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Is forest certification targeting areas of high biodiversity in cork oak savannas?

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Abstract Over the last four decades the world has been losing biodiversity at an alarming rate despite the increasing number of protected areas (PAs). Certified forest management may complement the role of PAs in protecting biodiversity. Forest certification aims to promote sustainable forest management and to maintain or enhance the conservation value of certified forests. The area of forest under certified forest management has grown quickly over the past decade. Forest Stewardship Council (FSC) certification, for example, currently covers 148 million hectares, i.e., 3.7 % of the world's forests. In spite of such increase there is, however, a dearth of information on how forest certification is related to biodiversity. In this study we assessed if FSC certification is being applied in high biodiversity areas in cork oak savannas in Portugal by comparing biodiversity values of certified and non-certified areas for birds, reptiles and amphibians. We calculated the relative species richness and irreplaceability value for each group of species in certified and non-certified areas and compared them using randomization tests. The biodiversity value of certified areas was not significantly greater than that of non-certified areas. Since FSC certification is expanding quickly in cork oak savannas it is important to consider the biodiversity value of these areas during this process. Prioritizing areas of high biodiversity value would enhance the conservation value of forest certification and facilitate integrating certification with other conservation initiatives.

Keywords Forest management · Biodiversity conservation · Conservation strategies · Mediterranean · Species richness · Irreplaceability

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Introduction

Over the last four decades the world has been losing biodiversity at an alarming rate, despite increasing conservation efforts (Butchart et al. 2010; Pereira et al. 2010). Protected areas (PAs) have long been the cornerstone of biodiversity conservation strategies worldwide, covering now 12.9 % of the terrestrial surface (Jenkins and Joppa 2009). However, this strategy has been insufficient to prevent biodiversity loss (CBD 2010) mainly due to conflicts with human activities (Joppa and Pfaff 2009; Loucks et al. 2008).

In 2050, the human population is expected to reach 9,000 million and resource consumption to increase considerably (Tilman et al. 2011; UNEP 2011). This will exert further pressure on biodiversity conservation and therefore it is crucial to find effective ways of reconciling sustainable production and biodiversity conservation (Miller et al. 2011; Shahabuddin and Rao 2010).

Forest certification is a conservation tool that aims to promote the sustainable management and conservation of forest ecosystems by adding market value to products generated according to environmental and socio-economic principles (Auld et al. 2008, Gomez-Zamalloa et al. 2011). It is based on third-party auditing of compliance with environmental and socio-economic standards, developed by governmental actors, environmental non-governmental organizations, industry associations, and social groups through participatory public processes. Forest certification relies on the willingness of a growing number of consumers to pay more for sustainably generated products and it aims to reward forest managers that follow sustainable forest management practices (Auld et al. 2008; Brown et al. 2001; Suzuki and Olson 2008).

The first steps towards the creation of sustainable forest certification were taken after the 1992 United Nations Conference on Environment and Development (UN CED), when governments failed to commit on a legally binding global forest management agreement that ensured the sustainable management of tropical forests (Humphreys 2009). Forest Stewardship Council (FSC) certification was created in 1993 to “promote environmentally appropriate, socially beneficial, and economically viable management of the world’s forests” (Auld et al. 2008; www.fsc.org).

FSC certification comprises 10 principles and 57 criteria that cover environmental, social and economic aspects of forest management. Biodiversity conservation is addressed by Principle 6 “Environmental Impact” and by Principle 9 “High Conservation Value Forests”. Principle 6 states that “forest management shall conserve biological diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes”. Principle 9 states that “management activities in high conservation value forests shall maintain or enhance the attributes which define such forests” (Auld et al. 2008; www.fsc.org).

The area under FSC certification has grown quickly over the last decades and now covers 148 million hectares (FSC 2012), representing 3.7 % of the world’s forests (www.fao.org). FSC certification has had positive effect on biodiversity conservation, both in tropical (Azevedo-Ramos et al. 2006) and temperate forests (Elbakidze et al. 2011; Gulbrandsen 2005; Gullison 2003; Ioras et al. 2009). However less is known for Mediterranean type forests, where currently there are 4 million ha of FSC certified forests. Specifically it is not known if FSC certification is occurring in areas of high biodiversity value and thus contributing to the sustainable management and conservation of these areas.

Mediterranean cork oak savannas are silvopastoral systems (hereafter cork oak savannas) typically of the West Mediterranean Basin which may have resulted originally from the transformation of dense cork oak forests through cattle grazing, shrub clearing, human induced fires and, more recently, through reforestation (Bugalho et al. 2009; Pinto-Correia and Fonseca 2009). They form multiple-use systems where cork and livestock production are dominant activities, that when properly managed have both economic and conservation value (Bugalho et al. 2011).

Cork oak savannas cover approximately 1.5 million hectares in southwestern Europe and 1 million hectares in North Africa (Pausas et al. 2009). This system is characterized by a sparse tree cover (30–60 trees/ha) of cork oak, solely or mixed with other evergreen oaks (e.g. *Quercus rotundifolia*) or pine trees (e.g. *Pinus pinea*), and an understory of shrub species (e.g. *Cistus sp.* interspersed with grasslands, fallows and sometimes cereal crops (Bugalho et al. 2009).

The heterogeneity and wide variety of habitats that coexist within these ecosystems supports a high diversity of animal and plant species. For instance, more butterfly and passerine bird species can be found in cork oak savannas than in adjacent closed-canopy oak woodlands, grasslands or croplands (Diaz et al. 1997). Also, more than 135 species of vascular plants can be found per 0.1 ha of cork oak savanna, including a high diversity of shrub species (Díaz-Villa et al. 2003).

Cork oak savannas support a high diversity of birds, mammals, amphibians and reptiles, many of which are endemic to the Iberian Peninsula, such as the Cabrera's vole (*Microtus cabrerae*), the Iberian midwife toad (*Alytes cisternasii*), the Iberian painted frog (*Discoglossus galganoi*) or the Bedriaga's skink (*Chalcides bedriagai*). Cork oak savannas are also a key habitat for several migratory and overwintering birds, such as the 70,000 Eurasian cranes (*Grus grus*) and the 6 million wood pigeons (*Columba palumbus*) that annually visit the Iberian Peninsula (Diaz et al. 1997) and for several critically endangered species such as the Iberian imperial eagle (*Aquila adalberti*), the Eurasian black vulture (*Aegypius monachus*) and the Iberian lynx (*Lynx pardinus*) (Cabral et al. 2006; Catry et al. 2010; Diaz et al. 1997; Equipa Atlas 2008; Loureiro et al. 2008).

FSC certification has been implemented in cork oak savannas in Portugal, which is the country with the largest area of cork oak cover, 716,000 ha. Forest certification schemes such as FSC may complement the role of other regulatory tools for conservation currently implemented in Portugal, including PAs which cover 1.69 % of cork oak savannas and the Natura 2000 network—a Pan European network of PAs—which covers 26 % of cork oak distribution (cork oak savannas are a "classified habitat" under Natura 2000). Also, farmers located in the Natura 2000 network can benefit from the Agri-environmental schemes of the Common Agricultural Policy of the European Union, which are a set of payments for farmers developed to favor sustainable agricultural practices in these areas (Bugalho et al. 2011).

The main source of income in cork oak savannas is cork production, 70 % of which is used to make wine bottle stoppers. Since 2003 cork market prices have declined 30 % due to the economic crisis and competition with metal screw caps and synthetic stoppers (Mendes and Graça 2009). Portugal is the world's largest cork producer, with 49.6 % of the world's production, followed by Spain with 30 % (Mendes and Graça 2009). Since 2007, cork oak landholders and producers in Portugal started certifying cork production according to FSC standards, in an attempt to reclaim market share, and as response to the global market demand for FSC certified cork (Berrahmouni et al. 2009; Bugalho et al. 2011). As of June of 2011 there were over 100,000 ha of FSC certified cork oak savannas in the Mediterranean, 90,000 of which in Portugal, 9,940 ha in Spain and the remaining area in Italy (www.info.fsc.org). In spite of such expansion there still is little information about how FSC certification is related to areas of high biodiversity value.

We addressed this issue by comparing the biodiversity value of certified and non-certified areas of cork oak savanna in Southern Portugal using data on the distribution of birds, reptiles and amphibians.

Methods

Study area

This study was conducted in south Portugal, where the world's largest continuous area of cork oak is located. Ninety-four percent of the cork oak cover in Portugal occurs in this region (Autoridade Florestal Nacional 2010). The terrain is moderately hilly with a mean altitude of 178 meters with values ranging between 0 and 1,019 m above the sea level. The climate is typically Mediterranean, with a hot and dry summer and a rainy winter. Mean annual temperatures range between 15 and 18 °C and precipitation levels between 600 and 800 mm/year (www.meteo.pt). The dominant forest cover types are cork (*Quercus suber*) and holm oak (*Q. rotundifolia*), interspaced with maritime pine (*Pinus pinaster*), stone pine (*Pinus pinea*) and blue gum (*Eucalyptus globulus*) plantations.

To define the study area we followed the criterion of Food and Agriculture Organization (FAO) that considers an area as a Mediterranean forest if it has a canopy projection ≥10 % (FAO 2006). We took the 10 × 10 km UTM grid used in national biodiversity surveys and defined the study area as the set of cells with canopy projection of cork oak ≥10 % (Fig. 1). This threshold value (Thr) is reasonable for cork oak savannas given the typically low tree density of the system.

Data collection

For each cell of the study area we compiled the most recent data on: (1) occurrences of breeding non marine birds (Equipa Atlas 2008), reptiles and amphibians (Loureiro et al. 2008) that spend part of their life cycle in cork oak savannas, (2) area of cork oak savannas (Autoridade Florestal Nacional 2010) and (3) area of FSC certified cork oak savannas (http://info.fsc.org) using Quantum GIS 1.8 (Quantum GIS Development Team 2011).

Two hundred and nine species were recorded in the study area, 172 birds, 15 amphibians and 22 reptiles. Of these, 10 species are classified as Critically Endangered (10 birds), 15 as Endangered (13 birds and 2 reptiles) and 25 as Vulnerable (23 birds and 2 Reptiles) (Appendix 1).

We gathered biodiversity data for 86,582 ha of cork oak savannas that were FSC certified between 2007 and June 2011. This value is overestimated because it also includes agricultural lands that are component of cork oak savannas, which could not be excluded from the analysis due to lack of information.

A cell was considered certified if the percentage of certified cork oak savanna in that cell was greater or equal than a Thr of 2, 5, 10 and 20 % (that is 200, 500, 1,000 and 2,000 ha, respectively). The use of thresholds is common when data are at different spatial scales (e.g. Araújo et al. 2007).

Assessing the biodiversity value of a set of cells

The biodiversity value of a group of cells, with respect to all species and threatened species, was measured in two different ways.

(1) One that only accounts for species representation and measures the percentage of species represented in a set of cells, in relation to the total number of species in the study area. We call this index the relative richness of the set of cells.

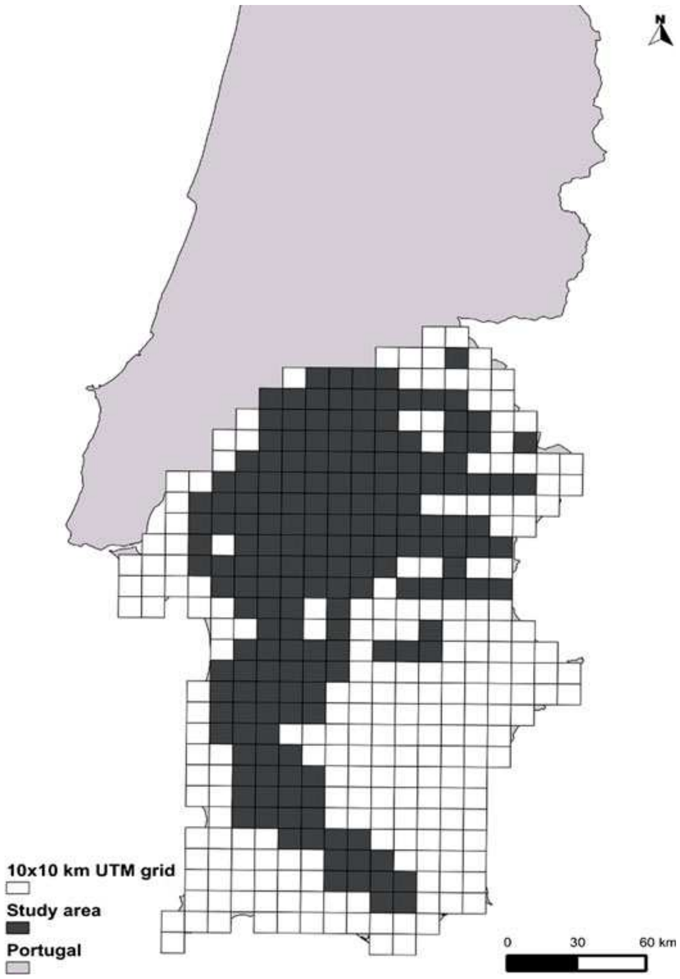

Fig. 1 Location of the study area (*black cells*) superimposed on the 10 × 10 km UTM grid (*white cells*). The cells included in the study area have a percentage of cover by cork oak savannas ≥10 %

(2) The other is based on the concept of irreplaceability (Carwardine et al. 2006; Ferrier et al. 2000; Pressey et al. 1994). To calculate the irreplaceability of each cell, we determined all minimum sets of cells where every species can be represented at least T times. This was achieved by repeatedly solving a "minimum set cover problem" with additional constraints which cut from feasibility the optimal solutions obtained in previous iterations (Rodrigues et al. 2000; Wilson et al. 2009). We implemented this approach in C ++ and used CPLEX (IBM 2010) as an integer programming solver. We defined the irreplaceability of a cell as the percentage of minimum solutions (m.s.) that include the cell, for the corresponding target representation T. We used targets T equal to 1 (T1) and 2 (T2) to consider two different conservation scenarios, a less demanding (1 representation per species) and a more demanding (2 representations per species, whenever possible).

To obtain the T-irreplaceability value of a group of cells, we summed the T-irreplaceability values of its cells. Note that contrarily to the relative richness, the T-irreplaceability of a set may exceed 100.

Groups of cells with a high relative richness may present high or low irreplaceability value, depending on the distribution of species with few representations. For example, if poorly represented species occur in cells with low relative richness, the irreplaceability value of the cells with high relative richness will be low.

Comparing the biodiversity value of certified and non-certified areas

To compare the relative richness and irreplaceability value of FSC certified and non-certified cells we used randomization tests described as follows. Considering the certification thresholds Thr = 2, 5, 10 and 20 %, we calculated the relative richness (overall relative richness and relative richness of threatened species) and summed T-irreplaceability of the group of certified cells. Then we compared the biodiversity value of the certified cells with the biodiversity value of 10,000 randomly selected groups of non-certified cells with the same size. We did this by calculating the percentage of randomly selected groups of non-certified cells that had lower relative richness and/or T-irreplaceability than the group of certified cells. High percentages (>90 %) indicate that the biodiversity value of the certified cells is significantly greater than that of the non-certified cells.

The group of threatened reptiles was excluded from the analysis because it only had three species. All computations were performed using R 2.12.2 (R Development Core Team 2011).

Results

Certified area

The area of cork oak savanna with at least 10 % of forest cover was mainly located in southwest Portugal (Fig. 1). Within this area, certified cells were concentrated in the northern part of the study area. The cells with higher percentages (≥10 %) of certified area were also clustered in the northern part of the study area (Fig. 2).

The distribution of certified area per cell was asymmetrical. There was a high number of cells with low percentages of certified area and a low number of cells with high percentages of certified area. For example, 37 % of certified cells had less than 10 % of certified area (Fig. 3).

Certified area varied with the certification threshold. For example, for Thr = 2 % (certified area ≥200 ha), 55 cells or 31 % of the study area was considered certified. Conversely, for Thr = 20 % only 16 cells or 9 % of the study area was considered certified (Table 1).

Relative richness

The number of species per individual cell in the study area varied between 68 and 118, with an average of 90 and a standard deviation (SD) of 10.5. The number of threatened species per cell ranged between 1 and 11, with an average of 4.2 and SD of 1.64. The cells

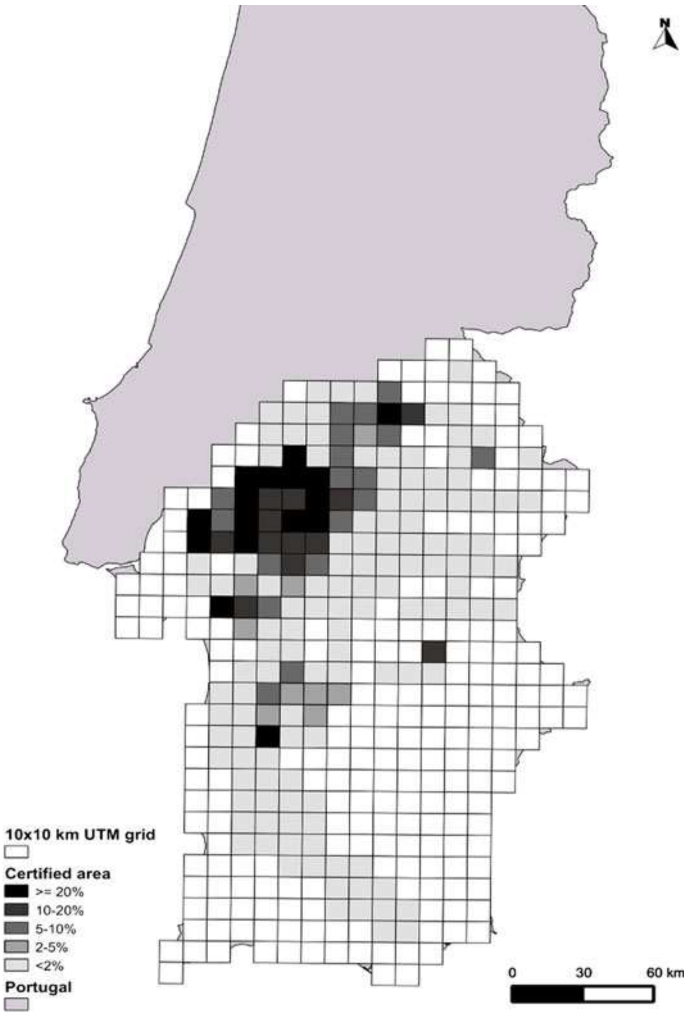

Fig. 2 Percentage of certified cork oak savanna per cell in the study area, according to the four certification thresholds, 2, 5, 10 and 20 %. A certification threshold of, for example 2 %, means that at least 2 % of the area of the cell is certified

with higher number of total species and threatened species were mostly located in the northern part of the study area (Fig. 5a, Fig. 6a).

The certified area covered 80.4 and 89.5 % of all species for Thr = 20 % and Thr = 2 %, respectively, and covered 63.3 and 71.4 % of the threatened species, for the same thresholds (Fig. 4). The cells with a certified area ≥2,000 ha represented most of the species occurring in the study area and the other certified cells only added a few unrepresented species.

Regardless of the threshold, more than 80 % of all species, all birds and all amphibians, and more than 60 % of all threatened species, all reptiles and threatened birds are represented in certified areas. Only one of the three threatened species of reptiles is represented in certified cells (Fig. 4).

Fig. 3 Frequency distribution of certified area per 10 × 10 km cell

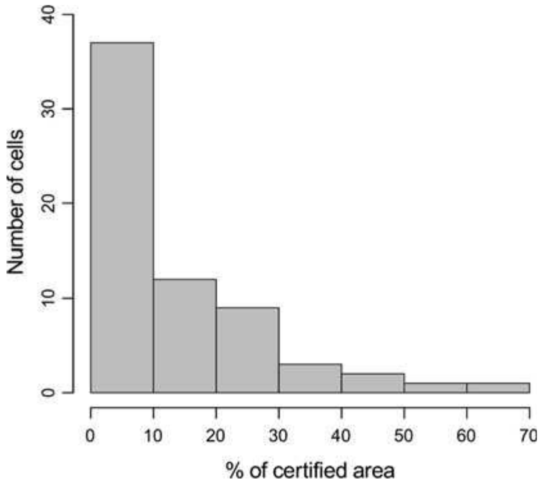

Table 1 Number and area of 10 × 10 km certified cells per certification threshold (% and area) as of June 2011. A cell is considered certified if its percentage of certified area is greater or equal than a Thr of 2, 5, 10 and 20 %

Threshold		Number of certified cells	Certified area within the study area (%)
%	ha		
2	200	55	31
5	500	46	26
10	1,000	28	16
20	2,000	16	9

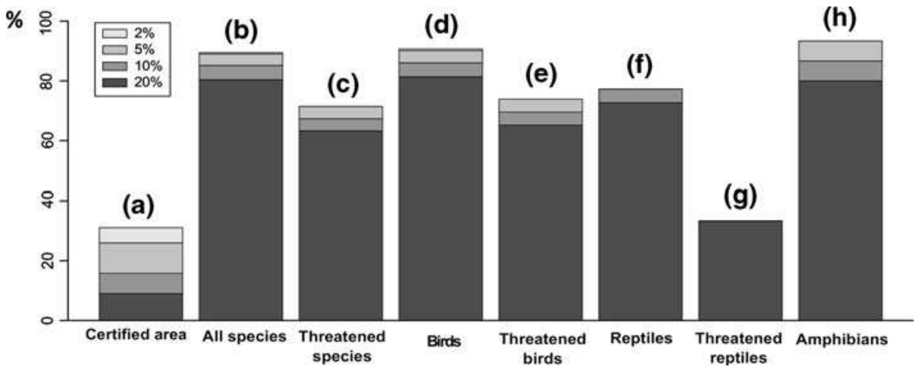

Fig. 4 *Bar* (*a*) is the ratio (%) between the number of certified cells and the total number of cells in the study area. *Bars* (*b–h*) are the relative richness of each group of certified cells. *Shaded areas* refer to four certification thresholds Thr = 2, 5, 10 and 20 %. A cell is considered certified if the percentage of certified area in that cell is greater or equal than a Thr of 2, 5, 10 and 20 %

Irreplaceability value

It is possible to represent all 209 species at least once and at least twice in 18 and 31 cells, respectively, which are the sizes of the corresponding minimum set cover solutions. The number of different m.s. are 48 and 684 for T1 and T2, respectively. All 49 threatened species can be represented at least once in 12 cells (78 m.s.) and at least twice in 21 cells (2,826 m.s.).

When considering all species, and regardless of the representation target (T1 and T2), the cells with irreplaceability >0 were scattered across the study area (Fig. 5b, c). The same was observed for threatened species (Fig. 6b, c). These cells also presented a low coincidence with certified areas (Fig. 2, Fig.5 and Fig. 6).

The percentages of T-irreplaceability of certified cells, for all groups of species, were below 34.9 %, regardless of the certification threshold. Birds presented the highest values and amphibians the lowest (Fig. 7).

For the groups of threatened species and threatened birds, all cells with positive T1-irreplaceability had a certified area ≥2,000 ha (i.e., are considered certified for a Thr = 20 %) (Fig. 7d, h). This was not the case for the other groups of species.

Comparing the biodiversity value of certified and non-certified areas

A visual comparison between Fig. 2 and Fig. 5 suggests a low degree of overlap between cells with high percentages of certified area and cells with high relative richness and high irreplaceability value. This was confirmed by the randomization tests that resulted in a low percentage of simulated groups of non-certified cells with biodiversity values lower than the group of certified cells (Table 2). This indicates that, in general, the relative richness and T-irreplaceability of randomly chosen non-certified cells was higher than that of certified cells. Only in two cases more than 90 % of the simulated sets of non-certified cells exhibited lower values than the certified cells, T1-irreplaceability for birds and for threatened birds (both for Thr = 20 %) (Table 2).

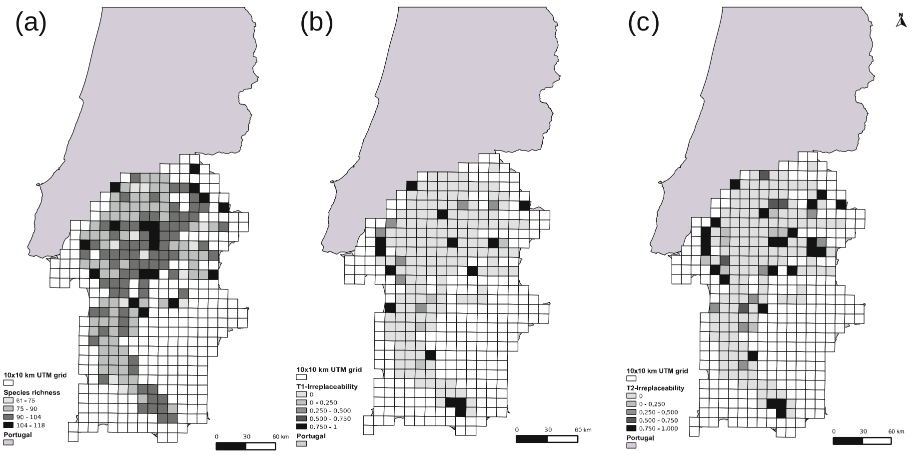

Fig. 5 Biodiversity value of the cells located in study area, considering all species, expressed in **a** species richness, **b** T1-irreplaceability **c** T2-irreplaceability

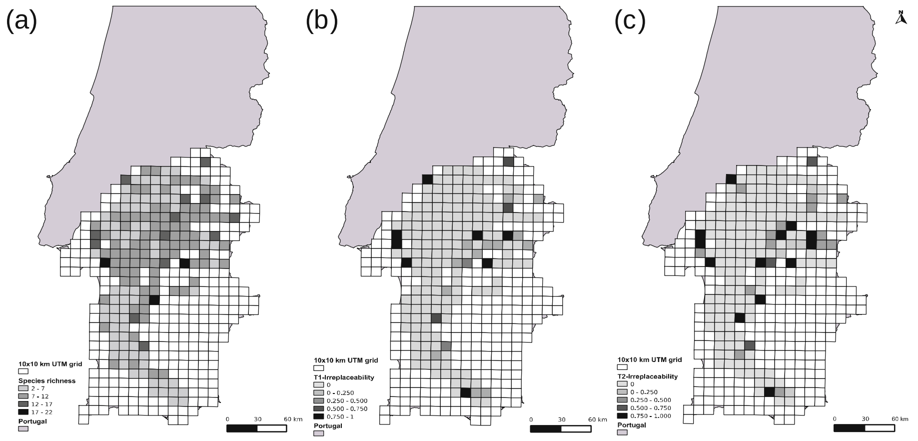

Fig. 6 Biodiversity value of the cells located in study area, considering only threatened species, expressed in **a** species richness, **b** T1-irreplaceability, **c** T2-irreplaceability

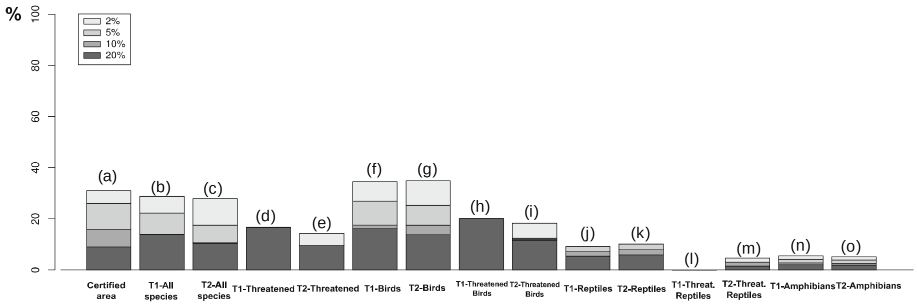

Fig. 7 *Bar* (*a*) is the ratio (%) between the number of certified cells and the total number of cells in the study area. *Shaded areas* refer to four certification thresholds Thr = 2, 5, 10 and 20 %. Bars (*b*–*o*) are the percentage of T-irreplaceability of certified cells. The height of each bar represents the ratio between the T-irreplaceability of certified cells and the T-irreplaceability of all cells in the study area. A cell is considered certified if its percentage of certified area is greater or equal than a Thr of 2, 5, 10 and 20 %

For Amphibians less than 7 % of simulated non-certified groups had lower irreplaceability values than the corresponding certified groups (Table 2).

Discussion

Most of the certified area of cork oak savannas is located in the northern part of the study area. Socio-economic reasons may contribute to explain why the certification of cork oak savannas has initiated in this region. For example, it is in this region that the highest productivity of cork is attained, with values ranging between 114 and 145 kg/ha/year when the national averages are between 90.8 and 125.5 kg/ha/year (Autoridade Florestal Nacional 2010). Also the mean property size in this area is the highest in the country, being approximately 103 ha, whilst on the southern edge of the study area it is below 20 ha (Coelho 2003). FSC certification is a demanding and costly process that requires frequent

Table 2 Percentage of the simulated groups of non-certified cells that had lower biodiversity value than the group of certified cells for the four certification thresholds. A cell is considered certified if its percentage of certified area is greater or equal than a Thr of 2, 5, 10 and 20 %. The irreplaceability of a cell is the percentage of minimum solutions that include that cell, for a given species representation target. The T-Irreplaceability of a group of cells is the sum of the irreplaceabilities of each individual cell

		Biodiversity value	Thr = 2 %	Thr = 5 %	Thr = 10 %	Thr = 20 %
All species	All	Relative richness	7.2	11.6	30.7	45.7
		T1 - irreplaceability	34.6	29.5	42	84.3
		T2 - irreplaceability	23	3.4	13.6	66.3
	Threatened	Relative richness	1.9	5.4	44.9	85.5
		T1-irreplaceability	2.2	11.1	58	88.8
		T2-irreplaceability	0.1	0.1	11.7	57.8
Birds	All	Relative richness	46.2	43	57.7	69.2
		T1 - irreplaceability	71.5	55.8	62.1	90.8
		T2 - irreplaceability	79.4	45.2	63.8	85.4
	Threatened	Relative richness	9.7	16.9	61.5	89.1
		T1 - irreplaceability	21.3	41.6	83.2	99.7
		T2 - irreplaceability	1.5	1.3	28.7	71.7
Reptiles	All	Relative richness	0	0	4.2	20.3
		T1 - irreplaceability	0.1	1.2	13.8	35.9
		T2 - irreplaceability	0.1	0.9	12	32.3
Amphibians	All	Relative richness	29.4	41.8	53.8	0.4
		T1 - irreplaceability	0	0	0.2	6.9
		T2 - irreplaceability	0	0	0.1	4.8

monitoring and auditing (Marx and Cuypers 2010). The relatively high cork production that landowners may atain in this region helps to dilute the costs of forest certification and explain why certification has started here.

We found that, in general, the biodiversity value of certified areas was not significantly higher than the values obtained for randomly selected non-certified areas with the same size. With the exception of T-irreplaceability for all birds and for threatened birds with a certification threshold of Thr = 20 %, less than 90 % of the simulated non-certified groups of cells presented lower biodiversity value than the certified cells (Table 2).

Although not significantly higher than that of non-certified areas, the relative richness of FSC certified cells regarding birds, reptiles and amphibians was substantial. More than 81 % of all birds, 72 % of all reptiles and 80 % of all amphibians were present in certified areas (Fig. 4). Threatened species of these groups were also relatively well represented in certified areas, with more than 65 % of the species present. For example, the Egyptian vulture (*Neophron percnopterus*) whose conservation status is Endangered and the northern goshawk (*Accipter gentilis*) that is listed as Vulnerable in Portugal, occur in certified areas. Reptiles were the only exception, since only one of the three threatened species that occurs in the study area (European pond turtle *Emys orbicularis*) was present in certified areas. The high relative richness of certified cells was due to a large number of species that are widespread over the study area. For example, 41 % of the species occur in more than 50 % of study area. Generalist species like the European goldfinch (*Carduelis carduelis*), the corn bunting (*Emberyza calandra*) and the African stonechat (*Saxicola torquatus*), that are very common in cork oak savannas (Catry et al. 2010), occur in every cell of the study area.

The 16 cells with a certified area above 2,000 ha (i.e., Thr = 20 %) had a remarkably high relative richness, representing more than 80.4 % of all the species occurring in the study area (Fig. 4). This is not completely surprising since these 16 cells cover a large area (160,000 ha). In fact, randomization tests confirmed that the relative richness of these cells is not significantly greater than that of any other 16 cells (Table 2). When the certification threshold is lowered to Thr = 2 % (i.e. increasing the number of certified cells from 16 to 55) the relative richness only increased by 9.1 %. Similar results were observed for birds, reptiles and amphibians separately.

The T-irreplaceability of certified areas was generally low (<34.9 %), regardless of the group of species considered and it was also not significantly higher than the observed for simulated groups, with the exception of birds (T1 and Thr = 20 %). For Amphibians the results suggest that non-certified areas presented higher irreplaceability value than the certified ones. In general these results can be explained by the lack of spatial coincidence between certified areas and irreplaceable cells. The minimum set cover solutions are strongly conditioned by the cells where species with only one or two representations occur (Rodrigues et al. 2000; Wilson et al. 2009). Ten among the 18 species that only occurred in 1 or 2 cells are not present in certified cork oak savannas. For example, the western olivaceous warbler (*Hippolais opaca*), that inhabits riparian vegetation associated with cork oak savannas, only occurs in one cell located in the south of the study area, that has no certified area. The reed bunting (*Emberiza schoeniclus),* that can be found in wetlands occurring in cork oak savannas, only occurs in one cell on the western limit of the study area, that also has no certified area. The Iberian frog (*Rana iberica)* and the golden eagle (*Aquila chrysaetos),* that inhabit cork oak savannas located in mountainous regions, only occur in two cells that also have no certified cork oak savannas. The non-overlap between certified areas and the regions where these poorly represented species occur determined the low T-irreplaceability values of the certified areas.

FSC certification provides an economic incentive for landowners to adopt sustainable forest management practices which also aim to benefit the conservation of biodiversity. In Portugal 26 % of all cork oak savannas are under PAs or the Natura 2000 network. Of the 87,307 ha of FSC certified cork oak savannas, only 5.3 % coincide with these areas. FSC certification is thus contributing to the sustainable forest management of an additional 12 % of cork oak savannas that were not under any conservation mechanism.

Conclusions

Although FSC certification has not targeted areas of high biodiversity in cork oak savannas, so far, it must be considered that the process only began 5 years ago and has only covered 12.6 % of the total area of cork oak savanna in Portugal. The main Association of cork oak producers and landholders in Portugal, "União da Floresta Mediterrânica", has made a public commitment to increase the area of certified cork oak savannas to 150,000 ha by the end of 2012 (www.unac.pt). If achieved, this objective would substantially enlarge the area of cork oak under forest certification. It would be desirable to consider the biodiversity value of these areas during this process. For example, prioritizing areas where productive forests coincide with high biodiversity values would enhance the conservation purposes of forest certification and facilitate integrating certification with other conservation initiatives.

Presently there are governmental funding programs that aim to compensate for the costs of forest certification and to incentivize it, such as the one implemented by the Forestry

National Authority in Portugal (www.afn.min-agricultura.pt/portal/apoiosinvest/ffp/apoios-a-certificacao-da-gestao-florestal) or the "Woodland Grant Scheme" of the Forestry Commission in the UK (http://www.forestry.gov.uk/ewgs). We suggest that these programs should, whenever appropriate, prioritize the certification of high biodiversity areas. Methods used here could contribute to identifying these priority areas.

Our study was a first step towards quantitatively assessing forest certification and its relation to biodiversity in cork oak savannas. Future research should address how certified forest management practices may contribute to maintaining or enhancing the biodiversity value of areas under forest certification.

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Appendix

See Tables 3, 4 and 5.

Table 3 List of bird species

Scientific name	Common name	Conservation status
Accipiter gentilis	Northern goshawk	VU
Accipiter nisus	Eurasian sparrowhawk	LC
Acrocephalus arundinaceus	Great reed warbler	LC
Acrocephalus scirpaceus	Eurasian reed warbler	NT
Actitis hypoleucos	Common sandpiper	VU
Aegithalos caudatus	Long-tailed tit	LC
Alauda arvensis	Eurasian skylark	LC
Alcedo atthis	Common kingfisher	LC
Alectoris rufa	Red-legged partridge	LC
Anas clypeata	Northern shoveler	EN
Anas crecca	Eurasian teal	LC
Anas platyrhynchos	Mallard	LC
Anas querquedula	Garganey	NE
Anas strepera	Gadwall	VU
Anthus campestris	Tawny pipit	LC
Anthus trivialis	Tree pipit	NT
Apus apus	Common swift	LC
Apus caffer	White-rumped swift	NE
Apus melba	Alpine swift	NT
Apus pallidus	Pallid swift	LC
Aquila chrysaetos	Golden eagle	EN
Aquila fasciata	Bonelli's eagle	EN
Ardea cinerea	Grey heron	LC

Table 3 continued

Scientific name	Common name	Conservation status
Ardea purpurea	Purple heron	EN
Ardeola ralloides	Squacco heron	CR
Asio otus	Long-eared owl	DD
Athene noctua	Little owl	LC
Aythya ferina	Common pochard	EN
Bubo bubo	Eurasian eagle-owl	NT
Bubulcus Ibis	Western cattle egret	LC
Burhinus oedicnemus	Eurasian stone-curlew	VU
Buteo buteo	Common buzzard	LC
Calandrella brachydactyla	Greater short-toed lark	LC
Calandrella rufescens	Lesser short-toed lark	CR
Caprimulgus europaeus	European nightjar	VU
Caprimulgus ruficollis	Red-necked nightjar	VU
Carduelis carduelis	European goldfinch	LC
Cercotrichas galactotes	Rufous-tailed scrub robin	NT
Certhia brachydactyla	Short-toed treecreeper	LC
Cettia cetti	Cetti's warbler	LC
Charadrius alexandrinus	Kentish plover	LC
Charadrius dubius	Little ringed plover	LC
Chlidonias hybrida	Whiskered tern	CR
Chloris chloris	European greenfinch	LC
Ciconia ciconia	White stork	LC
Ciconia nigra	Black stork	VU
Circaetus gallicus	Short-toed snake eagle	NT
Circus aeruginosus	Western marsh harrier	VU
Circus cyaneus	Hen harrier	CR
Circus pygargus	Montagu's harrier	EN
Cisticola juncidis	Zitting cisticola	LC
Clamator glandarius	Great spotted cuckoo	VU
Coccothraustes coccothraustes	Hawfinch	LC
Coloeus monedula	Western jackdaw	LC
Columba livia	Rock dove	DD
Columba oenas	Stock dove	DD
Columba palumbus	Common wood pigeon	LC
Coracias garrulus	European roller	CR
Corvus corax	Northern raven	NT
Corvus corone	Carrion crow	LC
Coturnix coturnix	Common quail	LC
Cuculus canorus	Common cuckoo	LC
Cyanistes caeruleus	Eurasian blue tit	LC
Cyanopica cooki	Iberian magpie	LC
Delichon urbicum	Common house martin	LC
Dendrocopos major	Great spotted woodpecker	LC

Table 3 continued

Scientific name	Common name	Conservation status
Dendrocopos minor	Lesser spotted woodpecker	LC
Egretta garzetta	Little egret	LC
Elanus caeruleus	Black-winged kite	NT
Emberiza calandra	Corn bunting	LC
Emberiza cia	Rock bunting	LC
Emberiza cirlus	Cirl bunting	LC
Emberiza schoeniclus	Common reed bunting	VU
Erithacus rubecula	European robin	LC
Falco naumanni	Lesser kestrel	VU
Falco peregrinus	Peregrine falcon	VU
Falco subbuteo	Eurasian hobby	VU
Falco tinnunculus	Common kestrel	LC
Fringilla coelebs	Common chaffinch	LC
Fulica atra	Eurasian coot	LC
Fulica cristata	Red-knobbed coot	CR
Galerida cristata	Crested lark	LC
Galerida theklae	Thekla lark	LC
Gallinago gallinago	Common snipe	CR
Gallinula chloropus	Common moorhen	LC
Garrulus glandarius	Eurasian jay	LC
Glareola pratincola	Collared pratincole	VU
Gyps fulvus	Griffon vulture	NT
Hieraaetus pennatus	Booted eagle	NT
Himantopus himantopus	Black-winged stilt	LC
Hippolais opaca	Western olivaceous warbler	DD
Hippolais polyglotta	Melodious warbler	LC
Hirundo daurica	Red-rumped swallow	LC
Hirundo rustica	Barn swallow	LC
Ixobrychus minutus	Little bittern	VU
Jynx torquilla	Eurasian wryneck	DD
Lanius excubitor	Great grey shrike	LC
Lanius senator	Woodchat shrike	NT
Locustella luscinioides	Savi's warbler	VU
Lophophanes cristatus	Crested tit	LC
Lullula arborea	Woodlark	LC
Luscinia megarhynchos	Common nightingale	LC
Melanocorypha calandra	Calandra lark	NT
Merops apiaster	European bee-eater	LC
Milvus migrans	Black kite	LC
Milvus milvus	Red kite	CR
Monticola saxatilis	Common rock thrush	EN
Monticola solitarius	Blue rock thrush	LC
Motacilla alba	White wagtail	LC

Table 3 continued

Scientific name	Common name	Conservation status
Motacilla cinerea	Grey wagtail	LC
Motacilla flava	Western yellow wagtail	LC
Muscicapa striata	Spotted flycatcher	NT
Neophron percnopterus	Egyptian vulture	EN
Netta rufina	Red-crested pochard	EN
Nycticorax nycticorax	Black-crowned night heron	EN
Oenanthe hispanica	Black-eared wheatear	VU
Oenanthe leucura	Black wheatear	CR
Oriolus oriolus	Eurasian golden oriole	LC
Otis tarda	Great bustard	EN
Otus scops	Eurasian scops owl	DD
Pandion haliaetus	Western osprey	CR
Parus ater	Coal tit	LC
Parus major	Great tit	LC
Passer domesticus	House sparrow	LC
Passer hispaniolensis	Spanish sparrow	LC
Passer montanus	Eurasian tree sparrow	LC
Pernis apivorus	European honey buzzard	VU
Petronia petronia	Rock sparrow	LC
Phoenicurus ochruros	Black redstart	LC
Phoenicurus phoenicurus	Hodgson's redstart	LC
Phylloscopus bonelli	Western Bonelli's warbler	LC
Phylloscopus collybita	Common chiffchaff	LC
Phylloscopus ibericus	Iberian chiffchaff	LC
Pica pica	Eurasian magpie	LC
Picus viridis	European green woodpecker	LC
Platalea leucorodia	Eurasian spoonbill	VU
Plegadis falcinellus	Glossy ibis	RE
Podiceps cristatus	Great crested grebe	LC
Porphyrio porphyrio	Purple swamphen	VU
Prunella modularis	Dunnock	LC
Pterocles orientalis	Black-bellied sandgrouse	EN
Ptyonoprogne rupestris	Eurasian crag martin	LC
Pyrrhula pyrrhula	Eurasian bullfinch	LC
Rallus aquaticus	Water rail	LC
Recurvirostra avosetta	Pied avocet	NT
Regulus ignicapilla	Common firecrest	LC
Riparia riparia	Sand martin	LC
Saxicola rubetra	Whinchat	VU
Saxicola torquatus	African stonechat	LC
Serinus serinus	European serin	LC
Sitta europaea	Eurasian nuthatch	LC
Sterna albifrons	Little tern	VU

Table 3 continued

Scientific name	Common name	Conservation status
Sterna hirundo	Common tern	EN
Sterna nilotica	Gull-billed tern	EN
Streptopelia decaocto	Eurasian collared dove	LC
Streptopelia turtur	European turtle dove	LC
Strix aluco	Tawny owl	LC
Sturnus unicolor	Spotless starling	LC
Sylvia atricapilla	Eurasian blackcap	LC
Sylvia borin	Garden warbler	VU
Sylvia cantillans	Subalpine warbler	LC
Sylvia communis	Common whitethroat	LC
Sylvia conspicillata	Spectacled warbler	NT
Sylvia hortensis	Western orphean warbler	NT
Sylvia melanocephala	Sardinian warbler	LC
Sylvia undata	Dartford warbler	LC
Tachybaptus ruficollis	Little grebe	LC
Tadorna tadorna	Common shelduck	NE
Tetrax tetrax	Little bustard	VU
Tringa totanus	Common redshank	CR
Troglodytes troglodytes	Eurasian wren	LC
Turdus merula	Common blackbird	LC
Turdus philomelos	Song thrush	NT
Turdus viscivorus	Mistle thrush	LC
Tyto alba	Western barn owl	LC
Upupa epops	Eurasian hoopoe	LC
Vanellus vanellus	Northern lapwing	LC

Conservation status according to the red book of vertebrates of Portugal (Cabral et al. 2006)

CR Critically endangered, *EN* Endangered, *VU* Vulnerable

Table 4 List of amphibian species

Scientific name	Common name	Conservation status
Alytes cisternasii	Iberian midwife toad	LC
Alytes obstetricans	Common midwife toad	LC
Bufo bufo	Common toad	LC
Epidalea calamita	Natterjack toad	LC
Discoglossus galganoi	Iberian painted frog	NT
Hyla arborea	European tree frog	LC
Hyla meridionalis	Mediterranean tree frog	LC
Pelobates cultripes	Western spadefoot	LC
Pelodytes sp	Parsley frog	NE
Pleurodeles waltl	Sharp-ribbed salamander	LC
Rana iberica	Iberian frog	LC

Table 4 continued

Scientific name	Common name	Conservation status
Pelophylax perezi	Perez's frog	LC
Salamandra salamandra	Common fire salamander	LC
Lissontriton boscai	Bosca's newt	LC
Triturus marmoratus	Marbled newt	LC

Conservation status according to the red book of vertebrates of Portugal (Cabral et al. 2006)

CR Critically Endangered, *EN* Endangered, *VU* Vulnerable

Table 5 List of reptile species

Scientific name	Common name	Conservation status
Acanthodactylus erythrurus	Spiny-footed lizard	NT
Anguis fragilis	Slow worm	LC
Blanus cinereus	Iberian worm lizard	LC
Chalcides bedriagai	Bedriaga's skink	LC
Chalcides striatus	Western three-toed skink	LC
Chamaeleo chamaeleon	Common chameleon	LC
Coluber hippocrepis	Horseshoe whip snake	LC
Coronella girondica	Southern smooth snake	LC
Elaphe scalaris	Ladder snake	LC
Emys orbicularis	European pond turtle	EN
Hemidactylus turcicus	Mediterranean house gecko	VU
Timon lepidus	Ocellated lizard	LC
Lacerta schreiberi	Schreiber's green lizard	LC
Macroprotodon cucullatus	False smooth snake	LC
Malpolon monspessulanus	Montpellier snake	LC
Mauremys leprosa	Mediterranian turtle	LC
Natrix maura	Viperine snake	LC
Natrix natrix	Grass snake	LC
Podarcis carbonelli	Carbonelli's wall lizard	VU
Podarcis hispanica	Iberian wall lizard	LC
Psammodromus algirus	Large psammodromus	LC
Psammodromus hispanicus	Spanish psammodromus	NT
Tarentola mauritanica	Common wall gecko	LC
Vipera latasti	Lataste's Viper	VU

Conservation status according to the Red Book of Vertebrates of Portugal (Cabral et al. 2006)

CR Critically endangered, *EN* Endangered, *VU* Vulnerable

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