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MONITORING SPATIAL AND TEMPORAL DYNAMICS OF BIRD COMMUNITIES IN MEDITERRANEAN LANDSCAPES AFFECTED BY LARGE WILDFIRES

SEGUIMIENTO DE LA DINÁMICA ESPACIAL Y TEMPORAL DE COMUNIDADES DE AVES EN PAISAJES MEDITERRÁNEOS AFECTADOS POR GRANDES FUEGOS

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SUMMARY.—*Monitoring spatial and temporal dynamics of bird communities in Mediterranean landscapes affected by large wildfires.*

We presented a bird-monitoring database in Mediterranean landscapes (Catalonia, NE Spain) affected by wildfires and we evaluated: 1) the spatial and temporal variability in the bird community composition and 2) the influence of pre-fire habitat configuration in the composition of bird communities. The DINDIS database results from the monitoring of bird communities occupying all areas affected by large wildfires in Catalonia since 2000. We used bird surveys conducted from 2006 to 2009 and performed a principal components analysis to describe two main gradients of variation in the composition of bird communities, which were used as descriptors of bird communities in subsequent analyses. We then analysed the relationships of these community descriptors with bioclimatic regions within Catalonia, time since fire and pre-fire vegetation (forest or shrubland). We have conducted 1,918 bird surveys in 567 transects distributed in 56 burnt areas. Eight out of the twenty most common detected species have an unfavourable conservation status, most of them being associated to open-habitats. Both bird communities' descriptors had a strong regional component and were related to pre-fire vegetation, and to a lesser extent to the time since fire. We came to the conclusion that the responses of bird communities to wildfires are heterogeneous, complex and context dependent. Large-scale monitoring datasets, such as DINDIS, might allow identifying factors acting at different spatial and temporal scales that affect the dynamics of species and communities, giving additional information on the causes under general trends observed using other monitoring systems.

Key words: dispersion, landscape context, open-habitat species, pre-fire vegetation, recently burnt areas, species colonisation.

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RESUMEN.—*Seguimiento de la dinámica espacial y temporal de comunidades de aves en paisajes mediterráneos afectados por grandes fuegos.*

Se ha presentado una base de datos de aves en paisajes mediterráneos (Cataluña, NE España) afectados por incendios forestales y se ha evaluado: 1) la variabilidad espacial y temporal de la respuesta de la comunidad de aves al fuego y 2) el impacto de la vegetación antes del incendio en la composición de la comunidad de aves. La base de datos DINDIS contiene información avifaunística de todas las áreas forestales quemadas desde el año 2000 en Cataluña. Se utiliza la información disponible hasta la fecha y se realiza un análisis de componentes principales para describir dos patrones esenciales de variación en la comunidad de aves, los cuales fueron utilizados como descriptores de la comunidad en los siguientes análisis. Se analiza la relación de dichos descriptores con las regiones bioclimáticas dentro de Cataluña, el tiempo transcurrido después del fuego y la vegetación antes del incendio (bosque o matorral). Se realizó un total de 1.918 censos en 567 transectos distribuidos en 56 áreas quemadas. Ocho de las veinte especies más comunes tienen valor de conservación, la mayoría asociadas a hábitats abiertos. Ambos descriptores de la comunidad de aves estuvieron significativamente relacionados con la componente regional y con la vegetación antes del incendio, y en menor medida con el tiempo transcurrido después del incendio. Se concluye que las respuestas de las comunidades de aves a los incendios son heterogéneas, complejas y dependientes del contexto del paisaje. Asimismo, la disponibilidad de una base de datos a gran escala como DINDIS permitiría identificar los factores que actúan a diferentes escalas espaciales y temporales que determinan la dinámica de las especies, ofreciendo información complementaria sobre las causas detrás de las tendencias poblacionales observadas utilizando otros sistemas de monitoreo.

Palabras clave: colonización de especies, contexto paisajístico, dispersión, especies de hábitats abiertos, vegetación antes del fuego, zonas recientemente quemadas.

INTRODUCTION

Humans have shaped the Mediterranean Basin during millennia through forest exploitation, raising of livestock and agriculture (Blondel and Aronson, 1999), using fire as a main management tool. The resulting silvo-agropastoral systems created upon a fine mosaic of interconnected habitats, resulting in a high global biodiversity (Covas and Blondel, 1998; MacDonald *et al.*, 2000; Fabbio *et al.*, 2003). Nevertheless, this biodiversity is highly threatened due to climatic changes, biological invasions and especially due to widespread land-use changes (Sala *et al.*, 2000).

Significant changes in the socioeconomic structure, during the second half of the last century, have induced extensive modifications in the composition and nature of prevailing landscapes in the European part of the Mediterranean Basin (Blondel and Aronson, 1999). The abandonment of traditional activities has lead to a progressive loss of open habitats and to an increase in forests and dense shrublands through secondary succession (Preiss *et al.*, 1997). At the same time, several economic incentives for afforestation of old fields (e.g. Fry, 1989; Stoate *et al.*, 2001) offered farmers the option to obtain some economic profit from their lands, promoting an increased of forest cover. Due to the large and continuous fuel accumulation, the number and intensity of wildfires have exponentially increased (Moreno *et al.*, 1998; Pausas and Vallejo, 1999; Pausas, 2004). Additionally, climatic changes seem to contribute to the current fire pattern, since the higher frequency of dry summers has been related to the higher amount of burnt area (Piñol *et al.*, 1998; Pausas, 2004). Thus, with more fires occurring in the area, the importance of fire disturbance in determining landscape structure and explaining species dynamics in Mediterranean ecosystems is increasing.

Wildfires affect habitats with different vegetation covers and structure, which converge towards simpler and open habitat configuration after the disturbance. These new open areas are pioneered by bird species preferring open and low vegetation habitats (Prodon *et al.*, 1984). The bulk of post-disturbance avian communities associated with fire dynamics is formed by species associated with open habitats and species showing site fidelity after fire. (Pons and Prodon, 1996; Herrando *et al.*, 2002; Ukmar *et al.*, 2007). Although the patterns of post fire change in bird community composition are well known, especially in Mediterranean systems (Lawrence, 1966; Prodon and Lebreton, 1981; Jacquet and Prodon, 2009), relatively little research has been directed at spatial analysis of fire effects; such as the role of unburnt patches, the relationship between fire extent and direct impacts, and the process of species colonisation (Stuart-Smith *et al.*, 2002). The mechanisms that determine the pool of pioneer species that colonise open habitat originated by fire disturbances are specially unknown.

In this work, we present a bird-monitoring database (DINDIS-Bird distribution dynamics in Mediterranean landscapes affected by fires) aimed at the large-scale monitoring of bird communities in burnt habitats. This database started in 2006 and includes the sampling of all areas affected by large wildfires after 2000 in Catalonia, a region dominated by Mediterranean climate and located in the north-east of Spain (figure 1). The monitoring arises as an extension and improvement of a previous large-scale study conducted from 2002 to 2005 (Brotons *et al.*, 2005; Pons and Bas, 2005). Here, we used data gathered by DINDIS from 2006 to 2009 to describe spatial and temporal patterns in the composition and structure of bird communities occupying burnt areas in relation to bioclimatic regions within Catalonia and time since fire. We included a regional factor to account for potential effects of spatial variation in bird community composition within the studied burnt sites. Finally, we evaluated the impact of pre-fire vegetation (forest or shrubland) in the bird community composition.

Material and methods

The DINDIS database

The DINDIS database aims at monitoring bird communities in wildfires that occur in Catalonia. Most fires in the region are severe, including crown fires that strongly affect both, forest canopy and undergrowth, and cause widespread tree mortality (Rodrigo *et al.*, 2004). The project started in 2006 and monitors all wildfires from 2000 in which more than 50 ha of forest and/or shrubland were affected.

Within each fire perimeter, we established a series of transects to estimate bird presence and abundance (Bibby *et al.*, 2000). Each survey lasted 15 min and was divided in 3 sections of 5 minutes each. Transects were characterised by four points collected with a GPS at minute 0, 5, 10 and 15. Birds were counted, when heard or seen, and were allocated into one of the four distance bands (0-25 m, 25-50 m, 50-100 m, > 100 m). Surveys were conducted once every breeding season (10^{th} May-15^{th} June) in good weather conditions (i.e. without rainfall or strong wind) during the first 3 hours after sunrise by experienced ornithologists at a speed of about 2 km/h (Bibby *et al.*, 2000).

The number of transects conducted at each wildfire increased non-linearly with burnt area (logarithmically; *NumberTransects* = 14.8 * Log $_{10}$ *BurntArea* (ha) – 24.6; R^2 = 0.97). The establishment of transects observed the following criteria:

a) They were conducted entirely across burnt wildland avoiding, when possible, unburnt patches (forest or farmland) and fire edges.
b) The minimum distance between two transects was 150 m.
c) The minimum distance between transects and fire edge was 50 m.
d) Transects were conducted preferably on existing trails in order to allow future repetition of the transects after vegetation recovery.
e) In the largest burnt areas, transects were distributed in a number of representative locations covering habitat heterogeneity within fire perimeter.

The location of transects was maintained in consecutive years, although in few case this was not possible (e.g. due to vegetation growth).

We assigned each fire to a bioclimatic region to account for potential effects of spatial variation in bird community composition. With this aim, we defined three different regions in Catalonia ('South', 'Northwest' and 'Northeast') differing broadly in climatic patterns and dominant forest species (derived from DGMN (1994) and Burriel *et al.* (2000-2004); see figure 1, Annex 1).

Data analysis

The present database includes data collected from 1,918 bird surveys performed at 567 transects established in 56 burnt areas. We used the bird surveys to search for spatial and temporal patterns in the composition of bird communities occupying recently burnt areas. We selected individuals detected within 100 m belts (the three closest census bands) on both sides of the track and used the presence and absence of those species detected in more than 5% of the censuses to construct the final matrix. First, we performed a principal components analysis (PCA) using each individual bird census as the sampling unit in order to resume the main gradients of variation in the composition of bird communities. The first two principal components (PCs) extracted by the PCA were interpreted as a function of the loadings and ecological requirements of bird species. Values of censuses along these gradients were kept as descriptors of bird communities.

For further analyses, the sampling unit was every combination of wildfire and census year (wildfire/year), instead of individual censuses. A wildfire/year sample was the result of calculating the mean value of the bird community descriptors (PCA1 and PCA2) of all transects conducted within a fire in a particular census year. We performed an analysis of variance (ANOVA) and a simple regression to analyze variations in bird community descriptors in relation to the bioclimatic regions and the number of years after fire respectively.

Finally, we analysed whether the characteristics of pre-fire vegetation influenced the bird community descriptors. As shown in other studies, pre-fire vegetation commonly constrains post-fire bird species composition (Herrando *et al.*, 2002). With this aim, we selected forest and shrubland fires, defining them as those in which more than 70% of the burnt area was covered by any of the two habitat types before wildfire occurrence. Then we ran one-way ANOVAs testing the influence of pre-fire vegetation (two levels: 'forest' and 'shrubland') on bird community descriptors. All statistical analyses were run with Statistica V. 7, StatSoft, Inc. 1984-2004.

RESULTS

Summary of the data from DINDIS

A total of 56 wildfires, widely distributed across Catalonia, have occurred from 2000 to 2007 (figure 1, Annex 2). None of the fires that occurred in 2008 in the study area fulfilled the conditions for our sample (i.e. a minimum of 50 ha burnt area). In 2006, 2007, 2008 and 2009 we conducted bird surveys in 44, 51, 45 and 47 sites respectively. In the present year, 2010, we expect to survey 41 sites (Annex 3). According to Catalonia land use maps of 1997 and 2002, 35% of the studied burnt areas (N = 20) was covered mostly by shrubland before the fire, 21% (N = 12) were covered by forest, with the rest of burnt sites (N = 24) being a mixture of these two habitat types (Annex 2). Most of the fires that occurred in the 'south' region were shrubland fires (13 out of 25), most of those that occurred in the 'northwest' region were

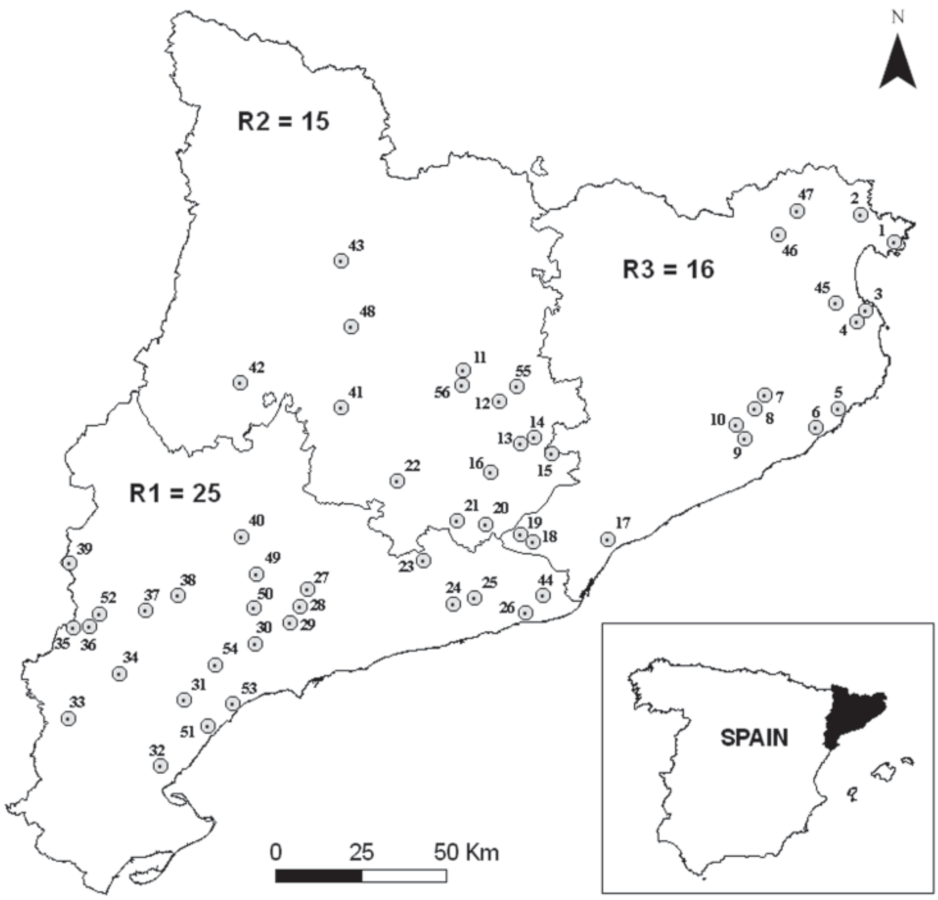

FIG. 1.—Geographical location of fires occurring in Catalonia from 2000 to 2007. Numbers correspond to wildfire codes (see Annex 2). The three bioclimatic regions (delimited by the black thin line) with the total number of fires within each one are shown. The map on the upper right corner shows the location of the study region (Catalonia), in black.

[Localización geográfica de los incendios acaecidos en Cataluña entre 2000 y 2007. Los números se corresponden con los códigos de incendio (véase Anexo 2). Se muestran las tres regiones bioclimáticas (delimitadas por la línea negra delgada) con el número total de incendios dentro de cada una.]

forest fires (8 out of 15) and the majority of the fires that occurred in the 'northeast' region were mixture fires (10 out of 16).

Data on bird communities were collected at different successional stages, from one to nine years after fire, thus allowing the analysis of the short-temporal responses of birds to fire. Most of the data were collected in the first six years after fire occurrence, since there was little information on sites where fire disturbance occurred between seven and nine years ago (figure 2).

Fire size varied from 50 to 6,389 ha. The number of transects conducted within fire perimeter went from 2 to 31 (Annex 2). A total of 1,918 bird surveys have been conducted describing the temporal variation of 567 transects; with a mean transect length of 440 m (SD = 95 m, range = 381-526 m).

Ninety-seven species have been detected with a total of 36,806 individuals observed. Raptors, aerial feeders (swallows, swifts and bee-eaters) and crepuscular species were excluded from the analyses (Bibby *et al.*, 2000). Eight out of the 20 most common species have an unfavourable conservation status (SPEC 1, 2 or 3); most of them associated to open-habitat species, highlighting the role of fires for threatened species.

General patterns in the observed species gradient

The first two principal components extracted by the PCA accounted for 16.2% of the original variability in bird community composition (figure 3). PCA1 represented a gradient of tree density, ranging from open-habitat and shrubland birds (forest-avoiding species) to forest species. The second factor PCA2 represented a biogeographical gradient

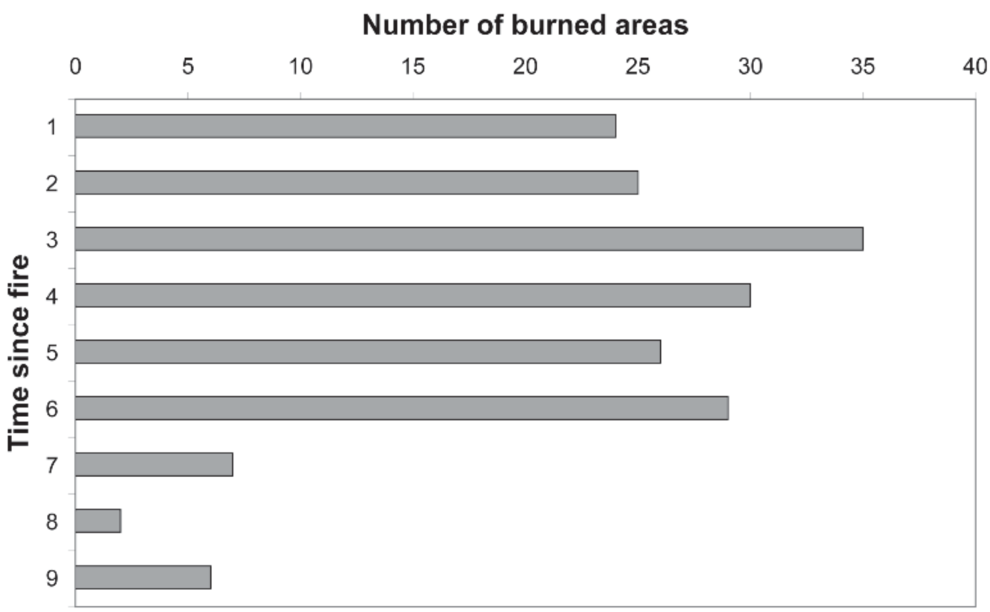

FIG. 2.—Number of burned areas monitored according to the years elapsed since the last wildfire.
[Número de áreas quemadas bajo seguimiento según los años transcurridos desde el último incendio.]

TABLE 1

List of bird species detected in more than 5% of the surveys (N = 1,918) and their frequency of occurrence (in percentage).
[Listado de especies de aves detectadas en más del 5% de los muestreos (N = 1.918) y su frecuencia de ocurrencia (en porcentaje).]

Scientific name	**Common name**	**Acronym**	**Occurrence**
Sylvia melanocephala	Sardinian warbler	SYLALA	61.4
Serinus serinus	Serin	SERSER	38.1
Sylvia undata	Dartford warbler	SYLUND	34.1
Lullula arborea	Woodlark	LULARB	32.6
Sylvia cantillans	Subalpine warbler	SYLCAN	30.9
Turdus merula	Blackbird	TURMER	29.9
Carduelis cannabina	Linnet	CARINA	29.4
Saxicola torquatus	Stonechat	SAXTOR	28.7
Emberiza calandra	Corn bunting	MILCAL	24.8
Parus major	Great tit	PARMAJ	24.6
Hippolais polyglotta	Melodious warbler	HIPPOL	23.4
Oenanthe hispanica	Black-eared wheatear	OENHIS	23.4
Carduelis carduelis	Goldfinch	CARLIS	22.9
Luscinia megarhynchos	Nightingale	LUSMEG	21.6
Galerida theklae	Thekla lark	GALTHE	19.0
Carduelis chloris	Greenfinch	CARCHL	17.9
Emberiza cia	Rock bunting	EMBCIA	16.9
Lanius senator	Woodchat shrike	LANSEN	15.7
Troglodytes troglodytes	Wren	TROTRO	15.6
Columba palumbus	Word pigeon	COLPAL	14.5
Passer domesticus	House sparrow	PASDOM	14.3
Fringilla coelebs	Chaffinch	FRICOE	12.8
Cyanistes caeruleus	Blue tit	PARCAE	10.9
Lophophanes cristatus	Crested tit	PARCRI	10.6
Emberiza cirlus	Cirl bunting	EMBCIR	10.5
Alectoris rufa	Red-legged partridge	ALERUF	10.4
Certhia brachydactyla	Short-toed tree-creeper	CERBRA	8.7
Garrulus glandarius	Jay	GARGLA	8.7
Anthus campestris	Tawny pipit	ANTCAM	8.6
Emberiza hortulana	Ortolan bunting	EMBHOR	8.2
Phylloscopus bonelli	Bonelli's warbler	PHYBON	7.7
Streptopelia turtur	Turtle dove	STRTUR	7.4
Dendrocopos major	Great spotted woodpecker	DENMAJ	6.2
Petronia petronia	Rock sparrow	PETPET	5.9
Sturnus vulgaris	Starling	STUVUL	5.9
Erithacus rubecula	European robin	ERIRUB	5.8
Oriolus oriolus	Golden oriole	ORIORI	5.4
Sylvia atricapilla	Blackcap	SYLATR	5.2
Sylvia hortensis	Orphean warbler	SYLHOR	5.2

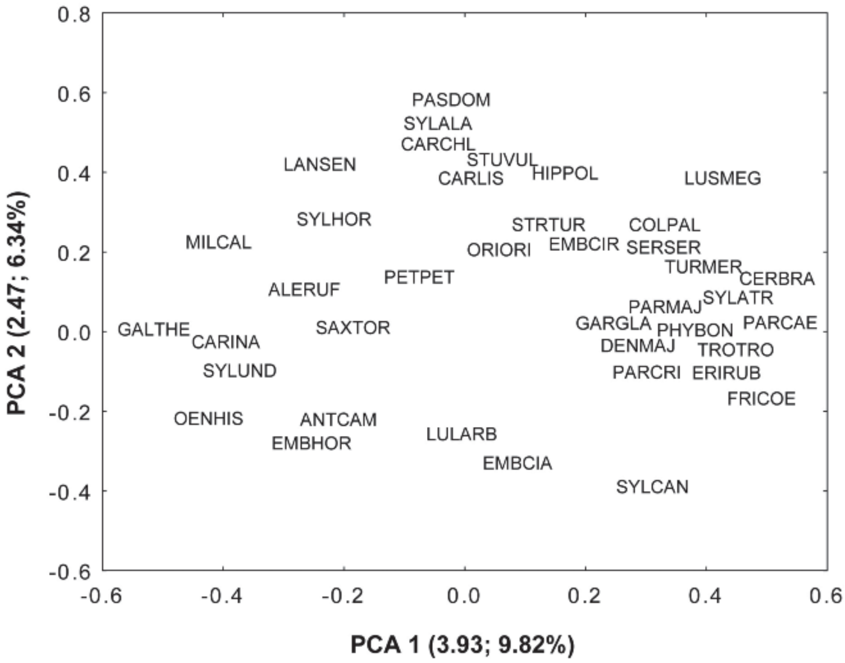

FIG. 3.—Factors loadings bird species for the first two principal components extracted by the PCA (eigenvalues and variance explained, in parentheses). Complete names of species are given in table 1. [*'Factor loadings' de las especies de aves para las dos primeras componentes extraídas mediante el PCA (autovalores y varianza explicada entre paréntesis). Véase tabla 1 para interpretar los acrónimos de las especies.*]

separating Mediterranean species (positive values) from inland species (negative values).

PCA1 and PCA2 were significantly different among the three bioclimatic regions, although the explained variance was greater when analyzing PCA2 (table 2). Burnt sites within the northwest region were characterized by inland species whereas burnt areas within the northeast region were distinguished by Mediterranean species. At the same time, fires within the south region had more forest-avoiding species than the others regions (figure 4).

On the other hand, PCA1 and PCA2 were also significantly related to time since fire (table 2). Time since fire was negative related to PCA1, indicating a temporal shift towards a community dominated by forest-avoiding species, and positive related to PCA2, thus suggesting a community change towards relatively more Mediterranean species. Nevertheless, the explained variance was very low for both axes (table 2). This result might suggest that, above to a certain level, the bird community response to fire at short-temporal scale depend on other factors rather than the number of years elapsed after fire.

The structure of pre-fire vegetation (i.e. whether it was a forest or shrubland) had a significant effect on both PCA factors, although its effect was much stronger in the case of PCA1 (table 2). Burnt forest areas showed higher proportion of forest species comparing to burnt shrubland areas (figure 5).

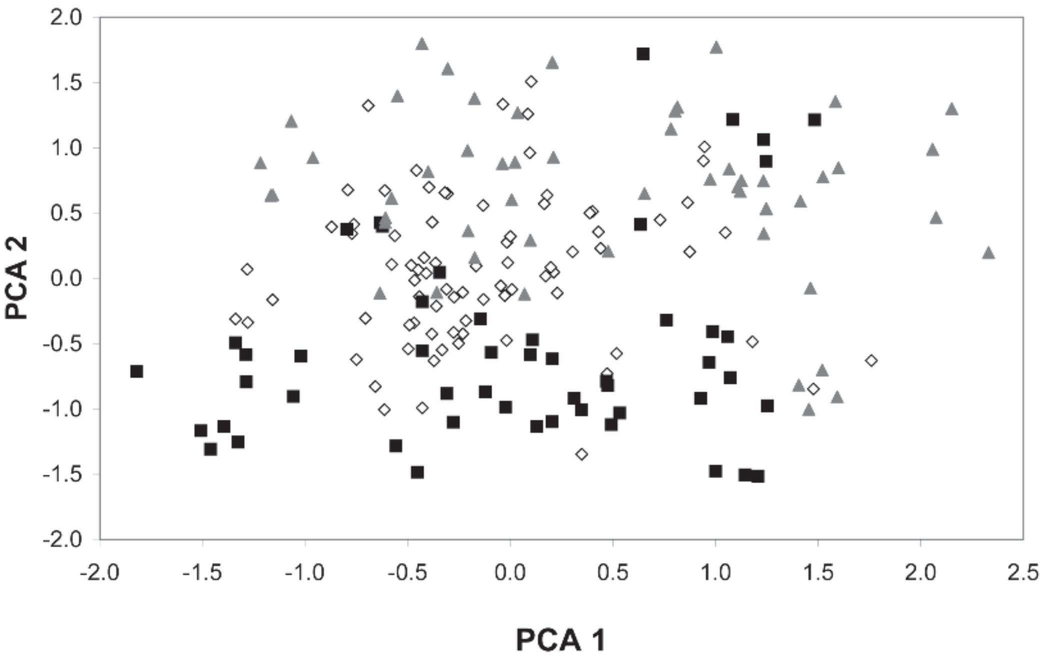

FIG. 4.—The arrangement of fire sites within the south region (open diamond), the northwest region (filled squares) and the northeast region (filled triangle) monitored during fieldwork in the two axes of the PCA.
[Ordenación de los incendios en los dos ejes del PCA en las zonas sur (rombos claros), noroeste (cuadrados oscuros) y noreste (triángulos oscuros).]

TABLE 2

Effects on bird community descriptors (PCA1 and PCA2) of bioclimatic region (three levels, see figure 1), time since fire (continuous predictor) and pre-fire vegetation (two levels, 'forest' and 'shrub').
[Efectos sobre los descriptores de la comunidad de aves (PCA1 y PCA2) de la región bioclimática (tres niveles, véase figura 1), el tiempo pasado desde el incendio (predictor continuo) y la vegetación previa al incendio (dos niveles, 'forestal' y 'arbustivo').]

Dependent variable	**Effect**	**Type of analysis**	**d.f.**	**F-value**	**P-value**	**R^2**
PCA1	Region	One-way ANOVA	2	9.62	< 0.01	0.09
	Time Since Fire	Simple regression	1	8.60	< 0.01	0.04
	Pre-fire vegetation	One-way ANOVA	1	43.43	< 0.001	0.30
PCA2	Region	One-way ANOVA	2	45.49	< 0.001	0.33
	Time Since Fire	Simple regression	1	6.03	< 0.05	0.03
	Pre-fire vegetation	One-way ANOVA	1	13.72	< 0.001	0.12

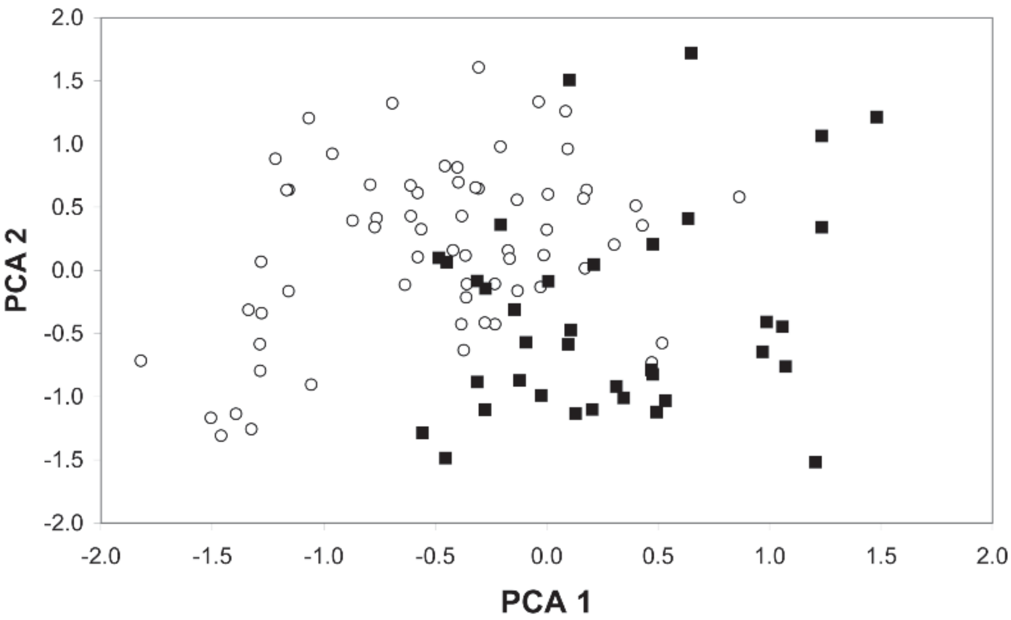

FIG. 5.—The arrangement of forest fires (filled squares) and shrubland fires (open circles) monitored during fieldwork in the two axes of the principal component analysis.
[Ordenación en los dos ejes del PCA de los incendios en medios forestales (cuadrados oscuros) y en medios arbustivos (círculos claros).]

DISCUSSION

Our results indicate a large temporal and spatial variability in the species response to fire. Post-fire bird community varied with time elapsed since fire and in the different bioclimatic regions, indicating that multiple factors acting at different spatial and temporal scales determine species composition after fire. Jacquet and Prodon (2009) studied the post-fire vegetation and bird succession in a Mediterranean oak woodland for 28 years and showed that the most important factor determining post-fire bird community in the long-term scale is vegetation recovery; first starting with open-habitat species, then shrubland species and finally forest species. In our work, we focussed on the first stage of the successional process, when habitat is characterized by low habitat structure (herbaceous and shrubland vegetation) and bird community is most often dominated by open-habitat species.

We found bird community composition to be strongly constrained by pre-fire vegetation. Fires that occurred in shrubland habitats, mostly concentrated in the southern region of Catalonia, contained more forest-avoiding species than fires affecting forests. The strong site tenacity, philopatry and habitat tolerance of some forest species and the persistence of standing dead trees might explain the presence of these species in the first years following fire (Prodon *et al*., 1987; Pons and Prodon, 1996; Hutto, 2006). Nevertheless, these species usually disappear during the following years and do not reappear until the vegetation attains a woody appearance

(Jacquet and Prodon, 2009). This would explain the results obtained in this study where bird community composition in forest burnt areas tended to shift towards more forest-avoiding species with time since fire, in what would seem the opposite pattern to that expected from bird responses to vegetation succession.

Additionally, fires sites within the northwest region had more inland species, whereas fires within the northeast region hosted more Mediterranean species. This result suggests that other factors acting at the regional scale determine the bird community response to fire. The habitat context and the species dispersal capacity might explain difference in the bird community at regional scale. Hence, Brotons *et al*. (2005) suggest that open-habitat species colonisation of recently burnt areas relies on relatively short-dispersal distance since they showed that only those fires located nearby open-habitat species population sources might have the chance of being colonised by these species. Our data suggests that these factors and its interactions may account for the strong spatial variability in bird community responses to fire.

Finally, some of the most common species detected in the studied wildfires during the study period were, as expected, associated to open-habitats. These species are among the most threatened European bird species due to land abandonment and agricultural intensification (BirdLife International, 2004), and Mediterranean burnt areas seem to counteract these negative processes by providing suitable habitat for them (Moreira and Russo, 2007). In this sense, this database represent a powerful tool to identify ecological processes affecting open-habitat bird dynamics, giving additional information on the causes under general trends observed using other monitoring systems. For instance, a recent study has shown that the expansion in Catalonia of the ortolan bunting *Emberiza hortulana*, a species that has suffered a great population decline across Europe, is due to the occupancy of recently burnt areas (Brotons *et al.*, 2008). On the other hand, it is also relevant the abundance of the Dartford warbler *Sylvia undata*. This species has been newly updated as near threatened (BirdLife International, 2009) due to its population declines in Spain. Nevertheless, it was one of the most common species in the studied sites (34% of occurrence), indicating a high occupancy of burnt areas.

In conclusion, we have shown that the bird community response to fire is heterogeneous and complex. The type of vegetation prior to the fire, subsequent post-fire management, and the landscape context are critical in determining bird community composition after fire. These factors and their interactions probably determine the capacity of pioneer species, mostly open-habitat bird species to arrive on burnt areas: for example there might be a lower probability of finding a population source in a forest burnt area than in a shrubland burnt areas (Brotons *et al.*, 2008). Further studies are needed to complete and document the progression towards a shrubland and forest species composition. Here, the current fire regime is especially worthy of attention. Recurrent fires may reduce the sprouting capacity of many Mediterranean plants; large wildfires may induce homogeneity and species that were previously less affected by fire might be more prone to fire (Pausas *et al.*, 2008). As a result, plant succession may be hampered and open vegetation may become permanent. In this context, the use of a large and an extensive bird-monitoring database including common bird species in burnt areas may offer a reliable tool to investigate such complex impacts.

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Annex 1

Summary description of the three bioclimatic regions of Catalonia, according to dominant forest species, mean annual temperature (T), and mean annual precipitation (P). Data are from DGMN (1994) and Burriel *et al.* (2000-2004).
[Descripción resumida de las tres regiones bioclimáticas de Cataluña de acuerdo a las especies de árboles dominantes, la temperatura media anual (T), y la precipitación media anual (P). Los datos proceden de DGMN (1994) y Burriel et al. *(2000-2004).]*

Region	**Mean annual T (ºC)**	**Mean annual P (mm)**	**Dominant forest species**
1. South	14.41	533.91	*Pinus halepensis, Quercus ilex, Pinus nigra*
2. Northwest	10.00	810.42	*Pinus sylvestris, Pinus nigra, Quercus ilex, Quercus humilis*
3. Northeast	13.02	841.99	*Quercus ilex, Quercus humilis, Pinus sylvestris, Quercus suber*

ANNEX 2

Description of the areas affected by fire, in chronological order. The description includes the name, code, main habitats before the fire, year when the fire occurred, fire area, and number of line transects conducted within fire perimeter in 2006, 2007, 2008 and 2009.

[Descripción de las áreas afectadas por los incendios, en orden cronológico. Se incluyen los nombres de las localidades, códigos, hábitats principales previos al incendio, año en que ocurrió el incendio, área quemada, y número de transectos lineales realizados dentro del perímetro del incendio en 2006, 2007, 2008 y 2009.]

Fire Name	**Fire Code**	**Year**	**Main Habitat**	**Fire area (ha)**	**2006**	**2007**	**2008**	**2009**
Albiol	29	2000	Shrubland	645.48	17	17	16	17
Camposines	34	2000	Shrubland	52.11	2	2		2
Fontrubi	23	2000	Forest (*Pinus halepensis*)	87.57	3	3		3
Garriguella	2	2000	Shrubland	6389.19	31	31		31
Olivella	25	2000	Shrubland and *P. halepensis*	382.77	12	12		10
PratdeCompte	33	2000	Forest (*P. halepensis*)	275.85	13	14		13
Badalona	17	2001	Shrubland	66.51	3	3		
Cadaques	1	2001	Shrubland	1744.11	25	25		
Castelldefels	26	2001	Shrubland	53.73	2	2		
Cubells	42	2001	Shrubland and *Quercus coccifera*	207.18	11	11		
Escala	3	2001	*P. halepensis* and shrubland	371.88	11	11	11	12
LaFloresta	40	2001	Shrubland	109.89	5	5		
VallbonaAnoia	21	2001	*P. halepensis*, *Pinus pinea*, shrubland and *Quercus ilex*	51.75	2	2		
Castellbisbal02	19	2002	Shrubland	126.72	5	5	5	
Tivissa	31	2002	Shrubland and *P. halepensis*	53.91	2	2	2	
VilaverdLilla	27	2002	Shrubland	495.27	15	15	15	
Alcover	28	2003	Shrubland	215.37	10	10	10	10
CaldesMalavella03	8	2003	*P. pinea* and shrubland	60.21	2	2	2	2

ANNEX 2 (cont.)

Fire Name	**Fire Code**	**Year**	**Main Habitat**	**Fire area (ha)**	**2006**	**2007**	**2008**	**2009**
CastellbelliVilar	16	2003	Shrubland and *P. halepensis*	296.91	14	14	13	12
DaltmarOlerdola	24	2003	Shrubland	129.24	6	6	6	6
GranjaEscarp	39	2003	Shrubland	1794.33	22	22	22	22
Jorba	22	2003	Shrubland	64.35	3	3	3	3
MasanetGran	9	2003	*Quercus suber*, *P. pinea*, *Pinus pinaster*, *Q. ilex* and shrubland	920.52	21	21	21	21
MasanetPetit	10	2003	*Q. ilex*, *Q. suber* and shrubland	62.64	2	2	2	2
Masquefa	20	2003	Forest (*P. halepensis*)	58.77	3	3	2	3
PlatjaAro	5	2003	Shrubland, *Q. suber*, *P. halepensis* and *P. pinea*	318.51	12	12	12	12
SantFeliuGuixol	6	2003	Shrubland, *Q. suber*, *P. halepensis* and *P. pinea*	514.44	18	18	18	18
SantLlorensSavall	15	2003	Forest (*P. halepensis*)	4483.26	30	30	30	30
Selvanera	41	2003	Shrubland	121.86	5	5	5	5
Talamanca	14	2003	Forest (*P. halepensis*)	191.07	7	7	7	7
Montanissell	43	2004	Shrubland and *Pinus nigra* subsp. *salzmanni*	80.82	4	4	4	4
Montgri	4	2004	Shrubland	500.85	16	16	16	16
Balsareny	12	2005	Forest (*P. halepensis*)	858.87	19	20	19	19
BorgesdelCamp	30	2005	Shrubland and *P. halepensis*	105.75	3	3	3	3
CaldesMalavella05	7	2005	*P. pinea* and shrubland	78.57	3	3	3	2
Cardona	11	2005	Forest (*P. halepensis*)	1216.17	21	21	21	21
Castellbisbal05	18	2005	Shrubland and *P. halepensis*	206.73	6	6	6	6

ANNEX 2 (cont.)

Fire Name	**Fire Code**	**Year**	**Main Habitat**	**Fire area (ha)**	**2006**	**2007**	**2008**	**2009**
Margalef	38	2005	*P. halepensis* and shrubland	384.21	13	13	13	13
PalmadeEbre	37	2005	Shrubland	90.18	4	4	4	4
Perello	32	2005	Shrubland	96.57	5	5	5	5
PobladeMasaluca	35	2005	Shrubland and *P. halepensis*	104.04	4	4	4	4
RibaRoja05	36	2005	*P. halepensis* and shrubland	605.25	18	18	18	18
Rocafort	13	2005	*P. halepensis* and shrubland	783.72	20	20	18	20
Viladecans	44	2005	Shrubland	57.78	3	3	3	3
Capmany	47	2006	Shrubland and *Q. suber*	239.85		11	11	11
Cistella	46	2006	*P. halepensis* and shrubland	200.52		9	7	7
LaFebro	50	2006	*Pinus sylvestris* and shrubland	50		2	2	2
Ogern	48	2006	Forest (*P. nigra* subsp. *salzmanni*)	86.04		4	4	4
Vandellos	51	2006	Shrubland	1129.5		21	21	20
Ventallo	45	2006	Forest (*P. halepensis*)	768.33		20	20	20
Vimbodi	49	2006	*P. halepensis* and shrubland	115.38		5	5	5
MontroigdelCamp	53	2007	Forest (*P. halepensis*)	287.1			12	12
NavasStSalvadorTo	56	2007	Forest (*P. halepensis*)	221.76			9	9
RibaRoja07	52	2007	Shrubland and *P. halepensis*	91.8			4	4
Sallent	55	2007	Forest (*P. halepensis*)	64.17			3	3
TorredeFontaubella	54	2007	Shrubland	419.58			12	12
Total					**453**	**527**	**449**	**488**

ANNEX 3

Proportion of burned areas surveyed from 2006 to 2009, and planned for 2010. Black, grey and white indicating 100%, 10-20% and 0% of wildfires monitored respectively. The total number of wildfires monitored per year is also shown. Note that in 2008 none of the wildfires occurring in Catalonia fulfilled the conditions to be included in DINDIS.
[Proporción de área quemada inspeccionada entre 2006 y 2009 y la prevista para 2010. En negro, gris y blanco se indican porcentajes de seguimiento del 100%, 10-20% y 0%, respectivamente. También se muestra el número total de incendios inspeccionados cada año. Nótese que en 2008 ninguno de los incendios catalanes cumplió las condiciones necesarias para ser incluido en DINDIS.]