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The impact of abandoned/disused marble quarries on avifauna in the anticline of Estremoz, Portugal: does quarrying add to landscape biodiversity?

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ABSTRACT
Although the extractive operations of quarrying are often considered environmental threats, there is some evidence that abandoned quarries may have a significant positive impact on biodiversity by enhancing habitat quality for several species. In Estremoz Anticlinal, SE Portugal, many of the existing marble quarries have been inactive for decades and were abandoned without any restoration project in progress. The impact of quarry abandonment on avifauna diversity was assessed relative to reference conditions using adjacent rural fields as control areas. No significant differences were found in within-community diversity (alpha diversity) between abandoned quarries and reference sites. However, several dissimilarity indices showed a clear divergence in species composition between abandoned quarries and reference sites. Furthermore, statistically significant differences in species compositions were found between quarries abandoned for different periods. Over time, species composition becomes more similar to that observed in reference sites, reflecting ecological succession and landscape resilience to quarrying. Nevertheless, the studied quarrying landscape exhibited higher gamma and beta diversity than the former traditional landscape; thus, our results suggest that abandoned quarries, rather than damaging and destroying niches, can promote new ecological niches and significantly diversify rural landscapes.

KEYWORDS
Land use change; habitat fragmentation; ecological niches; avian redistribution; landscape resilience

1. Introduction

According to the World Business Council for Sustainable Development (WBCSD, 2011), the extraction of raw materials from the earth's crust causes obvious impacts on nature, since the removal of soils and changes in topography affect local ecosystems and watersheds. Quarrying activities are prone to affect negatively the abiotic (lithosphere, atmosphere and hydrosphere) and biotic ecosystem components and, thus, are classically seen as potential threats to biodiversity (Ballesteros et al., 2012; Martínez-Hernández et al., 2011). The open pit mining rocky surfaces with large slopes and soilless hinder the establishment of vegetation, damaging their spontaneous regeneration, a boosted impact

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in Mediterranean climate zones, when combined with strong environmental constraints such as water scarcity and high summer temperatures.

Inadequate man-induced restoration of abandoned quarries can also be a serious threat to restricted endemic flora and promote the spread of colonising and invasive species (Gentili, Sgorbati, & Baroni, 2011; Mota, Sola, Jiménez-Sánchez, Pérez-García, & Merlo, 2004). However, if properly restored, allowing the recovery of autochthonous *taxa* and preventing the colonisation of non-native species (Gentili et al., 2011; Gilardelli, Sgorbati, Citterio, & Gentili, 2016), abandoned quarries do not seem to represent a major menace to rare/endemic plants. Moreover, recent ecological studies conducted in different environmental conditions have shown a significant positive impact on biodiversity after natural re-vegetation or the application of appropriated restoration methods (Bétard, 2013; Jefferson, 1984; Lucas, Michell, & Williams, 2014). The positive effects of quarrying on biodiversity are explained by the emergence of specific environmental conditions at the post-quarrying sites, offering new ecological niches, which generate original interaction networks. These explanations are consistent with the 'habitat heterogeneity hypothesis', since it assumes that structurally complex habitats enhance species diversity providing more niches which diversify ways of using resources (Cramer & Willig, 2005; Tews et al., 2004). Although habitat heterogeneity effects on species diversity may vary considerably, depending on the taxonomic group, the spatial scale and on what is perceived as a habitat, positive relationships between habitat heterogeneity and animal species diversity have been extensively documented (Tews et al., 2004). If rare or endangered species are able to find habitats in abandoned quarries, then the mining activity should not be regarded as a threat to biodiversity, but rather an opportunity for wildlife habitat restoration.

The impacts of marble quarrying on avifauna in Mediterranean ecosystems have been poorly documented and hardly discussed. In fact, we have no knowledge of any scientific publication focusing on this matter. Furthermore, predicting those impacts may be an ambiguous process, mainly for two reasons: (1) birds form an extremely vast group of species, exhibiting very different home ranges and occurring in very different abundances and (2) there are resident species, migratory species and species where populations are composed of a mixture of resident and migratory individuals. Studies conducted in different seasons and using diverse methods will produce varying results.

This paper describes an assessment of the avifauna diversity, considering 52 species belonging to ten taxonomic orders, during the reproductive period (spring/summer) in quarry landscapes. The aim of this study is to quantify the magnitude of quarrying impacts through the analysis of similarities (or absence thereof) between abandoned quarries and reference sites. The differentiation of communities was measured by several complementary dissimilarity indices, and the partitioning of gamma diversity into its alpha and beta components was used to access quarrying landscape diversity distribution. Besides providing a quantified example, the biocenotic analysis made in this study illustrates how the abiotic components affect the biotic components of an ecosystem. Furthermore, this study shows how quarry landscapes can be of recreational and ecological interest, with great potential for bird watching and environmental tourism.

2. Methods

2.1. Study area

The quarry landscape analysed is part of the anticline of Estremoz, a major geological structure located in the Évora district, Alentejo region, western central Portugal (38° 44′–38° 51′ N, 7° 23′–7° 36′ W). The eleven selected inactive quarries are spread over three counties: Estremoz (three quarries), Borba (seven quarries) and Vila-Viçosa (one quarry) (Figure 1). The study area belongs to the Mediterranean Ibero-Atlantic Province, where the Thermo-Mediterranean bioclimatic type prevails (Rivas-Martínez & Loidi, 1999). The elevation ranges from 300 to 500 m, the annual rainfall is close to 700 mm, and the mean annual temperature is about 16 °C. The summer drought from June to September favours sclerophyllic evergreen Mediterranean vegetation.

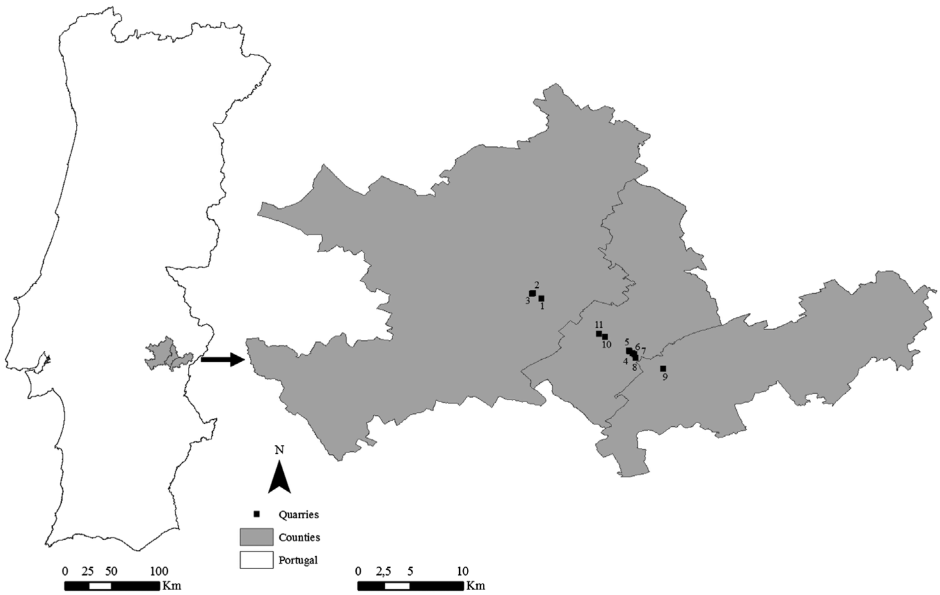

Figure 1. Location of the study area in the Alentejo region, western central Portugal.

Disassemble in depth (gap/well) is the method of extraction used in the studied quarries, where two areas may be distinguished: the extraction zones and a more industrial zone where the workshops are located. This extraction method increases the physical diversity at the quarry site, producing ponds, steep rocky scarps, caves, depositional landforms among other new potential biotopes. Furthermore, as ecological succession progresses, the number of years passed since abandonment plays a determinant role in the site community composition and its degree of complexity. The reference sites correspond to areas subject to traditional land cover in the region, mainly *montado*, a high nature value farmland in which the cork oak (*Quercus suber*) and/or holm oak (*Quercus* [*ilex*] *rotundifolia*) are the dominant tree species (European Environment Agency European Environment Agency, [EEA], 2004; Pinto-Correia, Ribeiro, & Sá-Sousa, 2011; Vicente & Alés, 2006). *Montado* has a high proportion of semi-natural vegetation and supports rare species or a high proportion of European or world populations. These farm systems have been relatively stable over the last decades—no changes in the land management model were observed—(Godinho et al., 2016) and, thus, provide a suitable and proximate comparator from which to assess the impact of quarrying activities on local avifauna biodiversity.

2.2. Data collection

Eleven inactive quarries and seven reference sites were monitored in order to collect data of three different classes of abandonment time and of their respective control sites. Quarries were randomly sampled to represent each of the following classes of abandonment time: class I—less than 10 years (four sampled quarries); class II—10 to 22 years (four sampled quarries); class III—more than 22 years (three sampled quarries). To each studied quarry, a reference site was attributed, which was selected outside a circle with centre in the quarry and 250 m radius. This circle acts as buffer zone assuring that the reference sites were selected in areas undisturbed by quarrying activities. Seven reference sites were enough to represent the environmental conditions of the eleven quarries before they were implemented. This happens because some quarries were implemented in similar environmental conditions and, thus, share the same reference site; for instance, quarries 6, 7 and 8 all have the same reference site.

Avifauna was chosen to study the impacts of marble quarrying on biodiversity because this group has the following methodological advantages and ecological interest (Bétard, 2013): (1) abundance and diversity of species; (2) species are easy to identify and their sampling is reliable; (3) existence of different functional groups; and (4) sensitivity of many species to ecological changes induced by human activities.

The avifauna survey was restricted to the breeding season (when many individual birds are more conspicuous and have relatively small territories) and was conducted in just one year; estimating the population's trends over time was not a goal of the study. We used the counting stations method, since it allows us to save time walking along a transect and it suits areas that are difficult to access, as well as dense habitats, cryptic and skulking species and populations at high densities (Bibby, Burgess, Hill, & Mustoe, 2000; Gilbert, Gibbons, & Evans, 1998; Gregory, Gibbons, & Donald, 2004). On the other hand, this is a simple method to assess the species composition in an area and give an idea of their relative abundances; we did not intend to derive estimates of population densities. A counting station was set at each sampled area (11 quarries and seven reference sites), and each was visited between 6:00–10:30 am over two different days during the survey period (March–June 2013). Proceeding according to standard protocol (Gregory et al., 2004), once the observers reached the count station, they allowed the birds two minutes to settle and then recorded all individuals identified by sight or sound during a 10-min period.

2.3. Data analysis

To estimate species richness, *S*, we considered the number of species identified in each site (Usher, 1986). To measure diversity as a function of both the number of species and their relative abundances, we used Shannon entropy, *H*, taking into account the number of individuals recorded in both visits to each site (Shannon, 1948; Spellerberg & Fedor, 2003). To solve the problems caused by using the Shannon entropy to measure diversity, we converted this index to the *effective number of species* by taking its exponential (Jost, 2007; Jost et al., 2010). To measure the relative differentiation between community sites, we used five different dissimilarity indices. The need to use different indices arises from the fact that differentiation measures tend to disagree in the way they rank data-sets, usually depending on sampling size and whether species frequencies are accounted for. To measure dissimilarity based just on presence/absence (incidence), we used the classical Jaccard index as well as the Sørensen coefficient, which gives more 'weight' to species common to both the compared sites than those found in only one (Jaccard, 1902 as cited by Jost, 2006; Sørensen, 1948 as cited by Wolda, 1981). To give a more realistic ecological dissimilarity, taking into account species abundance, we used the Morisita index and the simplified Morisita or Horn index (Morisita 1959 & Horn, 1966 as cited by Wolda, 1981). The Morisita index has been widely used for comparisons based on common species (Chao, Chazdon, Colwell, & Shen, 2005; Chao, Jost, Chiang, Jiang, & Chazdon, 2008). Finally, in order to incorporate the effect of unseen shared species, we used the Chao index (Chao et al., 2005). To determine the indices values and conduct the statistical analysis, we used R 3.1.3 (R Development Core Team, 2015) software and its package 'vegan' (Oksanen et al., 2015).

To analyse how biodiversity is distributed in quarrying landscapes, we used two popular methods of partitioning regional (gamma) diversity into its alpha and beta components (Couteron & Pélissier, 2004; Lande, 1996; Jost et al., 2010): additive partitioning (gamma = alpha + beta) and multiplicative partitioning (gamma = alpha × beta). We applied these methods of partitioning diversity to *S* and to *exp* (*H*). Alpha is the arithmetic mean value for groups. Both alpha and gamma were calculated directly from data, whereas beta was derived from them by subtraction or division, respectively.

3. Results

We recorded 42 species in the quarries and 40 species in the reference sites (Appendix 1), corresponding to 52 species identified through 1122 separate records. Thus, gamma diversity increased from 40 species in the former traditional landscape to 52 species in the current quarrying landscape. Quarries and reference sites share only 30 of those 52 species, that is, approximately 60%. The quarries and the

Table 1. Results of *T*-tests between different classes of quarries. Bold text indicates a statistically significant difference (*p*-value less than 0.05).

	Class I and II	Class II and III	Class I and III
S	0.195	0.576	0.487
H	0.141	0.328	0.528
exp (*H*)	0.153	0.348	0.547
Dissimilarity indices:			
Jaccard	0.142	0.214	**0.013**
Sørensen	0.157	0.202	**0.010**
Morisita	0.149	0.295	0.061
Horn	0.143	0.349	**0.046**
Chao	**0.023**	0.256	**0.025**

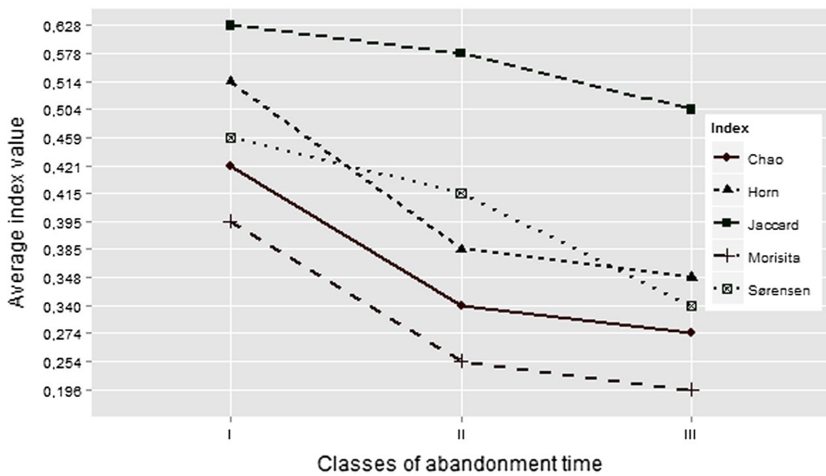

Figure 2. Dissimilarity indices between quarries and reference sites regarding different classes of abandonment time. Class I = less than 10 years; Class II = 10 to 22 years; Class III = more than 22 years.

reference sites hosted an average of 18.72 and 19.55 species and presented an average *exp* (*H*) of 14.32 and 14.43, respectively. No significant differences were noted in alpha diversity between quarries and reference sites (*T*-test *S*, $p = 0.6243$; *T*-test *exp* (*H*), $p = 0.8428$). When comparing the three classes of quarries, we found that both the average *S* and the average *exp* (*H*) increased from class I to class II, and presented a slight decrease from class II to class III. The overall variation from class I to class III showed an increment of both *S* and *exp* (*H*) (average *S*: class I—17.25, class II—20.00, class III—19.00; average *exp* (*H*): class I—13.41, class II—15.30, class III—14.28). Nevertheless, neither pairwise comparisons (Table 1) nor analysis of variance including the three classes of quarries (ANOVA *S*, $F = 0.898$, $p = 0.368$; ANOVA *exp* (*H*), $F = 1.443$; $p = 0.292$) showed any significant difference in alpha diversity among the studied quarries groups.

Though species richness, considering both the number of species and their relative abundance, was similar in quarries abandoned for different periods of time, differences in species composition and dominance were clearly noticed among classes I, II and III (Figure 2; Table 1). These compositional differences were sharply displayed by all the used dissimilarity indices, which, except the Morista index, presented statistically significant differences between class I and class III (Table 1). Furthermore, both additive and multiplicative partitions of diversity showed that beta diversity was bigger in the present quarrying landscape than in the former traditional landscape. In fact, the decrease in the arithmetic mean of alpha (from 19.55 to 19.13) combined with the gamma diversity increase (from 40 to 52) made beta diversity grow from 20.45 to 32.87 according to the additive framework, and from 2.05 to

2.72 according to the multiplicative framework. Considering both the number of species and their abundance, using the *effective number of species* by taking Shannon entropy exponential, the same pattern of diversity change was observed. The verified decrease of the arithmetic mean of alpha, which decreased from 14.43 to 14.38, combined with a growth of 3.63 in gamma diversity, produced a beta diversity increase of 3.69 according to the additive framework, and of 0.26 according to the multiplicative framework.

4. Discussion

Diversity measured at the species level, considering species richness and Shannon entropy, revealed no significant differences between quarries and reference sites. However, communities, though formed by the same number of species, are not ecologically identical if the species and/or their relative abundances differ. In fact, that is what occurred in the present case, since species composition between quarries and reference sites, and among sets of quarries abandoned for different periods, was quite different. Thus, the likeness in alpha diversity observed in quarries and abandoned sites, and in quarries inactive for different periods, provides an unreal view of environmental similarity. Bearing in mind that sample effort was identical in quarries and reference sites, the wide variation in species composition from quarries to reference sites must be related to a process of change of community structure over time. In fact, Prach (2003) considers that spontaneous vegetation succession in abandoned quarries is usually sufficiently fast, dismissing the need for a technical site restoration, and that seral stages often provide abundance of refugia to wildlife. Gilardelli et al. (2016) and Gilardelli, Sgorbati, Armiraglio, Citterio, and Gentili (2015) also found that spontaneous re-vegetation tends to begin soon after quarries abandonment, following a continuous and progressive pattern characterised by the replacement over time of pioneering communities by shrubland communities. Furthermore and in accordance with the 'habitat heterogeneity hypothesis', after cessation of quarrying activities, the landforms created by mining represent new habitats, or at least new habitat components, ready to be colonised. On the other hand, the former mining activity led to a loss of habitat quality for a number of other species. These habitat quality changes are predicted by basic ecological principles and concepts, since life forms depend on limiting factors (Odum, 1971), and the environment provides both the context for life and the restraints for its expression (Krebs, 1978).

Although species composition varies extensively from abandoned quarries to reference sites, the number of species is similar in both types of environment. The reason behind such similarity may be traced to the landmark Santa Rosalie paper (Colinvaux, 1993; Hutchinson, 1959). In fact, competition for energy along food chains restrains the possibilities of multiplying diversity. On the other hand, a necessary minimum separation between niches also sets a limit to the number of species. Quarries, by extinguishing and creating niches, brought together allopatric species to live in sympatry. However, quarries and reference sites seem to share energetic constraints and *minimal niche distances*; this parallelism is responsible for an identical number of species.

Our results agree with a growing number of studies, concerning very different *taxa*, showing that quarry abandonment can provide a suitable habitat for a considerable number of species that were previously absent in the area (Beneš, Kepka, & Konvička, 2003; Bétard, 2013; Jefferson, 1984; Lucas et al., 2014; Ngongolo & Mtoka, 2013). The lakes that emerged in the mine craters, either by groundwater retention or by rainwater accumulation, enabled the arrival of species, such as the mallard (*Anas platyrhynchos*), the common moorhen (*Gallinula chloropus*) or the common kingfisher (*Alcedo atthis*), in the area. The appearance of rock walls, rock cavities and steep slopes allowed the advent of species such as the rock dove (*Columba livia*) or the blue rock-thrush (*Monticola solitarius*): the latter with a rather fragmented distribution in Portugal (Equipa Atlas, 2008). The ecological gain is more relevant if the newcomers have high heritage or conservation values. This was the case in many of the above-cited studies, and is also the case in this study. According to Cabral et al. (2006), 45 of the 52 identified species are assigned to the Least Concern (LC) category, five are assigned to the Near Threatened (NT) category, one (*Oenanthe hispanica*) is assigned to the Vulnerable (VU) category, and one (*C. livia*) is assigned to the Data Deficient (DD) category. In fact, three out of the five species assigned to the Near Threatened category that were present in the study area were identified in quarries (Appendix 1), and the only species assigned to the Vulnerable category, black-eared wheatear (*O. hispanica*), was found only in quarries. However, if the IUCN Red List Criteria, instead of being applied to the national scale, are applied to the global scale (Cabral et al., 2006), the only species assigned to the Vulnerable category (Appendix 1), rufous-tailed scrub-robin (*Erythropygia galactotes*), is also exclusively present in quarries. The combination of arid conditions with aquatic biotopes provided by quarries seems to offer habitat quality for species like *O. hispanica*, *M. solitarius* and *E. galactotes*, which, in Alentejo, are associated with riversides dominated by rock and scarce emergent rooted vegetation (Godinho, Rabaça, & Segurado, 2010).

Moreover, the mosaic arrangement of the new biotopes within the traditional landscape provided a suitable habitat for a number of species benefiting from edge effect. The wild rabbit (*Oryctolagus cuniculus*), a key prey in the Iberian Peninsula (Delibes-Mateos, Redpath, Angulo, Ferreras, & Villafuerte, 2007) entering the diet of more than 40 predator species (Delibes-Mateos, Delibes, Ferreras, & Villafuerte, 2008; Delibes & Hiraldo, 1981), is one of the most notorious examples. The edge between natural or cultivated herbaceous and broken rock pieces covered with bush favours wild rabbit habitat quality (Godinho, Mestre, Ferreira, Machado, & Santos, 2013). The high abundance of this species attracts threatened predators to the area such as the booted eagle (*Aquila pennata*). On the other hand, abandoned quarries broke up the continuity of the traditional land cover raising habitat fragmentation concerns. More specifically, one question must be answered—has the abandonment of quarries led to the degradation and/or loss of habitats? Regarding birds, habitat loss is expected for species that depend on large tracts of the same cover type, particularly if the opening sizes are big and their range is small (Phalan, Onial, Balmford, & Green, 2011). In a landscape dominated by *montado*, that is, with a high proportion of suitable habitats, and considering the relatively small size of the openings, habitat loss for birds is not an expected consequence of quarrying abandonment at a regional level (Andrén, 1994). In fact, we are not aware of any species disappearance since quarry abandonment started.

The number of species is similar in quarries that were abandoned for a different number of years. Yet, abandonment time seems to play a decisive role in species composition and relative abundance, since a statistically significant decrease from class I to class III was observed in all dissimilarity indices, except for Morisita's index which has been criticised for being highly sensitive to dominant species and fails to reveal less common species (Chao, Chazdon, Colwell, & Shen, 2006; Colwell & Coddington, 1994; Magurran, 2004). This temporal change of communities, following a direction, may be considered a succession. In a very recent study, Craig et al. (2015) found that avian communities differed significantly among stages of a desirable succession pathway in a post-mining restoration plan. The poor congruence between vegetation and avian succession exhibited by the state-and-transition model used by those authors was attributed to four factors, that if considered should improve the model's ability to represent fauna succession (Craig et al., 2015). However, primary succession in abandoned quarries does not necessarily progress to a single end point—the climatic climax. This is so because, besides a large element of randomness, the factors that cause community changes vary from quarry to quarry and are different from those observed in the past. It seems that quarrying activities push the communities beyond their boundaries of resilience, moving them to a new transitory state of equilibrium. However, ecological succession makes the composition of communities similar to the composition observed in undisturbed adjacent areas; thus, in the end, the traditional landscape shows some resilience to quarry abandonment.

Gamma diversity, the diversity contained in the study area region, which is comprised of both of alpha and beta diversity, is higher in the present quarrying landscape than in the traditional landscape. This happens mostly because the rate at which species composition changes along space is higher in the present than in the former landscape, reflecting a more intensive gradient. Where abandoned quarries occur, there are abrupt changes in community composition; there is a characteristic avifauna associated with the inactive quarries. Similar results would be expected for other species that are sensitive to the changes in ecological conditions produced by quarrying activities. The inclusion of these species in the assessment of gamma diversity would most likely further stress the difference between the traditional landscape and the present quarrying landscape, being considerably higher in the latter. This prediction is supported by numerous studies undertaken in different environments and conducted in post-quarrying sites after re-vegetation, analysing flora, avifauna and insects such as butterflies, dragonflies and grasshoppers (Beneš et al., 2003; Bétard, 2013; Jefferson, 1984; Lucas et al., 2014; Wang et al., 2011). Thus, abandoned quarries properly managed (Gentili et al., 2011; Gilardelli et al., 2016; Mota et al., 2004) instead of harming species, namely priority species, might contribute to habitat creation that promotes landscape diversity and favours nature conservation. Quarrying landscapes, in particular, those including quarries that have been inactive for different periods, offer opportunities for wildlife tourism, which is defined as tourism based on encounters with non-domesticated animals (Higginbottom, 2004). In fact, those regions tend to be rich in wildlife and provide plenty of sites that offer ample fauna watching opportunities. In particular, quarrying landscapes in the Estremoz anticline have a high diversity of habitats suitable for a wide variety of birds in relatively small areas, revealing a special interest for bird watching. If wildlife tourism is responsible travel, which conserves the environment and improves the welfare of the local population, it fits in the ecotourism concept (The International Ecotourism Society, [TIES], 1990; Fennell, 2008). However, quarrying landscapes may also be seen as natural laboratories where community structure, change and resilience can be easily observed and taught. Thus, those landscapes have great scientific and educational interest and, therefore, have the proper attributes for environmental tourism, in which the key phrase is 'environmental education' (Machado, 2005).

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Appendix

Order	Family	Species	Common name	Presence		Category	
				Quarries	Reference sites	Continental portugal	IUCN
ANSERIFORMES	*Anatidae*	*Anas platyrhynchos* (Linnaeus, 1758)	Mallard	X		LC	LC
GALLIFORMES	*Phasianidae*	*Alectoris rufa* (Linnaeus, 1758)	Red-legged partridge	X	X	LC	LC
ACCIPITRIFORMES	*Accipitridae*	*Circaetus gallicus* (Gmelin, 1788)	Short-toed snake-eagle		X	NT	LC
GRUIFORMES	*Rallidae*	*Gallinula chloropus* (Linnaeus, 1758)	Common moorhen	X		LC	LC
COLUMBIFORMES	*Columbidae*	*Columba livia* (Gmelin, 1789)	Rock dove	X	X	DD	LC
		Columba palumbus (Linnaeus, 1758)	Common woodpigeon	X		LC	LC
		Streptopelia decaocto (Frivaldszky, 1838)	Eurasian collared-dove	X	X	LC	LC
CUCULIFORMES	*Cuculidae*	*Cuculus canorus* (Linnaeus, 1758)	Common cuckoo	X		LC	LC
STRIGIFORMES	*Strigidae*	*Athene noctua* (Scopoli, 1769)	Little owl		X	LC	LC
APODIFORMES	*Apodidae*	*Tachymarptis melba* (Linnaeus, 1758)	Alpine swift		X	NT	LC
CORACIIFORMES	*Alcedinidae*	*Alcedo atthis* (Linnaeus, 1758)	Common kingfisher	X	X	LC	LC
	Meropidae	*Merops apiaster* (Linnaeus, 1758)	European bee-eater	X	X	LC	LC
	Upupidae	*Upupa epops* (Linnaeus, 1758)	Common hoopoe	X	X	LC	LC
PASSERIFORMES	*Alaudidae*	*Galerida cristata* (Linnaeus, 1758)	Crested lark	X	X	LC	LC
		Lullula arborea (Linnaeus, 1758)	Wood lark	X	X	LC	LC
	Hirundinidae	*Delichon urbicum* (Linnaeus, 1758)	Northern house-martin	X		LC	LC
		Hirundo rustica (Linnaeus, 1758)	Barn swallow	X	X	LC	LC
	Motacillidae	*Motacilla flava* (Linnaeus, 1758)	Yellow wagtail	X		LC	LC
		Motacilla alba (Linnaeus, 1758)	White wagtail	X		LC	LC
	Troglodytidae	*Troglodytes troglodytes* (Linnaeus, 1758)	Winter wren	X	X	LC	LC
	Turdidae	*Erythropygia galactotes* (Temminck, 1820)	Rufous-tailed scrub-robin	X		NT	VU
		Luscinia megarhynchos (Brehm, 1831)	Common nightingale	X	X	LC	LC
		Monticola solitarius (Linnaeus, 1758)	Blue rock-thrush	X		LC	LC
		Oenanthe hispanica (Linnaeus, 1758)	Black-eared wheatear	X		VU	LC
		Phoenicurus ochruros (Gmelin, 1774)	Black redstart	X	X	LC	LC
		Phoenicurus phoenicurus (Linnaeus, 1758)	Common redstart		X	LC	LC
		Saxicola rubicola (Linnaeus, 1766)	Common stonechat	X	X	LC	LC
		Turdus merula (Linnaeus, 1758)	Eurasian blackbird	X	X	LC	LC
	Sylviidae	*Cisticola juncidis* (Rafinesque, 1810)	Zitting cisticola		X	LC	LC
		Sylvia melanocephala (Gmelin, 1789)	Sardinian warbler	X	X	LC	LC
		Sylvia undata (Boddaert, 1783)	Dartford warbler	X		LC	LC
	Muscicapidae	*Muscicapa striata* (Pallas, 1764)	Spotted flycatcher	X		NT	LC
	Paridae	*Parus caeruleus* (Linnaeus, 1758)	Blue tit	X	X	LC	LC
		Parus cristatus (Linnaeus, 1758)	Crested tit		X	LC	LC
		Parus major (Linnaeus, 1758)	Great tit	X	X	LC	LC
	Sittidae	*Sitta europaea* (Linnaeus, 1758)	Wood nuthatch		X	LC	LC
	Oriolidae	*Oriolus oriolus* (Linnaeus, 1758)	Eurasian golden oriole		X	LC	LC
	Laniidae	*Lanius meridionalis* (Temminck, 1820)	Southern grey shrike		X	LC	LC
		Lanius senator (Linnaeus, 1758)	Woodchat shrike	X	X	NT	LC

Corvidae	*Corvus corone* (Linnaeus, 1758)	Carrion crow	X	X	LC	LC
	Cyanopica cyanus (Pallas, 1776)	Azure-winged magpie	X	X	LC	LC
	Garrulus glandarius (Linnaeus, 1758)	Eurasian jay	X	X	LC	LC
	Pica pica (Linnaeus, 1758)	Black-billed magpie	X	X	LC	LC
Sturnidae	*Sturnus unicolor* (Temminck, 1820)	Spotless starling	X	X	LC	LC
Passeridae	*Passer domesticus* (Linnaeus, 1758)	House sparrow	X	X	LC	LC
Fringillidae	*Carduelis cannabina* (Linnaeus, 1758)	Eurasian linnet	X	X	LC	LC
	Carduelis carduelis (Linnaeus, 1758)	European goldfinch	X	X	LC	LC
	Carduelis chloris (Linnaeus, 1758)	European greenfinch	X	X	LC	LC
	Fringilla coelebs (Linnaeus, 1758	Eurasian chaffinch		X	LC	LC
	Serinus serinus (Linnaeus, 1766)	European serin	X	X	LC	LC
Emberizidae	*Emberiza calandra* (Linnaeus, 1758)	Corn bunting	X	X	LC	LC
	Emberiza cia (Linnaeus, 1766)	Rock bunting	X	X	LC	LC