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TRADITIONAL MANAGEMENT OF SCRUBLAND FOR THE CONSERVATION OF RABBITS *Oryctolagus cuniculus* AND THEIR PREDATORS IN DOÑANA NATIONAL PARK, SPAIN

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Abstract

Several endangered carnivores and raptors in Mediterranean Spain are very dependent on rabbits Oryctolagus cuniculus, *which have shown a progressive decline in abundance for several decades. Land use neglect, and the consequent abandonment of traditional land use methods such as burning, is considered one of the factors responsible for this decrease. To examine this hypothesis we have compared rabbit use of experimentally burned and unburned scrubland areas. Rabbit activity was found to be significantly higher in burned areas, with the greatest use in less productive habitats in close proximity to scrub cover. The promotion of traditional land practices for nature conservation in the natural ecosystems of the Mediterranean Basin is discussed.*

Keywords: Mediterranean Basin, habitat management, rabbit, fire.

INTRODUCTION

The European rabbit *Oryctolagus cuniculus* has become a pest in many areas where it has been introduced, so studies to reduce or control its numbers have been carried out (Delille, 1953; Phillips, 1955; Richards *et al.*, 1986; Boag, 1987).

The problem in the Iberian Peninsula is very different. Here, the European rabbit is a native species that has undergone a progressive decline in abundance (Beltrán, 1991). In Spain, the rabbit constitutes the staple prey of at least 29 predators (Delibes & Hiraldo, 1981) including threatened or endangered species such as black vulture *Aegypius monachus*, eagle owl *Bubo bubo*, Bonelli's eagle *Hieraaetus fasciatus*, imperial eagle *Aquila adalberti* and Iberian lynx *Lynx pardina*. Imperial eagles and Iberian lynxes are especially dependent on rabbits (Delibes, 1980; Gonzalez *et al.*, 1990; Beltran & Delibes, 1991). Therefore a decline in the abundance of rabbits will have substantial implications for the long-term survival of these species. On the other hand, the rabbit is an historical game species (García y Bellido, 1986) and its scarcity poses a serious economic problem.

Diseases such as myxomatosis and viral haemorrhagic disease have caused significant decreases in rabbit populations (Valverde, 1967; Villafuerte & Moreno, 1991; Villafuerte *et al.*, 1994).

Traditional land uses have also ceased on many areas protected for nature conservation (Machado Carrillo, 1988). For example, clearcutting and prescribed burning have been banned in the Coto Doñana since its declaration as a Natural Park in 1969, and it has been suggested that this might be partially responsible for the observed decline in rabbit populations in this area (Moreno & Kufner, 1988; Beltran, 1991; M. Delibes, pers. comm.).

Moreno and Kufner (1988) suggested that the resulting progressive scrub density and aging may be the cause of an increase in alternative prey species in the Park, including *Apodemus sylvaticus*. In apparent response, generalist predators such as *Genetta genetta* and *Vulpes vulpes* have increased while the specialist lynx has declined with the drop in rabbit populations (Rau *et al.*, 1985).

In addition, the recent establishment of 'set-aside' areas being promoted in Spain by the European Economic Community is having similar effects over large areas.

The objectives of this study were (1) to examine the hypothesis that scrub clearance by traditional prescribed burning is favourable for rabbit populations; and (2) to consider how the size and shape of these burned areas influence rabbit responses. If the technique proved successful, the resulting increase in rabbit populations would benefit predators that rely on them.

STUDY AREA

The study was conducted in Doñana National Park (0–100 m asl) located in the south-west coast of the Iberian Peninsula (*c.* 37°N and 6°20'W). The climate is Mediterranean with hot dry summers (average temperature in August 25°C) and wet mild winters (average temperature in January 10°C, average annual precipitation 600 mm).

The total area of the Park is about 68,000 ha, and there are three main biotopes: marshlands, sand dunes, and scrublands (Valverde, 1958; Rogers, 1974; Amat *et al.*, 1979). Marshlands are influenced by seasonal flooding and sand dunes by the mobility of the substrate. Scrublands are dominated by Mediterranean shrub species, principally *Halimium halimifolium, H. commutatum, Rosmarinus officinalis, Stauracanthus genistoides, Thymus mastichina*, and *Cistus livanotis* and bracken *Pteridium aquilinum*, whose cover and biomass are related to the depth of the underground water table. Rabbits occur mainly in this biotope (Rogers & Myers, 1979).

We distinguished two types of scrublands:

(1) Wet scrublands, located close to the marshlands. These had medium vegetation cover (scrub cover: 54·47%) and a diverse grass understorey including *Anthoxanthum ovatum, Vulpia membranacea, Chaetopogon fasciculatus, Polygodon maritimus, Cynodon dactylon* and *Panicum repens*. The protein and water content of these grasses are high (Lazo, 1992).

(2) Dry scrublands, located away from the marsh. Here, the water table level is lower and the shrubs constitute a more xerophytic formation with 66·75% of cover. Grasses are less diverse with lower protein and moisture content (Lazo, 1992).

METHODS

The use of burned and unburned (control) areas by rabbits was evaluated in both wet and dry scrublands. Twenty burned plots, about 300 × 200 m, were made in these habitats during summer 1989, according to the design of traditional uses, each with its respective control plot placed in the same habitat type but 1 km away to ensure independence, i.e. no interchange of rabbits between them. In summer 1991, 2 years after burning, the scrub cover in the burned plots was 24·91% in wet habitats and 25·25% in dry habitats. During 1991 monthly counts of rabbit pellets were made in six circular sampling units (1·54 m^2) randomly distributed in each plot. The relationship between the number of sampling units for each area and the accumulated variance showed that the variance was stabilized after 20 sampling units (Kershaw, 1973). We therefore increased the number of samples per plot from six to 30 in January 1992, and reduced the number of plots monitored from 40 to 16 (eight burned and eight control). Half of the monitored plots (4 + 4) were placed in wet scrubland and half in dry scrubland (Fig. 1). These were again monitored monthly during 1992.

To evaluate the effects of size of the burned areas we measured the shortest distance from each sampling unit to the surrounding scrub cover and grouped these into four categories (< 10 m, 10–19·9 m, 20–29·9 m, 30–39·9 m, > 40 m). One- and two-way analyses of variance were used to examine rabbit responses to burning and distance from cover.

RESULTS

No significant variation was detected in the seasonal results for the eight unburned plots, so this allowed us to pool all the 1992 data. Monthly mean pellet abundance among all the plots showed significant differences (F = 69·95; d.f.= 7, 2841; $p < 0.001$). Overall, pellet abundance was significantly higher in the wet than in the dry scrublands (F = 168·4; d.f = 1, 2568; $p < 0.0001$); only one of the dry plots had more pellets than the corresponding wet plot (Table 1).

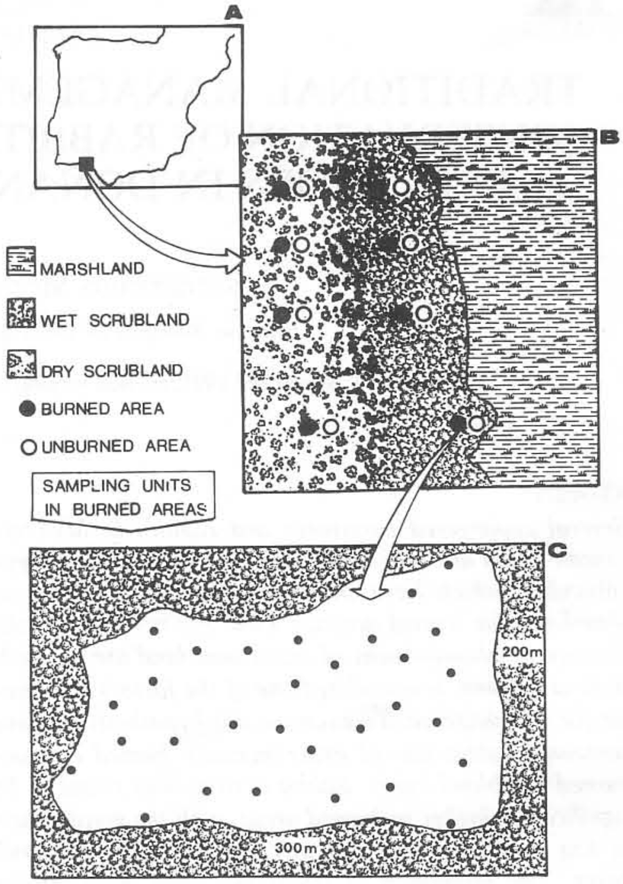

Fig. 1. (A) Location of the Doñana National Park in the Iberian Peninsula. (B) Sketch of the distribution of the study plots (burned and control) in wet and dry scrubland. The distance between each burned and its control plot is at least 1 km. (C) Example of distribution of the sampling units in a burned plot. The distance between each sampling unit and its closest surrounding scrubland was measured.

The pellet abundance was higher in the burned plots (Table 1) in seven of the eight pairs and the total pellet abundance in the burned plots was almost twice as high as in the control plots (F = 272·6; d.f= 1, 5875; $p < 0.001$). Analysis of variance showed differences in relation to burning (F = 244·7; d.f. = 1; $p < 0.0001$) and scrubland type (F = 217; d.f. = 1; $p < 0.0001$).

Pellet abundance was significantly higher in those sampling units located less than 20 m from cover than in those further away ($p < 0.001$). This is clearly shown for grouped data in Table 2.

There was a highly significant difference between the burned and control plots in the dry scrubland (4·19 times greater in the burned plots) but little difference in wet scrubland (1·17 times greater). However, in spite of the higher increase of pellet numbers in the burned plots of the dry scrubland, the final absolute pellet number was much higher in the wet scrubland.

Table 1. Annual mean pellet number (with standard error) in control and burned plots in dry and wet scrubland habitats (360 sampling units in each plot)

	Wet scrubland		Dry scrubland	
Area	Control	Burned	Control	Burned
1	1·42 (1·18)	5·34 (0·58)	2·55 (0·41)	7·66 (1·01)
2	10·02 (1·83)	18·55 (1·65)	1·55 (0·18)	2·33 (0·44)
3	22·21 (3·56)	16·97[a] (2·24)	1·07 (0·18)	12·18 (1·32)
4	2·67 (0·55)	5·38 (0·50)	1·33 (0·32)	2·09 (0·22)
Total	9·84 (1·05)	11·56 (0·74)	1·63 (0·15)	6·83 (0·46)
	Control		Burned	
Overall total	5·88 (0·56)		9·36 (0·44)	

[a]$n = 330$.

Table 2. Mean number of rabbit pellets in circular sampling units (1·54 m^2) in relation to nearest distance from the surrounding scrub

Distance to scrub (m)	*n*	X	SE
0–10	450	10·285	0·901
10–20	210	14·364	1·318
20–30	240	5·733	1·233
30–40	270	4·263	1·163
>40	240	6·364	1·233
Total	1410	8·297	0·509

DISCUSSION

Pellet counts have been used to compare the use of different habitats by animals and to assess the responses (mainly of ungulates) to habitat management (Klinger *et al.*, 1989; Peck & Peek, 1991). Other studies have reported the effectiveness of this method to estimate the density of lagomorphs (Taylor & William, 1956; Angerbjörn, 1983).

Although rabbit pellets may decay at different rates in different habitats, e.g. in wet or dry scrubland, the frequent (monthly) counting avoids confusion in this respect. On the other hand, our final aim was not to compare pellet abundance between habitats but its abundance in the same habitat with different situations.

Although counts were made at the same time in control and burned areas, the results are taken to reflect pre- and post-burning situations respectively. It is not possible to demonstrate that rabbit density increased in those areas subjected to fire, but the results on rabbit grazing activity are consistent with our hypothesis on the value of burned habitats to rabbits.

Pellet abundance in burned areas increased more than three times in plots located in dry, initially less productive, scrubland compared with areas located in the wet, richer habitat. If habitat quality and/or food requirements are limiting factors for rabbit populations, as shown by the lower pellet abundance in the dry unburned areas, the improvement of the habitat quality caused by fire may trigger a rapid rise in rabbit numbers. If there is an increase in nutritious forage after fire, then the increased use of the burned areas may also indicate an improvement in rabbit condition that could lead to improved survival and reproduction (Boyd, 1986; Boyd & Myhill, 1987).

Because of this relative increase of pellet abundance in dry scrubland after burning, and considering that the cost of burning is the same in both habitats, it would be more cost-effective to produce clearings in the dry scrubland. However, bearing in mind that the absolute abundance of pellet numbers in burned wet plots was much higher than that in dry habitat, and therefore the number of successful rabbits was also higher, we need to decide (a) whether we want to obtain a greater number of rabbits in a habitat where rabbits were initially more abundant or (b) to obtain a smaller number in a habitat where they were initially scarcer.

The choice depends on the ultimate objective of favouring endangered predators, principally lynxes and imperial eagles. The distribution of lynx territories depends to a great extent on the spatial abundance of rabbits. Due to the latter's scarcity in dry scrubland, lynxes rarely occupy this habitat (only subadult or wandering individuals) whereas they are constant in the wet scrubland where the carrying capacity for lynxes has already been reached (Ferreras *et al.*, 1992). Accordingly, dry scrubland management would be better for extending the distribution of lynxes. Similar reasons can probably be developed in relation to other predator species.

In the open burned areas (wet and dry), the greatest rabbit abundance was found at less than 20 m from scrub cover. This result is probably a response to predator vulnerability (Jaksic & Soriguer, 1981), and implies that the width of burned areas should not exceed 40 m. These small clearings would be the most advantageous for the lynx, which stalks its prey. These clearings do not damage the landscape and increase the chances of successful hunting by eagles, vultures and owls.

'Set-aside' practices are mainly determined by economics, and do not always have a positive effect on nature conservation (see Henderson, 1992). In the Mediterranean Basin, made-man fires and other similar practices such as clearcutting or small-patch crops have influenced natural ecosystems since the middle Pleistocene (Le Houerou, 1981). These have greatly influenced the composition and structure of the vegetation and are strongly linked to the stability and diversity of plant communities (Trabaud & Lepart, 1980; Trabaud, 1981; Casal, 1985). The cessation of such practices could therefore be detrimental to long-term conservation objectives, and this study suggests that it may be beneficial to maintain some traditional land uses to preserve a range of predator species.

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