

# The usefulness of field data and hunting statistics in the assessment of wild rabbit (*Oryctolagus cuniculus*) conservation status in Portugal

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## Abstract

**Context.** The wild rabbit (*Oryctolagus cuniculus*) is a keystone species from the Iberian Peninsula that has suffered a strong decline in Spain during the past decades. Data on historical and current population trends in Portugal are virtually non-existent.

**Aims.** To investigate changes in rabbit abundance at the national level so as to inform conservation status assessments, and to evaluate the usefulness of hunting bags as a rabbit abundance index.

**Methods.** Field surveys based on latrine counts in linear transects were performed in two periods (1995 and 2002) to assess variation in population abundance. Hunting bags were also analysed for the same period to verify whether these data showed the same trends. General trends of rabbit abundance were estimated using TRIM software.

**Key results.** Field data revealed that most of the sampling units across Portugal have low abundances, despite the observation of local high-density spots. A population reduction of 27% was estimated. Although some fluctuations were observed in hunting bags, global results obtained from these data suggest a slightly increasing trend in rabbit abundance.

**Conclusions.** A discrepancy between field data and hunting statistics was observed. Because hunting bags may be influenced by sporadic management operations undertaken by hunters and the lack of systematic procedures in data collection, we believe that hunting statistics are not representative of real changes in rabbit populations. Thus, observed reduction in rabbit abundance estimated by field data, combined with the high initial morbidity due to rabbit haemorrhagic disease (RHD) after 1988 and the potential for continuing decline in population trends because of other factors, led to an inference of a reduction of >30% in rabbit abundance in Portugal during the past decade.

**Implications.** Taking into account the estimated reduction, the species' biology and socioeconomic implications, wild rabbit in Portugal was listed in 2005 in the *Near Threatened* category under IUCN criteria. Because of its ecological and economic importance, this classification prompted the definition of several conservation actions aimed at the recovery of the species in Portugal.

**Additional keywords:** conservation status, hunting statistics, IUCN Red List, Portugal, wild rabbit.

## Introduction

In response to the accelerating rate of biodiversity loss, a commitment has been made worldwide to significantly reduce it by 2010 (SCBD 2003). This has been the propeller for the development of more rigorous indicators used to assess biodiversity loss (e.g. Pereira and Cooper 2006). The Red List Index is one of such indicators and is based on the IUCN Red List of Threatened Species™, the most objective system currently available for classifying species in terms of their risk of global extinction, through the assessment of individual species status, among other parameters (Butchart *et al.* 2007).

In 2002, the Portuguese government impelled the revision of the national Red List of Vertebrates, the last publication of which dated from the 1990s (SNPRCN 1990). Several target species were selected for national status assessment on the basis of their importance for conservation. One of the target species was the European wild rabbit (*Oryctolagus cuniculus*), a multifunctional keystone species of the Western Mediterranean Basin (Delibes-Mateos *et al.* 2007); the studies of this species over the past 15 years point to a sharp decrease in Spain, despite conservation efforts (e.g. Blanco and Villafuerte 1993; Calvete *et al.* 2006; Moreno *et al.* 2007; Delibes-Mateos *et al.* 2008). This decline is

considered to be due to the joint influence of factors such as habitat degradation, excessive hunting pressure, predation and occurrence of viral diseases (myxomatosis and RHD; e.g. Calvete *et al.* 2006; Moreno *et al.* 2007).

In Portugal, reliable data on the status of rabbit populations are scarce. Few studies have focussed on the factors influencing rabbit distribution and abundance of local populations (e.g. Carvalho and Gomes 2004; Ferreira and Alves 2009). Other studies had a wider regional context although many lacked a systematic and integrated approach. Therefore, because the available information is too inconsistent and fragmented to thoroughly ascertain rabbit demographic trends at a national level, a specific field study was carried out to provide information on the species' status in Portugal.

Hunting statistics have been previously used to evaluate trends in rabbit populations in Spain (Piorno 2006; Virgós *et al.* 2007), although the usefulness of this methodology has been questioned (Blanco-Aguiar *et al.* 2008; Delibes-Mateos *et al.* 2009). In Portugal, hunting data consist mainly of basic records, such as the total number of species harvested and number of hunters per hunting season. The data are collected only in hunting reserves, which, even though having increased in numbers in the past years, comprise only a fraction of the Portuguese territory. Despite the spatial gaps in the collection of hunting data, this information is potentially important and could be relevant when attempting to determine population status of wild rabbit in Portugal, given its volume and supposed systematic nature.

In the current paper, we present the results of a study aimed at assessing the variation in the abundance of wild rabbit in continental Portugal between 1995 and 2002, an interval within the post-RHD period, using original and previously unpublished survey data and hunting statistics. Our main goals were (1) to document the change in rabbit abundance at the national level between 1995 and 2002 and to inform assessments under IUCN criteria, and (2) to determine, *a posteriori*, whether during the same period (1995–2002) hunting statistics, in the format they are provided by the Portuguese administration, indicate the same rabbit population change and hence could be used as an alternative trend index in future assessments.

## Materials and methods

### *Wild rabbit surveys*

Wild rabbit surveys were planned for the whole Portuguese territory, using a grid of 20 × 30 km sampling units that correspond to 1 : 50 000 topographical plans (Portuguese Army Geographic Service, Lisbon, Portugal). Because of logistical limitations that constrained the performance of rabbit surveys in all of the national territory, a stratified sample of these units was selected by previously excluding sampling units in highly populated areas and dense forests (e.g. *Eucalyptus globulus* monocultures) and, therefore, maximising the possibilities of rabbit encounters. Hence, 84 and 111 sampling units were surveyed in 1995 and in 2002, respectively, of which 76 were surveyed in both years. The methodology used was the same in both surveys and was adapted from Blanco and Villafuerte (1993), with consideration given to the scale of the country and resources available. Briefly, in each unit a 4-km-long linear transect was established and surveyed during June and

July of each year. This period corresponds to the maximum abundance of wild rabbits in Mediterranean ecosystems (e.g. Gonçalves *et al.* 2002). All transects were selected in areas where habitat potentially favoured rabbit occurrence (Delibes-Mateos *et al.* 2008). Two observers walked together in a straight line across homogeneous environments and registered the number of rabbit latrines within a 4-m-wide band along the transect (Delibes-Mateos *et al.* 2008). A latrine was defined as a group of at least 20 pellets within an area of 200 × 300 mm<sup>2</sup> (Virgós *et al.* 2003). Latrine counts have been widely used by other authors in the Mediterranean region to monitor rabbit abundances because of their reliability (even in low-density situations), easiness of application in vast areas and need for little expertise by field assistants (e.g. Delibes-Mateos *et al.* 2008). Despite their lack of direct correspondence with absolute rabbit numbers, latrine counts still provide accurate information on changes in wild rabbit populations at large temporal and spatial scales, which explains why this method has been privileged in relation to others in many large-scale studies investigating rabbit population trends in the Iberian Peninsula (e.g. Calvete *et al.* 2006).

For each year, rabbit abundance was expressed as a standardised latrine abundance index (LAI) which corresponds to the number of latrines per transect-kilometre (Calvete *et al.* 2006).

### *Hunting statistics*

Potentially almost all of the Portuguese territory can be used for hunting purposes. Game management, however, is strongly associated with the establishment of hunting reserves, which gained further supporters after 1988 and were mainly established for private and associate use. The creation of a hunting reserve legally obliges its promoter to keep records of basic hunting statistics, such as the total number of species harvested, the number of hunters per hunting season, the definition of hunting periods for each species (within the season defined by government law) and the description of management actions to promote and/or control game species inside the hunting reserve. The areas not included in hunting reserves, except for sanctuary reserves (where hunting is forbidden), are called 'non-managed game land' and, as the term specifies, they correspond to areas where hunting is possible but no specific management is undertaken, and, hence, no records for hunting bags or hunting effort are available.

Although hunting data may not always reflect the true variations in species abundance (Blanco-Aguiar *et al.* 2008), some studies have indicated that correlations can be good (e.g. Kitson 2004). Hunting bags, and other related statistics, were provided by the Portuguese Ministry of Agriculture, Direcção-Geral dos Recursos Florestais (DGRF), for the period between 1994 and 2002. This information is centralised and administered by the DGRF, although data collection is organised and maintained by five administrative game regions defined within the Portuguese territory (see Fig. 4). Data supplied consisted of total number of rabbits harvested per hectare in 77 hunting reserves during each hunting season from 1994/95 to 2001/02. Hunting reserves were uniformly distributed throughout the country and were selected because these were active during

the whole sampling period. Additionally, the percentage of hunting reserves occupying each game region (1–5) from 1990 to 2005 was also analysed.

#### Data analysis

For easiness of data comparison between years, the following five classes of rabbit abundance (RA) were defined: RA1 (0–10 latrines), RA2 (11–40 latrines), RA3 (41–70 latrines), RA4 (71–100 latrines) and RA5 (>100 latrines) abundance. The change in rabbit population in each transect was estimated as the growth rate in LAI between 1995 and 2002, as follows (Calvete *et al.* 2006):

$$\text{Growth rate} = (\text{LAI } 2002 - \text{LAI } 1995) / \text{LAI } 1995.$$

Because the data did not meet the assumptions of normality, homoscedasticity and linearity, Spearman correlations were used to test the correlation between LAI 1995 and LAI 2002.

Rabbit hunting bags were expressed as the number of rabbits harvested per hectare. Trends and indices for hunting bags per hectare were produced with the software program TRends and Indices for Monitoring data (TRIM; Pannekoek and van Strien 2005) to obviate problems with missing spatial data. TRIM uses a Poisson general log-linear model to create a parameterised population index, with the first year of the time-series set to 1 and all subsequent years relative to the first. We used a time-effects model and accounted for overdispersion of the data. For further details on the TRIM analysis, see Pannekoek and van Strien (2005).

## Results

### Wild rabbit surveys

In all, 76 sampling units (44% of the Portuguese territory) were surveyed both in 1995 ( $n = 84$ ) and in 2002 ( $n = 111$ ). In >50% of the surveyed area in both years, the abundance of wild rabbits fell into the lower RA classes, RA1 and RA2 (in 1995 they represented 50.6% ( $n = 42$ ) and in 2002 71.8% ( $n = 80$ ); Fig. 1). The highest RA class (RA5, >100 latrines) was found in north-eastern and southern of Portugal, representing 10.8% ( $n = 9$ ) in 1995 and 2.73% ( $n = 3$ ) in 2002. From 1995 to 2002, RA declined in 57 sampling units and increased only in 19 units, mainly inland. In general, in 2002 an increase of 18% in RA1 and RA2 classes and a decrease of about 23% of the RA3–RA5 classes were registered. In addition, the highest RA classes (RAI3–RAI5) in 1995 fell into lower categories (RAI1–RAI2) in 2002 (Fig. 2) and this difference was significant ( $\chi^2 = 14.9$ , d.f. = 4,  $P > 0.01$ ), corroborating the decrease in rabbit abundance. Overall, between 1995 and 2002, population growth rate was negative (–0.27), indicating a declining population trend. The correlation between LAI 1995 and LAI 2002 was positive and significant (Spearman's  $r = 0.59$ ,  $P < 0.001$ ; Fig. 3).

### Hunting statistics

Up to 2003, the number of hunters in Portugal was 311 851, which corresponded to ~6% of the active population in the country. A progressive increase in the percentage of hunting reserves occupying national territory was evident from 1990 to 2005 (Fig. 4). In 1990, approximately half of the Portuguese

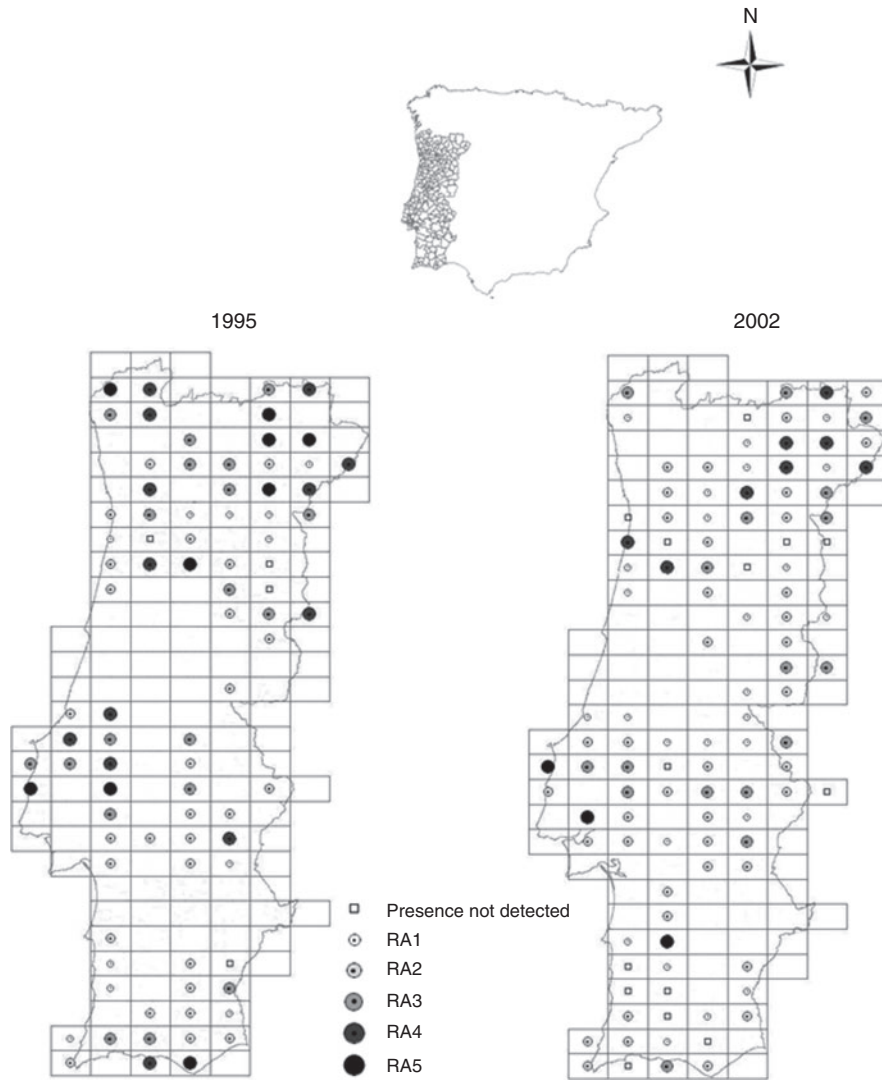
territory (mostly in the north of the country) did not include any established hunting reserve; in 2005, overall 90% of the municipalities presented 50–100% of its surface with established hunting reserves and ~10 municipalities were completely filled with hunting reserves.

From 1994/95 to 1996/97, the number of rabbits harvested per hectare in hunting reserves suffered a steep decline (Fig. 5). After this date and until 2001/02, the general observed trend was a moderate increase in the number of rabbits harvested per hectare in Portugal, despite punctual decreases (1999/00 and 2001/02). Overall, TRIM estimates point to a significant increase of 7% in rabbit hunting bags between 1994/95 and 2001/02 (log-linear  $\beta = 0.0636 \pm 0.0221$ ,  $P < 0.01$ ).

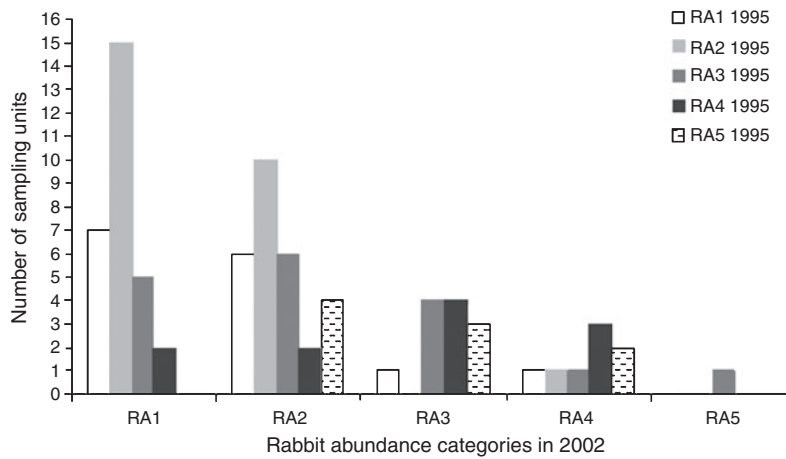
## Discussion

Overall, field data and hunting statistics provided different insights into rabbit population trends in Portugal between 1995 and 2002. Latrine count data suggested a reduction in wild rabbit abundance of 27% during this period, which is in accordance with the global scenario of declining numbers exhibited by the wild rabbit in Spain (Calvete *et al.* 2006; Moreno *et al.* 2007; Virgós *et al.* 2007; Delibes-Mateos *et al.* 2008). In Portugal, this decline was recorded a few years after the strong initial population crashes caused by the first outbreak of RHD in the country, at the end of the 1980s (Anonymous 1989). This suggests that rabbit populations were still declining even after the initial great mortality caused by this disease (Villafuerte *et al.* 1995), implying that several other factors (such as habitat quality, predation, myxomatosis) were limiting population recovery. Paradoxically, evidence was found for an increased rabbit abundance in some locations; however, the incidences of increased abundance corresponded to local and isolated events, with no apparent geographical pattern, in accordance with previous findings (Williams *et al.* 2007; Delibes-Mateos *et al.* 2008). In fact, the existence of hotspots of high rabbit abundance in prevailing low-abundance matrices has been ascertained and is thought to be associated with local episodes of recovery from disease (Fernández 2005). Nevertheless, these recovery events are still isolated enough to be threatened by stochastic factors and inadequate management, which increases the need to minimise the impact of factors regulating wild rabbit populations (Delibes-Mateos *et al.* 2009).

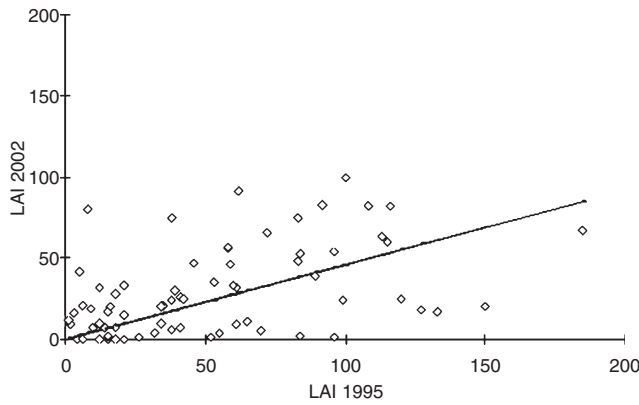
In contrast to latrine count data, available hunting statistics revealed an overall increase of 7% of wild rabbit hunting bags between 1995 and 2002, although sharp declines in the number of rabbits harvested per hectare were observed in some hunting seasons (1994/95–1995/96, 1998/99–1999/00 and 2000/01–2001/02). There are several explanations for these oscillations. First, it is possible that the impact of RHD was perceived in hunting bags only a few years later, which, together with the high spatio-temporal variation in the impact of this disease (Calvete 2006), could explain the reductions observed in the number of rabbits harvested per hectare in some periods. Also, the differential efforts in rabbit management, or in hunting-bag recording (either owing to the increase in the %hunting reserves over the past years (Fig. 4) or to the fact that hunters are more prone to register rabbits harvested after abundance crashes), the use of alternative management actions aimed at



**Fig. 1.** Location of transects per sampling unit (1 : 50 000 Portuguese Army Geographic Maps) across continental Portugal in 1995 and 2002. Point-size correlates with rabbit abundance classes (RA1–RA5).



**Fig. 2.** Histogram of rabbit abundance classes (RA1–RA5) in 1995 in relation to the same categories in 2002.



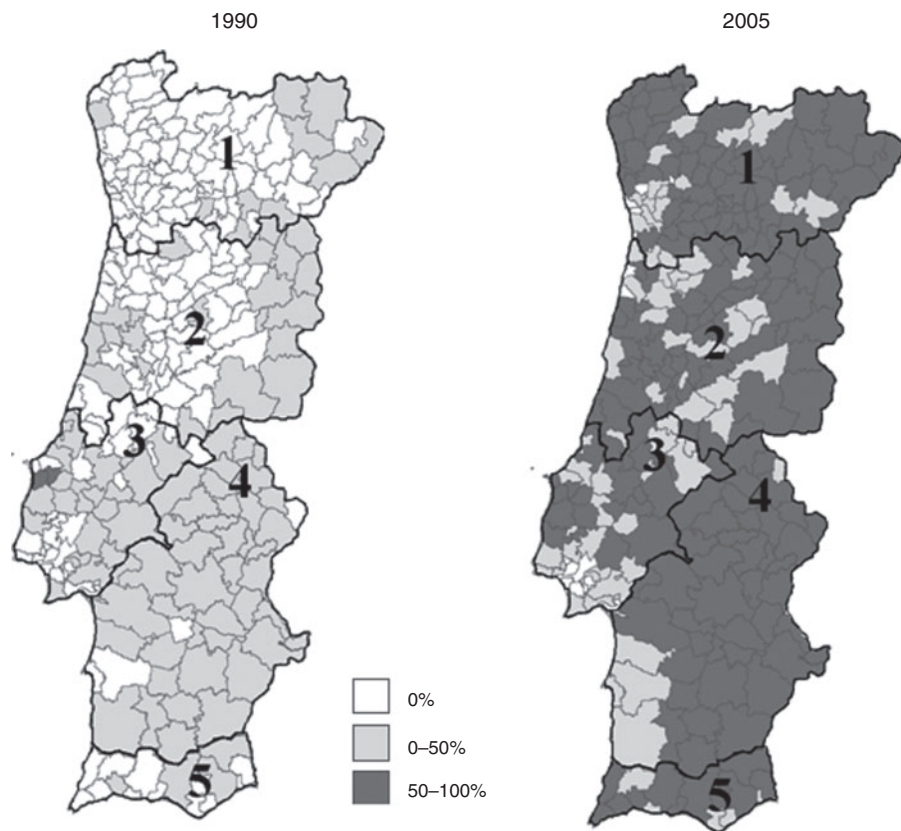
**Fig. 3.** Latrine abundance index (LAI) of 2002 in relation to those of 1995. The black line represents stable populations. Under this line, populations decreased whereas those above increased.

rapidly increasing rabbit numbers (e.g. restocking operations, very popular within Portuguese hunters, usually conducted before the opening of the hunting season) or even the putative lower hunting pressure may account for the oscillations observed in the numbers of harvested rabbits from 1995 to 2002. Any of these factors could have artificially increased the number of hunting bags, even though the real abundance of wild rabbits would have continued to decrease within hunting reserves. In conclusion, the

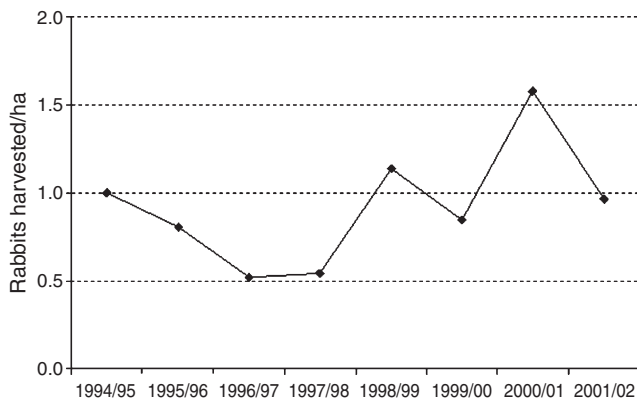
overall slightly positive trend in the numbers of rabbits harvested per hectare observed during the study period puts into evidence the lack of correspondence between hunting statistics and field data, in the post-RHD period.

Taken together, we believe that hunting statistics are not yet sufficiently accurate to assess rabbit trends in Portugal. The absence of a systematic and rigorous method to record hunting data in Portugal and the lack of supervision and integration of the records provided by hunters and game managers may explain the observed inconsistencies, a situation also experienced in Spain (see Delibes-Mateos *et al.* 2009 for a discussion on the usefulness of rabbit-hunting records in the Iberian Peninsula).

The results of the present work have provided valuable information for assessment of rabbit conservation status in Portugal. Taking into consideration the observed decline (27%), the potential maintenance of limiting factors (e.g. predation, habitat loss and/or the interaction between the latter and disease) after the initial high morbidity caused by RHD (Villafuerte *et al.* 1995), and the connectivity with the Spanish populations, the wild rabbit is classified as *Near Threatened* (NT) in the updated version of the Portuguese Red List of Vertebrates (Cabral *et al.* 2005). This supports the recognition that a nationwide conservation program for rabbits should include both socioeconomic constraints (importance of rabbit as a game species) as well as biological data on population trends (Virgós *et al.* 2007).



**Fig. 4.** Percentage of occupation of hunting reserves (all types) within each municipality in continental Portugal in 1990 and 2005. Numbers 1–5 represent 1st to 5th administrative game regions.



**Fig. 5.** Temporal trends obtained with the software TRIM for wild rabbit populations estimated from hunting bags (number of rabbits harvested per hectare) for continental Portugal between 1994/95 and 2001/02.

During the past years, wild rabbit has reached a worldwide paradigmatic situation (invasive alien *v.* endangered native species), which has been the focus of avid discussion and a catalyst for active attempts to improve management measures on both sides of the world (e.g. Lees and Bell 2008). Remarkably, the same paradox exists in the areas where the species is native (as evidenced by the results from field surveys in the present work). The Iberian Peninsula is the only region of the world where the species is both in steep decline and causing damage to crops, where it benefits from threatened conservation status and simultaneously is one of the three most important small game species, and where its spatial distribution is so heterogeneous that it can be considered simultaneously absent and a pest species in two locations just a few kilometres apart. Therefore, balancing perspectives and finding global satisfactory solutions for all sectors involved in rabbit management and conservation is even a harder task in its region of origin (Portugal and Spain). In this context, the attribution of a unique national conservation status could seem somewhat complex because of the disparity of abundance levels, conflicts of interest and even intrinsic biological characteristics of the rabbit, such as high productivity, that allow it to change local status rapidly.

The potential for continuing decline of rabbit populations in Portugal implies that management and conservation efforts should be enhanced to ensure a reversion of the current population trend. As a consequence of the classification of the wild rabbit as an NT species in the Portuguese Red List of Vertebrates in 2005, Portuguese authorities created the Wild Rabbit Recovery Program (in Portuguese, PRECOB; Portuguese Law issue no. 296/2007, 8-01), under the coordination of the DGRF, and in collaboration with other public institutions, namely NGOs and research centres. This document includes the definition of a national wild rabbit monitoring methodology and network, the establishment of epidemiological studies of myxomatosis and RHD and the adjustment of hunting efforts (especially hunting bags and hunting season) to current abundance levels of the species, among others. Clearly, improvements need to be made towards the quality of the information concerning the status of the wild rabbit in the country, mainly information regarding

hunting statistics, which could be of potential use if gathered in a more systematic and rigorous format. Other efforts are currently being made to enhance rabbit populations in the wild (such as restocking, habitat management, rabbit monitoring) although these lack global strategy and are still too local to be visible.

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