Ornis Fennica 83:97–107. 2006

Occupancy and abundance of Little Owl *Athene noctua* in an intensively managed forest area in Biscay

Jabi Zabala*, Iñigo Zuberogoitia, José A. Martínez-Climent, José E. Martínez, Ainara Azkona, Sonia Hidalgo & Agurtzane Iraeta

Zabala, J., Sebero Otxoa 45, 5 B. E-48480 Arrigorriaga. Biscay, Basque Country. Spain. jzabalaalbizua@yahoo.com (Corresponding author)*
Zuberogoitia, I., SEAR. Karl Marx 15, 4-F. E-48950 Erandio. Biscay, Basque Country. Spain. Icarus. C/ Pintor Sorolla 6. 1º. E-26007 Logroño. Spain. inigo.zuberogoitia@wanadoo.es
Martínez-Climent, J.A., C/ Juan de la Cierva 43 (S.T. 100), El Campello, 03560 Alicante, Spain
Martínez, J.E., Dept. Ecología e Hidrología Univ. Murcia. Campus Espinardo. E-30100 Espinardo Murcia. Spain
Azkona, A., SEAR. Karl Marx 15, 4-F. E-48950 Erandio. Biscay, Basque Country. Spain
Hidalgo, S., SEAR. Karl Marx 15, 4-F. E-48950 Erandio. Biscay, Basque Country. Spain
Iraeta, A., SEAR. Karl Marx 15, 4-F. E-48950 Erandio. Biscay, Basque Country. Spain

Received 10 October 2005, revised 30 December 2005, accepted 2 January 2006

We censused a population of Little Owls in Biscay (North Iberian Peninsula) using playback calls. We modelled their distribution using Geographic Information System (GIS), extracting data on land use and landscape composition in occupied and unoccupied areas at two different scales. Little Owl presence and habitat selection were mainly governed by land use practice. The species was linked to traditional agri-pastoral exploitations. Variables such as topography, altitude, road density and urban areas had an effect at the lower scale, whilst density of predator species had an effect only over habitat selection but not over occupancy. At larger scales, the occupancy of apparently suitable areas was related to the structure and spatial composition of land use and, especially, to the proportion of forest plantations. Current policies of land management pay no attention to traditional exploitations and associated wildlife, and the promotion of forest cultures is responsible for the decline of the species in many areas.

1. Introduction

Precise knowledge of the habitat requirements of a given species is needed for conservation purposes as well as for developing adequate landscape management practices and regional or global policies (Sánchez-Zapata & Calvo 1999, Pedrini & Sergio 2001). This holds especially true in areas of Western Europe, where demographic pressure, technological development and market preferences, as well as European agrarian policies, and global environmental policies, induce constant and drastic changes in traditional agricultural practices and land use (Potter 1997, Macdonald *et al.* 2000). In general, habitat studies focus on large, flagship, rare or endangered species, whereas species linked to traditional agri-pastoral and rural systems are usually regarded as abundant, and are therefore relatively little studied (Tucker & Heath 1994). Hence, there is a lack of information about species that occupy such areas, although these areas are among the most intensely managed ones. As a consequence, it is often difficult to evaluate the impact of common and widespread management practices.

This problem is illustrated by the Little Owl, whose biology has received not much scientific attention (with the exception of its diet), despite the fact that it is widely distributed throughout Europe (Mikkola 1983). Data available hitherto on Little Owl's habitat requirements are preliminary results of broad censuses, coarse-grained studies or studies conducted at large ecological scales, and generic data directly derived from field observations or personal experience (Zuberogoitia & Martínez-Climent 2001, Ferrus *et al.* 2002). Recently, some specific works have been published focusing on its ecology but mainly in Mediterranean areas (Martínez & Zuberogoita 2004a,b, Tomé *et al.* 2004). The Little Owl's suitable habitat is commonly described as open agri-pastoral areas, meadows and rural settlements. However, studies conducted so far stress a decline in numbers of the species and the existence of apparently suitable but unoccupied areas (Zuberogoitia *et al.* 1998, Ferrus *et al.* 2002, Zuberogoitia 2002).

Habitat selection studies are commonly used in ecology in order to understand distribution patterns and regression causes of species, although it should be noted that several problems regarding techniques and terminology have arisen (Garshelis 2000). The main aims of this study are to identify factors affecting site occupancy and density of Little Owls in an area with an oceanic climate. We here use habitat as a species-specific term, comprising the set of resources, conditions and structures required for its occupancy, and consider habitat selection as the choice or use of precise structures resulting in an enhancement of the fitness of the species (Garshelis 2000). Therefore, we compare occupied areas to similar but unoccupied ones in order to find variables defining habitat at fine-scales, and we use an indirect method for measuring habitat quality, assuming that higher quality areas can harbour more individuals and, therefore, that Little Owl occupancy and density are indicative of habitat quality and fitness.

2. Material and Methods

2.1. Study area

The study was conducted in Biscay (SW Europe) (Fig. 1). Biscay has an area of 2,236 km² and a population of about 1,200,000 inhabitants. The landscape is hilly and rugged, and altitudes range from sea level to 1,475 m.a.s.l. Hillsides and, especially, valley bottoms are densely populated. The climate is oceanic, with annual rainfall ranging between 1,200 and 2,200 mm, and annual average temperatures varying from 13.8ºC to 12ºC. Winters are mild and there is no summer drought. Outside urban areas, the land is mainly devoted to forest plantations, mainly exotic *Pinus radiata* and *Eucalyptus globulus*, which occupy more than half the surface of the area. Forest cultures underwent a great expansion in 1995, and have since then been expanding but to a much smaller extent (Department of Environment and Land Use 2001). These forests never reach maturity because they are cut down every 30 and 15 years respectively (Loidi 1987). There are no other extensive cultures, and agricultural practices are traditional small, mixed cultures and orchards, as well as cattle and sheep rearing, always in small quantities.

2.2. Census

The Little Owl population of Biscay was intensively monitored from 1992 to 2002 as a part of a wide research program on owl status and distribution in Biscay (Zuberogoitia 2002). For this purpose, we performed playback calls in 2,056 points homogenously distributed across the study area, since this overcomes the problem of sampling biases towards areas of known presence or apparently suitable ones. It also precludes errors in the perceived abundance of Little Owls due to changes in habitat quality, so that the obtained densities are reliable (Martínez & Zuberogoitia 2004a). Previous studies determined that playback broadcasting is the most efficient method for Little

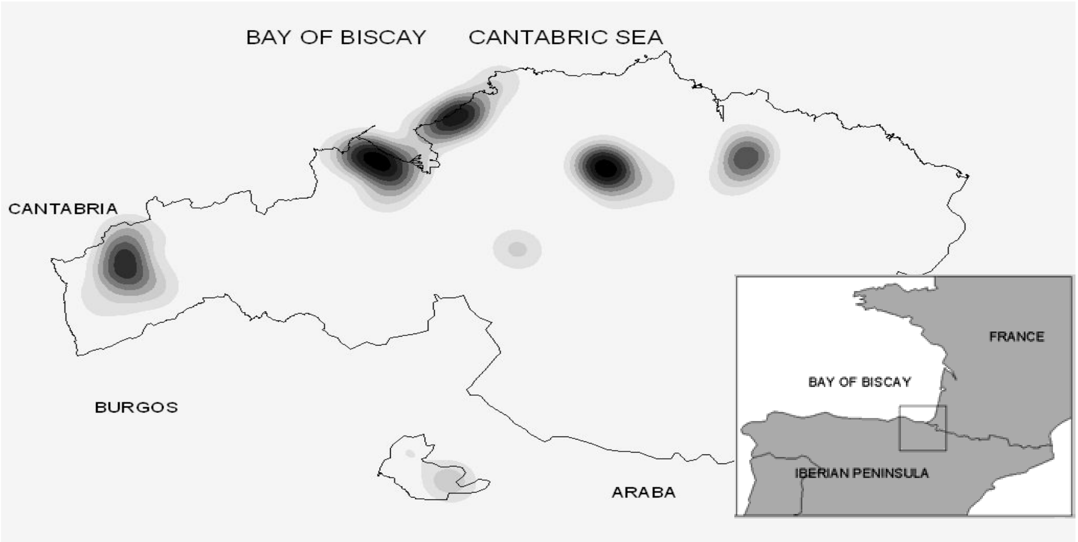

Fig. 1. Location of the study area (inset), and the distribution and density of Little Owl in Biscay, where darker areas show higher density.

Owl detection and that the season and the weather conditions under which the playbacks are broadcasted have no effect: Little Owl answering to playbacks throughout the year and in every weather conditions (Zuberogoitia & Campos 1998, Zuberogoitia 2002).

Therefore, we conducted censuses regardless of season and weather conditions with the exception of heavy rains, windy or stormy nights and others that might lessen the audibility of playbacks and responses. A tape with calls of males, females and chicks was broadcasted for five minutes followed by 10 minutes of listening (Zuberogoitia & Campos 1997). In case of broadcasting more than one owl species, taped vocalizations were broadcasted according to owl size, from the smallest to the biggest, to avoid antipredatory and competitive behaviours (Mikkola 1983). Distance between censusing points was 200 m in flat areas and a maximum of 500 m in slope ones. In addition, we visited 1,180 churches and old buildings, all the quarries in the study area, over 100 cliffs and rocky areas and an undetermined number of trees as possible nesting places, and conducted 713 interviews to keepers, wildlife biologists, naturalists and countryside inhabitants. A first survey was conducted from 1992 to 1996 covering the whole study area, and negative points were revisited at least two-three more times at different seasons to double-check them. From 1996 to 2002 only positives and apparently suitable areas were revisited to check the general status and trends of the population. For further details on census see Zuberogoitia & Campos (1997, 1998).

2.3. Geographic modelling

We translated the 276 presence data obtained during the census into a Geographic Information System (GIS) using digital cartography and geo-referenced aerial photographs at a scale of 1:5,000. We performed the Nearest Neighbour Analysis (NNA) and found that the species had a clumped distribution ($Z = -19.9$; $P = 0.361$) and it was possible to distinguish seven population nuclei. The average distance between Little Owls was 526 metres (SD = 573 m). We then produced a kernel density estimator for the species distribution, using Least Square Cross Validation (Kenward 2001) for the calculation of the window radius. Because the density estimator is not sensitive to grid size, we used an *ad hoc* grid of 25 × 25 m (Kenward 2001).

Table 1. Variables included in the different analyses. NO indicates that the variable was not considered for that particular analysis, and YES that it was included. Water, Rocky outcrops, Mixed uses, Urban, Meadows, Bushland, Conifers, and Broadleaves are the surface covered by each land use type in the area around the point of census. Polygons, the number of different land use polygons in the area, Land uses, the number of different land uses in the area. Altitude is the elevation (in m.a.s.l) of the Presence/Absence point. Relief and Buildings is the number of isoclines and buildings within the area. Roads and Rivers the distance of paved road, and of rivers and streams within the area. Tawny Owl is the density of that species in the central point of the area. Variables Meadow area, Meadow Perimeter and the Area/Perimeter ratio are only considered for the comparison of meadows where the Little Owl is present and those from which it is absent.

Variables	Habitat selection	Site occupancy at Home range scale	Site occupancy at local landscape scale	Meadows comparison
Mixed uses and others	NO	NO	YES	NO
Urban	YES	YES	YES	NO
Meadows	YES	YES	YES	NO
Bushland	YES	YES	YES	NO
Conifers	YES	YES	YES	NO
Broadleaves	YES	YES	YES	NO
Polygons	YES	YES	YES	NO
Land uses	YES	YES	YES	NO
Altitude	YES	YES	YES	NO
Relief	YES	YES	YES	NO
Buildings	YES	YES	YES	NO
Roads	YES	YES	YES	NO
Rivers	YES	YES	YES	NO
Tawny Owl	YES	YES	YES	NO
Meadow area	NO	NO	NO	YES
Meadow perimeter	NO	NO	NO	YES
Area/perimeter	NO	NO	NO	YES

2.3.1. Scale selection

We selected two scales for the analyses: home range scale and local landscape scale. For the calculation of home range size we used the Nearest Neighbour Distance (NND) and considered its half as the home range size. The obtained radius of 263 metres is in agreement with the size of home ranges obtained through radio-tracking in other areas (284 m in Müller *et al.* (2001), 309 m in Génot & Wilhelm (1993)). For the analysis of landscape scales, we could not use the landscape scale of 100 km² (Martínez *et al.* 2003, Martínez & Zuberogoitia 2004b), because it would have provided too few points for analysis, and would group together areas of presence with large areas of absence. Therefore, we used a smaller scale of 1,000 m radius as representative of local landscape and better suited to the clumped distribution of the Little Owl in the study area. This last scale did not produce sufficient presence data for an analysis of habitat selection and so we only tested its effect on occupancy.

2.3.2. Variable selection and extraction

To assess how the distribution and proportion of open areas, described as Little Owl's habitat (Génot & Wilhelm 1993, Zuberogoitia *et al.* 1998, Ille & Grinschgl 2001), and other land uses affect the species' distribution, we measured the proportion of each land use at both scales. The number of land use polygons and the number of different land uses within the area were included as indicators of the mosaic of land management and of landscape heterogeneity at both scales. We also computed the length of rivers within the area. Since road traffic is reported to have caused several Little Owl casualties (Fajardo et al 1998, Martínez & Zuberogoitia 2004a), we included the length of paved roads as a variable in the analyses. In the same way, as Little

Owls use old buildings as nesting sites and urban development may cause population decline (Martínez & Zuberogoitia 2004a), we included the number of buildings within the area as independent variable. The possible influence of altitude and topography were also considered, entering as independent variables the elevation of the centre of the area and the number of isoclines within the area (at each 20 m). Finally, because Tawny Owl (*Strix aluco*) has been proposed as having a negative effect on Little Owl distribution through predation (Zuberogoita *et al.* 1998, Zuberogoitia *et al.* 2005), we included the density of Tawny Owl as independent variable at both scales (Table 1).

To extract the values of the variables, we first randomly selected 110 out of the 276 presence points. Then we created a set of buffers around them using a radius of 263 metres and another of 1,000 m. To avoid pseudoreplication we discarded overlapping areas, reducing available points to 103 areas with 263 m radius and 48 areas with 1,000 m radius. Then we overlaid these areas on 1:5,000 digital cartographic maps and aerial photographs, and 1:25,000 based digital land use maps. Each area was converted into a 5 × 5 m grid, assigning to each cell its main use. Thus, land uses in areas of 263 m radius were defined with 8,648 cells, and in areas of 1,000 m radius with 125,046 cells. In addition, we randomly created 43 points in meadows without Little Owl to test for factors that precluded its presence in apparently suitable areas (Génot & Wilhelm 1993, Zuberogoitia *et al.* 1998, Ille & Grinschgl 2001, Ferrus *et al.* 2002), and characterised them using the 263 and 1,000 m radii.

For other variables, we calculated the number of buildings included, length of paved roads, the length of watercourses, altitude at the central point and number of isoclines within each area using digital cartography. In addition, to evaluate the incidence of Tawny Owl densities, 1,683 presence points of Tawny Owls obtained during the census were digitalised. Then, we produced a kernel density estimator for the Tawny Owl using the LSCV to set the window size and a 25 × 25 m grid. We considered the density value for the species at the central point of the areas as independent variable for the analyses.

Finally, we used the kernel 95% probability function for the Little Owl as species' presence area and separated meadows and pastures within Little Owl presence areas from those outside Little Owl areas. Then we measured the area and perimeter of each meadow and computed the area/perimeter ratio. We considered the former as indicator of the total surface and the latter two as estimators of the border effect and regularity of the shape.

2.4. Statistical analyses

2.4.1. Site occupancy

For the comparison of occupied and unoccupied sites, we performed a Logistic Regression (LR) (Morrison *et al.* 1998). The presence/absence binary response was used as dependent variable and those landscape elements detailed in Table 1 at each scale as dependent variables. Following the recommendations of Morrison *et al.* (1998), we used a set of 20 points and 5 plus for each variable and a balanced representation of presence and absence points in the LR. For the LR we used the Wald statistic and the Forward Stepwise method, which is an exploratory tool that allows the best predictors from the pool of potentially useful parameters to be identified. In this way, variables are entered into the LR individually if they fulfil certain requirements. The selection of variables ends when no further increase in the accuracy of the model can be achieved.

2.4.2. Habitat selection

For this, we used the value of the Little Owl kernel density estimator at the presence points as dependent variable, which was normally distributed /Kolmogorov-Smirnov test $Z = 0.938$; $P = 0.34$). We tested the relationship between dependent and independent variables using a Multiple Linear Regression (MLR). The MLR is a parametric test that analyses relationships between a normally distributed dependent variable and a set of independent variables, looking also for possible synergies and correlations among the latter (Shaw 2003).

Table 2. Final steps of a stepwise forward logistic regression (entering variables in Table 1) for the occupancy at the home range scale. Shown are the third and fourth steps. Variables included in the final model (third inclusion step) are shown in bold. The fourth step had a lower kappa value and the variable included (Relief) was not statistically significant, and this last step was therefore discarded (see text).

Step	Variable	Wald	Beta	P	Correctly predicts		
					Positives	Negatives	Total
3	Conifers	4.431	–0.001	0.035			
3	Altitude	3.881	–0.014	0.000	79.1	78.6	78.8
3	Roads	14.783	–0.003	0.000			
3	Constant	18.635	4.972	0.000			
4	Conifers	4.588	–0.001	0.032			
4	Relief	3.672	0.242	0.055			
4	Altitude	14.847	–0.016	0.000	74.4	78.6	76.5
4	Roads	9.021	–0.003	0.002			
4	Constant	7.754	3.620	0.005			

2.4.3. Comparison of meadows through presence or absence of the Little Owl in the area

We performed the Mann-Whitney test (Zar 1999) for the three variables, considering Little Owl presence and absence areas as different data sets.

The critical probability value for statistical acceptance was always set at 0.05.

3. Results

3.1. Site occupancy

We used 43 Little Owl presence data and 42 absence data located in meadows for the study of occupancy at the home range scale. Main difference between occupied and unoccupied sites was the proportion of pine cultures in the area, with Little Owl being absent of areas surrounded of or with a great proportion of conifer forest (Table 2). Second to the proportion of pine cultures, dense road networks precluded presence of Little Owl at the home range scale. Finally, a little proportion of absences was explained after the altitude of the area, with Little Owl being absent from highlands (Table 2). The LR for this scale produced a fourth step including relief with a positive value, indicating that Little Owl may prefer slope areas to flat ones, but this variable did no reach statistical significance and the fourth step had lower performance that the third ones, so we discarded it (Table 2). Little owl presence at the home range scale, therefore, was related to areas without conifers, scarce paved roads and low altitudes.

For the analysis of the occupancy at the local landscape scale we introduced 48 presence points and 42 absence points. Again the key variable was the amount of conifer cultures in the landscape (Single step LR, Wald $\chi^2 = 20.0$; $P = 0.001$; correctly predicts 78.7%) as responsible for the absence of the Little Owl.

In conclusion, whilst dense networks of paved roads and altitude of the area had a negative effect over presence of little owl at fine scales, occupancy of theoretically suitable areas for Little Owl was heavily influenced by the presence and density of conifer cultures in the area as well as in the surrounding landscape.

3.2. Habitat selection

In evaluating the effect of land use and other variables on the density of Little Owl, we used 103 presence points and the density of Little Owls as dependent variable. The MLR produced a model in six steps (Table 3), which included six variables indicating a complex pattern of habitat selection. The proportion of urban areas had a negative effect on Little Owl's density, with the species being scarce in highly urbanised areas. In this way, urbanisation of rural areas had a negative effect on the species, although it creates open areas, glades and fields in woodlands. In addition, Little Owls became scarcer at higher altitudes. Little Owl density declines as overall proportion of forests (both coniferous and broadleaved) increased and at higher Tawny Owl densities (Table 3). We performed Pearson's correlation analysis with these variables and found that, while Tawny Owl density was independent of broadleaved forest surface (Pearson's r = 0.099; P = 0.24; n = 145), there was a correlation between Tawny Owl density and the area covered by conifers (Pearson's r = 0.28; P = 0.001; n = 145). Relief was the only variable with positive value extracted by the MLR, indicating that Little Owl density was favoured in slope areas while decreased in flat ones.

Table 3. Final model of a stepwise forward multiple linear regression analysis on the habitat selection analysis at the home range scale. For all variables considered, see Table 1.

Variable	Cumulative R^2	t	Sig.
Urban	0.315	–6.3	0.000
Altitude	0.495	–5.7	0.000
Conifers	0.565	–3.5	0.001
Density of Tawny Owl	0.620	–3.1	0.003
Relief	0.651	2.9	0.005
Broadleaves	0.678	–2.5	0.013

3.3. Comparison of meadows through presence or absence of the Little Owl in the area

We characterised 3,113 meadows from the study area considering their area, perimeter and area/perimeter ratio. 1077 of them were included within the Little Owl's distribution area, and the other 2036 were from areas where Little Owl is absent. Meadows within Little Owl distribution area where larger than meadows from areas where the Little Owl is absent (Area: Mann-Whitney's U= 992526.50; z= –4.373; sig=0.001. Perimeter; U= 993557.5; Z = –4.3; P = 0.001.). More interesting, Meadows within Little Owl distribution area were more regular in shape as showed by their higher Area/perimeter ratio (U = 986168.0; Z = –4.6; P = 0.001), indicating lower incidence of fragmentation and border effect caused by woods and other land uses in meadows from areas where Little Owl is present than in meadows where the species is absent.

4. Discussion

4.1. Little Owl habitat in Biscay

We show that habitat occupancy and habitat selection of Little Owls are determined by a similar set of variables. Remarkably, our models stress the avoidance of certain features rather than the preference for some areas. This avoidance probably is a consequence of the procedure we used for the extraction of absence points. Instead of using points randomly distributed within the study area, we a priori considered absence points in areas similar to those actually occupied by the species. The main aim of this procedure was to enlighten which factors determine the absence of apparently suitable areas and to seek for habitat quality thresholds at fine-grained scales rather than finding broad preference/avoidance patterns for different land uses and landscape structures already described in the literature (Zuberogoitia *et al.* 1998, Ferrus *et al.* 2002). Therefore, our avoidance pattern can be viewed as indicative of habitat features that lessen the attractiveness to Little Owls of areas that are otherwise suitable for the species.

Our analyses show that Little Owls consistently avoid conifer plantations at every spatial scale. Rettie & Messier (2000) suggested that the relative significance of each limiting environmental factor could be related to the scale of selection, with more important factors driving preferences at the broadest scales. Consequently, our finding that the avoidance of conifers persists across the two spatial scales that we here consider shows that pine forests destined for timber is the main limiting factor for the distribution of the Little Owl in our study area. The avoidance of forest is in agreement with the reported selection of open areas elsewhere in Europe. During the last century, modern forestry has increasingly turned grasslands into plantations of exotic species for timber. Such plantations currently occupy more than 50% of the study area, and have led to a reduction in Little Owl densities through habitat degradation (Zuberogoitia 2002). Thus, the abundance of pine woodlands at broad scales explains previously reported gaps in the distribution of the Little Owl in apparently suitable areas (Zuberogoitia *et al.* 1998, Ferrus *et al.* 2002).

Interestingly, the absence of the Little Owl from apparently suitable areas, mainly meadows and pastures, is also in direct relation with the surface area and shape of these habitats, i.e. to an effect of edge. Little Owls tend to be absent from valleys with apparently abundantly suitable areas, but where the suitable area is fragmented (interspersed with forest cultures). This phenomenon occurs not only because the area is partially covered by unsuitable patches, but also because artificial increase of the length of ecotones creates favourable Tawny Owl hunting habitats (Zuberogoitia 2002). Indeed, our models show that Tawny Owl density negatively affected the density of Little Owls. This finding agrees well with an earlier study on aggression and interspecific competition in the owl community of Biscay, which showed that – although direct attacks are rare – most attacks were by Tawny Owl directed at Little Owls (Zuberogoitia *et al.* 2005). The negative effect of Tawny Owls on Little Owls is only highlighted in the habitat selection analysis. High Tawny Owl densities *per se* are thus not capable of preventing Little Owl occupancy, which probably reflects the low aggression intensity found by Zuberogoitia *et al.* (2005). Tomé *et al.* (2004) also found that predation could rule nest-site selection and influence the reproductive success of Little Owls. Taken together, these results therefore suggest a relationship between human made structures and potential predator densities. Increasing densities of Tawny Owl are related to increasing proportion of forested areas, and interactions between Tawny Owls and Little Owls are therefore enhanced by higher forest border and irregular meadow shapes, possibly because they reduce distances between forest edge and Little Owl nesting and hunting areas.

We show that altitude is another important habitat variable for Little Owls. Its effect is, however, difficult to explain. The absence of the Little Owl in high areas could be a consequence of a more extreme climate, but the presence of the species in latitudes northern than the study area does not bear out this hypothesis. Alternatively, the lower quality of the agricultural soils in elevated areas of Biscay, and the subsequent reduction in prey abundance, could explain the inverse relationship. Several studies have pointed out the importance for the Little Owl of small mammals, worms, insects and other prey, which typically occur in rich agricultural lands (Blache 2001, Goutner & Alivizatos 2003, Hounsome *et al.* 2004) that are more commonly found in the lowlands.

We further found that absence of the Little Owl is related to the abundance of roads. Several studies have highlighted the degradation of the environment caused by roads and how they may have a distancing effect on bird densities and activity (van der Zande *et al.* 1980, Reijnen *et al.* 1996, Bautista *et al.* 2004). Indeed, high road kill rates of Little Owls have been reported (Fajardo *et al.* 1998, Martínez & Zuberogoitia 2003a). Roads influence occupancy at home range level but not at landscape scale, nor do they influence habitat selection. This suggests that the effect of roads is local and that Little Owls can tolerate roads up to a certain threshold, above which the species simply disappears. However, this effect could be highly variable, depending on the type of road, traffic density and many other aspects. In relation to roads, the proportion of the area occupied by urban uses was the first variable extracted by the MLR. Obviously, paved areas offer scarce resources to Little Owls, but, on the other hand, rural settlements and old buildings are the main nesting places in the study area (Zuberogoitia 2002). Urban areas did not affect occupancy, but this might be an artefact since negative points were located in apparently suitable areas (meadows) rather than in obviously unfavourable areas such as big cities.

Relief was the only variable with a positive influence, as shown by the MLR. There are two non-mutually exclusive hypotheses to explain why Little Owls preferred rough terrain. On the one hand, flat areas are exposed to high construction pressure, with the consequent effects already discussed in relation to roads and housings. On the other hand, preference is probably related to food. Earthworms are known to be the staple food of Little Owls in oceanic climate areas (Hounsome *et al.* 2004). In addition, studies using night tape cameras have reported a high consumption of earthworms also in sub-Mediterranean areas (Blache 2001). Earthworms leave scarcely identifiable remains in pellets but are probably very common in the Little Owl diet across oceanic climatic areas of Europe, as they are for other animals (Kruuk 1989, Goszczynski *et al.* 2000, Zabala *et al.* 2002). Earthworms are fairly common in meadows, which is usually reported as Little Owl habitat (Mikkola 1983, Génot & Wilhelm 1993, Ille & Grinschgl 2001), but not in Mediterranean areas (Martínez & Zuberogoitia 2004a), where the dry climate prevents earthworm activity. Earthworms are especially active near the surface, and therefore available to Little Owls on warm humid nights and wet soils (Kruuk 1989). Areas with a certain degree of topographic relief may offer great opportunities for catching earthworms at different sites on most days. On rainy days high areas are wet, and after some days with no rain lower areas still retain water and earthworms, as a consequence of drainage. Besides, the effect of relief on dew may be important and in some areas earthworms are known to depend on dew for surface activity (Kruuk 1989). On the other hand, flat areas are close to rivers and usually water-logged as a consequence of the rainy climate, which prevents earthworm activity. It is worth noting that conifer plantations are the poorest earthworm areas (Kruuk 1989, Zabala *et al.* 2002).

4.2. Management and conservation implications

In general, with the exception of altitude and relief, habitat selection and occupancy of Little Owls in Biscay are governed by how the landscape is managed. In particular, forest plantations, urban areas and road development have a clear effect on Little Owls. Given the expansion that such land use has undergone in recent decades, it is clear why there has been a regression in the range occupied by Little Owls, not only in the study area but also across Europe (Tucker & Heath 1994, Génot *et al.* 1997).

International agreements and policies such as the European Common Agrarian Policy or the Kyoto protocol are partially aimed at preserving biodiversity by, for example, promoting traditional agricultural practices or the creation of new forests that act as carbonic dioxide sink. How resources available from such agreements are managed is the responsibility of local governments (MacDonald *et al.* 2000, Kleijn & Sutherland 2003). Such policies and programmes promote local and regional landscape changes at many scales, from reduced hedgerow presence to increased forest surface (MacDonald *et al.* 2000).

Our study, alongside others, suggests the failure of measures aimed at protecting biodiversity in the agri-forestal networks. Regarding Little Owls, this claim is based on: (1), Current forest policy, which artificially increases the length of ecotones. This increase creates hunting habitat for one of the largest European Tawny Owl populations (over 1,500 territories of Tawny Owls known in the study area, Zuberogoitia 2002) which may have reduce biodiversity through competition and predation. (2), The exponential decrease in the availability of habitat for Little Owls and for most of the owl guild (Zuberogoitia, 2002). In the same way, references to apparently suitable but unoccupied areas (Zuberogoitia *et al.* 1998, Ferrus *et al.* 2002) reveal that many ecologists and wildlife managers fail to understand habitat selection and occupancy processes as multi-scale processes (Johnson 1980). As a result, locally focused conservation efforts may fail and thereby waste money, time and enthusiasm (Kleijn *et al.* 2004). Research is needed to understand how species respond to changes at different scales in order to develop better local and regional policies, and management and conservation programmes that ensure productivity and wildlife conservation (Kleijn & Sutherland 2003).

Finally, research into habitat use and selection within the home range of Little Owls would help identify land uses and features of priority for the conservation and management of this Mediterranean species in non-Mediterranean areas, as well as temporal changes in habitat exploitation.

Acknowledgements. The authors wish to express their gratitude to L. Astorkia, F. Ruiz-Moneo, I. Castillo, C. González de Buitrago, I. Palacios, Z. Fernández, J. Isasi and J. Zuberogoitia for field assistance. We are also grateful to the Wildlife Bureau of the Biscay Regional Council for providing permission for studying and handling wildlife. Especial thanks to Hannu Pietiäinen for very constructive critics to a previous draft that improved its quality and made it more easily understandable.

Minervanpöllön esiintyminen ja runsaus intensiivisesti hoidetulla metsäalueella Biskajanlahden rannikolla

Tutkijat kartoittivat minervanpöllöjä Pohjois-Espanjassa käyttämällä atrappia. Havainnot liitettiin paikkatietojärjestelmään (GIS), ja pöllöjen esiintymistä eri ympäristöissä mallinnettiin kahdessa eri mittakaavassa. Minervanpöllöjen esiintyminen ja elinympäristön valinta riippui pääasiassa maankäyttötavasta. Pöllöt viihtyivät parhaiten perinteisessä maanviljelys- ja laidunmaisemassa. Alueen pinnanmuodot ja korkeus merenpinnasta sekä teiden ja rakennettujen alueiden runsaus vaikuttivat minervanpöllön paikalliseen esiintymiseen. Petojen esiintyminen vaikutti elinympäristön valintaan, mutta ei siihen, esiintyikö minervanpöllö ylipäätään alueella vai ei. Alueellisesti minervanpöllön esiintymisen vaikutti maankäyttö, ennen kaikkea metsien istuttaminen. Tutkitun alueen nykyinen maankäyttöpolitiikka ei ota huomioon perinteisiä maankäyttömuotoja ja niistä riippuvaista lajistoa. Monin paikoin minervanpöllö on vähentynyt, koska alueille on istutettu metsää.

References

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. — Conservation Biology 18: 726–732.

Blache, S. 2001: Étude du régime alimentaire de la Chevêche d'Athéna (Athene noctua, SCOP) en période de reproduction en zone agricole intensive dans le sud-est de la France. — Ciconia 25: 77–94.

Department of Environment and Land ordination. 2001: Medio Ambiente en la Comunidad Autónoma del País Vasco. — Basque Government, Vitoria-Gasteiz.

Fajardo, I., Pividal, V., Trigo, M. & Jímenez, M. 1998: Habitat selection, activity peaks and strategies to avoid road mortality by the Little Owl Athene noctua a new methodology on owls research. — Alauda 66: 49–60.

Ferrus, L., Génot, J. C., Topin, F., Baudry, J. & Giraudoux, P. 2002: Répartition de la chevêche d'Athéna (Athene noctua Scop.) et variation d'échelle d'analyse des paysages. — Revue d'Ecologie (Terre Vie) 57: 39–51.

Garshelis, D. L. 2000: Delusions in habitat evaluation: measuring use, selection and importance. — In Research techniques in animal ecology. Controversies and consequences. (ed. Boitani, L. & Fuller, T.K.): 111–164. Columbia University Press, New York.

Génot, J. C. & Wilhelm, J. L. 1993: Occupation et utilisation de l'espace par la Chouette chevêche Athene noctua en Bordure des Vosges du Nord. — Alauda 61: 181–194.

Génot, J.C., Juillard, M. & van Nieuwenhuyse, D. 1997: Little Owl. — In The EBCC Atlas of European Breeding Birds. Their abundance and distribution. (ed. Hagemeijer, W.J.M. & Blair, M. J.): 408–409. T & AD Poyser, London.

Goutner, V. & Alivizatos, H. 2003: Diet of the barn owl (Tyto alba) and Little Owl (Athene noctua) in the wetlands of northeastern Greece. — Belgian Journal of Zoology 133: 15–22.

Goszczynski, J., Jedrzejewska, B. & Jedrzejewski, W. 2000: Diet composition of badgers (Meles meles) in a pristine forest and rural habitats of Poland compared to other European populations. — Journal of Zoology, London 250: 495–505.

Hounsome, T., O'Mahony, D.& Delahay, D. 2004: The diet of Little Owls Athene noctua in Gloucestershire, England. — Bird study 51: 282–284.

Ille, R. & Grinschgl, F. 2001: Little Owl (Athene noctua) in Austria. Habitat characteristics and population density. — Ciconia 25: 129–140.

Johnson, D. H. 1980: The comparison of usage and availability measurements for evaluating resource preference. — Ecology 61: 65–71.

Kenward, R. E. 2001: A manual for wildlife radio tagging. — Academic Press, London.

Kleijn, D. & Southerland, W. 2003: How effective are European agri-environment schemes in conserving and promoting biodiversity? — Journal of Applied Ecology. 40: 947–969.

Kleijn, D., Berendse, F., Smit, R., Gilissen, N, Smit, J., Brak, B. & Groeneveld, R. 2004: Schemes in different agricultural landscapes in the Netherlands. — Conservation Biology 18: 775–786.

Kruuk, H. 1989: The social badger. — Oxford University Press, Oxford.

Loidi, J. 1987: El País Vasco. — In La Vegetación en España (Pinado-Lorca, M. & Rivas-Martínez, S.): 47–75. Universidad de Alcalá de Henares, Madrid.

Macdonald, D., Crabtree, J. R., Weisinger, G., Dax, Y., Stamou, N., Fleury, P., Gutierrez-Lazpita, J. & Gibbon, A. 2000: Agricultural abandonment in mountain areas of Europe: environmental consequences and policy response. — Journal of Environmental Management 59: 47–69.

Martínez, J. A. & Zuberogoitia, I. 2004a: Effects of habitat loss on perceived and actual abundance of the Little Owl Athene noctua in Eastern Spain. — Ardeola 51: 215–219.

Martínez, J. A. & Zuberogoitia, I. 2004b: Habitat preferences for Long-eared owls (Asio otus) and Little owls (Athene noctua) in semi-arid environments at three spatial scales. — Bird Study 51: 163–169.

Martínez, J.A. & Zuberogoitia, I. 2004c: Habitat preferences and causes of population decline of Barn Owls Tyto alba. — Ardeola 51: 303–317.
Martínez, J. A., Serrano, D. & Zuberogoitia, I. 2003: Predictive models of habitat preferences for the Eurasian Eagle Owl Bubo bubo: a multi-scale approach. — Ecography 26: 21–28.
Mikkola, H. 1983: Owls of Europe. Poyser & Carton, London.
Morrison, M. L., Marcot, B. G. & Mannan, R. W. 1998: Wildlife-habitat relationships. Concepts and applications. — The University of Wisconsin Press, Madison.
Müller, W., Eppeln, J. T. & Lubjuhn, T. 2001: Genetic paternity analyses in Little Owls (Athene noctua): does the high rate of paternal care select against extra-pair young? — Journal of Ornithology 142: 195–203.
Pedrini, P. & Sergio, F. 2001: Golden Eagle density and productivity in relation to land abandonment and forest expansion in the Alps. — Bird Study 48: 194–199.
Potter, C. 1997: Europe's changing farmed landscapes. — In Farming and Birds in Europe: The Common Agricultural Policy and its Implications for Bird Conservation. (ed. Pain, D.J. & Pienkowski, M.W.): 25–42. Academic Press, San Diego.
Reijnen, R., Foppen, R. & Meeuwsen, H. 1996: The effects of car traffic on the density of breeding birds in Dutch agricultural grasslands. — Biological Conservation 75: 255–260.
Rettie, W.J. & Messier, F. 2000: Hierarchical habitat selection by woodland caribou: its relationship to limiting factors. — Ecography 23: 466–478.
Sánchez-Zapata, J.A. & Calvo, J.F. 1999: Raptor distribution in relation to landscape composition in semiarid Mediterranean habitats. — Journal of Applied Ecology 36: 254–262.
Shaw, P.J.A. 2003: Multivariate statistic for the environmental sciences. — Arnold, London.
Tomé, R., Bloise, C. & Korpimaki, E. 2004: Nest-site habitat selection and nesting success of Little Owls (Athene noctua) in Mediterranean woodland and open habitats. — Journal of Raptor Research 36: 35–46.
Tucker, G.M. & Heath, M.F. 1994: Birds on Europe – their conservation status. — Birdlife International, Cambridge.
Van der Zande, A. N., ter Keurs, W. J. & van der Weijden, W. J. 1980: The impact of roads on the densities of four bird species in an open habitat – evidence of a long distance effect. — Biological Conservation 18: 299–321.
Zabala, J., Garin, I., Zuberogoitia, I. & Aihartza, J. 2002: Habitat selection and diet of badgers (Meles meles) in Biscay (North Iberian Peninsula). — Italian Journal of Zoology 69: 233–238.
Zar, J. H. 1999: Biostatistical analysis. — Prentice Hall, Upper Saddle River.
Zuberogoitia, I. & Campos, L. F. 1997: Intensive census of nocturnal raptors in Biscay. — Munibe 49: 117–127.
Zuberogoitia, I. & Campos, L. F. 1998: Censusing owls in large areas: a comparison between methods. — Ardeola 45: 47–53.
Zuberogoitia, I. & Martínez-Climent, J. A. 2001: The Little Owl in the "Proyecto Noctua". — Ciconia 25: 103–106.
Zuberogoita, I. 2002: Eco-etología de la comunidad de rapaces nocturnas de Bizkaia. —PhD Thesis, Basque Country University, Leioa.
Zuberogoitia, I., Campos, L. F., Crespo, T. & Ocio, G. 1998: Mochuelo. — In Vertebrados Continentales. Situación actual en la comunidad autónoma del País Vasco (ed. Fernandez de Mendiola, J.A. & Bea, A.): 227–228. Basque Government, Vitoria-Gasteiz.
Zuberogoitia, I., Martínez, J. A., Zabala, J. & Martínez, J. E. 2005. Interspecific aggression and nest-site competition in a European owl community. — Journal of Raptor Research 39: 156–159.