding success of breeding cinereous vultures in Spain. For the adults, the probability of nest abandonment was dependent on the distance of workers from the nest and the level of noise; activities within 500 m from the nest were likely to cause abandonment of the nest by adults, if the level of noise was intermediate or loud. Neither the size of the working group nor the use of machines *per se*, had any effect on the probability of nest abandonment. Pairs in an area of the colony exposed to intrusive anthropogenic activity had 20% lower breeding success than those in the same colony that were not exposed to these disturbances. If the application of buffer zones of 500 m is not possible (as is likely given the economic losses involved), several alternatives are recommended based on our results to minimize the impact of these activities, in particular to diminish the noise level of cork extraction activities. Observational studies like this help understanding the magnitude of the problem and finding alternative solutions for harmonizing conservation and economic development.

Introduction

The relationships between the development of human activities and wild animal species are of concern to managers and policy makers searching for alternative solutions making conservation compatible with anthropogenic activities (Young *et al*., 2005; Preisler, Ager & Wisdom, 2006). Human disturbance and its effects on the behaviour or breeding success of birds are a widely studied subject in several avian species (Blumstein *et al*., 2005; Gill, 2005; Langston *et al*., 2007), including threatened raptors (Steidl & Anthony, 2000; Arroyo & Razin, 2006; González *et al*., 2006; Zuberogoitia *et al*., 2008). The conservation measure most often used by managers and conservationists to avoid disturbance is the establishment of spatial and temporal buffer zones around potentially sensitive areas (e.g. breeding sites), where the disturbing activities are limited or prohibited. The radius for these buffer areas usually depends on the sensitivity of the species, and may be calculated through the observations of distances at which an activity produces alert behaviour or nest abandonment (Richardson & Miller, 1997; Fernández-Juricic *et al*., 2005; Whitfield, Ruddock & Bullman, 2008). The establishment of buffer zones is generally easily regulated in those cases when the disturbing activities are leisure activities, such as hunting or ecotourism (see Richardson & Miller, 1997; Guil & Moreno-Opo, 2008). However, in the case of activities with strong economic interests (industrial activities such as the construction of highways and roads or forest-related activities such as logging), the implementation of conservation measures may be more difficult (Donázar *et al*., 2002; Bautista *et al*., 2004; Speziale, Lambertucci & Olsson, 2008). Additionally, the economic interests associated with the same activities that may be disturbing to the birds may help to maintain the habitat on which the birds themselves depend. This may be the case with the exploitation of forest products causing disturbance to the fauna in the area in which the activity is carried out. Harmonizing conservation and economic development can pose a challenge for managers and necessitates appropriate and objective research studies leading to solutions making anthropogenic activities compatible with the conservation of a threatened species.

An example of this dilemma is the case of the cinereous vulture *Aegypius monachus* and cork harvesting, a traditional socio-economic activity carried out in several Mediterranean countries including Spain and Portugal, as well as Morocco, France, Italy and Algeria. The cinereous vulture is a species considered Near Threatened by IUCN (BirdLife International, 2008) and the Spanish population (*c*. 1845 pairs) represents 98% of the European population and between 18 and 25% of the world population (De la Puente, Moreno-Opo & Del Moral, 2007). This species breeds frequently in cork oak *Quercus suber* trees in Spain. Cork harvesting generates an annual turn over of €1.5 billion and results in the direct and indirect creation of around 100 000 jobs (WWF, 2006), but it is considered to be one of the main causes of disturbance to the cinereous vulture during its breeding period, because this activity is carried out in June–July, while chicks are being reared (Moreno-Opo & Arredondo, 2007). During this period, it is essential that the adults provide their chicks with shade in order to protect them from direct sunlight, which could lead to dehydration of the chicks (Donázar, 1993; Moreno-Opo & Arredondo, 2007). The study of the interaction of this activity and any possible disturbance that it may create and its impact on breeding cinereous vultures might offer information that could enable possible solutions to be found.

In this paper, we examine the effects of cork harvesting on the cinereous vulture's behaviour during the breeding season and on their breeding success. We discuss the results to assess whether and in what circumstances this anthropogenic activity may be compatible with the conservation of this endangered vulture and, more generally, discuss the use of observational studies as a tool in finding optimal solutions for harmonizing conservation and economic development.

Methods

Study area

Cork harvesting and its impact on the cinereous vulture's breeding was monitored in June 2005 in the Umbría de Alcudia colony (Ciudad Real, Spain, Fig. 1), an 11 115 ha sector containing 99 breeding pairs. Within this area, cork extraction in 2005 occurred in a 3200 ha area, containing 51 pairs (Fig. 2).

The habitat in the study area consists of mature Mediterranean landscapes, made up of arboreal species such as the cork oak *Q. suber*, holm oak *Quercus ilex*, prickly juniper *Juniperus oxycedrus* and the strawberry tree *Arbutus unedo*, with a well-developed shrub cover, on slopes with an incline of 25–45% and at altitudes ranging between 736 and 1115 m.

The cork harvest

Cork harvesting is a forestry activity that consists of the removal of the bark from cork oaks. Each tree is harvested every 9–10 years. The initial prospecting activity and the subsequent harvest are carried out between May and mid August with the optimum time for cork extraction (according to the physiological state of the tree) being between June and mid July (Borges, Oliveira & Costa, 1997; Pereira,

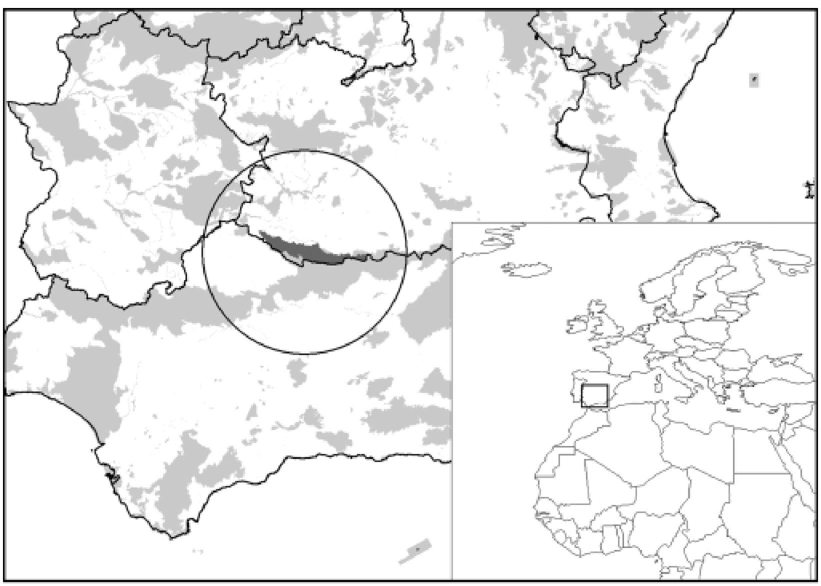

Figure 1 General location of the study area in Spain. Special protected area (SPA) in which the breeding colony of cinereous vultures *Aegypius monachus* studied is found, highlighted in dark grey. In light grey appears the whole Natura 2000 network in the Southern mid Spain.

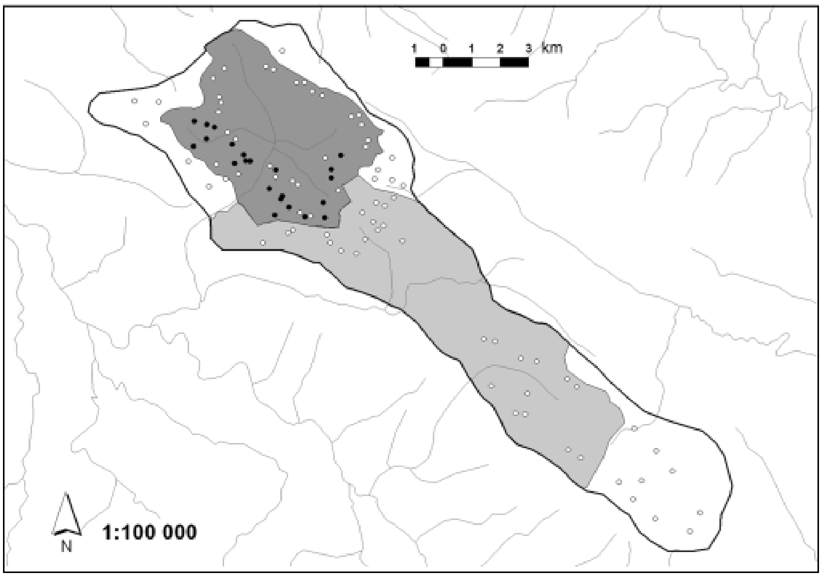

Figure 2 Location of the cinereous vulture *Aegypius monachus* breeding pairs in the studied colony in 2005. Dark grey corresponds to the cork harvesting area ($n=51$ nests), while light grey is the control area for breeding success analysis ($n=28$ nests). Black dots: nests in which vulture behaviour was studied in relation to cork-harvesting activity ($n=22$); white dots: rest of nests of breeding cinereous vultures ($n=77$). Black line: outline of the breeding colony; grey lines: river network.

2007). The harvest is carried out between 07:00 AM and 02:30 PM by teams of 15–30 workers, who remove the cork with manual tools and then transport it using animal transport and/or vehicles.

Field procedures

First, we conducted meetings with the managers of the cork harvesting to know in advance the areas and timing where harvesting works would occur. A total of 12 days in June 2005 were spent monitoring the impact of cork harvesting on 22 cinereous vulture nests with chicks, with a total of 122 observations. The minimum distance between neighbouring pairs was 150 m. Observers were placed at >800 m from the areas with cork extraction activity, usually in the opposite slopes to where work was carried out. Each observation day corresponded to a different harvesting event. On average, we monitored simultaneously two nests daily (range 1–5, $n = 14$). Observations were carried out with $\times$20–60 spotting scopes. The visible reactions of breeding individuals and chicks were noted. These were divided into three categories for the adults: *No reaction*, when the bird displayed no apparent change in behaviour; *alert reaction*, when the bird stood up in the nest with its head outstretched and looked in the direction of the human activity, but did not leave the nest; and *flight reaction*, when the adult bird left the nest. In the third case, the minimum time the adults were absent from the nest was noted (in some cases the observation ended before the adult returned to the nest). In the case of the chicks, we described chick behaviour as *no reaction* or *alert reaction* as above. In each case, we also noted the following variables: (1) the distance between people and the nest, noted by the positions in aerial photographs and the subsequent measurement of distances using GIS computer programs; (2) the noise level as perceived by the observers (and thus, theoretically, as perceived by the vultures), considering this to be *zero* (no voices), *slight* (when only a few voices were heard sporadically), *moderate* (when voices were heard often, but not constantly or loudly) and *loud* (when generalized voices were heard constantly and at a loud volume), independently; (3) the number of people present; (4) the presence or absence of machinery.

To evaluate whether cork extraction activities influenced breeding success, we compared two areas of the colony in 2005 (Fig. 2). The two areas correspond to two different private estates, with different management regimes, but have similar habitat characteristics and similar vulture breeding densities. In one area, containing 51 breeding pairs, cork harvesting occurred in 2005. The other one (hereafter called ‘control area’), containing 28 pairs, had no cork harvesting activities in 2005. Breeding success was monitored in both areas with the same methodology and survey effort. Observations of all nests in the colony were periodically conducted each fortnight; we noted the breeding status in each visit (nest occupied or unoccupied and, in the former case, incubation, chick present, adult/s presence/absence, abandonment or failure, chick fledged). For each area, we calculated the breeding success (number of pairs in which a chick fledged divided by total number of pairs with clutches) and the chick mortality rate (number of nests in which the chick died divided by the total number of nests with hatched eggs). Cinereous vultures rear a maximum of one chick per breeding event (Hiraldo, 1983).

Statistical analyses

We carried out generalised linear mixed models to analyse vulture behaviour. We included nest, date (i.e. harvesting event) and their interaction as random variables to account for the lack of independence of observations carried out the same day for different nests and different observations (in the same or different dates) for the same nest.

We first analysed the probability that the nestling would be alarmed in relation to various attributes of the activity. As explanatory variables we included distance to the nest, number of people involved, level of noise (because of the sample size for this analysis, we combined the zero and slight noise categories), whether vehicles and machines were involved or not, the interaction between distance and noise, the interaction between distance and presence of machines and the interaction between distance and number of people.

In analysing the effect of cork harvesting work on the behaviour of the adults, we were particularly interested in evaluating the probability of reactions that may have a potential effect on reproductive success. We thus analysed the probability of nest abandonment (and lumped observations when adults showed ‘no reaction’ or ‘alert reaction’ for analyses). The initial model was the same as that described above for nestlings.

The dependent variables were fitted with a binomial error, and a log link function. Backward selection was used to identify the most parsimonious model. Type III results are presented.

Finally, in order to observe the impact of cork harvesting on the breeding parameters of cinereous vultures, we tested whether breeding success and chick mortality rate varied between the subsections of the colony that were subjected to human disturbance ($n = 51$ nests) and the control area ($n = 28$ nests), with Fisher’s exact tests.

Results

Effect of cork harvesting on vulture behaviour

The probability of nestlings being alarmed depended only on distance between the activity and the nest, and on the level of noise ($F_{1,102} = 15.44$, $P = 0.0001$ for distance, $F_{2,102} = 4.99$, $P = 0.009$ for level of noise). Activities with a high level of noise occurring within 500 m from the nest had a high probability of alarming the nestlings (Fig. 3a). If the level of noise was low, nestlings were alarmed only when the activities were closer to the nest (Fig. 3a).

For the adults, the probability of nest abandonment was also only dependent on distance from the nest, and there was a near significant effect on the level of noise ($F_{1,78} = 10.66$, $P = 0.002$ for distance; $F_{1,78} = 2.55$, $P = 0.08$ for level of noise). Any activity within 500 m from the nest, if the level of noise was intermediate or loud, was highly likely to cause abandonment of the nest by adults (Fig. 3b). The average observed flight distance was 220.21 ± 153.8 m (range 10–600, $n = 23$). Average observed alert distance was 332.2 ± 174.2 m (range 50–700, $n = 39$). When adults flew from the nest, the average observed time of nest abandonment was 132 ± 85 min (range 12–330 min, $n = 22$).

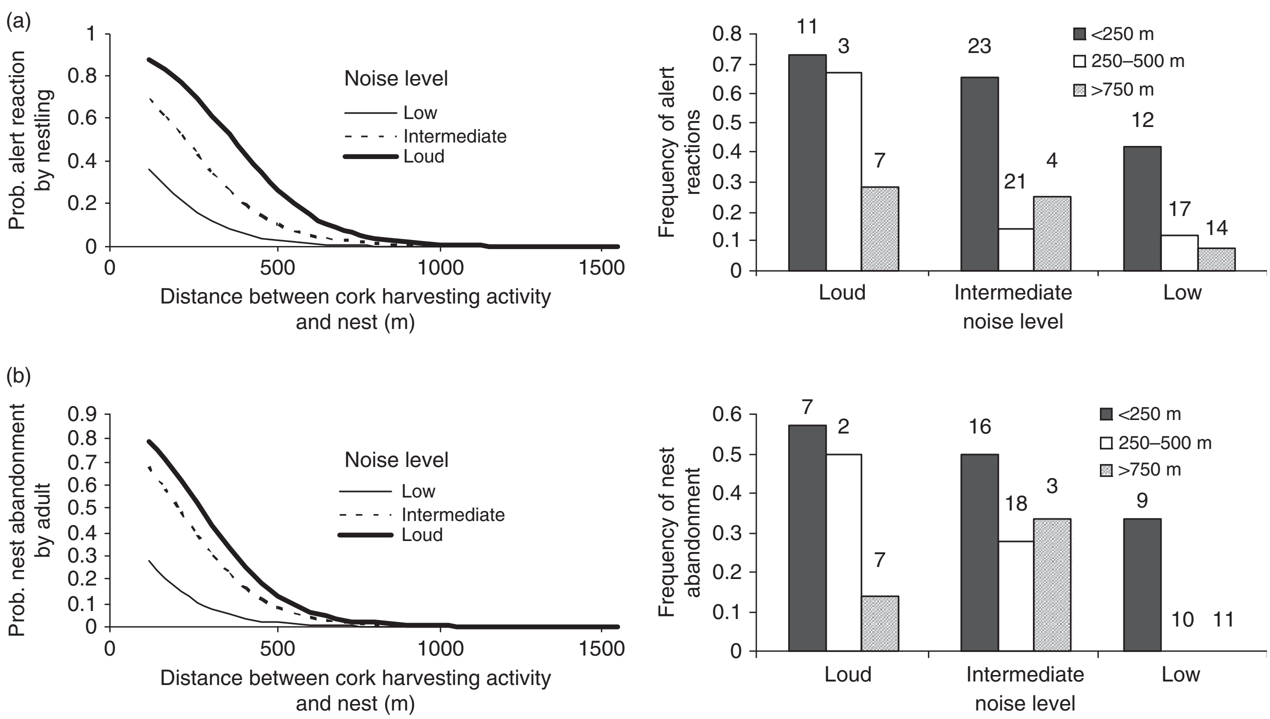

Figure 3 Probability of (a) alert reactions of cinereous vulture *Aegypius monachus* chicks (above) or (b) nest abandonment by breeding adults (below) in response to cork-harvesting activities, in relation to the distance to the nest and intensity (low, intermediate and loud) of the noise. Modelled results are presented in the left figures, whereas raw data are presented in the right ones. Sample sizes (number of observations) above bars.

Influence on breeding success

The breeding success of pairs in the area with cork harvesting activities was 0.55 ± 0.50 chicks per pair with clutches ($n = 51$), whereas in the control area it was 0.75 ± 0.44 ($n = 28$). Differences approached statistical significance (Fisher's exact test $P = 0.06$).

Taking into account only the pairs where hatching was observed, in the cork harvesting area chick mortality was 24.6% ($n = 37$ nests with hatching), whereas in the control area this percentage was three times lower, 8.7% ($n = 23$), although the differences were not statistically significant (Fisher's exact test $P = 0.12$). In the cork harvesting area, two chicks died dehydrated at age 29 and 32 days old as a consequence of nest abandonment by the adults directly related to the cork harvesting activity, as showed by necropsies conducted in official veterinarian centres. In a third nest, cork harvesting activity led to nest abandonment for 2 consecutive days and the chick was rescued the second day at the age of 26 days with symptoms of dehydration.

Discussion

Our observations indicate that cork extraction activities resulted in a high likelihood that breeding cinereous vultures would leave the nest for long periods and in lower breeding success. However, they also suggest that the overall impact of this loss at the population level may be lower than that arising from stopping cork harvesting, indicating how to best minimize this impact. We discuss these results below, as well as the conflict between maintenance of economic activities, habitat and wildlife conservation.

Cork harvesting and cinereous vulture conservation

Nest abandonment by breeding cinereous vultures during the incubation or early chick-rearing periods is rare because of the high temperatures and the consequent risk of chick dehydration (Hiraldo, 1983). The higher probability of nest abandonment during cork extraction observed here is thus likely to have strong impacts on the nestlings and, indeed, our data indicate that nests exposed to this activity had a chick mortality three times higher than those in a control area (although this difference was not statistically significant). Our results also suggest that the elimination of the disturbance could lead to a 20% increase in successful nests. The life history of a long-lived species such as this is characterized by low fecundity and high survival rate (Hiraldo, 1983), and adult survival is the most sensitive parameter affecting variations in population dynamics (e.g. Meretsky *et al*., 2000; Oro *et al*., 2008). Thus, it could be argued that the global effects of disturbance in the vulture populations might be negligible (particularly bearing in mind that this activity is carried out on each tree every 9–10 years, and hence, the activities affect only a fraction of the breeding population each year). Nevertheless, as yet, no demographic models have been constructed to measure the effect of this loss and, in any case, this decrease in productivity could be an added detrimental factor to already threatened populations. In addition, it could be useful to measure the non-lethal physiological stress effects of disturbance (Gill, Norris & Sutherland, 2001; Holmes, Giese & Kriwoken, 2005), which may have consequences beyond the nest stage. A simple method to measure the stress level would be to analyse corticosterone levels in chick feathers collected in the nests (Bortolotti *et al*., 2008).

Our results showed that activities occurring <500 m from the nest had a $>25\%$ probability of adults abandoning the nest. This suggests that cork harvesting activities should be minimized within 500 m of active nests in order to avoid disturbance, and the subsequent decrease in breeding success. However, each kilo of cork generates a turnover of €1.43 (MMAMRM, 2009), and in the area of 500 m around a nest, the amount of money lost could be as great as €67 650. Moreover, cork that is not removed at the optimal time decreases in unit value and thus could be lost for future generations. A delay in cork extraction until August, when nestlings have fledged, is not a valid option because extraction outside the optimal physiological time for the tree also has added costs (Borges *et al*., 1997; Pereira, 2007). Ultimately, the exploitation of the cork oaks allows these forests to be conserved, due to their economic yield leading to their protection (WWF, 2006), and biodiversity conservation necessitates not only the preservation of species but also their habitats (Behera, Kushwaha & Roy, 2005). This creates a dichotomy from a conservation standpoint, because cork-harvesting activity is interlinked to the conservation of the cinereous vulture.

A cost–benefit analysis suggests, as described above, that the costs of reducing cork harvesting activities are much greater than the benefits (in terms of increased productivity) for the cinereous vultures. Finding a compromise that maintains this economic activity while minimizing the detrimental effects on this endangered species should be considered. Our data show that, in addition to distance, the noise level also determined the reaction of species toward disturbance, a factor that has been shown to modify the behaviour of other bird species that come in contact with humans (Bowles, 1995; Bautista *et al*., 2004; Arroyo & Razin, 2006). The distance at which there was a high probability of nest abandonment during cork extraction was greatly reduced if the activity was silent, or almost silent. Hence, simply diminishing the noise level would promote the conservation of such umbrella Mediterranean raptor species. In addition, aspects such as carrying out the activities during hours of cooler temperatures, not prolonging activities affecting the same nests by more than one consecutive day or carrying out work on a slope below the nest such that activity can be observed by adults from above, would strongly minimize the impact of these activities. Thus, supervision of cork-extraction activities by teams of technicians trained in advising workers and in taking action towards rescuing birds subjected to a prolonged absence of the parents is advisable.

Reconciling conservation of endangered species with economically important anthropogenic activities

The conservation of threatened species is a crucial challenge in the current context of biodiversity loss, and there are social and international objectives for halting this loss (Butchart *et al*., 2010; Marton-Lefèvre, 2010). However, it is increasingly recognized that the creation of protected areas alone is not always sufficient for the preservation of biodiversity. Finding adapted, alternative solutions as in our case may result in more effective conservation. Thus, it is extremely important to integrate the management of protected areas with the human activities and land use occurring in their surroundings (Sergio *et al*., 2005), particularly for species living in habitats dominated and conditioned by human activities. In most cases (at least within populated Europe), conservation of threatened species needs to be compatible with human activities if conservation programmes aim to be sustainable (Margalida *et al*., 2010). Additionally, the economic benefits arising from human activities may help to preserve the ecosystems in which they occur. For example, the economic benefit from red grouse *Lagopus lagopus scoticus* hunting helps to maintain the ecologically important heather moorland habitat (Thompson *et al*., 1995). Otherwise, human activities may cause negative effects on wildlife, such as disturbance, causing disruption of normal breeding behaviour or even breeding failure in wildlife (Blumstein *et al*., 2005; Arroyo & Razin, 2006; González *et al*., 2006; Langston *et al*., 2007; Zuberogoitia *et al*., 2008). Additionally, these negative effects may be direct, as for example in the case of hunting (e.g. persecution of predators considered competitors) or agriculture (losses of nests or incubating birds through mechanization of practices) (see Thompson *et al*., 2003; Woodroffe, Thirgood & Rabinowitz, 2005). Thus, conflicts between human development and wildlife conservation are common, and their resolution is a key aspect of current conservation philosophy (Conover, 2002; Woodroffe *et al*., 2005; Macdonald & Service, 2007).

Ecotourism, fisheries and forestry exploitation are economically important anthropogenic activities that, in addition, are key sources of disturbance (Bowles, 1995; Donázar *et al*., 2002; Arlettaz *et al*., 2007). The creation of buffer zones into which humans are prohibited to enter, or in which certain activities are temporally restricted, may constitute a tool for minimizing the impact of the human disturbance (González *et al*., 2007), but may be unviable in certain circumstances and even detrimental in terms of conservation if the activities that are limited are rendered economically unsustainable, and this in turn causes land use changes that are as negative for the species as the disturbance itself (or even more so). Examples of such conflicts between economic activities that are negative for a particular species, but that maintain the habitats on which these species depend are, for instance, the hunting of red grouse in Scotland, which has a negative effect on hen harrier *Circus cyaneus* conservation, but that helps to maintain its breeding habitat (Thirgood *et al*., 2000), the timber exploitation in mature boreal forests overlapping the breeding activity of different animal species but constituting a long-term sustainable forest management and the protection of important biodiversity hotspots (Lindenmayer, Margules & Botkin, 2000; Rosenvald and Lõhmus, 2003) or burning vegetation in a sustainable way to prevent the spread of scrub and to increase the heterogeneity in grasslands for animal communities conservation (Fuhlendorf *et al*., 2006; Spottiswoode *et al*., 2009).

In the specific case of human activities being a source of disturbance, studies quantifying their impact on wildlife help us to understand the magnitude of the problem. It is thus particularly important to quantify the effects of disturbance not only on behaviour but also on population sustainability (via quantifying the effects of behaviour change on population parameters such as productivity or survival), such that we can measure the costs and benefits (in terms of population changes) of not limiting these activities. In this sense, it seems advisable to examine the cost-effective conservation actions before their application (Pullin *et al*., 2004; Sutherland *et al*., 2004). Additionally, observational studies (such as this one) aid in finding optimal solutions for harmonizing conservation and economic development when the application of buffer zones is not possible. Overall, these studies may help to decrease the tension between stakeholders by putting the conflict in an objective, traceable context.

Acknowledgements

We thank F. Guil, N. El Khadir, J. Oria, C. Soria, R. Higuero, M. Panadero, R. Jiménez, J. Guzmán, M. Martín, J.F. Sánchez and M. Mata for their help. The comments of A. Amar, L.M. González, T. Katzner and two anonymous reviewers improved this manuscript. We also thank the kind help provided by the owner and the field workers of the estate where this study was developed. This study was carried out within the framework of the monitoring programme of the LIFE 03/NAT/E/0050 project 'Conservation of the Spanish imperial eagle, cinereous vulture and black stork', implemented by the Fundación CBD-Habitat in conjunction with the autonomous communities of Castilla-La Mancha, Extremadura and Madrid and the Ministerio de Medio Ambiente, Medio Rural y Marino.

References

Arlettaz, R., Patthey, P., Baltic, M., Leu, T., Schaub, M., Palme, R. & Jenni-Eiermann, S. (2007). Spreading free-riding snow sports represent a novel serious threat for wildlife. *Proc. Roy. Soc. Lond. Ser. B* **274**, 1219–1224.

Arroyo, B.E. & Razin, M. (2006). Effects of human activities on bearded vulture behaviour and breeding success in the French Pyrenees. *Biol. Conserv*. **128**, 276–284.

Bautista, L.M., García, J.T., Calmaestra, R.G., Palacín, C., Martín, C.A., Morales, M.B., Bonal, R. & Viñuela, J.

(2004). Effect of weekend road traffic on the use of space by raptors. *Conserv. Biol.* **18**, 1–7.

Behera, M.D., Kushwaha, S.P.S. & Roy, P.S. (2005). Rapid assessment of biological richness in a part of Eastern Himalaya: an integrated three-tier approach. *Forest Ecol. Mgmt.* **207**, 363–384.

BirdLife International. (2008). *Aegypius monachus. IUCN Red List of Threatened Species*. Gland, Switzerland: IUCN. Available at www.iucnredlist.org.

Blumstein, D.T., Fernández-Juricic, E., Zollner, P.A. & Garity, S.C. (2005). Inter-specific variation of avian responses to human disturbance. *J. Appl. Ecol.* **42**, 943–953.

Borges, J.G., Oliveira, A.C. & Costa, M.A. (1997). A quantitative approach to cork oak forest management. *Forest Ecol. Mgmt.* **97**, 223–229.

Bortolotti, G.R., Marchant, T.A., Blas, J. & German, T. (2008). Corticosterone in feathers is a long-term, integrated measure of avian stress physiology. *Funct. Ecol.* **22**, 494–500.

Bowles, A.E. (1995). Responses of wildlife to noise. In *Wildlife and recreationists: coexistence through management and research*: 109–132. Knight, R. & Gutzwiller, K. (Eds). Washington: Island Press.

Butchart, S.H.M., Walpole, M., Collen, B., Strien, A.V., Scharlemann, J.P.W., Almond, R.E.A., Baillie, J.E.M., Bomhard, B., Brown, C., Bruno, J., Carpenter, K.E., Carr, G.M., Chanson, J., Chenery, A.M., Csirke, J., Davidson, N.C., Dentener, F., Foster, M., Galli, A., Galloway, J.N., Genovesi, P., Gregory, R.D., Kapos, M.H.V., Lamarque, J.-F.,Leverington, F., Loh, J., McGeoch, M.A., McRae, L., Minasyan, A., Morcillo, M.H., Oldfield, T.E.E., Pauly, D., Quader, S., Revenga, C., Sauer, J.R., Skolnik, B., Spear, D., Stanwell-Smith, D., Stuart, S.N., Symes, A., Tierney, M., Tyrrell, T.D.,Vié, J.-C. & Watson, R. (2010). Global biodiversity: indicators of recent declines. *Science* **328**, 1164–1168.

Conover, M. (2002). *Resolving human–wildlife conflicts: the science of wildlife damage management*. Boca Raton: CRC Press.

De la Puente, J., Moreno-Opo, R. & Del Moral, J.C. (2007). *El buitre negro en España. Censo nacional 2006*. Madrid: SEO/BirdLife.

Donázar, J.A. (1993). *Los buitres ibéricos. Biología y Conservación*. Madrid: J.M. Reyero.

Donázar, J.A., Blanco, G., Hiraldo, F., Soto-Largo, E. & Oria, J. (2002). Effects of forestry and other land-use practices on the conservation of cinereous vulture. *Ecol. Appl.* **12**, 1445–1456.

Fernández-Juricic, E., Venier, M.P., Renison, D. & Blumstein, D.T. (2005). Sensitivity of wildlife to spatial patterns of recreationist behaviour: a critical assessment of minimum approaching distances and buffer areas for grassland birds. *Biol. Conserv.* **125**, 225–235.

Fuhlendorf, S.D., Harrell, W.C., Engle, D.M., Hamilton, R.G., Davis, C.A. & Leslie, D.M. (2006). Should heterogeneity be the basis for conservation? Grassland bird response to fire and grazin. *Ecol. Appl.* **16**, 1706–1716.

Gill, J.A. (2005). Approaches to measuring the effects of human disturbance on birds. *Ibis* **149**, 9–14.

Gill, J.A., Norris, K. & Sutherland, W.J. (2001). Why behavioural responses may not reflect the population consequences of human disturbance. *Biol. Conserv.* **97**, 265–268.

González, L.M., Arroyo, B.E., Margalida, A., Oria, J. & Sánchez, R. (2006). Effect of human activities on the behaviour of breeding Spanish imperial eagles (*Aquila adalberti*): management implications for the conservation of a threatened species. *Anim. Conserv.* **9**, 85–93.

González, L.M., Arroyo, B.E., Margalida, A., Oria, J. & Sánchez, R. (2007). Can buffer zones have detrimental effects on conservation of Spanish imperial eagle *Aquila adalberti*? *Anim. Conserv.* **10**, 295–296.

Guil, F. & Moreno-Opo, R.(Coords). (2008). *Guía práctica para la elaboración de planes de gestión Natura 2000 en fincas y montes*. Madrid: Obra Social Caja Madrid-Fundación CBD-Habitat.

Hiraldo, F. (1983). Breeding biology of the cinereous vulture. In *Vulture biology and management*: 197–213. Wilbur, S.R. & Jackson, J.A. (Eds). Berkeley: University of California Press.

Holmes, N., Giese, M. & Kriwoken, L.K. (2005). Testing the minimum approach distance guidelines for incubating royal penguins *Eudyptes schlegeli*. *Biol. Conserv.* **126**, 339–350.

Langston, R.H.W., Liley, D., Murison, G., Woodfield, E. & Clarke, R.T. (2007). What effects do walkers and dogs have on the distribution and productivity of breeding European Nightjar *Caprimulgus europaeus*? *Ibis* **149**, 27–36.

Lindenmayer, D.B, Margules, C.R. & Botkin, D.B. (2000). Indicators of biodiversity for ecologically sustainable forest management. *Conserv. Biol.* **14**, 941–950.

Macdonald, D. & Service, K. (2007). *Hot topics in conservation*. Oxford: Blackwell Publishing.

Margalida, A., Donázar, J.A., Carrete, M. & Sánchez-Zapata, J.A. (2010). Sanitary versus environmental policies: fitting together two pieces of the puzzle of European vulture conservation. *J. Appl. Ecol.* **47**, 931–935.

Marton-Lefèvre, J. (2010). Biodiversity is our life. *Science* **313**, 1051.

Meretsky, V., Snyder, N., Beissinger, S. & Clendenen, D.J. (2000). Demography of the California condor: implications for reestablishment. *Conserv. Biol.* **14**, 957–967.

Ministerio de Medio Ambiente, Medio Rural y Marino (2009). *Estadísticas agrarias*. Available at http://www.mapa.es/es/estadistica/pags/preciospercibidos/metodologia/metodologia.html (accessed 10 September 2010).

Moreno-Opo, R. & Arredondo, A. (2007). Descorche y buitre negro. In *Manual de gestión del hábitat y de las poblaciones de buitre negro en España*: 296–306. Moreno-Opo, R. & Guil, F. (Eds). Madrid: Ministerio de Medio Ambiente.

Oro, D., Margalida, A., Carrete, M., Heredia, R. & Donázar, J.A. (2008). Testing the goodness of supplementary feeding to enhance population viability in an endangered vulture. *PLoS One* **3**, e4084.

Pereira, H. (2007). *Cork. Biology, production and uses*. Oxford: Elsevier Ltd.

Preisler, H.K., Ager, A. & Wisdom, M.J. (2006). Statistical methods for analysing responses of wildlife to human disturbance. *J. Appl. Ecol.* **43**, 164–172.

Pullin, A.S., Knight, T.M., Stone, D.A. & Charman, K. (2004). Do conservation managers use scientific evidence to support their decision-making? *Biol. Conserv.* **119**, 245–252.

Richardson, C.T. & Miller, C.K. (1997). Recommendations for protecting raptors from human disturbance: a review. *Wildl. Soc. Bull.* **25**, 634–638.

Rosenvald, R. & Lôhmus, A. (2003). Nesting of the black stork *Ciconia nigra* and white-tailed eagle *Haliaeetus albicilla* in relation to forest management. *Forest Ecol. Mgmt.* **185**, 217–223.

Sergio, F., Blas, J., Forero, M., Fernandez, N., Donázar, J.A. & Hiraldo, F. (2005). Preservation of wide-ranging top predators by site-protection: black and red kites in Doñana National Park. *Biol. Conserv.* **125**, 11–21.

Speziale, K.L., Lambertucci, S.A. & Olsson, O. (2008). Disturbance from roads negatively affects Andean condor habitat use. *Biol. Conserv.* **141**, 1765–1772.

Spottiswoode, C.N., Wondafrash, M., Gabremichael, M.N., Dellelegn, Y., Mwangi, M.A.K., Collar, N.J. & Dolman, P.M. (2009). Rangeland degradation is poised to cause Africa's first recorded avian extinction. *Anim. Conserv.* **12**, 249–257.

Steidl, R.J. & Anthony, R.G. (2000). Experimental effects of human activity on breeding bald eagles. *Ecol. Appl.* **10**, 258–268.

Sutherland, W.J., Pullin, A.S., Dolman, P.M. & Knight, T.M. (2004). The need for evidence-based conservation. *Trends Ecol. Evol.* **19**, 305–308.

Thirgood, S.J., Redpath, S.M., Newton, I. & Hudson, P.J. (2000). Raptors and grouse: conservation conflicts and management solutions. *Conserv. Biol.* **14**, 95–104.

Thompson, D.B.A., MacDonald, A.J., Marsden, J.H. & Galbraith, C.A. (1995). Upland heather moorland in Great Britain: a review of international importance, vegetation change and some objectives for nature conservation. *Biol. Conserv.* **71**, 163–178.

Thompson, D.B.A., Redpath, S.M., Fielding, A.H., Marquiss, M. & Galbraith, C.A. (Eds). (2003). *Birds of prey in a changing environment*. Edinburgh: The Stationery Office.

Whitfield, D.P., Ruddock, M. & Bullman, R. (2008). Expert opinion as a tool for quantifying bird tolerance to human disturbance. *Biol. Conserv.* **141**, 2708–2717.

Woodroffe, R., Thirgood, S.J. & Rabinowitz, A. (Eds). (2005). *People and wildlife: conflict or co-existance?* Cambridge: Cambridge University Press.

WWF. (2006). *Cork screwed? Environmental and economic impacts of the cork stoppers market. A WWF Report*. WWF/MEDPO. Available at http://assets.wwfes.panda.org/downloads/corcho_amenazado_ingles.pdf (accessed 10 September 2010).

Young, J., Watt, A., Nowicki, P., Alard, D., Clitherow, J., Henle, K., Johnson, R., Laczko, E., McCracken, D., Matouch, S., Niemela, J. & Richards, C. (2005). Towards sustainable land use: identifying and managing the conflicts between human activities and biodiversity conservation in Europe. *Biodivers. Conserv.* **14**, 1641–1671.

Zuberogoitia, I., Zabala, J., Martínez, J.A., Martínez, J.E. & Azkona, A. (2008). Effect of human activities on Egyptian vulture breeding success. *Anim. Conserv.* **11**, 313–320.

