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Abstract One of the main factors involved in the decline in the European wild rabbit in the Iberian Peninsula is the loss of suitable habitats caused by abandonment of agricultural and grazing activities. Nowadays, Mediterranean landscapes suffer from wildfires that affect extensive areas and produce considerable habitat changes. However, little is known about the influence of wildfires and post-fire treatments on rabbit abundance to address policies to recover their populations. To do so, we studied abundances of this species in four types of plots during three consecutive years after a wildfire in Catalonia (NE Spain): (A) unburnt forests, (B) burnt forests with removal of burnt trees but with branches left, (C) burnt forests with removal of burnt trees and branches, and (D) non-forested burnt plots. Rabbits progressively colonised burnt plots, where their abundance increased for at least 5 years after the fire, but decreased or even disappeared in unburnt ones, indicating that forest fires have a positive effect on rabbit populations. Although abundances did not differ between the three burnt plot types, plots with removal of burnt branches had the highest increase in abundance. In addition, soil covered by branches or by dense vegetation appeared negatively correlated with abundance, indicating that this could hinder rabbit movements, while some plant species could benefit rabbits by providing high quality food. Thus, post-fire treatments favourable to rabbit populations might therefore be a good way of increasing the conservation and economic value of areas affected by forest fires.

Keywords *Oryctolagus cuniculus* · Forest fires · Mediterranean scrubland · Management · Burnt branches

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Introduction

The European wild rabbit (*Oryctolagus cuniculus*) has undergone a steep decline in the Iberian Peninsula since the 1950s due to viral diseases (myxomatosis and rabbit hemorrhagic disease), loss of suitable habitat and unfavourable game management (Villafuerte et al. 1995; Calvete et al. 2002; Calvete et al. 2004; Virgós et al. 2007; Williams et al. 2007; Delibes Mateos et al. 2008). This decrease has been considered as a serious conservation problem because the rabbit is a keystone species in Iberian Mediterranean ecosystems, being the staple prey of several predators (Delibes and Hiraldo 1981; Delibes Mateos et al. 2007, 2008a) such as the endangered Iberian lynx (*Lynx pardinus*), the Spanish imperial eagle (*Aquila adalberti*) and Bonelli's eagle (*Aquila fasciata*). In addition, it is also the primary small game hunting species and is an important source of income for rural areas (Angulo and Villafuerte 2003; Calvete and Estrada 2004; Monzón et al. 2004).

Rabbits live in a wide variety of habitats, from agricultural landscapes to woodlands. However, they prefer open areas of grassland, farmland and Mediterranean scrubland (Rogers and Myers 1979; Moreno et al. 1996; Palomares and Delibes 1997; Villafuerte and Moreno 1997; Fa et al. 1999; Lombardi et al. 2003; Virgós et al. 2003; Calvete et al. 2004). The abundance of this lagomorph in scrublands is mainly determined by the vertical vegetation structure and composition and seems to be favoured by a trade-off between abundant low herbaceous vegetation providing high quality food and a certain amount of tall vegetation offering cover but without hindering movement (Fa et al. 1999; Beja et al. 2007; Ferreira and Alves 2009).

Forest fires have played an important role in the landscape structure of the Mediterranean Basin (Moreno and Oechel 1994; Rundel 1998), one of the world's biodiversity hotspots (Myers et al. 2000). After a wildfire, there is a change in vegetation structure and composition over large areas. It is known that early stages of post-fire successional development, which are dominated by herbaceous plants, are favourable to the animal species typical of open habitats (Prodon et al. 1984; Prodon 1987; Fons et al. 1988; Arrizabalaga et al. 1993; Pons and Prodon 1996; Herrando et al. 2002; Herrando et al. 2003). Therefore, it is to be expected that wildfires will benefit rabbit populations in the same way as they do other species with similar habitat requirements.

Information on the effects of fire on rabbit populations is restricted to one study of prescribed fires in small experimental areas (300×200 m) of Mediterranean scrubland in the Doñana National Park (Moreno and Villafuerte 1995). This study showed an increase of pellet counts in burnt areas compared to unburnt ones, which was attributed to an increase in nutritious forage after fires in the first sample plots. However, the effects of wildfires on rabbit populations are to some extent unknown. In contrast to prescribed fires, wildfires occurred unexpectedly as a result of particular climatic circumstances in specific seasons (Chandler et al. 1983) and their characteristics (such as heterogeneity and intensity) and consequences differed from prescribed fires (Wade and Lunsford 1989; Fernandes and Botelho 2003).

One of the most generalised post-fire forest treatments consists of the clear cutting and removal of burnt trees, and then leaving of branches on the ground. This treatment is frequently subsidised by environmental institutions, whose main objective is forest regeneration. During this kind of management, burnt branches are left on the ground, mainly for economic reasons but also to prevent soil erosion (Bautista et al. 2004). However, the non-forestry consequences of this practice for biodiversity or ecology are poorly known (Bautista et al. 2004). Since rabbits seem to be favoured by scrublands with open access at ground level (Fa et al. 1999; Beja et al. 2007), it might be expected that leaving burnt branches on the ground would have a negative effect on this species' abundance.

In light of the serious decline in rabbit populations in recent decades, the ecological and economic value of this species and the high frequency and extension of wildfires in the Mediterranean Basin, we aimed to assess the effect of wildfires and post-fire forest treatments on rabbit abundance. To do so, we used data on rabbit abundance in different plot types during three consecutive years after a forest fire in north-eastern Spain. Our results were then used to provide management guidelines for improving rabbit populations in Mediterranean habitats after wildfires.

Materials and methods

Study area

The study area was located in the massif of Sant Llorenç del Munt (Catalonia, NE Spain), affected in summer 2003 by a high intensity forest fire that burnt 4,600 ha (Fig. 1). The climate of this area is Mediterranean, with an average annual temperature of 13°C and annual rainfall of 700 mm, mainly concentrated in autumn and spring. Landscape had two different areas depending on the pre-fire dominant vegetation and soils. Whereas the Southern burnt area was dominated by *Pinus halepensis* forests in conglomerate-clay soils, the Northern area was dominated by *Pinus nigra* ssp. *salzmanii* and *Pinus sylvestris*, all with a dense undergrowth of shrubs and *Quercus ilex* beneath the pines in loam-sandstone soils.

The study of rabbit abundance was focused on the Southern burnt area, which had a characteristic Mediterranean habitat for rabbits (Palomares and Delibes 1997; Fa et al. 1999; Virgós et al. 2003; Calvete et al. 2004), in order to avoid landscape heterogeneity, and also excluding rugged terrain, urban areas or other elements such as roads or streams. Within the area, 50 plots of 100×100 m were randomly established on gentle slopes at altitudes ranging from 440 m to 655 m a.s.l. The surface of plots corresponded to the area commonly used by an individual rabbit (Gibb 1993; Lombardi et al. 2007; Devillard et al 2008) and the average distance (±SD) between plots was 2,412±1,256 m, ranging from 200 to 6,615 m (n=2,450 pairs of plots). Thus, distance between plots was at least 200 m, as cited by Richardson et al. (2002) for rabbit dispersal distances. Taking into account forest types and the different post-fire treatments (Fig. 1), four types of plots were considered: (A) unburnt forests, considered as control plot of the pre-fire vegetation (n=10); (B) burnt forests with clear cutting and the removal of burnt trees during 2004, but with branches left on the ground (n=20); (C) burnt forests with clear-cutting and the removal of burnt trees during 2004, but with branches left on the ground that were subsequently shredded outside the plots in spring 2006 (n=10); due to the high initial cover of burnt branches in these plots (average=33.4%;SD=5.7%), some branches were

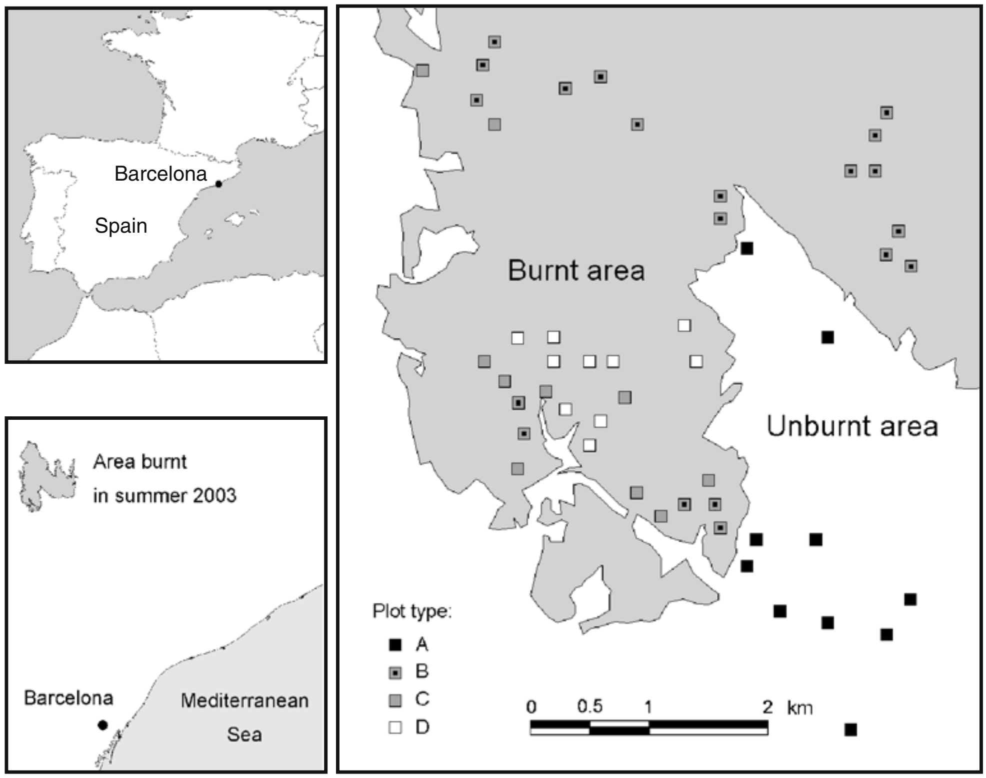

Fig. 1 Location of the study area in the western Mediterranean and location of sampled plots (*A* unburnt forest, *B* burnt forests with the removal of burnt trees and branches left on the ground, *C* burnt forests with the removal of burnt trees and a reduction in the soil area covered by branches, *D* burnt shrublands and bare rocks) within the study area

piled up and were left in the plots (average cover=10.8%; SD=5.1%; <5 piles/ha); (D) burnt shrublands and bare rocks, which had a high percentage of bare ground and no tree cover before the fire (n=10).

Hunting was not allowed within the study area from 2003 to 2008 so as not to affect the results.

Estimation of rabbit abundance

In order to estimate rabbit abundance, plots were sampled once a year during 2006, 2007 and 2008 at peak rabbit abundance in June at the end of the breeding season (Cabezas and Moreno 2007; Catalán et al. 2008).

Rabbit abundances in each plot were estimated by counting the number of latrines within 2 m on either side of a 500-m itinerary (500×2 m). Three classes of latrines were defined in terms of the number of pellets (1=5–50 pellets; 2=51–150 pellets; 3>150 pellets), as in Fa et al. (1999). After a number of trials, we decided to classify latrine classes in terms of their diameter (1<10 cm; 2=10–30 cm; 3>30 cm). Every 25 individual pellets found outside a latrine were classed as belonging to a class 1 latrine. Relative rabbit abundance (number of pellets) was estimated by multiplying the number of pellets within each latrine class by the midpoint of that latrine class, i.e. class 1, ×27 pellets; class 2, ×100 pellets; class 3, ×300 pellets. We considered rabbits were absent on a plot when latrines or pellets were not found.

Independent variables

The independent variables shown in Table 1 were determined for each burnt plot every year (2006, 2007 and 2008) in July. In order to compare the initial soil area covered by burnt branches (%) in each burnt plot type, the C plots were surveyed in February before the burnt branches were shredded in spring 2006. Variables were extracted from the measurements made along two 100 m-long transects (N-S and E-W) intercepting at the centre of each plot using the Point Intercept Method (Elzinga et al. 2001), a GPS receiver and a tape measure. At sampling points distributed every 1 m along the itineraries (200 points per plot), the presence of burnt branches and the plant species (as well as maximum height of the plants) were recorded and computed in one or more variables shown in Table 1.

Since hard soils hamper warren building and thus might be a limiting factor for rabbit abundance (Fa et al. 1999; Virgós et al. 2003; Calvete et al. 2004; Delibes-Mateos et al. 2008b), soil hardness was determined for each plot as the percentage of the sampling points with soft soils (mostly clays) or hard soils (mostly conglomerates).

Statistical analyses

To assess the effect of wildfires and post-fire forest treatments on rabbit abundance, we used the Kruskal-Wallis and Mann-Whitney U tests (Zar 2007) to compare

Table 1 List of independent variables used to characterise burnt plots

Variable	Definition
Bare ground	Bare ground surface, without vegetation or burnt branches (%)
Burnt branches	Soil covered by burnt branches, with or without presence of vegetation (%)
Veg <0.25 m	Soil covered by vegetation <0.25 m, with or without presence of branches (%)
Veg <0.5 m	Soil covered by vegetation <0.5 m, with or without presence of branches (%)
Veg <1 m	Soil covered by vegetation <1 m, with or without presence of branches (%)
Veg	Soil covered by vegetation, with or without presence of branches (%)
Veg >0,5 m	Soil covered by vegetation >0.5 m, with or without presence of branches (%)
Veg >1 m	Soil covered by vegetation >1 m, with or without presence of branches (%)
Veg <0.25 m no/br	Soil covered by vegetation <0.25 m without burnt branches (%)
Veg <0.5 m no/br	Soil covered by vegetation <0.5 m without burnt branches (%)
Veg <1 m no/br	Soil covered by vegetation <1 m without burnt branches (%)
Veg no/br	Soil covered by vegetation without burnt branches (%)
Veg <0.25 m br	Soil covered by vegetation <0.25 m with burnt branches (%)
Veg <0.5 m br	Soil covered by vegetation <0.5 m with burnt branches (%)
Veg <1 m br	Soil covered by vegetation <1 m with burnt branches (%)
Veg br	Soil covered by vegetation with burnt branches (%)
Veg >0.5 m br	Soil covered by vegetation >0.5 m with burnt branches (%)
Veg >1 m br	Soil covered by vegetation >1 m with burnt branches (%)
Plant name	Soil covered by a particular plant species (%)
Soil hardness	Surface of hard soils (%)

(a) rabbit abundances in 2006, 2007 and 2008 and (b) the rate of change in rabbit abundances (Delibes-Mateos et al. 2008b) in the period 2006-2008 between types of plots. The rate of change in rabbit abundances from 2006 to 2008 was calculated for each plot by means of the formula:

$$\mathrm{RATE} = (\text{number of pellets}_{2008} - \text{number of pellets}_{2006}) / (\text{number of pellets}_{2006} + 1)$$

To assess the effect of burnt branches, vegetation and other ecological factors (see Table 1) on rabbit abundance, we performed a covariance analysis (ANCOVA) using data from 30 burnt plots (types B and D) from the years 2006, 2007 and 2008. The number of pellets was normalised by using the square root transformation; independent variables were normalised with the arcsin transformation (Zar 2007). We only considered the percentages of soil covered by the ten mosy common plant species (*Brachypodium phoenicoides*, *B. retusum*, *Cistus albidus*, *Coriaria myrtifolia*, *Dorycnium pentaphyllum*, *Psoralea bituminosa*, *Q. ilex*, *Rosmarinus officinalis*, *Rubia peregrina* and *Rubus ulmifolius*) as they were the only species common enough to be normalised. To assess the individual effect of each independent variable on rabbit abundance, we performed an ANCOVA model for each variable including the year as a factor. To determine which group of variables most affected rabbit abundance, we performed a model to explain the maximum variance of rabbit abundance. In this case, we only used groups of variables fully independent between them in order to avoid collinearity. We checked for ANCOVA assumptions as independence of variance estimates, normal distribution of errors, homogeneity of variance and homogeneity of linear regression (Zar 2007). The significance level was set at 0.05. All data analyses were run using SPSS v. 14.0 for Windows.

Results

Effect of wildfires and post-fire forest treatments on rabbit abundance

During the course of this study from 2006 to 2008, the presence of rabbits increased in all types of burnt plots (from 18 to 19 in the B plots, from 6 to 10 in the C plots and from 8 to 10 in the D plots). However, rabbit presence dropped in the unburnt A plots from 9 to 7.

Rabbit abundances did not differ between the plot types in years 2006 ($x_{\text{Kruskal-Wallis}}{}^{2}$=6.328; d.f.=3; p=0.097) and 2007 (x^2=3.065; d.f. = 3; p=0.382), but did in 2008 ($x_{\text{Kruskal-Wallis}}{}^{2}$=17.397; d.f.=3; p<0.001). When we excluded the unburnt A plots from our analysis of year 2008, abundances between burnt plots B, C and D did not differ ($x_{\text{Kruskal-Wallis}}{}^{2}$=4.839; d.f.=2; p=0.089), indicating that the differences between plot types were caused by differences between the unburnt and burnt plots.

While average rabbit abundance increased from 2006 to 2008 in all burnt plot types, they did not in unburnt

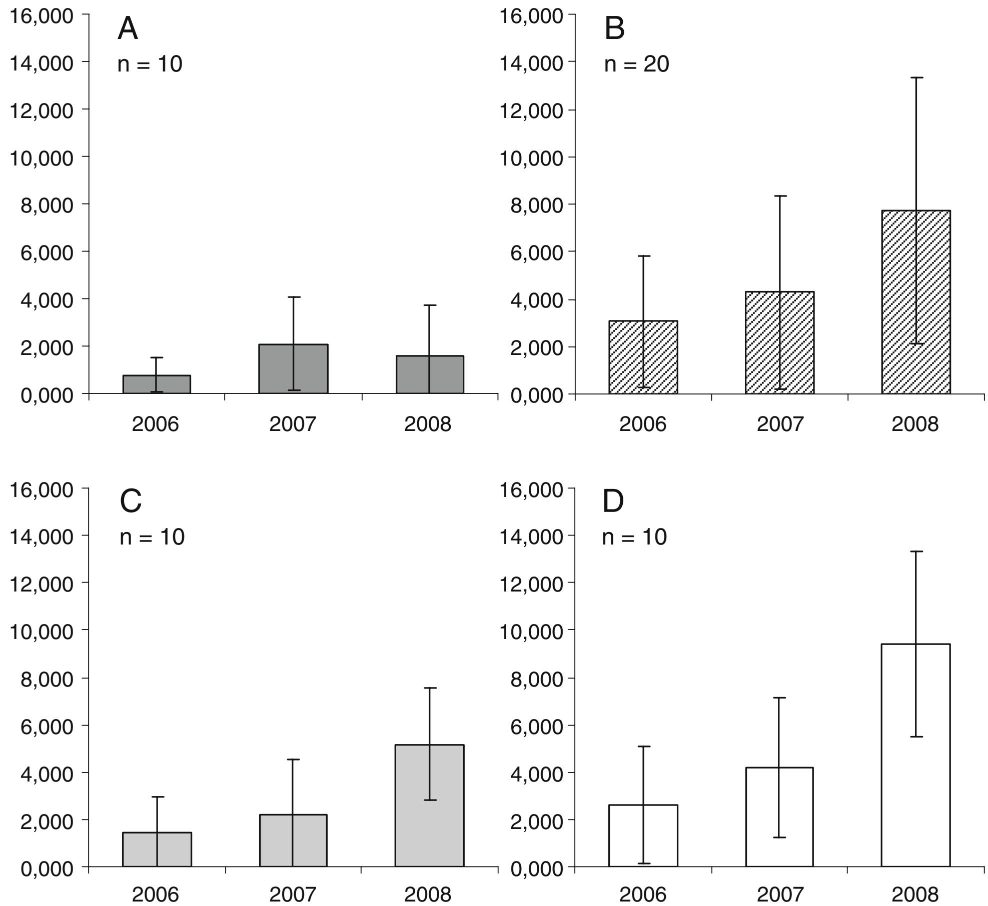

Fig. 2 Relative rabbit abundance expressed as the number of pellets (mean and SE) within different plot types (*A* unburnt forest, *B* burnt forests with the removal of burnt trees and branches left on the ground, *C* burnt forests with the removal of burnt trees and a reduction in the soil area covered by branches, *D* burnt shrublands and bare rocks) during years 2006, 2007 and 2008

plots, where rabbits remained in low abundance throughout this period (Fig. 2). The rate of change in rabbit abundance from 2006 to 2008 was 5.87±17.94 (average± SD) in A plots (n=10), 318.5±1344.15 in B plots (n=20), 1673.58±2332.67 in C plots (n=10) and 153.53±438.94 in D plots (n=10), differing between plot types ($x_{\text{Kruskal-Wallis}}{}^2$ =9.019; d.f.=3; p=0.029). Differences were found between plots A and B ($U_{\text{Mann-Whitney}}$=52.000; p=0.035), plots A and C ($U_{\text{Mann-Whitney}}$=16.000; p=0.010) and plots A and D ($U_{\text{Mann-Whitney}}$=18.000; p=0.016), whereas no differences were found between burnt plot types ($x_{\text{Kruskal-Wallis}}{}^2$=1.497; d.f.=2; p=0.473).

Effect of burnt branches on rabbit abundance

We only found four independent variables that had an individual effect on rabbit abundance (see ANCOVA models a, b, c and d in Table 2). Bare ground surface area (%) and soil covered by *P. bituminosa* (%) were positively correlated with rabbit abundance, whereas soil covered by vegetation (%) or covered with burnt branches (%) was found to be negatively correlated with rabbit abundances. Despite appearing negatively correlated ($F_{1,\ 86}$=3.624; p= 0.06), burnt branches did not appear to have a significant individual effect on rabbit abundance.

The ANCOVA model that explains the maximum variance in rabbit abundance (up to 55.2%; see model e in Table 2) includes soil covered (%) by burnt branches, *B. phoenicoides*, *B. retusum*, *P. bituminosa*, *Q. ilex*, *R. officinalis* and *R. peregrina*. Soil covered (%) by burnt branches, *B. phoenicoides*, *B. retusum* and *Q. ilex* appeared negatively correlated with rabbit abundance, whereas soil covered (%) by *P. bituminosa*, *R. officinalis* and *R. peregrina* was positively correlated with rabbit abundance.

Discussion

The progressive appearance of rabbits in burnt plots where they had previously been absent indicates that this species will colonise burnt areas after wildfires. Moreover, in burnt plots, rabbits progressively increased their abundance to the extent that their numbers probably exceeded those from before the wildfire. In 2001, rabbit abundances were very low in this area (0.006–0.030 rabbits/km, KAI with car at dusk; Ballesteros and Degollada 2002), in comparison to the 0.5–2 rabbits/km found in other Mediterranean areas (Moreno et al. 2007). Furthermore, the greater rabbit abundance in burnt plots, as well as the maintenance of rabbits in or even disappearance from unburnt plots,

Table 2 Effect of independent variables considered in Table 1 on rabbit abundance according to the covariance analysis (ANCOVA)

Model	R^2	d.f.	F	p	Coefficient
A					
Bare ground		1	4.543	0.036	1.207
Year		2	13.732	<0.001	
Total	0.253	90			
B					
Veg		1	5.282	0.024	−1.133
Year		2	14.256	<0.001	
Total	0.259	90			
C					
Veg br		1	4.074	0.047	−0.778
Year		2	11.697	<0.001	
Total	0.249	90			
D					
P. bituminosa		1	7.640	0.007	1.154
Year		2	11.665	<0.001	
Total	0.277	90			
E					
Burnt branches		1	5.192	0.025	−0.692
B. phoenicoides		1	11.622	0.001	−1.346
Brachypodium retusum		1	14.023	<0.001	−1.506
P. bituminosa		1	13.882	<0.001	1.389
Q. ilex		1	18.104	<0.001	−2.084
Rosmarinus officinalis		1	4.062	0.047	1.482
Rubia peregrina		1	13.783	<0.001	2.702
Year		2	11.840	<0.001	
Total	0.552	90			

indicates that wildfires may favour the presence and abundance of rabbits, a finding which agrees with the situation of other Mediterranean vertebrates typical of open habitats (Prodon et al. 1984; Prodon 1987; Fons et al. 1988; Arrizabalaga et al. 1993; Pons and Prodon 1996; Herrando et al. 2002; Herrando et al. 2003).

Observed rabbit colonisation and the increase in rabbit abundance in burnt areas could be related to the appearance of open habitats with a significant surface area occupied by bare ground and a high diversity of low herbaceous, mostly gramineous and leguminous vegetation (Martínez-Sánchez and Herranz 1999; De las Heras et al. 2004), which coincides with known habitat preferences for rabbits (Fa et al. 1999; Beja et al. 2007; Ferreira and Alves 2009). Our study shows an increase in rabbit abundance for at least 5 years after the fire indicating that in the mid-term, forest fires have a relatively positive effect on rabbit abundance. This agrees with results obtained with prescribed fires in Mediterranean shrublands, where higher pellet counts were obtained in burnt plots in comparison to unburnt plots for at least 3 years after fires (Moreno and Villafuerte 1995). However, the long-term effect of wildfires on rabbit abundance is still unknown, although it is expected that rabbit abundance decreases or even disappears as the soil area covered by vegetation increases (and especially by woody species) during plant succession after fire (Pausas et al. 1999; Kazanis and Arianoutsou 2004), as occurs in other species with similar requirements (Prodon et al. 1984; Prodon 1987; Fons et al. 1988; Arrizabalaga et al. 1993; Pons and Prodon 1996; Herrando et al. 2002; Herrando et al. 2003).

In regard to different post-fire forest treatments, the greater rate of change in rabbit abundance in C plots seems to indicate that reducing the soil area covered by burnt branches, but as well creating piles with these branches that might be used by rabbits as refuges, has a positive effect on the colonisation and the increase in rabbit numbers. The fact that C plots did not have the highest rabbit abundance can probably be attributed to the lower initial rabbit numbers in C, due possibly to the significantly higher initial soil area covered by burnt branches (33.4±5.7% in the C plots and 25.3±6.1% and 3.1±2.9% in the B and D plots, respectively, expressed as average±SD) ($x_{\text{Kruskal-Wallis}}{}^2$=27.070; d.f.=2; p<0.001). On the other hand, rabbit abundance in the C plots might have been conditioned by the general extent of the post-fire treatment, which included clear cutting and the removal of burnt trees and branches left on the ground (as in the B plots). Furthermore, the C plots probably had lower initial rabbit abundance because they were more forested before the fire, as shown by the higher soil area covered by burnt branches. Thus, these factors might have conditioned the effects of the post-fire treatment in the C plots and mitigated the effect of reducing the amount of soil covered by branches.

The negative correlation between rabbit abundance and the soil area covered by burnt branches or by dense vegetation might be due to the fact that woody cover hinders rabbit movement, an idea reinforced by the positive correlation between the percentage of bare ground and rabbit numbers (Fa et al. 1999; Beja et al. 2007). Plant species such as *B. phoenicoides*, *B. retusum*, and *Q. ilex* that form dense soil cover appeared negatively correlated with rabbit abundance. On the other hand, rabbits were positively correlated with other plant species such as *R. officinalis* that had low soil coverage and do not hinder rabbit movements.

Other plant species might also determine rabbit abundance as a result of their nutritional value (Boyd 1986; Boyd and Myhill 1987; Moreno and Villafuerte 1995; Ferreira and Alves 2009). For instance, it is known that *P. bituminosa*, which is very common during the first years after fires (Martínez-Sánchez and Herranz 1999; De las Heras et al. 2004) and *R. peregrina* (both positively correlated with the abundance of rabbits), are commonly favoured by other herbivores due to their high nutritive value (Chapuis et al. 1995; Bartolomé et al. 1998; Sternberg et al. 2000; Ventura et al. 2000; Sternberg et al. 2006).

Although it is known that hard soils hinder warren building and might be a limiting factor on rabbit abundance (Fa et al. 1999; Virgós et al. 2003; Calvete et al. 2004; Delibes-Mateos et al. 2008b), our study found no effects of soil hardness on rabbit abundance; this might be because in our study area there was enough vegetation cover to provide protection and breeding refuges (Kolb 1994; Moreno et al. 1996) and possibly due to the scale of the study as soils may have a role at a regional scale.

In conclusion, taking into account the rate of increase of rabbit abundance in the C plots and the overall negative correlation in burnt plots between burnt branches and rabbit abundance, it is suggested that a reduction in the coverage of burnt branches will have a positive effect on rabbit abundance.

Conservation implications

In recent years, forest fires have become more frequent in Mediterranean areas due to the increase in the forested surface area and the biomass therein resulting from rural abandonment (Moreno and Oechel 1994; Rundel 1998). Fires create open areas which could benefit rabbit populations and other significant species found in Mediterranean ecosystems.

The main objective of one of the most generalised post-fire treatments—the clear cutting and removal of burnt trees but with branches left on the ground—is forest regeneration. However, most Mediterranean forest areas are usually quite unproductive (Merlos and Croitoru 2005), although they are of great ecological value and harbour significant levels of biodiversity (Myers et al 2000). Post-fire treatments favourable to rabbit populations might increase the economic and conservation value of areas affected by forest fires. Branches should be removed at the same time as burnt trees, as soil covered by burnt branches appears to have a negative effect on rabbit abundance and colonisation. In areas where burnt branches cannot be totally removed or where there is little vegetation to provide cover for breeding, refuges for rabbits could be built with burnt branches (San Miguel 2006). As well, prescribed fires or livestock could be used to keep vegetation in early succession stadiums that are favourable for rabbit populations (Mayor et al. 2005; Casals et al. 2008). Such measures should be accompanied by other actions such as the imposition of sustainable hunting strategies. Long-term monitoring of rabbit populations would also improve knowledge of the effects of wildfires and post-fire treatments on rabbit populations.

The increase in rabbit populations would benefit predators (Delibes and Hiraldo 1981; Delibes Mateos et al. 2007, 2008a) such as the endangered Iberian lynx (*L. pardinus*), the Spanish imperial eagle (*A. adalberti*) and Bonelli's eagle (*A. fasciata*). In addition, hunting would also provide an important source of income in rural areas affected by forest fires (Bota et al. 2000).

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