

## Impact of recreation on forest bird communities: non-detrimental effects of trails and picnic areas<sup>\*</sup>

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**Abstract** We analyzed changes in distribution and abundance of forest birds due to different types of recreational activity in the Madrid province (Guadarrama Range, Central Spain). Census plots were distributed in forest interiors (undisturbed sites), along forest trails (transiently disturbed hiking tracks), and in recreational areas (long-lasting disturbed picnic sites). Parameters describing the overall bird community (i.e. total bird abundance, species richness and diversity), groups of species (i.e. abundance of corvids and nesting or foraging guilds) and individual species abundances were compared. Forest sites with any type of human presence (trails and picnic sites pooled) had higher overall abundances and species richness per sampling plot than undisturbed forest interiors. Furthermore, fourteen species were significantly more abundant in disturbed sites than in forest interiors, while the converse was true only for five species. Anthropogenic sites did not affect forest specialists. Canopy-nesters, trunk and ground-foragers, and corvids were more abundant at recreational sites than in undisturbed forests, while the converse pattern was observed for ground-nesters. These patterns were more distinct in deciduous than in coniferous forest tracts. The positive effects of recreational sites were mostly associated with picnic sites, since forest trails were mostly indistinguishable from undisturbed forest interiors in terms of bird community patterns. Several habitat characteristics of disturbed sites can explain some of these differences: increased maturity of the tree layer, less dense subcanopy vegetation, higher abundance of holes and crevices, and greater predictability and availability of human food waste in picnic areas. So, contrary to expectations, we conclude that these types of nonconsumptive recreation do not decrease habitat suitability for most birds, although it might decrease suitability for ground-nesting birds [*Acta Zoologica Sinica* 53 (1): 54–63, 2007].

**Key words** Forest birds, Human recreation, Disturbance effects, Community patterns, Nesting/foraging guilds

## 人类休闲活动对森林鸟类群落无有害影响<sup>\*</sup>

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**摘要** 我们对西班牙马德里森林深处(未受到人类干扰)、森林小路沿线(间或有徒步旅行者经过)以及森林野餐区(有较持久干扰)的鸟类进行了调查,以查明人类休闲活动对该地区鸟类群落的分布和多度的影响。结合样方法对以上3类区域鸟类群落的总体特征(如:鸟类的多度、物种的丰富度和多样性)、不同鸟类群体的特征(如:鸚科鸟类的多度,营巢或者取食集团的特征)、各鸟种的多度等参数进行了比较。结果表明:小路沿线和野餐区样方内鸟类的多度和物种丰富度比森林深处更高,已查明14种鸟类的多度在人为干扰区域比森林深处高,只有5种鸟类的多度在森林深处更高一些;在树冠层筑巢的鸟类、在树干和地面觅食的鸟类及鸚科鸟类在休闲活动区有更高的多度;地巢性鸟类在休闲区的多度较低,这种差别尤以阔叶落叶林中加明显。而森林小路的鸟类群落结构与森林内部非常相似,说明人类休闲活动对这些林区鸟类群落的影响更多缘自野餐。原因是野餐区常常具有以下特点:具有高大的乔木、中层植被稀疏、有较多的洞和缝隙以及野餐后会遗留下一些垃圾。以上结论与研究的预期目标正好相反,人类的这些休闲活动可能会降低地巢性鸟类的适宜度,但是对大多数鸟

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关键词 森林鸟类 人类休闲活动 干扰效应 群落模式 营巢/觅食资源集团

A key conservation goal of developed countries is to reconcile the effective protection of their wild areas with increasing recreational uses (Cole and Landres, 1995; 1996). This aim becomes urgent when considering two conflicting qualities of natural reserves in these regions: nature reserves are usually scarce and/or small, and they are increasingly demanded for leisure by growing human populations. However, outdoor recreational activities are highly diverse, and have different levels of potential impacts on wildlife according to whether they are consumptive or not, regular or occasional, or have cumulative effects over time or not (Boyle and Samson, 1985; Knight and Cole, 1995). Thus, a precise assessment of activity-specific negative effects is necessary for setting management priorities appropriately. Because humans tend to prefer wooded ecosystems for outdoor amusement (Ulrich, 1986; Gómez-Limón and de Lucio, 1999), forests are particularly susceptible to impacts from recreational uses, especially when precise data on particular activities is lacking (Cole and Landres, 1996; Hüttl et al., 2000).

Because birds are an ecologically and taxonomically diversified taxa, widespread and conspicuous, and with a marked sensitivity to environmental changes, they are a useful taxa for evaluating effects of recreation (Furness et al., 1993). Basic diversity components, such as overall bird density or species richness, identify the main effects of recreation on the general structure of the bird community. Because individual species differ in their level of tolerance for disturbance, it is also important to investigate effects of recreation on a per-species basis to determine if some species are impacted more frequently or intensely than others (Knight and Cole, 1995). Finally, an intermediate approach examining effects of recreation on bird guilds (i.e. functional sets of species sharing some ecological traits) is of interest because ecological traits may differently predispose groups of species to disturbance from recreation (Severinghaus, 1981; Landres, 1983; Roberts, 1987). Most existing research investigating the impact of recreation on woodland birds has found negative effects: specifically declines in avian diversity and species richness, changes in community composition by means of favouring generalist species (e.g. Hickman, 1990; Riffell et al., 1996; Miller et al., 1998; Laiolo and Rolando, 2005), altering behaviour and increasing perceived predation risk (e.g. Fernández-Juricic, 2000), or reducing quality of nesting habitat (e.g. Miller et al., 1998; Miller and Hobbs, 2000; Neatherlin and Marzluff, 2004; Rosenberg et al., 2004).

The main goal of this research was to examine patterns of forest bird distribution/abundance change due

to the presence of forest trails and recreational areas. We addressed this question by comparing variables at the community level (total bird abundance, species richness, and diversity), guild level (nesting and foraging preferences, and abundance of corvids: avian nest predators), and species level for each type of recreation. Differences in these patterns between coniferous and deciduous forests were also tested, since bird community composition and habitat structure vary between both forest types. The study area (Guadarrama range in the northwestern region of Madrid province, Central Spain) poses an excellent opportunity for examining the effects of outdoor recreation on forest wildlife, due to its proximity to Madrid (3.5 million people, 40 km distant). Nonconsumptive recreational activities are increasingly usual, especially during periods of mild weather. Namely, hikers and bikers (i.e. transient types of disturbance) use the abundant unpaved trails crossing the wooded areas, and there are numerous picnic areas where people gather during daylight hours. The study area will be included within the buffer area of the future National Park of Sierra de Guadarrama, so there is a need of knowledge about the influence of recreational activities on avian biodiversity.

## 1 Study area and methods

### 1.1 Study area

This study area was located on the southern slope of the Guadarrama Range (Madrid Province, Central Spain, 40° 47' N, 04° 00' W), a region of Mediterranean-continental cold climate, with a mean temperature of 14.5°C and rainfall of 130 mm in spring time (April – June). Pine forests (predominantly *Pinus sylvestris* at higher and *P. pinaster* at lower altitudes) are the most mature woodlands in the region. They extend from 1 100 to 1 900 m above the sea level. Oak forests of Pyrenean oak *Quercus pyrenaica* are currently recovering from previous clear-cutting. They are younger and more patchy than pine forests, and spread out over slopes and valleys at 900 and 1 300 m a.s.l.

Field work was conducted in May and early June 2002 and 2003 on the extensive forests of the study region. Census plots were located at El Escorial, Guadarrama, Cercedilla, Navacerrada, Manzanares and Miraflores, and spanned over 500 km<sup>2</sup>. The studied forests comprise a wide array of environmental conditions, including pinewoods of *P. sylvestris* and *P. pinaster*, and oakwoods at altitudes ranging from 900 to 1 850 m. a. s. l. Census plots were established throughout the study area, including recreational sites, forest trails and nearby forest interiors. We tried to sample different combinations of altitude (from 900 to 1 850 m), forest types (pine and

oakwoods) and human presence (forest interiors, forest trails and picnic areas) throughout the whole study region, and during the two working years. For details on the habitat structure of the studied plots see Table 1.

A dense net of unpaved forest tracks covers this area. They are three to five meters wide on average, and are closed to regular motor vehicles. Though most of them were planned with forestry purposes, the most prevalent current uses are recreational. There is also an extensive net of hiking trails in the highest parts of the range (one to three m wide). Some of them are very popular,

crossing forest areas that are regularly trekked by hikers and mountaineers. The selected forest tracks and trails are mainly visited on a weekend basis in spring and summer, supporting peak numbers of passing visitors of 10 – 50 per hour. Recreational areas range between 4 and 10 ha. They have free access although camping is not allowed. They are provided with picnic facilities such as parking areas, barbecues, bars or toilets, and during mild weather they are continuously used by many people. There is a constant occupancy of 100 – 300 visitors per hectare on weekends of spring and summer.

**Table 1 Mean and standard errors (in brackets) of habitat variables describing habitat structure of the studied census plots according to forest type and three levels of human intrusion**

Census plots Number of plots	Coniferous forest			Deciduous forest		
	Interior 25	Trail 41	Picnic 16	Interior 16	Trail 6	Picnic 10
Herbaceous cover (in%)	34.5 (5.5)	37.3 (3.4)	41.2 (8.2)	56.1 (5.3)	61.7 (6.5)	55.3 (8.2)
Shrub cover (in%)	9.9 (2.4)	14.4 (2.3)	8.4 (1.7)	44.6 (5.7)	21.2 (5.1)	17.8 (7.6)
Shrub height (cm)	0.8 (0.1)	0.9 (0.1)	0.9 (0.1)	1.6 (0.1)	1.7 (0.1)	1.4 (0.1)
Tree cover (in%)	61.4 (3.4)	57.8 (2.3)	49.8 (3.9)	40.8 (5.7)	35.5 (11.9)	50.9 (8.7)
Average tree height (m)	15.8 (0.6)	14.3 (0.4)	17.4 (0.7)	9.5 (0.7)	10.2 (0.5)	13.5 (0.9)
# trees < 10 cm/0.2 ha	26.2 (6.1)	19.0 (4.0)	12.4 (3.8)	73.6 (30.7)	69.5 (20.9)	22.2 (8.2)
# trees 10 – 30 cm/0.2 ha	119.3 (18.3)	93.3 (10.9)	68.7 (16.1)	83.3 (15.9)	38.5 (12.8)	78.1 (21.5)
# trees > 30 cm/0.2 ha	42.2 (5.1)	38.3 (3.3)	47.8 (5.1)	2.6 (0.8)	2.8 (1.1)	13.7 (2.8)
Average trunk Ø (cm)	23.6 (0.8)	24.2 (0.7)	27.6 (1.3)	16.1 (1.2)	12.0 (1.4)	19.0 (1.7)

## 1.2 Bird censuses

We assessed breeding bird abundances through 114 single-visit point counts, lasting 20 min, and recording all birds heard or seen within 50-m radius (0.8 ha). This combination of point count duration and area sampled is adequate for surveys of breeding woodland birds (Shiu and Lee, 2003). These point counts do not efficiently sample all species due to interspecific differences in detectability. However, this is not a major concern in our work, as the sampling period of 20 min maximizes the probability of detection of established breeding birds within the radius of 50 m if they are actually present. Furthermore, we were more interested in relative abundances per unit of area than in 'exact' bird densities (Bibby et al., 2000). Point counts were conducted by the same person (DP) on windless and rainless days (to reduce detectability problems) between sunrise and 11:00 h GMT in the morning, or between 18:00 h GMT and sunset in the evening. Only a very small fraction of bird records were strictly visual contacts (0% – 5% depending on the species), as song activity is very intense at this time of the year, and 20 min is long enough to make auditive contacts with nearly all the birds within 50-m radius.

Sampling points were located to include homogeneous forest plots, and were set at least 200 m apart from each other. They were georeferenced with a Garmin 12 GPS

(precision of 1 m by means of the average location function). Field data were gathered on weekdays only, when both trails and picnic areas are less visited, to ensure that the observed distribution and abundance patterns of birds were not biased by the actual presence of people. One hundred and fourteen census plots were obtained in the two study years (see Table 1 for details on sample sizes).

Habitat structure was sampled within a radius of 25-m centered in each census plot; habitat sampling was carried out before bird counts began. We estimated by eye, after training, some structural features of the habitat: percentage cover of herbaceous, shrub and tree canopy layers, average height of the shrub and tree layers, and number of young (5 – 10 cm in diameter at breast height), medium-sized (10 – 30 cm d.b.h.) and old trees (> 30 cm d.b.h.).

## 1.3 Statistical analyses

In addition to the overall bird abundance and number of species per sampling plot, the relative abundance and richness of forest specialists were separately considered. These species were identified using the quantitative descriptions of marked woodland preferences in Carrascal and Lobo (2003; Appendix 1).

We classified species into ecological guilds using the information provided by Perrins (1998) and Carrascal et al. (1987). Four nesting categories (open ground,

shrub, tree canopy and natural cavities, including those nesting in holes located in tree trunks, ground or small rock outcrops, e.g., *Parus ater*, *Parus caeruleus*) and four foraging categories (ground, shrub, tree canopy and tree trunk) were defined (see Table 2). Because several

species could be equally ascribed to two types of nesting or foraging preferences, overall guild abundances were calculated using one-half of their abundances in each census plot.

**Table 2** Results of two-way ANOVAs testing for the effects of two forest types (deciduous vs. coniferous woodlands) and three levels of human intrusion (forest interiors, trails and picnic areas tested by means of an ordered ‘a priori’ planned comparison) on global bird abundance and species richness (first four rows) and on the abundance of corvids (*Corvus corax*, *Corvus corone*, *Corvus monedula*, *Pica pica*, *Garrulus glandarius* and *Cyanopica cooki*) and several nesting and foraging guilds

	Forest type (conif. vs. decid.)		Human intrusion (interior < trail < picnic)		Interaction (forest type × human intrusion)	
	$F_{1,103}$	$P$	$F_{1,103}$	$P$	$F_{1,103}$	$P$
Abundance (total)	1.46	0.230	7.96	0.006	1.37	0.244
Abundance (forest spp.)	0.01	0.903	0.93	0.338	2.99	0.086
Richness (total)	0.26	0.612	4.90	0.029	2.95	0.089
Richness (forest spp.)	0.79	0.377	0.84	0.361	3.91	0.051
Abundance of foraging guilds						
Canopy	0.13	0.716	4.07	0.046	0.72	0.399
Shrub	0.75	0.389	0.03	0.854	2.41	0.124
Ground	20.58	<0.001	8.41	0.005	16.91	<0.001
Cavity	7.51	0.007	0.34	0.561	1.49	0.225
Abundance of foraging guilds						
Canopy	0.09	0.766	1.58	0.211	5.65	0.019
Trunk	14.73	<0.001	0.83	0.363	5.95	0.016
Shrub	1.04	0.310	0.88	0.350	0.72	0.397
Ground	6.79	0.011	8.32	0.005	2.69	0.104
Abundance of corvids	0.46	0.497	15.78	<0.001	0.15	0.702

ANOVAs were carried out on log-transformed data. The values of the longitude and latitude coordinates, as well as the interaction and their square terms, were entered in all the two-way ANOVAs as covariate ‘nuisance’ variables to control for spatial autocorrelation of the location of sampling plots.

Corvids as a group, including six species (*Corvus corax*, *C. corone*, *C. monedula*, *Cyanopica cooki*, *Garrulus glandarius* and *Pica pica*), were also included as a guild, since they are opportunistic foragers and avian nest predators.

The census plots were divided in three sampling groups: trails ( $n = 47$ ), picnic areas ( $n = 26$ ) and forest interiors (at least 200 m from any trail or recreational area measured on 1:250 00 maps;  $n = 41$ ). When choosing these interior plots, other types of potential disturbances were avoided (e.g. logging, electricity pylons, firebreaks). To control for possible spatial autocorrelation of sampling plots, data analyses were carried out considering their geographical coordinates using the procedure proposed by Legendre (1993). The values of the longitude ( $X$ ) and latitude ( $Y$ ) UTM coordinates, as well as the interaction ( $XY$ ) and the square terms ( $X^2$  and  $Y^2$ ) were entered in all the analyses as independent nuisance variables. The position coordinates ( $X$ ,  $X^2$ ,  $Y$ ,  $Y^2$  and  $XY$ ) were included as covariates in the ANOVA models performed to examine bird variation

among sites.

Log-transformed bird community parameters were examined across forest types and levels of human intrusion by two-way ANOVAs. The effect of human perturbation was tested by means of an ordered ‘a priori’ planned comparison considering an increasing gradient of human intrusion (i.e., forest interiors < trails < picnic areas). These three habitat categories were defined according to the number of visitors and time of residency in the studied areas: (forest interiors: less than 1 visitor/week; trails: 10 – 50 transient visitors/h mainly on weekends; picnic areas: 100 – 300 sedentary visitors per hectare on weekends).

Finally, Pearson chi-square tests were used to compare, at the species level, the frequencies of occurrence at forest interior plots versus (1) trail sites, (2) picnic sites, and (3) both human-disturbed woodlands pooled. All the statistical analyses were carried out using Statistica 6.0 (StatSoft, 2001) software packages.

## 2 Results

### 2.1 Habitat structure

Overall, coniferous sites had a more dense and mature tree layer (higher figures of average height and mean trunk diameter at breast height -d. b. h.-, and number of old trees > 30 cm d. b. h.), but a less developed undergrowth strata (lower figures of herbaceous cover, height and cover of the shrub layer, and number of young trees 5 – 10 cm d. b. h.) than deciduous plots (Table 1;  $P < 0.05$  for all comparisons using two way-ANOVAs). In tests comparing habitat structure at varying levels of human presence, statistically significant differences were only observed in shrub cover (larger in forest interiors in deciduous but not in coniferous forests), and in average tree height and trunk diameter (higher values in picnic areas; Table 1;  $P < 0.05$  in the tests for these variables). The only significant interaction effect between forest type and human intrusion was detected for shrub cover, which was much lower in intruded plots (either trails or picnic areas) than in forests interiors of deciduous woodlands ( $F_{2,108} = 7.34$ ;  $P = 0.001$ ), whereas no differences in any habitat structure variable were observed in coniferous plots.

### 2.2 General bird patterns

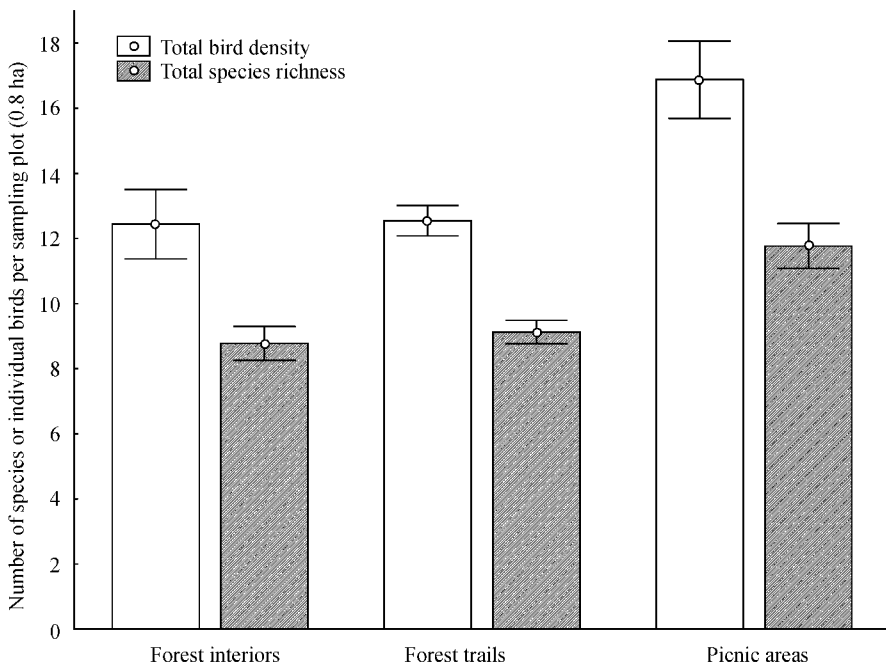
We did not detect significant differences in total abundance and species richness between deciduous and coniferous forests (see the Forest type effects in Table 2). Nevertheless, our results showed that the higher the level

of human presence, the higher total abundance and species richness (see the ordered 'a priori' effects of Human intrusion in Table 2 and Fig.1). These patterns were not found when repeating the analyses with bird forest specialists (see Table 3). The interaction terms Forest type x Human intrusion were also not significant (Table 2), indicating that the effect of human perturbation is generalizable across coniferous and deciduous forests.

Fourteen species were more abundant in at least one category of disturbance than in forest interiors, while the converse was true only for four species (*Anthus trivialis*, *Garrulus glandarius*, *Parus caeruleus* and *Phylloscopus bonelli*; Table 4).

### 2.3 Effects on bird guilds

The Table 2 summarizes the effects of forest type and/or human presence on relative abundances of avian guilds (see means and standard errors in Table 3). Canopy-nesters were consistently more abundant in sites supporting regular human presence, irrespective of forest type. Shrub-nesters did not show any significant trend. A significant interaction was observed for ground-nesters: the high abundance of this guild in deciduous forests markedly decreased from interior sites to intruded ones, whereas in coniferous forests (with lower overall abundances of these species) they were more abundant in picnic sites. Cavity-nesters were more abundant in coniferous than in deciduous woodlands, irrespective of human disturbance level.



**Fig.1** Mean ( $\pm$  SE) of species richness and total bird abundance per sampling plot (0.8 ha) in the three woodland types according to human disturbance

Data for coniferous and deciduous forests were pooled due to the lack of significant differences between these two forest types in bird abundance and species richness (see Table 2).

**Table 3** Mean and standard errors (SE) of species richness and bird abundance per sampling plot (0.8 ha) according to forest type and three levels of human intrusion

Census plots		Coniferous forest			Deciduous forest		
		Interior	Trail	Picnic	Interior	Trail	Picnic
		25	41	16	16	6	10
Abundance (forest spp.)	Mean	8.6	10.2	12.0	15.2	8.4	13.1
	SE	1.3	1.2	1.4	1.3	2.4	1.8
Richness (forest spp.)	Mean	6.6	8.2	8.5	8.8	5.0	8.0
	SE	0.7	0.6	0.7	0.6	1.2	0.9
Abundance of nesting guilds							
Canopy	Mean	2.7	3.3	3.5	3.3	3.5	5.6
	SE	0.6	0.5	0.6	0.6	1.1	0.8
Shrub	Mean	2.7	3.7	3.6	5.0	3.8	4.2
	SE	0.5	0.5	0.5	0.5	0.9	0.7
Ground	Mean	0.3	0.2	0.7	4.2	0.9	0.6
	SE	0.1	0.1	0.4	0.8	0.4	0.2
Cavity	Mean	3.7	4.8	4.5	3.7	2.0	3.5
	SE	0.3	0.3	0.5	0.8	0.3	0.8
Abundance of foraging guilds							
Canopy	Mean	4.8	6.0	5.1	9.5	3.8	4.7
	SE	0.5	0.3	0.6	1.5	0.6	0.5
Trunk	Mean	1.0	1.4	2.1	0.8	0.5	1.5
	SE	0.2	0.1	0.2	0.2	0.4	0.3
Shrub	Mean	0.9	1.4	1.3	1.3	1.8	1.2
	SE	0.2	0.2	0.2	0.2	0.4	0.3
Ground	Mean	2.3	3.0	3.8	4.6	4.7	9.1
	SE	0.2	0.2	0.9	0.7	0.7	1.2
Abundance of corvids							
	Mean	0.1	0.2	3.0	0.9	1.1	3.0
	SE	0.6	0.6	0.7	0.6	1.2	0.9

Abundance of canopy-foragers decreased from forest interiors to picnic areas in deciduous woodlands but not in coniferous forests (see interaction term in Table 2, and average values in Table 3). Trunk-foragers were more abundant in coniferous than deciduous woodlands, and their abundances increased from forest interiors to picnic areas in coniferous woodlands (see the significant interaction term in Table 3). No significant differences were found in shrub-foragers. Finally, relative abundance of ground-foragers increased consistently towards sites with more regular human presence in both forest types, and they were more abundant in deciduous than in coniferous forests.

The abundance of corvid species significantly increased from undisturbed forest interiors to picnic sites. Nevertheless, the relative density of corvid species was not significantly correlated with either the abundance ( $r$

$= 0.004$ ,  $P = 0.466$ ,  $n = 114$  using all the sampling points) or the species richness ( $r = 0.014$ ,  $P = 0.213$ ,  $n = 114$ ) of the remaining bird species.

### 3 Discussion

Repeated human intrusion can interfere with routine activities of species, and may have a negative influence on the distribution and abundance of birds (see general reviews of Boyle and Samson, 1985 or Cole and Landres, 1995). Among those studies showing empirical data on this question, a few have reported reduced habitat suitability for birds with increasing disturbance levels (e.g. Riffell et al., 1996; Fernández-Juricic, 2000; Fernández-Juricic and Tellería, 2000). However, our results do not show clear negative influences on birds by different degrees of nonconsumptive outdoor activities, because neither overall densities of birds nor densities of

**Table 4 Guild categories, relative density (birds/0.8 ha) and frequency occurrence (expressed in percentage within brackets) of common species in each forest environment**

	Guilds			
	Nesting/ Foraging	Forest interiors	Forest trails	Picnic areas
<i>Aegithalos caudatus</i>	C, S/C	0.20 (9.8)	0.04 (2.1)	0.08 (3.7)
<i>Anthus trivialis</i>	G/G	0.12 (12.2)	0.00 (0.0)*	0.00 (0.0)
<i>Carduelis chloris</i>	C, S/G	0.00 (0.0)	0.04 (2.1)	0.23 (22.2)**
<i>Certhia brachydactyla</i>	H/B	0.55 (56.1)	0.89 (68.1)	1.04 (85.2)**
<i>Columba palumbus</i>	C/C, G	0.05 (7.3)	0.24 (17.0)	0.43 (29.6)*
<i>Corvus corone</i>	Corvidae	0.00 (4.9)	0.07 (8.5)	0.62 (29.6)**
<i>Corvus corax</i>	Corvidae	0.00 (0.0)	0.30 (12.8)*	0.16 (14.8)*
<i>Corvus monedula</i>	Corvidae	0.00 (0.0)	0.01 (6.4)	0.04 (3.7)
<i>Cuculus canorus</i>	C, S/C, G	0.12 (34.1)	0.10 (19.1)	0.03 (29.6)
<i>Cyanopica cooki</i>	Corvidae	0.25 (9.8)	0.19 (6.4)	1.19 (25.9)
<i>Dendrocopos major</i>	H/B	0.17 (17.1)	0.13 (17.0)	0.35 (29.6)
<i>Erithacus rubecula</i>	S/S, G	0.98 (68.3)	1.15 (83.0)	1.12 (77.8)
<i>Ficedula hypoleuca</i>	H/C	0.17 (17.1)	0.13 (12.8)	0.04 (3.7)
<i>Fringilla coelebs</i>	C, S/C, G	2.50 (95.1)	2.11 (97.9)	1.62 (85.2)
<i>Garrulus glandarius</i>	Corvidae	0.47 (43.9)	0.35 (31.9)	0.31 (18.5)*
<i>Hippolais polyglota</i>	C, S/C, S	0.00 (0.0)	0.06 (6.4)	0.12 (11.1)*
<i>Loxia curvirostra</i>	C/C	0.00 (4.9)	0.14 (17.0)	0.08 (3.7)
<i>Lullula arborea</i>	G/G	0.23 (19.5)	0.01 (6.4)	0.04 (7.4)
<i>Luscinia megarhynchos</i>	S, G/G, S	0.03 (7.3)	0.13 (8.5)	0.23 (22.2)
<i>Miliaria calandra</i>	G/G	0.00 (0.0)	0.06 (4.3)	0.04 (7.4)
<i>Oriolus oriolus</i>	C/C	0.01 (9.8)	0.00 (0.0)	0.20 (18.5)
<i>Parus ater</i>	H/C	0.98 (43.9)	1.92 (78.7)***	0.85 (40.7)
<i>Parus caeruleus</i>	H/C	0.67 (34.1)	0.06 (4.3)***	0.27 (18.5)
<i>Parus cristatus</i>	H/C	0.46 (39.0)	0.64 (48.9)	0.31 (22.2)
<i>Parus major</i>	H/C	0.45 (39.0)	0.28 (21.3)	0.50 (33.3)
<i>Passer domesticus</i>	Building/G	0.00 (0.0)	0.00 (0.0)	0.73 (14.8)*
<i>Phylloscopus bonelli</i>	G/C	1.34 (39.0)	0.15 (12.8)**	0.23 (22.2)
<i>Phylloscopus collybita</i>	S, G/C	0.00 (0.0)	0.04 (4.3)	0.12 (11.1)*
<i>Pica pica</i>	Corvidae	0.00 (0.0)	0.04 (4.3)	0.58 (33.3)***
<i>Picus viridis</i>	H/G, B	0.06 (19.5)	0.22 (29.8)	0.21 (33.3)
<i>Regulus ignicapillus</i>	C/C	0.32 (22.0)	0.55 (40.4)	0.62 (48.1)*
<i>Regulus regulus</i>	C/C	0.12 (12.2)	0.19 (19.1)	0.00 (0.0)
<i>Serinus citrinella</i>	C/S, G	0.07 (4.9)	0.07 (8.5)	0.00 (0.0)
<i>Serinus serinus</i>	C/G	0.08 (12.2)	0.30 (25.5)	0.54 (44.4)**
<i>Sitta europaea</i>	H/B	0.12 (9.8)	0.17 (12.8)	0.35 (25.9)
<i>Sturnus unicolor</i>	H, Building/G	0.00 (0.0)	0.09 (6.4)	0.75 (37.0)***
<i>Sylvia atricapilla</i>	C, S/C	0.59 (46.3)	0.35 (34.0)	0.55 (48.1)
<i>Troglodytes troglodytes</i>	S/S	0.25 (31.7)	0.52 (57.4)*	0.55 (48.1)
<i>Turdus merula</i>	C, S/G	0.57 (53.7)	0.47 (44.7)	1.13 (77.8)*
<i>Turdus viscivorus</i>	C/G	0.20 (17.1)	0.17 (14.9)	0.16 (18.5)

Asterisks denote significant differences in frequency of occurrence ( $\chi^2$  tests) between forest interiors and each category of disturbance (\*  $P < 0.05$ ; \*\*  $P < 0.01$ ; \*\*\*  $P < 0.001$ ). The nesting substrates distinguished are: G-open ground, S-shrubs, C-tree canopy, H-natural holes and Buildings. The main foraging substrates of species are: G-ground, S-shrubs, C-tree canopy, and T-tree trunk.

most nesting/foraging guilds were negatively affected in the study area. Moreover, our results demonstrate significant increases in overall abundance and species richness of birds at disturbed areas, irrespective of forest type. Similar conclusions supporting the idea of non-detrimental effects on forest birds due to regular human presence were shown by Gutzwiller et al. (1997, 1998a, 1998b), though pertaining particular issues of avian behaviour (singing, vertical distribution) rather than general abundance patterns.

Trails and forest interiors have very similar values in the bird parameters measured. This result strengthens the findings of previous papers reporting that linear woodland openings have a very low or negligible effects on bird community patterns (e.g., Rich et al., 1994; but see Laiolo and Rolando, 2005). Picnic areas, on the other hand, do clearly differ from trails in bird community parameters, showing higher figures. Nevertheless, since our analyses show that the anthropogenic sites do not favour forest specialists, the higher overall species richness reached in picnic areas is mostly due to the attraction of several ecotonal species, such as *Carduelis chloris*, *Hippolais polyglota*, *Pica pica*, *Serinus serinus*, *Sturnus unicolor* or *Turdus merula*. This is in agreement with other works concluding that one of the main effects of recreational activities on woodland birds is that generalists species become favoured (e.g. Hickman, 1990; Riffell et al., 1996; Miller et al., 1998; Laiolo and Rolando, 2005).

Some characteristics of vegetation structure in these areas could consistently explain the observed bird abundance differences through their effects on foraging and nesting guilds. Maturity of trees significantly increases at picnic areas and hiking trails (measured as mean height and diameter of trees and density of thick trunks in deciduous forests). Because larger trees provide branches for nesting at heights far from ground predators, canopy-nesters and trunk-foragers should become favoured in recreational sites versus forest interiors. A well developed understorey layer provides nesting and foraging opportunities for many bird species (Kirk and Hobson, 2001; Lohr et al., 2002; Brotons et al., 2003; Jobs et al., 2004; Doyon et al., 2005). Nonetheless, the lower shrub cover in more human impacted sites does not imply lower densities of bird nesting or foraging on shrubs in our study area, as the abundance of shrub-dwellers does not significantly change with human presence. A very thick layer of shrubs markedly constrains bird density and species richness because it limits the development of a diverse herbaceous strata, necessary for ground and shrub gleaners dealing with invertebrates, therefore providing less feeding opportunities (Haveri and Carey, 2000; Hayes et al., 2003; Hagar et al., 2004).

Ground-nesters are clearly less abundant in disturbed sites than in forest interiors of deciduous woodlands.

Nevertheless, a contrasting pattern emerges for ground-foragers: they are consistently more abundant in recreational areas than in forest interiors. This effect is specially marked in deciduous forests, since undergrowth clearance in recreational areas is also more intense (i.e., a significantly lower shrub cover; Table 1). This difference in sensitivity to picnic areas between ground-nesting and ground-foraging could reflect that human disturbance poses greater constraints on nesting versus foraging requirements at the ground level (e.g. Blakesley and Reese, 1988; Gutzwiller et al., 1998b; Fernández-Juricic, 2000).

Corvid abundance increases towards more impacted forest sites, irrespective of forest type. This result is in agreement with other studies pointing out that these species become favoured by recreational activities (e.g. Marzluff et al., 2001; Gutzwiller et al., 2002; Neatherlin and Marzluff, 2004; Piper and Catterall, 2005). Corvids are opportunistic avian nest predators whose overabundance can cause declines in songbird populations (e.g. Engels and Sexton, 1994; Miller et al., 1998; Miller and Hobbs, 2000). Nevertheless, corvid abundance was not negatively correlated with the overall relative density or species richness of the remaining bird species. Therefore, our results do not support the negative effect of corvids on population levels of potential avian prey species, although there may be an important influence of these opportunistic predators on nest failure (Piper and Catterall, 2005).

One concern with our approach is that the measured parameter is bird abundance. Van Horne (1983) warned that density could be a misleading indicator of habitat quality if it were negatively correlated with other critical population attributes, specially reproductive success and survival. Nevertheless, Bock and Jones (2004) have recently reviewed these relationships. They have found that the available studies indicate that birds are usually more abundant in habitats where reproduction is highest, confirming the legitimacy of using bird counts as indicators of breeding habitat quality and as a basis for management decisions.

In summary, contrary to expectations, current types of human recreation in forest environments were not clear sources of avian disturbance, at least at the scale of bird distribution/abundance patterns. Parameters describing the bird community at forest trails are mostly indistinguishable from those at forest interiors, indicating that transient human passage and habitat transformations associated with tracks are not significantly influential. On the other hand, the environmental alterations linked to long-lasting presence of people in picnic sites provide new foraging opportunities to birds, so these areas support denser and more diverse bird communities. These effects are generalizable across deciduous and coniferous forests of the study region.



However, our results point out the necessity of considering several species-specific autecological traits for a better assessment of forest bird disturbance. Some relevant subtleties appear regarding ecological niches of species, useful for forestry actions reconciling nonconsumptive recreation with avian conservation. First, abundance of species nesting in tree canopy increase in picnic sites because maturer trees, free from timber logging, are favoured in recreational sites. Second, effects of human recreation show opposite impacts on species of ground habits depending on foraging (positively influenced) or nesting (adversely affected) requirements, which suggests a detailed monitoring for this group of species. This result points to the necessity of keeping intact some forest interior sectors near picnic areas to allow ground-nesting birds to thrive.

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