BIRD COMMUNITY SUCCESSION AFTER FIRE IN A DRY MEDITERRANEAN SHRUBLAND

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Animal succession and restoration of community structure after fire are related to vegetation regeneration, which is influenced by climate. As the thermo-Mediterranean life zone is characterised by stronger dryness conditions than other Mediterranean zones, we hypothesised that the bird community succession here is very slow. We used the point-count method to census birds from the first to the sixth breeding seasons after fire in burnt and control shrublands of the northeastern Iberian Peninsula. Bird richness and abundance increased rapidly and even exceeded the values of the control zone six years after the fire. Nevertheless, in the burnt zone, the expected change from communities dominated by open-space species to communities dominated by shrubland species was not detected and high proportions of the former were maintained in the species pool throughout the study period.

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INTRODUCTION

The understanding of ecosystem response to perturbations has greatly interested biologists and wildlife managers (Meffe *et al.* 1997). In particular, the effects of fire in bird communities has focused researchers' attention all over the world, but despite the high frequency of this disturbance in the Mediterranean basin, post-fire bird studies are rather scarce for these systems (Prodon & Pons 1993). The studies of post-fire bird successions in Mediterranean systems were initiated in California by Lawrence (1966), who showed that flames did not kill birds, but rather forced relocation in appropriate adjacent habitats, and that grassland bird species colonised the burnt areas. Prodon *et al.* (1984) started bird successional studies in the Mediterranean Basin and showed that trends in bird populations were dependent on how vegetation regenerated. Thus, bird communities reached pre-fire species composition faster in areas where trees sprouted from main branches (e.g. the Cork Oak *Quercus suber*) than in those where fire killed the aerial parts of plants (e.g. the Holm Oak *Quercus ilex*). Prodon *et al.* (1987) found that, as a consequence of site tenacity and habitat tolerance of some forest species, avian succession could be temporally non-equilibrated with vegetation regeneration in some burnt habitats. Later, Pons & Prodon (1996) reported an early and continuous use of burnt shrublands and explained the moderate effects of fire on bird communities as a consequence of site tenacity and the persistence of patches of unburnt vegetation.

All these studies have been carried out in the 'meso-Mediterranean' life zone, which has a moderate climate and is characterised by evergreen oaks such as Holm Oak and Cork Oak as dominant tree species (Blondel & Aronson 1999). No attempt has been made to study bird successions after fire in the dryer 'thermo-Mediterranean' life zone, which is characterised by dense coastal woodlands of Wild Olive Trees *Olea europaea*, Lentisk *Pistacia lentiscus*, Mediterranean Dwarf Palm *Chamaerops humilis* and a variable abundance of Aleppo Pines *Pinus halepensis* (Blondel & Aronson 1999). Furthermore, these plant communities are known to recover slowly after fire since water limitation is one of the key factors in the succession dynamics of Mediterranean vegetation (Zavala *et al.* 2000). In addition, Stanton (1986) indicated that bird community dynamics after fire in dry Mediterranean coastal shrublands of California differed notably from that of the more humid chaparrals.

The aim of this work was to study the succession of bird communities in a thermo-Mediterranean shrubland. We hypothesised that, given the dryness of this area, avian succession after fire would be characterised by a slow increase of richness and abundance and by a slow change from communities dominated by open-space bird species to communities dominated by shrubland bird species.

MATERIAL AND METHODS

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 skeletic soils which implies very dry conditions for plant communities. In fact, the Garraf Massif represents the northern border of the thermo-Mediterranean life zone in the Iberian Peninsula. After a long period only slightly interrupted by small fires, two extensive wildfires have profoundly marked the latest decades: the first burnt 10000 ha in 1982 and the second, which encompassed the first, affected 5000 ha in 1994. This last fire was very intense and, as a result, less than 2% of the area located within the 1994-burnt matrix remained covered by small and isolated patches of unburnt vegetation.

Similarities between the zone burnt in 1994 and the zone not affected by that fire were not tested before the fire event. Nevertheless, we did not find significant differences in relief and landscape characteristics between these zones when the study was carried out (Table 1). Furthermore, the floristic composition was quite similar in the two zones, including shrub species such as Kermes Oak *Quercus coccifera*, Lentisk, *Phillyrea latifolia*, Rosemary *Rosmarinus officinalis*, Wild Olive Trees and Mediterranean Dwarf Palm, scattered young Aleppo Pines and grasses such as *Brachypodium restusum*. Thus, the main differences between zones were of structural nature, in

Table 1. Location characteristics of zones burnt and not burnt in 1994. Variables compared include altitude, slope orientation and landscape structure (percentage of habitat burnt in 1994 within the zone affected by the 1994-fire, and percentage of habitat burnt in 1982 within the zone only affected by the 1982-fire). Data comes from the comparison of 30 surveys (12.5 ha) randomly distributed in each zone. Mean (SD) and *t*-test for independent samples are shown for parametric variables, but for orientation, a circular variable, mean angle (angular deviation) and the Watson-Williams test are shown (Zar 1984).

	burnt in 1994	unburnt in 1994	test	*P*
Altitude (m)	333 (101)	376 (104)	t = - 1.62	0.111
Slope (degrees)	14.1º (8.8º)	17.0º (8.4º)	t = - 1.28	0.207
Orientation (degrees)	-24º (63º)	-33º (72º)	$F_{1,53}$ = 0.12	0.265
Habitat (%)	95.6 (8.28)	95.4 (7.03)	t = 1.26	0.900

Table 2. Comparison of habitat structure between burn and the control study zones. Data was obtained in 1997, an intermediate point in the study period, and comes from the comparison of 30 surveys (12.5 ha) randomly distributed in each zone. The relative cover value of each vegetation layer was obtained following Prodon & Lebreton's (1981) procedure. Mean (SD) and Mann-Whitney U-test results are shown.

	burnt in 1994	unburnt in 1994	Mann-Whitney *U*- test	*P*
% Cover (0-0.25 m)	55.0 (14.3)	31.3 (16.7)	4.79	<0.001
% Cover (0.25-0.5 m)	43.3 (10.9)	53.3 (17.8)	-2.36	<0.05
% Cover (0.5-1 m)	18.9 (8.7)	49.1 (20.0)	-6.01	<0.001
% Cover (1-2 m)	1.7 (1.8)	15.9 (14.8)	-5.28	<0.001
% Cover (2-4 m)	0.6 (0.2)	2.5 (4.3)	-3.88	<0.001

close association with fire effects (Table 2). Therefore, we considered the zone unburnt in 1994 as a suitable control to study the temporal dynamics of bird communities occurring in the burnt one. Hereafter and to simplify the terminology, the two zones are called burnt zone (the zone burnt in 1994) and control zone (the zone not burnt in 1994). The simultaneous monitoring of burnt and control zones represents a suitable way to study succession after fire since it incorporates a parallel control which eliminates the influence of temporal variations unrelated to the occurrence of fire (Prodon & Pons 1993).

Bird counts

The censuses were carried out in the burnt and control zones during the breeding seasons of 1995, 1997, 1998 and 2000. Point-counts with no estimation of distance were employed to assess the abundance of bird species (Bibby *et al.* 1992). We selected 35 counting stations (19 in burnt zone, 16 in control zone), locating them at a minimum 400 m distance from each other to minimise pseudoreplication. The area around each station was homogeneous and did not include farmland, urbanised areas or cliffs. Each station was surveyed once in each of the four years and thus, a total of 140 censuses was carried out during the study period. Counting was conducted in the morning, during the period of maximum activity of birds, starting 1 h after dawn and 5 min after the arrival at the station. Point counts 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. Raptors, aerial feeders (such as swallows, swifts or bee-eaters) and crepuscular species were not taken into account in the calculations because this method is not appropriate for assessing their abundance (Bibby *et al.* 1992). We carried out bird censuses under uniformly good weather conditions, without rainfall or wind.

Analysis

Bird abundance and richness were assessed as the total number of individuals and species detected at each station during 10 minutes. Classical measurements of diversity such as the Shannon index H' were not assessed because they are positively correlated with richness and the supplementary information conveyed by H' is usually low in breeding bird communities (Prodon 1992). Correspondence analysis was used to obtain a main factor that summarised the principal ordination of bird species and was interpreted *a posteriori* regarding the ecology of the species concerned. Correspondence analysis is a descriptive/exploratory technique designed to analyse multiway tables containing some measure of correspondence between the rows and columns (Greenacre 1984). This analysis attributes scores to both species and stations so that the correlation between station scores and species scores is maximal, giving the best 'correspondence' between

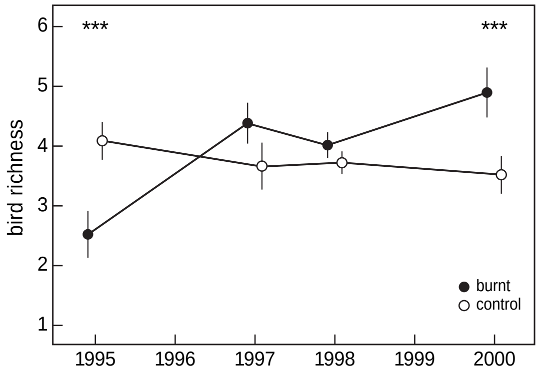

Fig. 1. Variation in bird richness after 1994 fire. Bars indicate Standard Error. According to Tukey HSD test, significant differences between zones in a year are marked *** in the top of the figure.

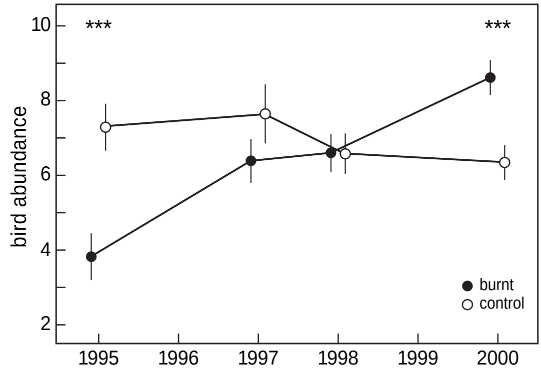

Fig. 2. Variation in bird abundance after 1994 fire. Bars indicate Standard Error. According to Tukey HSD test, significant differences between zones in a year are marked *** in the top of the figure.

species and stations (Prodon 1992). We used repeated measures ANOVA and the post-hoc Tukey Honest Significant Difference (HSD) Test (Sokal & Rohlf 1995) to analyse variations in bird community descriptors (richness, abundance and the main factor from the correspondence analysis) in relation to zone (burnt and control) and time since fire. All statistical analyses were run with Statistica Statsoft, Inc. 1999.

RESULTS

Considering the whole study period, bird richness did not differ between burnt and control zones ($F_{1,33}$ = 0.39, P = 0.536). However, bird richness was not constant across years ($F_{3,99}$ = 4.17, P < 0.01). This temporal variation in bird richness was not homogenous and was greatly determined by the zone under study ($F_{3,99}$ = 10.74, P < 0.01). Richness was higher in the control zone than in the burnt one during the first year after fire, did not differ between zones from the second to the fourth year after fire and became higher in the burnt zone in the sixth year after fire (Fig. 1).

Similarly, bird abundance did not differ between zones ($F_{1,33}$ = 1.01, P = 0.321), but differed between years ($F_{3,99}$ = 4.63, P < 0.01). The interaction between the zone and the year was also highly significant ($F_{3,99}$ = 9.74, P < 0.001). As for bird richness, the abundance was higher in the control zone than in the burnt zone during the first year after fire. This difference disappeared in the next years until the sixth year after fire, when bird abundance became higher in the burnt zone (Fig. 2).

A total of 18 breeding species were found in the set of stations during the study period

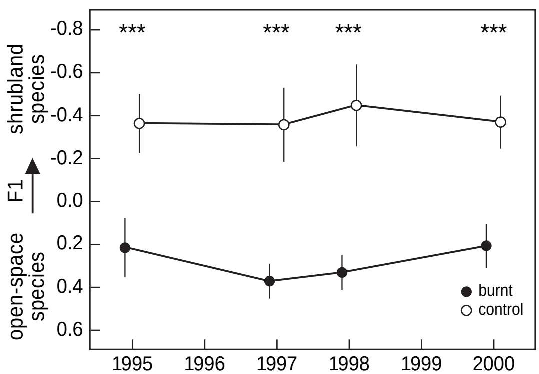

Fig. 3. Variation in the gradient open-space species / shrubland species (F1) after 1994 fire. Bars indicate Standard Error. According to Tukey HSD test, significant differences between zones in a year are marked *** in the top of the figure.

Table 3. Relative abundance of the bird species found in the two studied zones (burnt zone / control zone), expressed as the mean number of individuals detected in a station during the 10 min. census. The score of the first factor of the correspondence analysis (F1) for each bird species is also shown.

Bird species	1995	1997	1998	2000	F1
Tawny Pipit *Anthus campestris*	0.05 / 0	0.21 / 0.06	0.16 / 0.13	0.21 / 0	1.51
Ortolan Bunting *Emberiza hortulana*	0.11 / 0.13	0.11 / 0	0.05 / 0.13	0.26 / 0	0.93
Thekla Lark *Galerida theklae*	0 / 0	0.11 / 0	0.11 / 0	0.16 / 0	0.88
Corn Bunting *Miliaria calandra*	0.21 / 0.13	0.37 / 0	0 / 0	0.26 / 0	0.78
Rock Thrush *Monticola saxatilis*	0.05 / 0.30	0.11 / 0.06	0 / 0.13	0.05 / 0.06	0.64
Southern Grey Shrike *Lanius meridionalis*	0.21 / 0.13	0.42 / 0.19	0.37 / 0.13	0.32 / 0.25	0.62
Western Black-eared Wheatear *Oenanthe hispanica*	0.74 / 0.19	1.05 / 0.31	1.05 / 0.13	0.79 / 0.12	0.56
Woodchat Shrike *Lanius senator*	0.26 / 0.06	0.26 / 0	0.05 / 0	0.11 / 0	0.5
Red-legged Partridge *Alectoris rufa*	0.47 / 0.13	0.95 / 0.31	0.53 / 0.06	0.16 / 0.13	0.4
European Stonechat *Saxicola rubicola**	0.42 / 1.06	0.53 / 0.75	1.00 / 0.50	1.21 / 0.50	0.35
Dartford Warbler *Sylvia undata*	0.68 / 1.94	1.32 / 2.19	2.37 / 2.00	3.11 / 1.82	-0.1
Sardinian Warbler *Sylvia melanocephala*	0.26 / 1.44	0.79 / 2.00	0.63 / 1.81	1.58 / 2.62	-0.4
Great Tit *Parus major*	0.05 / 0.44	0.11 / 0.25	0 / 0.06	0.11 / 0.25	-0.8
Rock Bunting *Emberiza cia*	0 / 0	0 / 0.13	0 / 0.13	0 / 0	-0.8
Blackbird *Turdus merula*	0.16 / 0.75	0.05 / 0.56	0.26 / 1.00	0.26 / 0.19	-1
Wren *Troglodytes troglodytes*	0 / 0.38	0 / 0.19	0 / 0.25	0 / 0.25	-1.4
Long-tailed Tit *Aegithalos caudatus*	0 / 0	0 / 0.44	0 / 0	0 / 0	-1.8
Nightingale *Luscinia megarhynchos*	0 / 0.19	0 / 0.19	0 / 0.13	0 / 0.13	-2.2

*previously known as Stonechat *Saxicola torquata* (see *Ardea* 87: 150-151)

(Table 3). The first factor (F1) of the correspondence analysis, which represented 13.4% of total data variance, corresponded to an ecological gradient ranging from open-space bird species (positive values) to shrubland bird species (negative values). The extreme negative values represented forest species that managed to breed in stations with a high shrub development (Table 3). Therefore, variations of F1 corresponded to the variations from communities dominated by open-space species to communities dominated by shrubland species. In the burnt stations, independent of year, the community composition was clearly dominated by open-space birds, whereas shrubland species characterised the control stations ($F_{1,32}$ = 20.06, P = 0.001) (Fig.3). However, F1 remained very stable during the studied period (five years) in both burnt and control zones, and no significant trend was found between years ($F_{3,96}$ = 0.30, P = 0.827) nor in the interaction between years and zone ($F_{3,96}$ = 0.56, P = 0.645) (Fig. 3). Therefore, we did not detect any change from communities dominated by open-space species to communities dominated by shrubland species from the first to the sixth breeding season after the 1994-fire.

DISCUSSION

Our results show that bird richness and abundance increased rapidly after the 1994-fire and even exceeded the values reported in the control zone the sixth year after fire, whereas these parameters did not change in the control zone. This rejects our hypothesis of a slow increase of these parameters in dry thermo-Mediterranean areas. The results are also at variance with the reported speed of bird successions studied in more humid meso-Mediterranean burnt shrublands (Prodon *et al.* 1984). Trabaud & Papió (1987), studying the vegetation regeneration in the Garraf Natural Park after the 1982-fire found a slow recovery of the pre-fire vegetation. However, they reported a rapid plant growth during the first two years after fire, followed by a slowing down of the process later on. Initially, this fast vegetation regeneration seemed to be rapid enough to allow birds to reach, and even exceed, pre-fire abundance and richness. Nevertheless, it should be remarked that the whole process of vegetation recovery after fire may take several decades. As an example, the zone burnt in 1982 had, in the year 2000, pines only 4 m tall. This gives an idea of the time frames involved in restructuring completely forest communities in the dry conditions prevailing in our study area.

Low richness and abundance in burnt areas one year after fire, compared with unburnt controls, are common in post-fire studies in the Mediterranean Basin (e.g. Prodon *et al.* 1987; Pons & Prodon 1996; García 1997). Later, as succession continued, we found that richness and abundance even surpassed the values observed in the control. Prodon *et al.* (1984) also reported higher bird richness in meso-Mediterranean burnt shrublands than in unburnt controls. As suggested by these authors, this event may indicate that the number of ecological niches at the scale of a census station was higher in burnt shrublands than in adjacent control ones, which may be related to a higher heterogeneity of habitat structure in burnt stations. This association between spatial heterogeneity and bird richness has been repeatedly reported (Wiens 1989). In our case, six years after fire isolated shrubs had grown enough to form a mosaic with grasses and stony grounds, which contrasted with the high uniformity of habitat within control stations. Actually 5-6 years after fire often represents the best period for bird species diversity in Mediterranean-type ecosystems, whereas old matorrals maintain poor bird communities (Blondel, pers. comm.). However, the spatial heterogeneity of landscapes is usually scale-dependent (Forman & Gordon 1986). In fact, the spatial variation of habitat structure and avifauna in our two study zones differed more among control stations than among burnt ones (unpubl. data). This suggests that on a large scale (zone), the area affected by the 1994-fire is more homogeneous than the control area, whereas on a small scale (stations) the relationship is opposite.

We did not found any shift from communities dominated by open-space species to communities dominated by shrubland species during the six year study period. This was related to the simultaneous increase in the occurrence of both shrubland species (such as Dartford Warbler and Sardinian Warbler) and open-space species (such as Thekla Lark *Galerida theklae* and Tawny Pipit

Anthus campestris), which is consistent with the progressive increase in bird richness and abundance observed in the burnt zone. Thus, in spite of the short-time scale, these results clearly show differences with those found by Prodon *et al.* (1987) in burnt Holm Oak forests, since these authors reported the departure of open space-species (larks, buntings, wheatears) in the five years after fire. These findings have interesting implications for bird conservation in Mediterranean areas because 75% of bird species inhabiting the burnt zone are considered to have decreasing or vulnerable populations in Europe (Tucker & Heath 1994), especially through habitat loss (Rocamora 1997). The permanence of populations of open-space species during the first six years after fire suggests that burnt dry Mediterranean shrublands may be appropriate habitats for their conservation. Several of these species were also present in the control (which in fact was also burnt in 1982), but with lower abundance than in the burnt zone, suggesting that recently burnt areas are a more suitable habitat. From a management perspective, prescribed burning may contribute to maintain high quality habitats for such species. In the Mediterranean France, Pons (1998) reported colonisation of open-space species (e.g. Tawny Pipit and Woodlark *Lullula arborea*) after a prescribed fire. However, he found a marked decrease in the densities of this group of birds as early as the second year after fire, when the shrub cover had regenerated enough. Our results suggest that these types of management policies could be of great interest in burnt thermo-Mediterranean shrublands, in which open-space species do not decrease as rapidly after fire.

In conclusion, our results suggest that bird community succession after fire in the thermo-Mediterranean life-zone is, at least during initial stages, characterised by a fast increase in bird richness and abundance, but not by a clear change from communities dominated by open-space species to communities dominated by shrubland species. Further studies are needed to complete and document the progression towards a shrubland and forest species composition. The interest in long-term studies is stressed by current fire frequency. Recurrent fires may reduce the sprouting capacity of many Mediterranean plants, impede storage of enough seeds during the pre-fire stage and degrade soils via erosion (Le Houérou 1981; Blondel & Aronson 1999). As a result, plant succession may be hampered and open vegetation may become permanent, even if fire frequency decreases. During the last decades, this phenomenon has taken a predominant role in many areas of the Iberian Mediterranean coast (Carreira & Niell 1992; Puigdefàbregas & Mendizabal 1998).

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REFERENCES

Bibby C.J., N.D. Burgess & D.A. Hill 1992. Bird Census Techniques. Cambridge Univ. Press, Cambridge.

Blondel J. & J. Aronson 1999. Biology and wildlife of the Mediterranean region. Oxford Univ. Press, Oxford.

Carreira J.A. & F.X. Niell 1992. Plant nutrient changes in a semi-arid Mediterranean shrubland after fire. J. Veg. Sc. 3: 457-466.

Forman R.T.T. & M. Gordon 1986. Landscape Ecology. Wiley, New York.

Fuller R.J. & D.R. Langslow 1984. Estimating numbers of birds by point counts: how long should counts last? Bird Study 31: 195-202.

García J.A. 1997. Caracterización y uso del hábitat por la avifauna en los bosques quemados de la provincia de León. Ph.D.-thesis, University of León, León.

Greenacre M.J. 1984. Theory and applications of correspondence analysis. Academic Press, New York.

Lawrence G.E. 1966. Ecology of vertebrate animals in relation to chaparral fire in the Sierra Nevada foothills. Ecology 47: 278-291.

Le Houérou H.N. 1981. Impact of man and his animals. In: di Castri F., D.W. Goodall & R.L. Specht (eds). Mediterranean-type shrublands: 479-521. Collection Ecosystems of the world, 11. Elsevier, Oxford.

Meffe G.K. & C.R Caroll (eds) 1997. Principles of Conservation Biology. Sinauer Associates INC, Massachusetts.

Pons P. & R. Prodon 1996. Short term temporal patterns in a Mediterranean shrubland bird community after fire. Acta Oecol. 17: 29-41.

Pons P. 1998. Bird site tenacity after prescribed burning in a Mediterranean shrubland. In: Trabaud L. (ed.). Fire Management and landscape Ecology: 261-270. International Association of Wildland Fire, Fairfield, Washington.

Prodon R. & Lebreton J.D. 1981. Breeding avifauna of a Mediterranean succession: the Holm Oak and the Cork Oak series in eastern Pyrenees. Analysis and modelling structure gradient. Oikos 37: 21-38.

Prodon R., R. Fons & A.M. Peter 1984. L'impact du feu sur la végétation, les oiseaux et les micromammifères dans diverses formations des Pyrénées-Orientales: premiers résultats. Rev. Eco. Terre Vie 39: 129-158.

Prodon R., R. Fons & F. Athias-Binche 1987. The impact of fire on animal communities in Mediterranean area. In: Trabaud L. (ed.) The role of fire on ecological systems: 121-157. SPB Academic Publ., The Hague.

Prodon R. 1992. Animal communities and vegetation dynamics: measuring and modeling animal community dynamics along forest successions. In: Teller A., P. Mathy & J.N.R. Jeffers (eds). Responses of forest ecosystems to environmental changes: 126-141. Elsevier, London.

Prodon R. & P. Pons 1993. Postfire bird studies: methods, questions and perspectives. Fire in Mediterranean ecosystems. In: Trabaud L. & R. Prodon (eds) Ecosystems research reports 5: 332-343. Commission of the European communities, Brussels.

Puigdefàbregas J. & T. Mendizabal 1998. Perspectives on desertification: Western Medit. J. arid environm. 39: 209-224.

Rocamora G. 1997. Mediterranean forest, shrubland and rocky habitats. In: Tucker G.M. & M.I. Evans (eds). Habitat for birds in Europe: a conservation strategy for a wider environment: 239-265. BirdLife International, Cambridge.

Sokal R.R. & F.J. Rohlf 1995. Biometry. Freeman, New York.

Stanton P.A. 1986. Comparison of avian community dynamics of burnt and control coastal sage scrub. Condor 88: 285-289.

Trabaud L. & C. Papió 1987. Recuperació de les garrigues cremades de Montpellier i Garraf. In: Terrades J. (ed.). Ecosistemes terrestres: la resposta als incendis i a d'altres pertorbacions, 8: 101-112. Quaderns d'Ecologia Aplicada. Diputació de Barcelona, Barcelona.

Tucker G. M. & M. F. Heath 1994. Birds in Europe: their conservation status. Bird Conservation Series 3., BirdLife International, Cambridge.

Wiens J.A. 1989. The ecology of bird communities, I-II. Cambridge University Press, Cambridge.

Zar J. R. 1984. Biostatistical analysis. Prentice-Hall Inc., New Jersey.

Zavala M.A., J.M. Espelta & J. Retana 2000. Constraints and trade-offs in Mediterranean plant communities: The case of Holm Oak – Aleppo pine forests. Bot. Rev. 66: 119-149.

SAMENVATTING

Aan de noordgrens van de thermo-mediterrane zone in Spanje namen verscheidenheid en talrijkheid van vogels snel toe na een felle brand in 1994. Merkwaardigerwijs werd geen verschuiving van open-terrein soorten naar struweelsoorten vastgesteld, iets wat wel de verwachting was op grond van onderzoek elders. Vermoedelijk was -althans voor dit droge gebied- de onderzoeksperiode van zes jaar te kort om deze verschuiving te kunnen vaststellen. Doordat soorten van open terrein, zoals Duinpieper *Anthus campestris* en Boomleeuwerik *Lullula arborea,* zo lang profiteerden van de nieuw ontstane open gebieden, zou brand in struweelrijke Mediterrane leefgebieden een belangrijke beheersmaatregel kunnen zijn om dergelijke soorten te steunen. Gezien de hoge frequentie van branden in het Mediterrane gebied in de laatste decennia, en het nadelige effect dat deze branden hebben op regeneratie van struweel en bos, is nader onderzoek gewenst naar de lange-termijn effecten op broedvogels. (RGB)

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