

DOES FIRE INCREASE THE SEASONAL VARIABILITY OF BIRD COMMUNITIES? A CASE IN MEDITERRANEAN SHRUBLANDS

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RÉSUMÉ

Les incendies, phénomènes habituels dans les paysages méditerranéens, sont l'une des principales perturbations écologiques des systèmes terrestres. On a cherché à vérifier l'hypothèse selon laquelle les variations saisonnières des communautés d'oiseaux augmenteraient dans les zones brûlées. En utilisant la méthode des points d'écoute pendant la période de nidification et l'hiver 1997 et 1998, on a déterminé la composition et l'abondance de ces communautés dans trois zones (non-brûlée, brûlée en 1982 et brûlée en 1994).

Entre ces deux saisons, les zones incendiées ont montré un accroissement du nombre d'espèces forestières, tandis que dans la zone intacte la communauté est restée stable le long du gradient forêt-milieux ouverts. De plus, le turn-over saisonnier fut supérieur dans les zones brûlées sans que ceci implique une variation de la richesse spécifique au long de l'année. Contrairement aux zones brûlées, les parties intactes n'ont pas montré de grandes fluctuations d'abondance des espèces, ce qui y suggère une plus forte cyclicité annuelle de la disponibilité des ressources. Ces résultats indiquent que le feu augmenterait la variabilité saisonnière des communautés d'oiseaux.

SUMMARY

Fire, a frequent phenomenon in Mediterranean landscapes, is a major ecological disturbance in terrestrial ecosystems. We hypothesized that bird communities undergo greater seasonal changes in burnt areas than in unburnt ones. Using the point-count method we assessed bird species composition and abundance in three zones (unburnt, burnt in 1982, and burnt in 1994) during the breeding and wintering seasons of 1997 and 1998.

From the breeding to the wintering seasons, burnt zones showed an increase in forest species, whereas the bird community of the unburnt zone remained stable in the gradient open-forest species. Moreover, the seasonal turnover of communities was higher in burnt zones than in the unburnt ones, although this did not imply that the former varied in richness through the year. The pattern of bird abundance in the unburnt zone was similar during the two study years, in contrast with that of burnt zones, suggesting higher annual cyclicity in resource availability in unburnt areas. These findings suggest that fire increases the seasonal variability of bird communities.

INTRODUCTION

Fires are a natural component of the dynamics of many ecosystems, and have played a dominant role in the Mediterranean Basin (Blondel & Aronson, 1999).

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Studies of the effects of fires on Mediterranean bird communities have mostly dealt with the turnover of avifauna and its close association with the changes in vegetation following post-fire dynamics (Lawrence, 1966; Prodon *et al.*, 1984; Stanton, 1986; Prodon *et al.*, 1987; Pons & Prodon, 1996; Izhaki & Adar, 1997). Nevertheless, bird communities that are under successional processes, such as those provoked by fire, are subjected to other types of temporal variations besides the species turnover that characterizes the succession itself: on the one hand, trends due to stochastic events such as droughts, diseases, variations in nearby "source" population, etc. and, on the other hand, seasonal changes in species composition and abundance that result from cyclical environmental changes which occur each year (Wiens, 1989). Seasonal variations in bird communities in relation to habitat characteristics have been widely studied (*e.g.* Herrera, 1978; Rice *et al.*, 1980; Alatalo, 1981; Bilcke, 1984; Kwok & Corlett, 1999). However, few attempts have been made to link seasonal shifts of bird communities directly with the effects of habitat disturbances (but see Hayes & Samad, 1998).

The objective of this study was to determine the consequences of fire on the seasonal variability of bird communities. As mature systems are believed to contain a more stable bird community than recently disturbed habitats (Margalef, 1968; Odum, 1969), we hypothesized that bird communities in burnt zones undergo greater seasonal shifts than in unburnt areas. Specifically, we examined whether seasonal fluctuations in bird communities differed between three zones: a zone burnt 3 years before the beginning of the study, a zone burnt 15 years before, and an unburnt zone.

MATERIAL AND METHODS

STUDY AREA

This study was carried out in the Garraf Natural Park, situated 20 km to the south of the city of Barcelona (NE Iberian Peninsula). The study area (41° 15' N, 1° 55' E) consists of low hills and small valleys located between 100 and 500 m a.s.l. Yearly average precipitation ranges from 450 to 650 mm, but the karstic lithology of these hills provides only skeletal soils, which implies very dry conditions for plant communities.

The study area was intensively farmed until the end of the nineteenth century, when the *Phylloxera* crisis ruined the vineyards that occupied the slopes of the hills almost entirely and, as a consequence of land abandonment, afforestation played a major role in changing the landscape. Forests of the Aleppo pine *Pinus halepensis* covered large areas until the latest decades of the twentieth century, when two extensive fires profoundly marked the landscape of the Park. The first fire burnt 10,000 ha in 1982 and the second, which burnt over the first, affected 5,000 ha in 1994. The northern and western areas of the Park have not been damaged by fire in recent years and here the pines were present everywhere, even in sites where soil is very thin. Hereafter these zones will be also called F82, F94 and the unburnt zone respectively. This area provided an appropriate framework in which to study the seasonal variation of bird communities that inhabit dry Mediterranean landscapes affected by large fires.

BIRD COUNTING

Field work was carried out during the breeding seasons (between March and June) of 1997 and 1998, and during the wintering seasons (between December and

February) of 1997/98 and 1998/99. We repeated the same censuses two consecutive years in order to contrast the seasonal trends observed between years. This was done because bird populations and communities vary from year to year for various reasons and, therefore, no single year can be considered as typical or average (Wiens, 1989).

The point-count method was used to determine bird species composition and abundance at each counting station. We selected 30 counting stations in each of the three zones (F94, F82 and the unburnt zone), but we made sure that the area covered by the census around the station was homogeneous and did not include farmland or cliffs. Although we started the monitoring in 1997 with 90 stations, we finished the field work with only 84 stations because some were reburnt or logged. Bird censuses were conducted twice in each season and thus a total of 710 point-counts were carried out. Counting was conducted in the morning, during the period of maximum bird activity, starting 1 h after dawn, and 5 min after arrival at the station, and each count took 10 min. Point counts taken by other authors have ranged from 5 to 20 min, but following the recommendations of Fuller & Langslow (1984), 10 min was chosen as a compromise. All birds heard or seen were allocated to several circular bands around the observer (Bibby *et al.*, 1992). Raptors, aerial feeders (swallows, swifts, bee-eaters, ...) and crepuscular species were not taken into account because this method is inappropriate for a census of these species (Bibby *et al.*, 1992). Field work was carried out exclusively under uniformly good weather conditions, without rainfall or wind.

Richness and abundance were used as descriptors of the bird community. For each station, season and year, richness was calculated by considering the total number of species detected within an unlimited radius from the observer at any of the two replicates performed. However, not all the birds detected were used for estimating bird abundance. To compare bird abundance between seasons it must be considered that the detectability of each species changes throughout the year. Passerine birds are usually more detectable in the breeding season, when their territorial songs make them more conspicuous and as a result they can be detected from further away than in the wintering season (Bibby *et al.*, 1992). Therefore, abundance estimates must be taken only within a radius that allows all species to be detected equally in both periods. We estimated the detectability of each species in each season and in each habitat following the methodology of Reynolds *et al.* (1980). Thus, we assessed the appropriate radius for estimating the abundance of birds at each station. Classical measurements of diversity, such as the Shannon index H' , were not used because they are positively correlated with richness and the supplementary information conveyed by H' is usually low (Prodon, 1992).

STATISTICAL ANALYSES

Correspondence analysis was applied to the matrix of bird species composition and counting stations to detect the main factors influencing bird assemblages. This analysis is a descriptive/exploratory technique designed to analyse multi-way tables containing some measure of correspondence between the rows and columns (Greenacre, 1984). This statistical tool attributes scores both to species and to stations so that the correlation between the two is maximal, given the best "correspondence" between species and stations (Prodon, 1992). Correspondence analysis avoids the intercorrelation between variables and reduces the number of

initial variables to a number of factors which are sorted according to their relative weight in the total data matrix variance. We selected only the number of factors that were unequivocally interpreted.

We used repeated measures ANOVA (Sokal & Rohlf, 1995) to compare the seasonal shift in bird community descriptors (richness, abundance and the main factors from correspondence analysis) in each zone (F94, F82 and the unburnt zone). All statistical analyses were run with Statistica Statsoft, Inc 1999.

RESULTS

A total of 44 bird species were observed during the field work, 27 in F94, 34 in F82 and 32 in the unburnt zone. Of the bird species found in F94, 44.4 % were all year-residents, whereas this percentage reached 55.9 % in F82 and 59.4 % in the unburnt zone (Table I). F1, the first factor obtained from the correspondence analysis, accounted for 12.1 % of total data matrix variance and represented a progressive gradient ranging from birds of open habitats (positive scores) to forest birds (negative scores). On the other hand, F2 (6.9 % of total data matrix variance) represented a gradient ranging from bird species that were widespread during the winter (negative scores) to those that were widespread during the breeding season (positive scores) (Table I).

The seasonal changes in the open-forest species gradient (F1) differed between zones in both 1997 and 1998 (Table II). This seasonal shift was significantly less pronounced in the unburnt zone than in F94 ($F_{1,58} = 51.20$, $P < 0.001$ in 1997; $F_{1,55} = 73.70$, $P < 0.001$ in 1998) or in F82 ($F_{1,58} = 25.81$, $P < 0.001$ in 1997; $F_{1,52} = 50.96$, $P < 0.001$ in 1998) (Fig. 1). Therefore, the zones affected by fire, which had a breeding bird community clearly dominated by open and shrubby species, increased the number of forest species during the wintering season whereas the unburnt zone did not undergo any trend for this factor. Accordingly, five summer visitors were clearly associated with open spaces: Black-eared Wheatear, Woodchat Shrike, Ortolan Bunting, Rock Thrush and Tawny Pipit, whereas only two species of winter visitors were strictly linked to open spaces: Black Redstart and Meadow Pipit. Furthermore, many resident species that inhabited burnt zones became more scarce there in the wintering season but did not enter the unburnt zone (eventually the Dartford Warbler entered), which contrasted with the observations that most winter visitors of burnt zones were typically forest species such as the Robin, Wren, Goldcrest or Blackcap.

The seasonal changes in the gradient from birds that were frequent in the wintering season to birds that were frequent in the breeding season (F2) also differed between zones in both 1997 and 1998 (Table III). This seasonal change was stronger in F94 than in the unburnt zone ($F_{1,58} = 11.88$, $P < 0.01$ in 1997; $F_{1,55} = 7.61$, $P < 0.01$ in 1998) (Fig. 2). However, F82 and the unburnt zone did not differ ($F_{1,58} = 0.58$, $P = 0.810$ in 1997; $F_{1,55} = 1.46$, $P = 0.232$ in 1998) (Fig. 2). Therefore, although the three study zones showed a significant change from communities characterized by summer birds in the breeding season to winter birds in the non-breeding period, this seasonal shift was significantly greater in the most recently burnt zone.

The seasonal changes in richness also differed between zones in both 1997 and 1998 (Table IV). However, the change was more marked in the unburnt zone

TABLE I

List of the bird species found in the three study zones (F94, F82 and unburnt zone). Each value indicates the mean percentage of stations occupied in 1997 and 1998 and the bar separates values for the breeding season (first number) from those for winter (second number). Scores of the first two factors (F1 and F2) of the correspondence analysis are also shown.

Bird species		F94	F82	Unburnt	F1	F2
Red-legged Partridge	<i>Alectoris rufa</i>	56.5/30	18.5/8.5	0/0	1.30	0.17
Common Cuckoo	<i>Cuculus canorus</i>	0/0	6.5/0	32/0	-0.82	1.06
Green Woodpecker	<i>Picus viridis</i>	3/0	0/0	31.5/20	-0.80	0.53
Wood Pigeon	<i>Columba palumbus</i>	0/0	1.5/1.5	48/16.5	-0.91	0.51
Turtle Dove	<i>Streptopelia turtur</i>	0/0	1.5/0	25/0	-0.85	0.79
Thekla Lark	<i>Galerida theklae</i>	15/14	3.5/3	0/0	1.58	0.30
Meadow Pipit	<i>Anthus pratensis</i>	0/10	0/6.5	0/0	0.88	-3.13
Tawny Pipit	<i>Anthus campestris</i>	21.5/0	3/0	0/0	2.13	1.76
Wren	<i>Troglodytes troglodytes</i>	0/17	20/40	88.5/73.5	-0.54	-0.08
Hedge Sparrow	<i>Prunella modularis</i>	0/19	0/6.5	0/7	0.51	-1.64
Robin	<i>Erithacus rubecula</i>	0/65	0/72	10/91.5	-0.09	-0.93
Nightingale	<i>Luscinia megarhynchos</i>	0/0	15/0	58.5/0	-0.78	0.78
Black Redstart	<i>Phoenicurus ochruros</i>	0/24	0/0	0/0	0.73	-1.75
Stonechat	<i>Saxicola torquata</i>	61.5/34	41.5/5	0/0	1.37	0.34
Black-eared Wheatear	<i>Oenanthe hispanica</i>	80/0	23.5/0	0/0	1.58	0.90
Rock Thrush	<i>Monticola saxatilis</i>	3.5/0	5/0	0/0	1.31	1.28
Blackbird	<i>Turdus merula</i>	26.5/20	60/55	83/86.5	-0.22	-0.07
Cetti's Warbler	<i>Cettia cetti</i>	0/0	6.5/3	5/7	-0.67	0.31
Dartford Warbler	<i>Sylvia undata</i>	97/100	91.5/94	0/15	0.78	-0.34
Blackcap	<i>Sylvia atricapilla</i>	0/12	0/5	0/13.5	-0.09	-1.17
Sardinian Warbler	<i>Sylvia melanocephala</i>	62/75	90/87	100/95	0.08	-0.19
Bonelli's Warbler	<i>Phylloscopus bonelli</i>	0/0	0/0	47/0	-1.00	0.93
Chiffchaff	<i>Phylloscopus collybita</i>	0/1.5	0/25	0/21.5	-0.32	-1.25
Goldcrest	<i>Regulus regulus</i>	0/0	5/5	0/6.5	-0.49	-1.30
Firecrest	<i>Regulus ignicapillus</i>	0/0	8.5/17	57/48.5	-0.74	0.00
Spotted Flycatcher	<i>Muscicapa striata</i>	0/0	1.5/0	1.5/0	-0.47	1.20
Long-tailed Tit	<i>Aegithalos caudatus</i>	0/0	5/5	40/35	-0.81	0.14
Crested Tit	<i>Parus cristatus</i>	0/0	0/0	68.5/83.5	-0.84	0.07
Coal Tit	<i>Parus ater</i>	0/0	0/0	17/8.5	-0.96	0.33
Blue Tit	<i>Parus caeruleus</i>	0/0	0/1.5	3/12	-0.86	-0.26
Great Tit	<i>Parus major</i>	10/7	33.5/18	80/48	-0.48	0.15
Short-toed Treecreeper	<i>Certhia brachydactyla</i>	0/0	0/0	60/46.5	-0.89	0.19
Golden Oriole	<i>Oriolus oriolus</i>	0/0	0/0	21.5/0	-0.96	1.14
Southern Grey Shrike	<i>Lanius meridionalis</i>	51.5/35	28.5/19	0/0	1.24	0.06
Woodchat Shrike	<i>Lanius senator</i>	10/0	0/0	0/0	1.67	1.65
Jay	<i>Garrulus glandarius</i>	0/0	6.5/3	40/43.5	-0.78	0.19
Magpie	<i>Pica pica</i>	0/0	0/0	22/10	-0.98	0.73
Chaffinch	<i>Fringilla coelebs</i>	0/14	0/12	0/38.5	-0.34	-0.87
Serín	<i>Serinus serinus</i>	18.5/8	50/19	78/10	-0.14	0.52
Greenfinch	<i>Carduelis chloris</i>	6.5/5	5/3	25/7	-0.27	0.59
Goldfinch	<i>Carduelis carduelis</i>	0/1.5	3/3.5	16.5/11.5	-0.56	0.11
Rock Bunting	<i>Emberiza cia</i>	3/5	6.5/1.5	8.5/0	0.12	0.38
Ortolan Bunting	<i>Emberiza hortulana</i>	7/0	5/0	0/0	1.99	1.81
Corn Bunting	<i>Miliaria calandra</i>	11.5/1.5	0/0	0/0	1.87	1.16

TABLE II

ANOVA models for the open-forest species gradient (F1) according to zone (unburnt zone, F94 and F82) and season (breeding and wintering). Results are given for the two periods (1997 and 1998).

Factor	d.f.	F	P
1997			
Zone	2.87	248.5	< 0.001
Season	1.87	23.2	< 0.001
Interaction	2.87	20.9	< 0.001
1998			
Zone	2.81	175.4	< 0.001
Season	1.81	50.1	< 0.001
Interaction	2.81	40.6	< 0.001

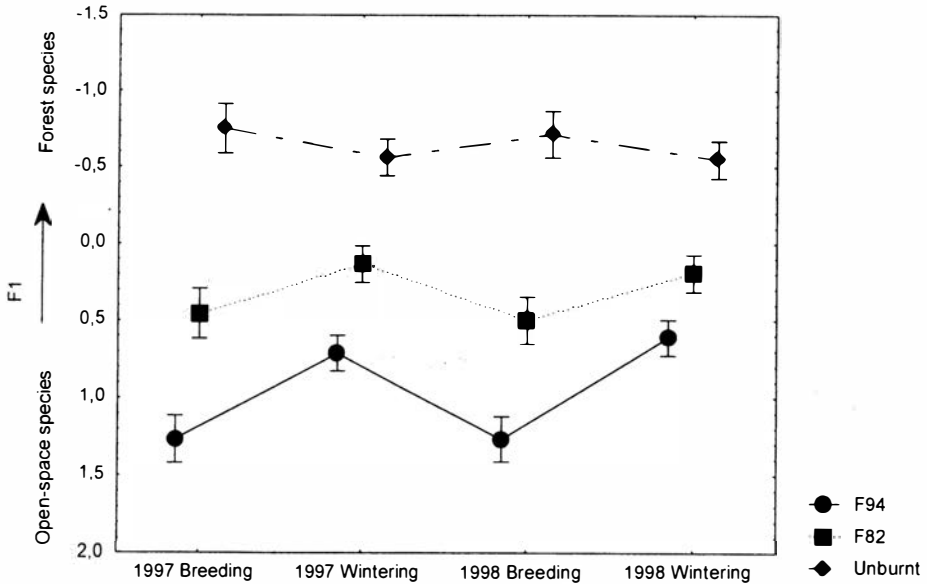


Figure 1. — Changes in the gradient from birds of open habitats (positive scores) to forest birds (negative scores) (F1) in the three study zones. Bars indicate standard error.

than in F82 in both years ($F_{1,58} = 6.35$, $P < 0.05$ in 1997; $F_{1,52} = 3.81$, $P = 0.056$ in 1998), and in F94 in 1998 ($F_{1,58} = 2.47$, $P = 0.121$ in 1997; $F_{1,56} = 9.34$, $P < 0.01$ in 1998) (Fig. 3). The slight trend towards an increase in richness in F94 during the 1998 wintering season (Fig. 3) was caused by an irruption of the Black Redstart, a species that was not present in the winter of 1997. Therefore, although

TABLE III

ANOVA models for the breeding-wintering species gradient (F2) according to zone (unburnt zone, F94 and F82) and season (breeding and wintering). Results are given for the two periods (1997 and 1998).

Factor	d.f.	F	P
1997			
Zone	2.87	14.3	< 0.001
Season	1.87	205.8	< 0.001
Interaction	2.87	6.9	< 0.01
1998			
Zone	2.81	5.8	< 0.01
Season	1.81	183.8	< 0.001
Interaction	2.81	3.0	0.056

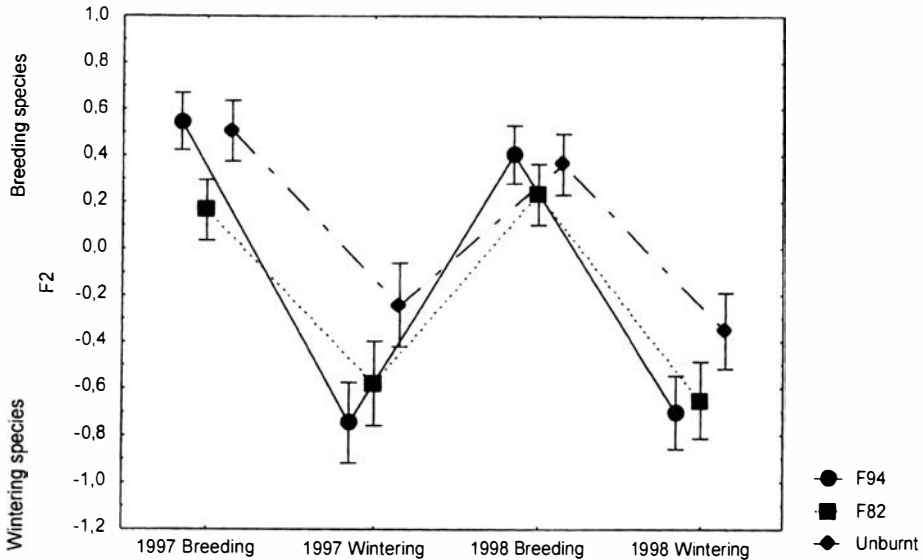


Figure 2. — Changes in the gradient from birds that were widespread during the winter (negative scores) to birds that were widespread in the breeding season (positive scores) (F2) in the three study zones. Bars indicate standard error.

the stations situated in F82 and F94 changed their bird species composition more than those of the unburnt zone, they did not show significant seasonal changes in the total number of species.

Finally, the seasonal changes in total bird abundance also differed between zones, although only marginally in 1998 (Table V), when the pattern was quite different from that of the previous year (Fig. 4). In 1997 the seasonal change in

abundance shown by the unburnt zone was significantly different from that of F94 ($F_{1,58} = 5.16$, $P < 0.05$) and F82 ($F_{1,58} = 13.96$, $P < 0.001$). In 1998, bird abundance increased in all zones from the breeding to the wintering season. However, this increase did not differ between F82 and the unburnt zone ($F_{1,52} = 0.04$, $P = 0.945$), whereas it did between F94 and F82 ($F_{1,55} = 5.92$, $P < 0.05$) and

TABLE IV

ANOVA models for the richness according to zone (unburnt zone, F94 and F82) and season (breeding and wintering). Results are given for the two studied periods (1997 and 1998).

Factor	d.f.	F	P
1997			
Zone	2.87	64.8	< 0.001
Season	1.87	14.9	< 0.001
Interaction	2.87	3.7	< 0.05
1998			
Zone	2.81	55.7	< 0.001
Season	1.81	2.8	< 0.1
Interaction	2.81	5.8	< 0.01

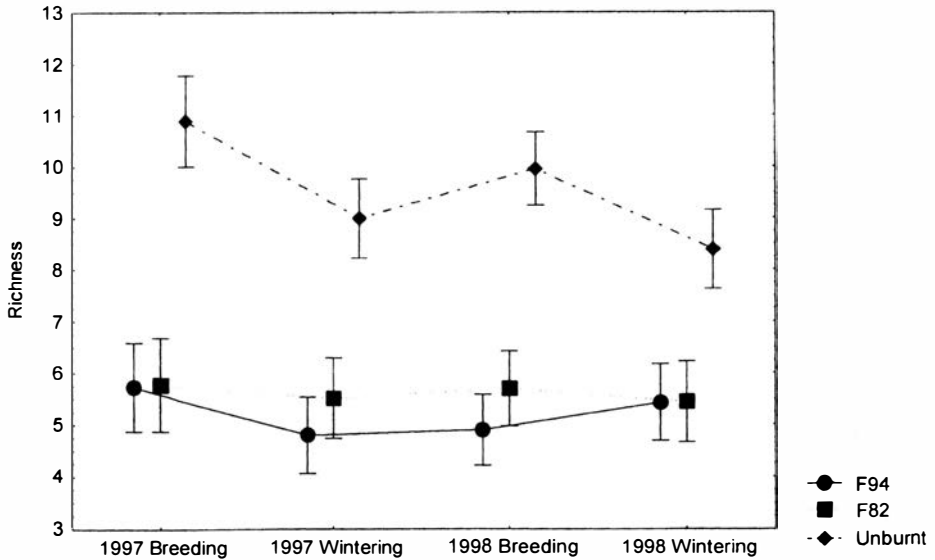


Figure 3. — Changes in richness in the three study zones. Bars indicate standard error.

between F94 and the unburnt zone ($F_{1,55} = 3.70, P = 0.059$). Thus, the most remarkable pattern observed was the high interannual variation in bird abundance in the two burnt zones.

TABLE V

ANOVA models for the abundance according to zone (unburnt zone, F94 and F82) and season (breeding and wintering). Results are given for the two periods (1997 and 1998).

Factor	d.f.	F	P
1997			
Zone	2.87	57.5	< 0.001
Season	1.87	0.1	n.s.
Interaction	2.87	9.6	< 0.001
1998			
Zone	2.81	17.3	< 0.001
Season	1.81	69.3	< 0.001
Interaction	2.81	2.9	0.58

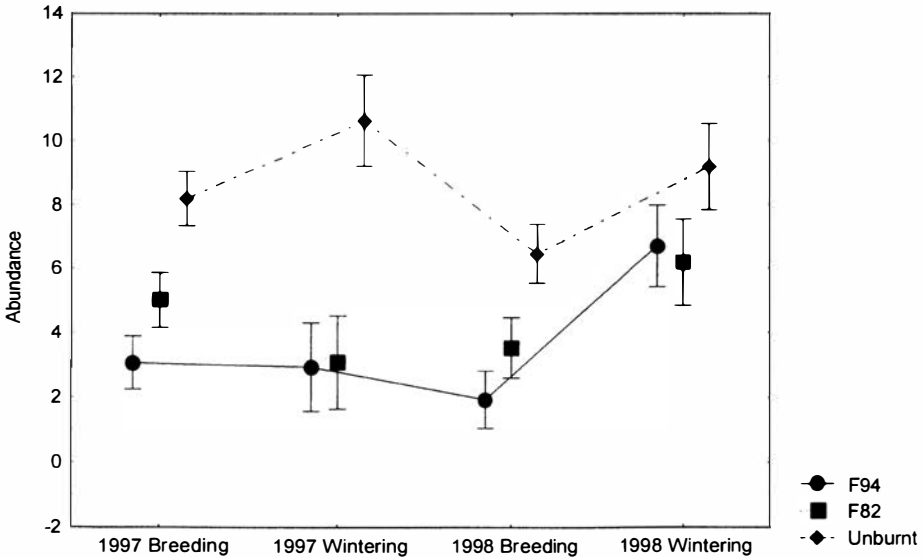


Figure 4. — Changes in bird abundance in the three study zones. Bars indicate standard error.

DISCUSSION

Our results indicate that burnt zones show a noticeable shift towards a more “forested” species composition from the breeding to the wintering season, whereas the unburnt zone did not show any significant trend. Therefore fire increased the “open-species” component of bird communities but to a greater extent during the breeding season. Our data show that burnt zones are comparatively rich in forest species in the wintering season. These species seemed to enlarge niche breadth and were also found in unforested habitats during this period. The finding that the range of habitats occupied by species is less restricted in the wintering than in the breeding season is not new (Alatalo, 1981; Rice *et al.*, 1983; Bilke, 1984), but interestingly, our results show that this niche shift is not the same for all ecological categories and, at least in our case, was more common from forest to open habitats than vice versa.

We show that all study zones undergo a seasonal change from communities characterized by summer visitors in the breeding season to those characterized by winter visitors in the wintering season. Nevertheless, this shift was more pronounced in F94, which indicates that the seasonal turnover of bird communities is higher in recently burnt zones. Migration itself is essentially a strategy to adapt to fluctuations in food supply that, at least some years, might lead to the extinction of local populations (Stocker & Weihs, 1998). The Mediterranean region, which is an important scene of Palearctic migration, is an essential wintering ground for many bird species (Lövei, 1989; Blondel & Aronson, 1999). Nevertheless, although non-resident birds became extraordinarily abundant in many Mediterranean habitats, there are marked differences in non-resident bird abundance in relation to habitat (Lövei, 1989). For example, Herrera (1978) found in Iberian holm-oak forests that the ratio between resident and non-resident birds was balanced in favour of the former. He proposed that this may be the result of a low degree of seasonality and high predictability of food supply. According to this author, non-resident species are more generalist, exploiting diverse and spatially unpredictable resources. Mönkkönen & Helle (1989) showed that the higher predictability of resources in forests was not sufficient to explain residency patterns, since North-American forest bird communities were dominated by migrant species, whereas European ones were dominated by resident species. These authors pointed out the role of landscape in the wintering grounds since the proportion of forests is much lower in Africa than in Central and South America. Therefore, resource predictability in the Mediterranean forests of Western Palearctic and the scarcity of this type of habitat in African wintering grounds may be under the high sedentarity of the bird communities inhabiting unburnt areas compared with recently burnt ones.

The seasonal shift in richness was clear and repeated in the two census years in the unburnt zone, where the number of species decreased from the breeding to the wintering season. In contrast, the burnt zones, where species composition varied more between seasons, showed an almost constant richness throughout the study period. Our results differ from those reported by Prodon *et al.* (1987) in cork-oak forests, in which maximum bird richness was found in the breeding season in both burnt and unburnt zones. However, as Prodon *et al.* revealed in the same work and in contrast to calcareous shrublands, post-fire avian dynamics is accelerated fast in cork-oak forests due to the capacity of this tree to sprout from main branches after fire.

Seasonal patterns in relation to F1, F2 and richness, that is, in relation to bird assemblages were very repeatable during the two study periods. This contrasts with a lower overall annual cyclicality in bird abundance. This is an interesting observation, since it reveals two distinct processes in the structuring of bird communities. On the one hand, bird species composition, which has been described as being shaped by the physical structure of habitat (McArthur & McArthur, 1961; Wilson, 1974; Wiens, 1989). On the other hand bird abundance, which is thought to be related to either habitat productivity (Nilsson, 1979) or, far from the level of carrying capacity, shaped via stochastic processes (Wiens, 1974; Jarvinen, 1978). There is an underlying but interesting difference between the patterns that influence both bird species composition and bird abundance: in the absence of disturbances such as fire, physical structure is supposed to remain quite stable during consecutive years whereas stochastic processes are, by definition, quite unpredictable and may appear in short periods. For example, the amount of some fleshy-fruit crops, which are a basic food resource for many Mediterranean birds during the wintering season (Blondel & Aronson, 1999), vary considerably and are only abundant some years (Herrera, 1994). Therefore, some seasonal variation in bird abundance of habitats involved in post-fire dynamics may be hidden by differences in food supply or by stochastic processes which influence bird populations directly or indirectly through resources. The increase in bird abundance observed in the two burnt zones should therefore be considered within this context more than as a result of succession itself. However, it is remarkable that the pattern of abundance in the unburnt zone was quite repeatable during the two study periods, which suggests a higher annual cyclicality in resource availability in unburnt areas. Again, this result suggests that these unburnt areas of the Mediterranean are more stable and undergo fewer productivity oscillations than those affected by fire. Indeed, it is also interesting to note that in 1998, F94 showed a higher increase in bird abundance than F82, which suggests that recently burnt areas may be subjected to greater annual oscillations than those burnt longer ago.

In contrast to our results, García (1997) found that in both, burnt and unburnt zones of holm-oak forests of the Iberian plateaux, bird abundance peaked during the breeding season. This pattern might be related to the distinct climate, since the Garraf Natural Park is much warmer in winter than the Iberian plateaux. Nevertheless, in areas with a similar mild climate in southern France, Prodon *et al.* (1987) and Pons & Prodon (1996) also reported that in both burnt and unburnt areas maximum bird abundance was observed in spring and minimum in winter. These trends, in contrast to the pattern observed in our unburnt zone for 1997 and 1998 and that found in burnt zones in 1998, may not only be associated with climate. According to the plant species composition cited in their articles, fleshy-fruit producing plants are much less abundant in these acid-soil areas of southern France than in our calcareous Iberian study area. Therefore, we suggest that, besides climate, plant species composition, which is also highly influenced by lithology, may play a key role in the seasonal patterns of bird abundance.

In conclusion, our results are consistent with the classical view of succession that states that undisturbed systems internalize better environmental fluctuations without changing their structure than recently disturbed ones (Margalef, 1968; Odum, 1969) since seasonal variations in bird communities were more marked in burnt than in unburnt zones.

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