J Raptor Res. 32(3):208–214

SELECTION OF SETTLEMENT AREAS BY JUVENILE BONELLI'S EAGLE IN CATALONIA

SANTI MAÑOSA, JOAN REAL AND JORDI CODINA
Departament de Biologia Animal, Facultat de Biologia, Universitat de Barcelona, Avinguda Diagonal, 645, 08028 Barcelona, Catalonia, Spain

ABSTRACT.—We observed Bonelli's Eagles (*Hieraaetus fasciatus*) outside their breeding range in Catalonia (northeastern Spain) to identify the main dispersal areas of juvenile eagles in the Central Catalan Basin. Autumn counts were conducted to determine the size of the nonbreeding population in the main dispersal area and to analyze factors leading to the selection of settlement areas by juveniles. The permanent eagle population in the area was estimated at about 18 >1-yr-old eagles for an average density of 0.90 eagles/100 km^2. Number of eagles in the area <1-yr old fluctuated seasonally between 17–94 eagles with the number reaching a maximum in early autumn followed by a rapid decline during winter. Juvenile settlement areas appeared to be selected based on gamebird and rabbit abundance, rather than on landscape variables. As a consequence, game management measures appeared to be key in the conservation of Bonelli's Eagles.

KEY WORDS: *Bonelli's Eagle;* Hieraaetus fasciatus; *population density; conservation; habitat selection; juvenile dispersal; Spain.*

Selección de zonas de asentamiento juvenil por el águila perdicera en Cataluña

RESUMEN.—Describimos la localización y características ambientales de la principal zona de dispersión juvenil de las águilas perdiceras *Hieraaetus fasciatus* en Cataluña (España). Se realizaron conteos otoñales en coche con objeto de evaluar el tamaño de la población de águilas no reproductoras que utilizan esta zona, y se analizan los factores que conducen a la selección de las áreas de asentamiento dentro de esta región. La población de águilas dispersantes está formada por una población permanente de unos 18 ejemplares de más de 1 año de edad, a una densidad de 0.90 aves/100 km^2 , y una población estacionalmente fluctuante de 17–94 aves de menos de un año de edad, máxima a principios de otoño y que disminuye rápidamente a lo largo del invierno. Las águilas seleccionan sus áreas de asentamiento en función de la abundancia de perdiz y conejo, mientras que las características del paisaje aparecen como un factor mucho menos importante. La gestión correcta de la caza menor constituye una pieza clave para la supervivencia de las águilas perdiceras jóvenes en sus áreas de asentamiento temporal.
[Traducción Autores]

In long-lived birds of prey, the acquisition of sexual maturity is delayed for several years which means that nonbreeding individuals, whose behavior and ecology may differ from that of breeding birds, form an important fraction of the total population (Newton 1979, Ferrer 1993a, Omland and Hoffman 1996, Bustamante et al. 1997). In some species, nonadult birds (those not in definitive plumage) tend to settle in areas outside the breeding range in juvenile dispersal or temporary settlement areas where they stay for variable periods before moving to another settlement area or joining breeding populations (González et al. 1989, Ferrer 1993b, 1993c). Lack of appropriate settlement areas or reduction in their habitat quality may result in a reduction in nonadult survival and have serious effects on population stability. Full understanding of the habitat requirements of long-lived raptors during the nonadult stages of their lives is, therefore, necessary to design appropiate conservation measures for threatened or declining populations.

The Bonelli's Eagle (*Hieraaetus fasciatus*) is such a long-lived raptor. It does not mature sexually until 2–4 yr of age (Newton 1979, del Hoyo et al. 1994, Real and Mañosa 1997) and it is an Endangered Species whose populations have declined across Europe (Rocamora 1994, Real and Mañosa 1997). The current Spanish breeding population of 675–751 pairs represents about 80% of the European population (Arroyo 1991, Real et al. 1994, Real et al. 1996). The nonbreeding population is

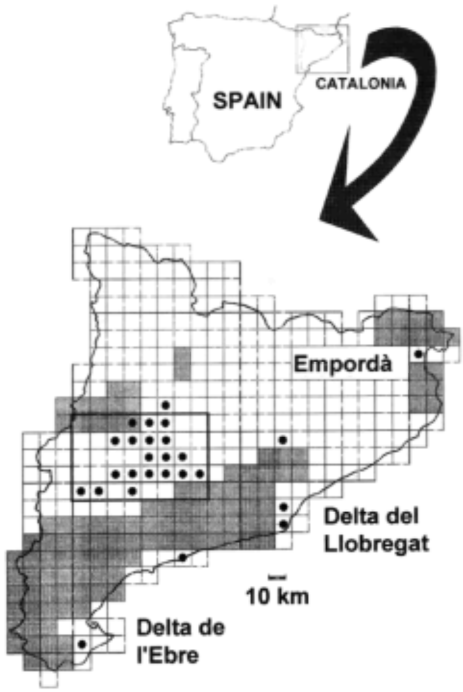

Figure 1. Breeding range (shaded area) and dispersal areas (dotted squares) of Bonelli's Eagles in Catalonia (northeastern Spain). The area depicted in Fig. 2 is outlined.

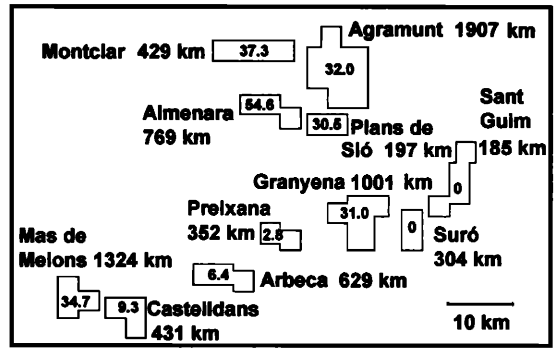

Figure 2. Areas surveyed during autumn eagle counts. The number of km driven and the linear index of abundance of eagles/1000 km are given for each sector.

estimated at approximately 700 eagles (Real and Mañosa 1997). These nonbreeders are commonly seen in areas unsuitable for nesting (Cramp and Simmons 1980, Cugnasse and Cramm 1990, Real et al. 1990, Cheylan et al. 1996), but little is known concerning the exact locations and physical characteristics of these settlement areas (González et al. 1989, Ferrer 1990, Cugnasse and Cramm 1990, Real and Mañosa 1992, Real et al. 1994). The aims of this study were to describe the locations and general characteristics of juvenile dispersal areas of Bonelli's Eagles in Catalonia (northeastern Spain), to estimate the size, age structure, and temporal dynamics of the nonbreeding population in these areas, and to describe factors leading to the selection of these settlement areas by nonadult Bonelli's Eagles.

STUDY AREA AND METHODS

In Catalonia, the Bonelli's Eagle breeds along the coastal and pre-pyrenean mountain ranges (Fig. 1). A total of 70–80 pairs, or about 10% of the European breeding population, breeds in this area (Real and Mañosa 1992). From 1980–94, we compiled observations from as many ornithologists as possible on Bonelli's Eagles outside their breeding range. Results were plotted on 10 × 10 km Universal Transverse Mercator (UTM) squares showing the presence or absence of nonbreeding eagles in each square of the grid (Fig. 1).

We also conducted counts of Bonelli's Eagles in the autumn and winter in central Catalonia in the main nonbreeding area where eagles were more seen. Counts were conducted for 3 yr from August–March 1991–94. They were made to identify the areas used by eagles and to estimate the number of eagles in the region. We selected 11 sectors (Fig. 2), each one exhibiting uniform landscape in terms of topography, land use, and vegetation cover and patterns. Sectors were selected in order to represent all types of landscape patterns available to eagles. Each sector was driven by car once a week at a speed not exceeding 40 km/hr. Because of the large area to be covered on each sampling day, counts were conducted continuously from sunrise to sunset. In order to obtain an equal sample for each sector at all times of the day, the sampling sequence for sectors was changed each day, but travel constraints prevented perfect randomization. To analyze potential biases introduced by different sampling schedules between sectors, counts were grouped into four time intervals: early morning (before 0700 H), morning (0700–1200 H), afternoon (1200–1700 H), and evening (after 1700 H).

Transects were driven by teams of two observers with each team including at least one trained observer and a driver. Each team counted eagles in all of the sectors so bias among observers was reduced. Each time a sector was sampled, time of day, number of km driven, number of Bonelli's Eagles, and number of prey species (Red-legged Partridge [*Alectoris rufa*] and European rabbits [*Oryctolagus cuniculus*]) were recorded. When possible, eagles were classified as juvenile (<1 yr), immature (1–2 yr), subadult (2–3 yr), or adult (>3 yr) according to plumage criteria (Parellada 1986). Although some practice is needed to sex Bonelli's Eagles in the field, the most probable gender of the eagles was determined based on size and color, females being larger and darker than males (Parellada 1986). When possible, eagles were classified as having full or empty crops. From these data, linear indices of abundance for partridges, rabbits, and each age class of eagles were computed for each sector.

Distance sampling (Buckland et al. 1993) was used to estimate the abundance and density of eagles within the sectors where they were observed. Each eagle observation was plotted on a 1:50 000 map and the perpendicular distance to the transect was measured. An overall detection function was fitted to these data using the DISTANCE software (Laake et al. 1993). Because most contacts (93%) involved single birds, the model was fit by considering each eagle as a single object. To obtain a more robust estimate of the detection function, observations were truncated at 1.0 km after visual inspection of the distance histogram (Buckland et al. 1993). The detection function allowed the estimation of the Effective Strip Width for the counts and an overall density estimate was computed from sector density estimates weighted by the area of each sector.

To determine habitat selection, each sector was divided on 3 × 3 km UTM squares (900 ha or 9 km^2 each) on which landscape variables (Table 1) were measured from a CORINE Land Cover 1:250 000 habitat digital database processed by means of Arc/Info software, and 1:50 000 military maps. The landscape of every sector was then described using the same variables averaged over each sector. The area variables were measured on the 900 ha unit squares from each sector and could be considered as proportions, so they were better analysed by converting them to log-ratios (Table 1) to make them independent from one another (Robertson et al. 1993). Spearman rank correlation coefficients between eagle abundance indices and partridge indices, rabbit indices, habitat variables, and land cover log-ratios were computed to show the cause of spatial variation in eagle abundance between sectors.

RESULTS

Location and General Characteristics of the Juvenile Dispersal Areas. We compiled 81 independent observations of Bonelli's Eagles outside their usual breeding range in Catalonia. Some occurred along the coast, in wetland areas such as Aiguamolls de l'Empordà, Delta del Llobregat, and Delta de l'Ebre, but most observations came from the Central Catalan Basin. Overall, 14 records were reported in coastal areas (2.8 records per 100 km^2) and 67 in inland areas (3.19 records per 100 km^2) (Fig. 1). The main juvenile dispersal area in Catalonia was a belt of extensive dry farmland, bounded by the Pyrenees, the litoral mountains, and the irrigated lands of central Catalonia. This is a nearly flat region, lacking cliffs and large forests, and is mainly devoted to cereal crops and to a lesser extent olive, almond and vineyards.

Origin, Sex-ratio, Age-ratio and Abundance of Birds. Within the 11 sectors, 355 autumn counts were conducted along 7528 km. Eagles were observed on only 322 counts from nine sectors over 7039 km. In these counts, Bonelli's Eagles were observed on 196 occasions totalling 211 birds. One eagle was observed on 183 (93%), two on 11 (6%), and three on two (1%) occasions. Over 25% of eagles had wing tags that had been attached in 1989–93 while they were nestlings in the nearby Catalan breeding population. Forty (27%) of the juvenile, six (18%) of the immature, and four (28%) of the subadult eagles had wing tags. No eagles tagged outside Catalonia (24 eagles in southeastern France and 60 eagles in Murcia-Alacant, southeastern Spain) were seen in our survey.

For eagles whose sexes were determined (24%), 32 were male (63%) and 19 female (37%; Binomial test, $P = 0.093$). For wing-tagged birds of known sex, six were male and three female.

Table 1. Names, definition, units, and source for habitat variables recorded in juvenile Bonelli's Eagle settlement areas.

NAME	DESCRIPTION, UNITS AND SOURCE
ROAD	Paved roads (km/9 km^2); CORINE
TRAC	Unpaved roads and tracks (km/9 km^2); CORINE
URBA	Urban, residential, and other developed areas (ha/9 km^2); CORINE
CROP	Arable land (ha/9 km^2); CORINE
BUSH	Low bush and dry grassland (ha/9 km^2); CORINE
WOOD	Woodland (ha/9 km^2) (m^2); CORINE
MIXE	Land occupied by agriculture with areas of natural vegetation (ha/9 km^2); CORINE
ALTI	Average elevation (m) (Minimum elevation + Maximum elevation)/2; 1:50 000 map
RELI	Relief index (total number of 20 m isolines crossed by the diagonals of the 3 × 3 km square [*N*]); 1:50 000 map
IKARUFA	Number of partridges/1000 km; Linear counts
IKACUNI	Number of rabbits/1000 km; Linear counts
IKAFASC	Number of Bonelli's Eagles/1000 km; Linear counts
LR-WC	Log-ratio woodland-crop: ln(wood/(crop+1)+1)
LR-BC	Log-ratio bush-crop: ln(bush/(crop+1)+1)
LR-MC	Log-ratio mixed-crop: ln(mixed/(crop+1)+1)
LR-BW	Log-ratio bush-wood: ln(bush/(wood+1)+1)
LR-MW	Log-ratio mixed-wood: ln(mixed/(wood+1)+1)
LR-MB	Log-ratio woodland-crop: ln(mixed/(bush+1)+1)

Table 2. Summary statistics for the variables recorded in sectors where Bonelli's Eagles were detected ($N = 9$) or not detected ($N = 2$). Mean ± SD (minimum-maximum)

	EAGLES PRESENT ($N = 9$)	EAGLES ABSENT ($N = 2$)
ROAD	2.1 ± 0.7 (0.9–3.3)	2.3 ± 2.5 (0.5–4.1)
TRAC	23.3 ± 6.1 (11.4–34)	26.3 ± 1.0 (25.6–27.1)
URBA	2.3 ± 2.3 (0–6.5)	2.0 ± 1.5 (0.9–3.0)
CROP	640 ± 195 (274–898)	618 ± 151 (510–725)
BUSH	49 ± 70 (0–223)	7 ± 7 (2–11)
WOOD	23 ± 28 (0–67)	45 ± 2 (43–46)
MIXE	186 ± 182 (213–567)	229 ± 162 (114–343)
ALTI	402 ± 65 (307–544)	676 ± 18 (663–689)
RELI	35 ± 10 (21–48)	50 ± 10 (43–56)
IKARUFA	2582 ± 1900 (182–5470)	1115 ± 362 (859–1372)
IKACUNI	78 ± 90 (8–289)	39 ± 1 (38–39)
IKAFASC	26 ± 17 (3–55)	—

No significant difference in the linear index of abundance of eagles was found between periods when the six sectors visited in every period were included (Kruskall-Wallis test, $x^2 = 0.05$, df = 2, $P = 0.98$), or when the 10 sectors visited in both the last two periods were compared (Kruskall-Wallis test, $x^2 = 0.006$, df = 1, $P = 0.94$). There was also no significant difference between the linear indices of abundance of nonjuvenile (immatures, subadults, and adults) eagles between periods (Kruskall-Wallis test, $x^2 = 1.377$, df = 2, $P = 0.50$ or $x^2 = 0.006$, df = 1, $P = 0.94$). Therefore, periods were considered together.

Of the 198 individuals we aged, 145 (73%) were juvenile, 33 (17%) immature, 14 (7%) subadult,

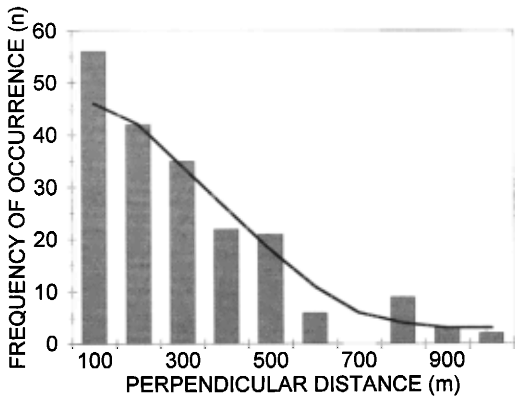

Figure 3. The number of eagles observed in relation to the perpendicular distance to the transect line. The solid line shows the shape of the adjusted detection model.

and six (3%) adult eagles. Two (1%) were only identified as >1 yr of age. The observation rate for nonjuveniles remained fairly stable around 0.75 eagles/100 km during autumn and winter, while the observation rate of yearlings reached a maximum of 3.2 eagles/100 km in early autumn and declined to 0.72 eagles/100 km in December–March (Fig. 4). As a consequence, the age ratio of nonjuveniles to juveniles increased from 0.37 in August to 1.00 after November. The seasonal variation on eagle abundance correlated to a similar variation in Red-legged Partridge abundance ($r_s = 0.73$; $P = 0.015$, $N = 10$).

The age ratio also varied between sectors (0.91 in Mas de Melons, $N = 42$ eagles; 0.67 in Almenara, $N = 40$ eagles; 0.45 in Montclar, $N = 16$ eagles; 0.16 in Granyena, $N = 29$ eagles; and 0.07 in Agramunt, $N = 59$ eagles), but was not significantly related to eagle abundance ($r_s = 0.68$; $P = 0.205$, $N = 5$) or prey abundance ($r_s = -0.50$; $P = 391$, $N = 5$). The linear index of abundance of young eagles was positively correlated with the linear index of abundance of mature eagles ($r_s = 0.63$; $P = 0.04$, $N = 11$).

A uniform function with two cosine adjustments was found to be the best model to fit the perpendicular distance data (Fig. 3). After truncation at 1.0 km, only 196 birds remained in the analysis, and the Effective Strip Width was estimated at 416 m (95% C.I. = 370–469). For the sectors where eagles were observed, we obtained an overall encounter rate of 2.7 eagles/100 km (95% C.I.= 1.9–3.8), and an average density estimate of 3.2 eagles/

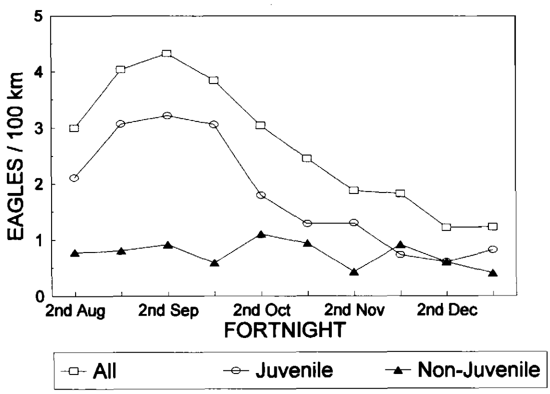

Figure 4. The number of Bonelli's Eagles in the central Catalonia dispersal area according to the time of the year expressed as the number of individuals seen/100 km of transect.

100 km^2 (95% C.I.= 2.3–4.5). Maximum eagle density was attained in late September (5.2 eagles/100 km^2), and minimum density in January–March (1.5 eagles/100 km^2). The number of mature eagles remained fairly stable at about 0.90 eagles/100 km^2, while the number of young showed large variation from late September (3.9 eagles/100 km^2) to late winter (0.73 eagles/100 km^2, Fig. 4). If these density estimates are extrapolated to the entire potential dispersal area in central Catalonia (dotted area in Fig. 1 = 2000 km^2), an estimate of 18 nonjuvenile eagles and 17–94 yearlings would be obtained for the entire area.

Selection of Settlement Areas, Eagle Behavior and Habitat Use. Although the sequence of sampling was changed on each sampling day, differences in the average sampling time between sectors were detected (Kruskall-Wallis test, $P < 0.000$). However, a two-way ANOVA of the square-root transformed $(x + 3/8)^{1/2}$ index of eagle abundance (Zar 1984) showed no significant relationship between eagle abundance indices and time of day ($F_{3,323} = 0.759$; $P = 0.518$) and a significant effect of sector ($F_{10,323} = 5.537$; $P < 0.000$), so differences in eagle abundance between sectors were not the result of a different sampling pattern (Fig. 2). A large variation was found in the habitat characteristics of the sectors where eagles were observed (Table 2). The linear index of abundance of Bonelli's Eagles was positively correlated with the linear index of abundance of Red-legged Partridge ($r_s = 0.74$; $P = 0.01$, $N = 11$), and to the log-ratio of bush-woodland ($r_s = 0.73$; $P = 0.01$, $N = 11$). If only the nine sectors where eagles were observed were considered, the linear index of abundance of Bonelli's Eagles was found to be positively correlated with the Red-legged Partridge linear index of abundance ($r_s = 0.72$; $P = 0.03$, $N = 9$), the rabbit linear index of abundance ($r_s = 0.77$; $P = 0.02$, $N = 9$), the log-ratio mixed-crop ($r_s = 0.87$; $P = 0.002$, $N = 9$), and the log-ratio bush-woodland ($r_s = 0.71$; $P = 0.031$, $N = 9$).

Within the settlement areas, eagles were observed feeding on Red-legged Partridge on one occasion, twice on European rabbits, and once on Quarry Guineafowl (*Numida meleagris*). Unsuccessful attacks were observed once on feral pigeon (*Columba livia*), once on Wood Pigeon (*Columba palumbus*), once on pigeon (*Columba sp.*), twice on Red-legged Partridges, and once on an unidentified bird. Full crops were observed in 43% of the eagles whose crop contents could be determined ($N = 120$, 57% of all eagles). This was probably an overestimate since empty crops were probably recorded as unnoticed more than full crops. For those sectors in which crop contents were estimated for >5 eagles, those with a higher linear index of eagle abundance had a larger proportion of eagles with full crops ($r_s = 0.98$; $P = 0.02$, $N = 4$). In some sectors, eagles were more often observed perching (Plans de Sió 100%, Almenara 69%, Mas de Melons 50%) than in others (Montclar 25%, Granyena 29%, Agramunt 31%), but this was not related to eagle abundance ($r_s = -0.20$; $P = 0.70$, $N = 6$). Of 97 perches observed, trees were the most frequently used (52%) followed by large rocks (19%), the ground (18%), large transport power poles (6%), buildings (4%), and small distribution power poles (1%).

DISCUSSION

Eagle abundance was related to partridge and rabbit abundance in the dispersal area. In sectors with larger eagle concentrations, eagles with full crops were more frequently encountered and these areas had more bush, dry grassland or cropland mixed with natural habitats relative to woodland or homogeneous farmland. These open habitats were likely the most suitable for eagles because of their prey abundance and because their open habiat maximized eagle foraging success (Bohall and Collopy 1984, Janes 1985, Preston 1990). Therefore, given the large variation in habitat pattern between sectors where eagles were observed, we concluded that nonadult Bonelli's Eagles selected settlement areas mainly on food availability rather than their topographic and landscape patterns. A similar habitat selection strategy has been described in other species of birds, in which food is a proximate factor for habitat selection (Hildén 1965, Hutto 1985, González et al. 1989, Ferrer 1990, Gerrard et al. 1990, Heredia et al. 1991, Bustamante et al. 1997).

Although yearlings form the bulk of the nonbreeding Bonelli's Eagle population in central Catalonia, older birds form the stable fraction of the population. Yearlings arrive in the region in late summer, following independence (Real et al. 1989), and probably occupy only those areas left available by older birds which die, move to other areas, or are recruited into the breeding population. In these dispersal areas, young eagles find sufficient food and probably avoid competition with breeders. The seasonal decline of the dispersal population after October probably results from a combination of factors including further innate dispersal (Horn 1983), competitive exclusion (Waser 1985), juvenile mortality (Real et al. 1996, Real and Mañosa 1997), or a decline in prey availability (Newton 1979, Ferrer 1993b, Brodeur et al. 1996) which was supported by the fact that the seasonal decline of eagle abundance matched that of Red-legged Partridges. A continuous turnover of eagles with other dispersal areas, temporary returns to natal areas, or movements to nearby breeding areas may also occur as has been described in the Spanish Imperial Eagle (Ferrer 1993c).

According to our wing-tagging information, the Catalan breeding population is the main source of Bonelli's Eagles that come to the dispersal area in central Catalonia. A higher number of males were observed in the area than females. This suggested that there may be female-biased juvenile dispersal in this species, as is commonly found in raptors (Clarke et al. 1997) or, alternatively, a sex-biased mortality (Ferrer and Hiraldo 1992). Given the size and demographic parameters (Real and Mañosa 1997) of the breeding population in Catalonia, every year 55 independent juveniles, 22 immatures, and 9 subadults enter this eagle population. The dispersal area in central Catalonia can only give permanent refuge to about 35 of these birds, so many must disperse farther away. Although the mechanisms of dispersal and recruitment in Bonelli's Eagles are only partially understood, in our opinion increasing the carrying capacity of dispersal areas adjacent to breeding areas would contribute to reduced juvenile dispersal, decrease preadult mortality, and improve recruitment rates in nearby breeding areas (González et al. 1989), which would be particularly helpful to stop the decline of isolated subpopulations or those found on the edge of the species range. Sensible game management is an essential tool to achieve this objective. However, reduced dispersal will only be advantageous if the main mortality factors for eagles in the area (Real et al. 1996, Real and Mañosa 1997) are also eliminated.

ACKNOWLEDGMENTS

We are indebted to Rodrigo del Amo, Joan Manel Baqués, Dani Díaz, Joan Estrada, Daniel González, Ferran Gonzàlez-Prat, Glòria Laviga, Montse López, Marc Noguera, Vittorio Pedrocchi and Montserrat Tortosa for contributing to field work. We also thank Dr. J. Loman, Dr. H. Källander, Dr. G.R. Bortolotti and Dr. M. McGrady for their useful comments on earlier versions of the manuscript. Josep Garriga, Cap del Servei d'Agents Rurals del Departament d'Agricultura, Ramaderia i Pesca de la Generalitat de Catalunya, provided access to the CORINE database, and Emili Ponsa helped in the extraction of data from it. We especially thank Fundació Miquel Torres for continous financial support of Bonelli's Eagle conservation in Catalonia. We also thank Caixa de Sabadell for financial support of the fieldwork on which this paper is based. The Fundació Bosch i Gimpera cooperated in the administration of part of the project. The first author received a postdoctoral grant from Comissió Interdepartamental de Recerca i Innovació Tecnològica (CIRIT) de la Generalitat de Catalunya (BPOST-9316).

LITERATURE CITED

ARROYO, B. 1991. Resultados del censo nacional de águila perdicera. *Quercus* 70:17.

BOHALL, P.G. AND M.W. COLLOY. 1984. Seasonal abundance, habitat use, and perch sites of four raptor species in north-central Florida. *J. Field Ornithol.* 55:181–189.

BRODEUR, S., R. DÉCARIE, D.M. BIRD AND M. FULLER. 1996. Complete migration cycle of Golden Eagles breeding in northern Quebec. *Condor* 98:293–299.

BUCKLAND, S.T., D.R. ANDERSON, K.P. BURNHAM AND J.L LAAKE. 1993. Distance sampling. Chapman and Hall, London, U.K.

BUSTAMANTE, J., J.A. DONÁZAR, F. HIRALDO, O. CEBALLOS AND A. TRAVAINI. 1997. Differential habitat selection by immature and adult Grey Eagle-Buzzards *Geranoaetus melanoleucus. Ibis* 139:322–330.

CHEYLAN, G., A. RAVAIROL, J.M. CUGNASSE, J.M. BILLET AND C. JOULOT. 1996. Dispersion des aigles de Bonelli *Hieraaetus fasciatus* juvéniles bagués en France. *Alauda* 64:413–419.

CLARKE, A.L., B.E. SÆTHER AND E. RØSKAFT. 1997. Sex biases in avian dispersal: a reappraisal. *Oikos* 79:429–438.

CUGNASSE, J.M. AND P. CRAMM. 1990. L'erratisme de l'aigle de Bonelli *Hieraaetus fasciatus* en France. *Alauda* 58:59–66.

CRAIG, E.H., T.H. CRAIG AND L.R. POWERS. 1986. Habitat use by wintering Golden Eagles and Rough-legged Hawks in southern Idaho. *J. Raptor Res.* 20:69–71.

CRAMP, S. AND K.E.L. SIMMONS [EDS.]. 1980. The birds of the western Palearctic. Vol. 2. Hawks to Bustards. Oxford Univ. Press, Oxford, U.K.

DEL HOYO, J., A. ELLIOT AND J. SARGATAL [EDS.]. 1994. Handbook of the birds of the world. Vol. 2. New World Vultures to Guineafowl. Lynx Edicions, Barcelona, Spain.

FERRER, M. 1990. Dispersión juvenil de la población de águilas imperiales del Parque Nacional de Doñana. Ph.D. dissertation, Universidad de Sevilla, Sevilla, Spain.

———. 1993a. El águila imperial. Eurofauna, Madrid, Spain.

———. 1993b. Reduction in hunting success and settlement strategies in young Spanish Imperial Eagles. *Anim. Behav.* 45:406–408.

———. 1993c. Juvenile dispersal behavior and natal philopatry of a long-lived raptor, the Spanish Imperial Eagle *Aquila adalberti*. *Ibis* 135:132–138.

——— AND F. HIRALDO. 1992. Man-induced sex-biased mortality in the Spanish Imperial Eagle. Biol. Conserv. 60:57–60.

GERRARD, J.M., G.R. BORTOLOTTI, E.H. DZUS, P.N. GERRARD AND D.W.A. WHITEFIELD. 1990. Boat census of Bald Eagles during the breeding season. *Wilson Bull.* 102:720–726.

GONZÁLEZ, L.M., B. HEREDIA, J.L. GONZÁLEZ AND J.C. ALONSO. 1989. Juvenile dispersal of Spanish Imperial Eagles. *J. Field Ornithol.* 60:369–379.

HEREDIA, B., J.C. ALONSO AND F. HIRALDO. 1991. Space and habitat use by Red Kites *Milvus milvus* during winter in the Guadalquivir marshes: a comparison between resident and wintering populations. *Ibis* 133: 374–381.

HILDÉN, O. 1965. Habitat selection in birds: a review. *Ann. Zool. Fenn.* 2:53–75.

HORN, S.H. 1983. Some theories about dispersal. Pages 55–62 *in* R.S. Swingland and P.J. Greenwood [EDS.], The ecology of animal movement. Oxford Univ. Press, Oxford, U.K.

HUTTO, R.L. 1985. Habitat selection by non-breeding migratory land birds. Pages 455–476 *in* M.L. Cody [ED.], Habitat selection in birds. Academic Press, Orlando, FL U.S.A.

JANES, S.W. 1985. Habitat selection in raptorial birds. Pages 159–188 *in* M.L. Cody [ED.], Habitat selection in birds. Academic Press, Orlando, FL U.S.A.

LAAKE, J.L., S.T. BUCKLAND, D.R. ANDERSON AND K.P. BURNHAM. 1993. Distance user's guide, Version 2.0. Colorado Coop. Fish Wildl. Res. Unit, Colorado State Univ., Fort Collins, CO U.S.A.

NEWTON, I. 1979. Population ecology of raptors. T. & A.D. Poyser, Berkhamsted, U.K.

OMLAND, K.S. AND S.W. HOFFMAN. 1996. Seasonal, diet, and spatial dispersion patterns of Golden Eagles migration in southern Montana. *Condor* 98:633–636.

PARELLADA, X. 1986. Variació del plomatge i identificació de l'àliga cuabarrada *Hieraaetus fasciatus fasciatus*. Pages 87–96 *in* Rapinyaires Mediterranis, II. Centre de Recerca i Protecció de Rapinyaires, Barcelona, Spain.

PRESTON, C.R. 1990. Distribution of raptor foraging in relation to prey biomass and habitat structure. *Condor* 92:107–112.

REAL, J. AND S. MAÑOSA. 1992. La Conservació de l'àliga perdiguera a Catalunya. Univ. Barcelona, Barcelona, Spain.

——— AND ———. 1997. Demography and conservation of western European Bonelli's Eagle *Hieraaetus fasciatus* populations. *Biol. Conserv.* 79:59–66.

———, S. MAÑOSA, J. BERTRAN, P. ROMERO, A. SOROLLA, J. FERNÀNDEZ AND L. BALAGUER. 1989. El procés d'independització en els joves d'àliga perdiguera, *Hieraaetus fasciatus*, al Parc Natural de Sant Llorenç del Munt i l'Obac. Pages 43–47 *in* I Trobada d'estudiosos de Sant Llorenç del Munt i l'Obac. Diputació de Barcelona, Servei de Parcs Naturals, Barcelona, Spain.

———, S. MAÑOSA, R. DEL AMO, J.A. SÁNCHEZ ZAPATA, M.A. SÁNCHEZ, D. CARMONA AND J.E. MARTÍNEZ. 1990 La regresión del águila perdicera: una cuestión de demografía. *Quercus* 70:6–12.

———, S. MAÑOSA AND J. CODINA. 1996. Estatus, demografía y conservación del águila perdicera (*Hieraaetus fasciatus*) en el Mediterráneo. Pages 83–89 *in* J. Muntaner and J. Mayol [EDS.], Biología y conservación de las rapaces mediterráneas, 1994. Monografías, No. 4 SEO, Madrid, Spain.

——— S. MAÑOSA, J. CODINA AND R. DEL AMO. 1994. Estado de varias poblaciones de águila perdicera en Europa occidental durante 1993. *Quercus* 98:8–11.

ROBERTSON, P.A., M.I.A. WOODBURN, W. NEUTEL AND C.E BEALEY. 1993. Effects of land use on breeding pheasant density. *J. Appl. Ecol.* 30:465–477.

ROCAMORA, G. 1994. Bonelli's Eagle *Hieraaetus fasciatus*. Pages 184-185 *in* G.M. Tucker and M.F. Heath [EDS.], Birds in Europe, their conservation status. Birdlife Conserv. Ser. No. 3. BirdLife International, Cambridge, U.K.

WASER, P.M. 1985. Does competition drive dispersal? *Ecology* 66:1171–1175.

ZAR, J.H. 1984. Biostatistical analysis. Prentice Hall, Princeton, NJ U.S.A.

Received 6 June 1997; accepted 20 May 1998