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RESEARCH ARTICLE

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Evolution of land cover in the special area of conservation of Monchique (Southern Portugal): Have the objectives of the Natura 2000 network been achieved (1995–2018)?

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Abstract

The Natura 2000 Network, as the European Union's ecological network, aims to ensure the long-term conservation of Europe's most threatened species and habitats, helping to stop the loss of biodiversity. Based on this assumption, the changes in land cover in the Special Area of Conservation (SAC) of Monchique between 1995 and 2018 are analysed and related to identify favourable and unfavourable policies concerning the habitats and respective species conservation. The most important land covers are compared with the habitats and species legally protected at the National and European level, as well as the Red List of Vascular Flora of Mainland Portugal. As main results can be highlighted the increase in the forest area occupied by species such as *Eucalyptus globulus* and *Pinus pinaster*, and a reduction in the areas of grazing and shrub species. Can also be noted an increase in the areas covered by invasive species, which may be associated with the abandonment of rural areas. We identified 21 taxa with high heritage interest in the Monchique SAC, occurring mainly in forest habitats, namely 91E0, 92A0, 9240, 9330 and 9340, which should be considered in the elaboration of future Territorial Management Plans. Thus, it can be concluded that the objectives initially stipulated by the Natura 2000 Network were not fully achieved within the Monchique SAC. Alternative management methods must be studied to allow conservation in a territory with a high land consolidation and low population density.

KEYWORDS
endangered species, geobotany, IUCN, land cover change, landscape mosaic, nature politics, territorial planning

1 | INTRODUCTION

In order to protect biodiversity in Europe, a coordinated network of protected areas, the Natura 2000 Network, was established (Ostermann, 1998). The main objective of these areas is to ensure the long-term survival of Europe's most valuable and threatened species and habitats, listed in the Birds Directive and Habitats Directive (Evans, 2012; Kati et al., 2015).

According to the latest Habitats Directive implementation reports, most forest habitats in Portugal present low national coverage and an unfavourable conservation status. On the other hand, several European countries have already identified the need to improve the global conservation strategy (Maiorano et al., 2007; Spiliopoulou et al., 2021; Trochet & Schmeller, 2013). To change this situation, some studies have indicated the urgent need to raise awareness and improve engagement with society (Blicharska et al., 2016; Gantioler et al., 2014; Schneider et al., 2020). However, understanding management actions and the long-term results achieved is essential for designing and correcting conservation strategies (Baquero et al., 2021; Mazaris & Katsanevakis, 2018).

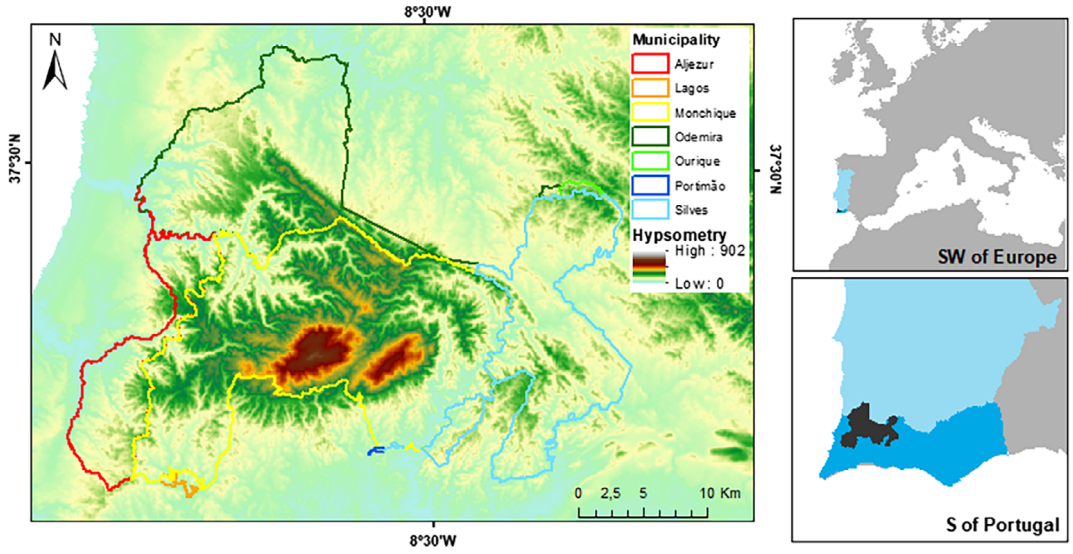

FIGURE 1 Location of the Monchique Special Conservation Area (SAC). [Colour figure can be viewed at wileyonlinelibrary.com]

The year 2022 marks 30 years after the publication of Directive 92/43/EEC of May 21, 1992, and, therefore, a moment to identify the positive and negative aspects of the decisions taken, and the results obtained within the special areas of conservation (SAC). However, in addition to the national reports about the implementation of the Habitats Directive, few studies outside this scope addressed the results obtained in Portugal (Gameiro et al., 2020; Silva et al., 2011; Simonson et al., 2013). Although the definition of these areas encompassed agricultural and forestry production areas, it seems that several SAC remains little active in achieving the objectives initially defined at the European level (Forstmaier et al., 2020; Guerra et al., 2018).

One of the areas in mainland Portugal with the greatest biodiversity heritage is Serra de Monchique, representing the highest point in the Algarve region (da Gama et al., 2000; Deil et al., 2008; Malato-Beliz, 1982; Porley et al., 2021). The Monchique SAC (PTCON0037) is part of one of the greatest biodiversity hotspots worldwide—the Mediterranean Basin (Myers et al., 2000). Also, has 12 threatened species that are included in the Red List of the Vascular Flora of Mainland Portugal (Carapeto et al., 2020; Hagemann & Deil, 2008), and several priority habitats for conservation, such as the temperate Atlantic wet heaths of *Erica ciliaris* and *Erica tetralix* (4020*), arborescent thickets of *Laurus nobilis* (5230*), the sub-steppes of grasses and annuals of *Thero-Brachypodietea* (6220*) and the alluvial forests of *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*) (91E0*). However, land cover is profoundly altered by areas of monoculture forestry (especially with exotic species) and heliophile bushes representing a serial vegetation stage which implies an added risk by increasing the probability of starting fires (Deus et al., 2022; Mitchell et al., 2009; Seng & Deil, 1999; Tedim et al., 2013).

This study intends to understand the evolution of land cover over time in the Monchique SAC and to identify the consequences of the policies adopted on the flora and habitats in this area. On the other hand, it is intended to relate the impact of population evolution in the various municipal councils with the evolution of the land cover type. Finally, the main management measures for the Monchique SAC are presented to value the conservation of the Natura 2000 Network habitats.

2 | MATERIALS AND METHODS

2.1 | Location of the area under study

The Monchique SAC is in the southwest of Portugal and has approximately 67.5 thousand hectares (Figure 1). The area under study extends over seven municipalities divided by the Algarve and Baixo Alentejo regions, covering a significant part of the Serra de Monchique, whose highest point reaches 902 m next to Fóia (37°18′53.37″ N, 8°35′46.34″ W). This territory is influenced by the oceanic pluvial-seasonal Mediterranean bioclimate, with a thermotype varying from thermo to mesomediterranean and an ombrotype from sub-humid to humid (Rivas-Martínez et al., 2017).

Lithology consists majorly in schists, and at higher altitudes, the nepheline syenites dominate (Bernard-Griffiths et al., 1997; CNA, 1982b). Soils are formed by humic cambisols derived from eruptive rocks (CNA, 1982a). These are normal, cambic humic litholic soils, composed of syenites, belonging to the felsic massive compact materials (Pissarra, 1980), transmitting a basic pH to groundwater (Rock, 1982).

The landscape is profoundly altered and the potential natural vegetation belongs to the domain of the cork oak of the *Lavandulo viridis-Querco suberis sigmetum* series and the African oak of *Euphorbio monchiquensis-Querco canariensis sigmetum* (Malato-Beliz, 1982). However, other taxa of the genus *Quercus* mark the landscape, such as *Quercus estremadurensis*, *Q. marianica*, *Q. broteroi*, *Q. rotundifolia*, *Q. coccifera* and *Q. lusitanica* (Costa et al., 2012).

2.2 | Data collection and analysis

The limits of the SAC were obtained from the official website of the Instituto para a Conservação da Natureza e da Floresta—ICNF (available at https://sig.icnf.pt/, on 20 August 2022). The land use maps were obtained from the Direção Geral do Território—DGT (available at https://www.dgterritorio.gov.pt/, on 20 August 2022). In order to identify the species with legal protection status and with high conservation interest, national legislation for the protection of cork oaks and holm oaks was consulted (Decree-law no. 11/97, of 14 January, Decree-law no. 169/2001, of 25 May, modified by Decree-law no. 155/2004, of 30 June), as well as the Red List of the Vascular Flora of Mainland Portugal (available at https://www.spbotanica.pt/, accessed on 20 August 2022) (Carapeto et al., 2020). It was also included the *Rhododendron ponticum* subsp. *baeticum* (Boiss. & Reut.) Hand.-Mazz. to the list, as it is a rare species at a national level (with only two areas of known occurrence) and due to the lack of natural regeneration (Mejías et al., 2007).

All available land cover maps were used (issued in 1995, 2007, 2010, 2015 and 2018). The classes were converted into 12 categories, as presented in Table 1, to differentiate the habitats listed in the Habitats Directive (92/43/EEC) and the main target areas for forest exploitation. The information was processed and analysed using ArcGIS software (Environmental Systems Research Institute—ESRI, 2012, ArcGIS Release 10.1. Redlands, CA.), which allowed to evaluate the differences between the land cover areas.

3 | RESULTS AND DISCUSSION

3.1 | Changes in land cover

Since the implementation of the Habitats Directive in 1992, land cover in the Monchique SAC has undergone several changes, as presented in Table 2. The most significant changes were the decrease in bushes and pasture areas and the increase in forest areas covered by *Eucalyptus* and pines (Figure 2). The decrease in pasture areas is mainly related to the abandonment of the rural regions, where the new generations prefer to settle in large cities and abandon the rural lifestyle. On the other hand, the decrease in areas with bushes is associated with the demand and increase in areas for installing new *Eucalyptus* and pine plantations. However, the areas with exotic species continue to increase due to abandonment and increased fires. It would be expected that, in an area dedicated to conservationist purposes (as a SAC), alien species would decrease. With the establishment of this protected area, there was an attempt to increase *Quercus* forests until 2007 through programmes to encourage the planting of *Quercus suber*. However, from 2007 to 2018, there was a significant decrease of 840.8 ha in the area with *Quercus* taxa. The water level also increased, mainly due to the construction of the Odelouca reservoir, with a capacity of 157 hm3, which had an impact on the existing riverside habitats and climatophilous forests.

Changes in land use in the Monchique SAC result in *Eucalyptus* forest cultivation remaining the dominant land cover, with about 35% of the area under analysis. This situation is followed by areas dominated by scrub and by *Quercus* forests. Associated with an ageing population, agricultural and grazing areas declined. More recently emerged the invasive exotic species, such as the genus *Acacia*.

3.2 | Nature management and conservation

In the Monchique SAC, 21 species with high conservation interest or with legal protection status were identified (Table 3). These species are distributed in 12 habitats of Directive 92/43/EEC. However, most species with high conservation value present their ecological optimum in forest habitats, especially in Habitats 9240—'Iberian oak woods of *Quercus faginea* and *Quercus canariensis*' and 9330—'Forests of *Quercus suber*' (Figure 3). Although the vegetation cover of the Monchique SAC is profoundly altered, the plants with the most significant conservation value are still associated with the few natural forests of *Quercus* that exist. Noteworthy is the presence of *Quercus canariensis*, a tree that inhabits wet and cool areas (Almeida et al., 2005; Pérez-Ramos & Marañón, 2009), which is currently assessed, according to IUCN criteria, with the category of Critically Endangered (Carapeto et al., 2020). Another plant that will certainly have a threat status in the future is *Rhododendron ponticum* subsp. *baeticum* that, although it is used as a tourist promotion of Serra de Monchique, changes in land cover and changes in the hydrological flows will certainly affect the 5230 and 92B0 habitats. These species need urgent legal protection measures, as well as actions that promote their habitat recovery. Given the greater recurrence of fire in these landscapes, it was concluded that the rarest habitats are the least resistant to fire (Mitchell et al., 2009). Therefore, it is urgent to create strategies to reduce the risk of fire and enhance the territory, through the use of energy from agroforestry residues (Casau et al., 2022).

Some changes in land use are associated with the decline in population in rural areas, such as the decline in subsistence agriculture and grazing. In cities with low population density, there was a decrease in population, while in cities with approximately more than 20,000 inhabitants, the population increased. The exception to the rule is the municipality of Aljezur due to the growing need for labour (mainly foreign) for agricultural work in the greenhouses. However, more recently, there has been an attempt to counter rural abandonment by investing in tourism that moves outside the cities (Antunes & Águas, 2017; Bento et al., 2022).

The population increased in the last 30 years from 138,613 inhabitants in 1991 to 177,068 in 2021, corresponding to an increase of about 22%. These urban dwellers, still owners of rural land, see the *Eucalyptus* crop as a way of making the land profitable without close monitoring. Thus, to contribute to ensuring biodiversity through conserving natural habitats, wild fauna, and flora, it is necessary to create adequate management measures to enhance habitats. One of the principles should be to regulate the use of herbicides within SAC areas (Piñar Fuentes et al., 2021). Works to retain water in the Serra de

TABLE 1 Typology of land use and respective category used.

Land cover category	Categories
1.1.1.2 Predominantly horizontal continuous built fabric	1. Construction
1.1.2.1 Discontinuous built fabric	1. Construction
1.1.2.2 Sparse discontinuous built fabric	1. Construction
1.2.1.1 Industry	1. Construction
1.2.3.1 Agricultural facilities	1. Construction
1.3.2.1 Infrastructure for capturing, treating and supplying water for consumption	1. Construction
1.4.1.1 Road network and associated spaces	1. Construction
1.5.1.2 Quarries	1. Construction
1.5.3.1 Areas under construction	1. Construction
1.6.1.2 Sports facilities	1. Construction
1.6.5.1 Other tourist equipment and facilities	1. Construction
2.1.1.1 Temporary rainfed and irrigated crops	2. Agriculture
2.2.1.1 Vineyards	2. Agriculture
2.2.2.1 Orchards	2. Agriculture
2.2.3.1 Olive groves	2. Agriculture
2.3.1.2 Temporary crops and/or improved pastures associated with orchards	2. Agriculture
2.3.1.3 Temporary crops and/or improved pastures associated with olive groves	2. Agriculture
2.3.2.1 Complex cultural and partial mosaics	2. Agriculture
2.3.3.1 Agriculture with natural and semi-natural spaces	2. Agriculture
3.1.1.1 Improved pastures	3. Pastures
3.1.2.1 Spontaneous grazing	3. Pastures
4.1.1.1 SAF of cork oak	8. *Quercus*
4.1.1.2 SAF holm oak	8. *Quercus*
4.1.1.5 SAF of other species	10. Other hardwoods
4.1.1.6 SAF of cork oak with holm oak	8. *Quercus*
4.1.1.7 SAF of other mixtures	10. Other hardwoods
5.1.1.1 Cork oak forests	8. *Quercus*
5.1.1.2 Holm oak forests	8. *Quercus*
5.1.1.4 Chestnut forests	10. Other hardwoods
5.1.1.5 *Eucalyptus* forests	7. *Eucalyptus*
5.1.1.6 Forests of invasive species	12. Invasive trees
5.1.1.7 Forests of other hardwoods	10. Other hardwoods
5.1.2.1 *Pinus pinaster* forests	9. *Pinus*
5.1.2.2 *Pinus pinea* forests	9. *Pinus*
5.1.2.3 Forests of other softwoods	11. Other softwoods
6.1.1.1 Bushes	4. Bushes
7.1.2.1 Bare rock	5. Open fields
7.1.3.1 Sparse vegetation	5. Open fields
9.1.1.1 Natural watercourses	6. Water
9.1.2.1 Artificial inland lakes and ponds	6. Water
9.1.2.3 Reservoirs of dams	6. Water
9.1.2.4 Reservoirs of dams or weirs	6. Water
9.1.2.5 Ponds	6. Water

Abbreviation: SAF, Agroforestry surfaces.

TABLE 2 Evolution of land cover in Monchique SAC between 1995 and 2018.

Land cover		1995 (ha)	2007 (ha)	2010 (ha)	2015 (ha)	2018 (ha)	Evolution (ha)	Evolution (%)
1	Construction	222.4	232.0	284.0	283.2	293.6	71.1	24%
2	Agriculture	3507.9	3284.7	3324.0	3215.5	3004.6	−503.3	−14%
3	Pastures	3548.7	2311.7	2312.9	2325.8	2505.5	−1043.2	−29%
4	Bushes	21,832.1	20,377.9	19,889.8	19,590.8	19,295.7	−2536.4	−12%
5	Open fields	42.4	52.7	118.5	105.4	37.6	−4.8	−11%
6	Water	348.7	336.5	542.7	827.9	828.8	480.1	58%
7	*Eucalyptus*	25,300.4	26,139.2	26,319.9	26,993.6	26,855.3	1554.9	6%
8	*Quercus*	18,564.4	19,844.0	19,696.9	19,122.5	19,003.2	438.8	2%
9	*Pinus*	2137.3	2774.5	2976.6	2994.3	3636.1	1498.7	41%
10	Other hardwoods	1031.0	1080.1	1068.2	1074.5	1073.2	42.2	4%
11	Other softwoods	5.3	2.8	2.8	2.8	2.8	−2.6	−49%
12	Invasive trees	0.0	4.6	4.5	4.5	4.5	4.5	100%
Total		76,540.7	76,540.7	76,540.7	76,540.7	76,540.7		

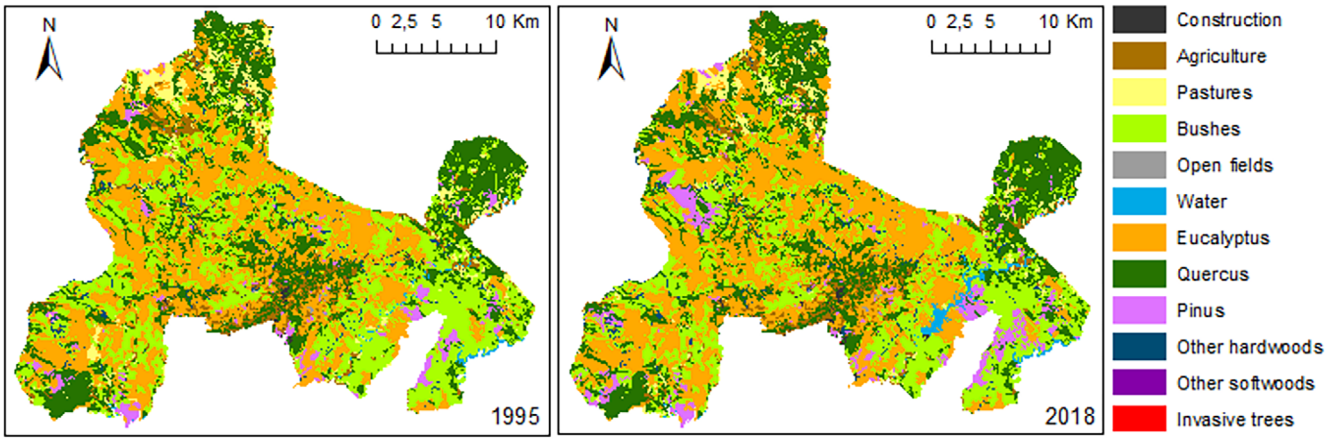

FIGURE 2 Example of the images compared to assess the difference between the areas between 1995 and 2018. [Colour figure can be viewed at wileyonlinelibrary.com]

Monchique have increased the water in the soil by up to 35%, which could contribute to mitigating the impacts of climate change (Carvalho et al., 2018). On the one hand, it is necessary to reconvert a good part of the current land use, through the renaturalization of the landscape, to the potential natural forests of *Quercus*, as other authors mention (Magalhães et al., 2021; Simonson & Allen, 2014). In fact, a protected area is expected to be a place with high biodiversity and not with the dominance of monospecific stands with exotic and invasive species, which reduce existing biodiversity (Barrocas et al., 1998; Neto Duarte et al., 2020). An important and worrying fact is the general population's lack of knowledge of the Natura 2000 Network areas, since public participation is a key factor for successful nature conservation initiatives (Oliveira et al., 2020).

One of the great aids for valorizing natural habitats could be the monetary retribution of ecosystem services if it becomes a reality since most of the areas of the Monchique SAC belong to private owners. Another way to encourage the increase of *Quercus* forests is by demonstrating good examples (Anaya-Romero et al., 2016; García-Llorente et al., 2020). Improving the conservation status of the study area should involve establishing the clear advantages that the native forest is more beneficial at an economic, social and environmental level.

4 | CONCLUSIONS

The Monchique SAC was initially implemented in an area profoundly altered from the view of vegetation, so it presented an unfavourable general state of conservation of its habitats. However, 30 years after the entry into force of conservation objectives at the European level, few changes have taken place to improve and restore existing areas. Instead, monospecific forest areas for production with exotic species

TABLE 3 Species with high conservation value in the Monchique SAC.

Species	SAC Monchique	Family	Category (IUCN)	Legal protection	Habitat
1	*Arabis verna* (L.) R.Br.	*Brassicaceae*	Vulnerable	Red List	8220
2	*Armeria beirana* subsp. *monchiquensis* (Bernis) Franco	*Plumbaginaceae*	Vulnerable	Red List	6220
3	*Campanula primulifolia* Brot.	*Campanulaceae*	Vulnerable	Red List	5230, 91E0
4	*Centaurea crocata* Franco	*Asteraceae*	Vulnerable	Red List	6220
5	*Centaurea vincentina* Mariz	*Asteraceae*	Near Threatened	Natura 2000 Annex II and IV	4030
6	*Cheilanthes guanchica* Bolle	*Pteridaceae*	Endangered	Red List	8220
7	*Doronicum plantagineum* L.	*Asteraceae*	Vulnerable	Red List	9240, 9330
8	*Drosophyllum lusitanicum* (L.) Link	*Drosophyllaceae*	Vulnerable	Red List	4020
9	*Ilex aquifolium* L.	*Aquifoliaceae*	Not Evaluated	Decree-law no. 423/89	5230
10	*Quercus canariensis* Willd.	*Fagaceae*	Critically Endangered	Red List	9240
11	*Quercus rotundifolia* Lam.	*Fagaceae*	Not Evaluated	Decree-law no. 169/2001	9340
12	*Quercus suber* L.	*Fagaceae*	Not Evaluated	Decree-law no. 169/2001	9330
13	*Rhododendron ponticum* L.	*Ericaceae*	Not Evaluated	Red List	5230, 92B0
14	*Ruscus aculeatus* L.	*Asparagaceae*	Least Concern	Natura 2000 Annex V	9240, 9330
15	*Salix salviifolia* subsp. *australis* Franco	*Salicaceae*	Least Concern	Natura 2000 Annex II and IV	92A0
16	*Scorzonera baetica* (DC.) Boiss.	*Asteraceae*	Endangered	Red List	4030
17	*Senecio lopezii* Boiss.	*Asteraceae*	Endangered	Red List	9240, 9330
18	*Silene mellifera* Boiss. & Reuter	*Caryophyllaceae*	Vulnerable	Red List	9240, 9330
19	*Spiranthes aestivalis* (Poiret) Rich.	*Orchidaceae*	Near Threatened	Natura 2000 Annex IV	6420
20	*Taraxacum triforme* Soest	*Asteraceae*	Vulnerable	Red List	9240, 9330
21	*Thymus villosus* L.	*Lamiaceae*	Least Concern	Natura 2000 Annex IV	4030

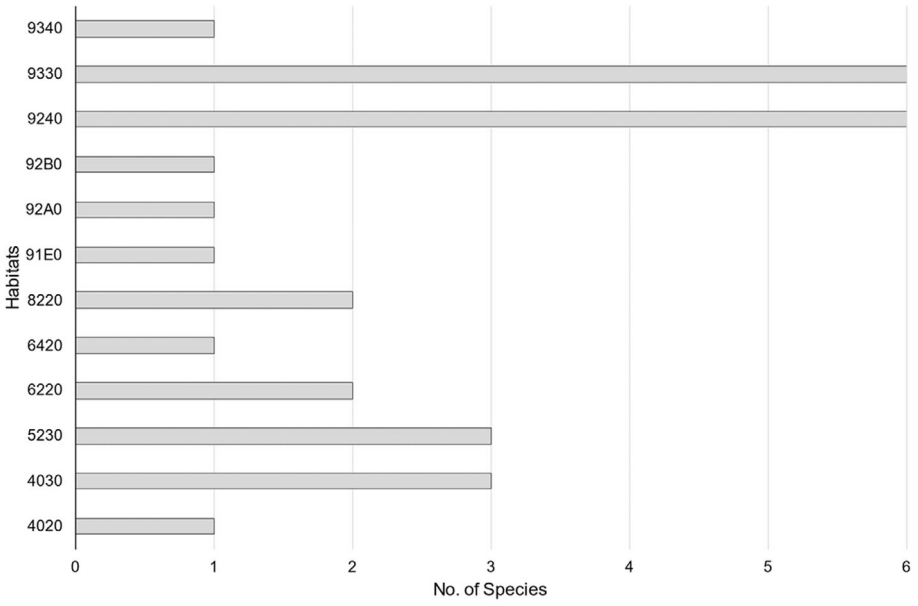

FIGURE 3 Number of plant species with high conservation interest per Habitat of Directive 92/43/EEC.

increased, areas with grazing (associated with priority habitat for conservation 6220*) were reduced, and several areas with invasive species appeared, such as the species of the genus *Acacia*, one of the most invasive and difficult to control in mainland Portugal and there was a depopulation of towns and villages with less than 10 thousand inhabitants. However, some sites remain relatively well preserved,

allowing the residual presence of rare and threatened species such as *Quercus canariensis*, *Cheilanthes guanchica*, *Scorzonera baetica* and *Senecio lopezii*. Since most of the botanical values occur in forest environments, forest habitats should prioritize recovery and conservation within the Monchique SAC. In addition, using the chorological information used in the evaluation of the Red List of Vascular Flora of Mainland Portugal could help, through the PDM (Municipal Master Plan), to conserve endangered plants at a local level. Given this scenario, it is up to the political power to reverse this marked biodiversity loss and enhance this landscape of high scenic and heritage value.

AUTHOR CONTRIBUTIONS

All authors (Mauro A. M. Raposo, Leonel J. R. Nunes and Carlos J. Pinto-Gomes) contributed in equal shares to the conclusion of the article.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Direção-Geral do Território at https://www.dgterritorio.gov.pt/dados-abertos.

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