Estimating the population and distribution trends of owls in Portugal using citizen science data from Program NOCTUA-Portugal and other sources

Estimativa da tendência populacional e distribuição das aves de rapina noturnas em Portugal usando dados de ciência cidadã do Programa NOCTUA-Portugal e outras fontes

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ABSTRACT

During the last eight years (2010-2017), the Working Group on Nocturnal Birds of SPEA (GTAN-SPEA) has carried out a volunteer monitoring program (NOCTUA-Portugal) to determine the population trends of seven owl species at a national scale. We used generalized estimating equations models to assess trends. In addition, we used the distribution data from breeding bird atlases, observations sent by collaborators, and data from the public online database PortugalAves/eBird to detect changes in distribution in a four-decade period (1978-2017). We defined four periods to study potential changes in distribution of owls in Portugal: 1978-1984 (1st breeding bird atlas); 1999-2005 (2nd breeding bird atlas); 2006-2014 (interval between 2nd and 3rd breeding bird atlases); and 2015-2017 (ongoing 3rd breeding bird atlas). Three species had negative population and distribution trends: Common Barn-owl (*Tyto alba*), Eurasian Scops-owl (*Otus scops*), and Little Owl (*Athene noctua*). The Eurasian Eagle-owl (*Bubo bubo*) had a slightly positive population and distribution trends, while the Tawny Owl (*Strix aluco*) was sta-

ble or slightly declined. The population trend of the Northern Long-eared Owl (*Asio otus*) was unknown because of large fluctuations, and due to the low number of records it was not possible to determine a population trend for the Short-eared Owl (*Asio flammeus*).

Keywords: Citizen-science, distribution change, owls, population trend, Portugal

RESUMO

Durante os últimos oito anos (2010-2017), o Grupo de Trabalho sobre Aves Noturnas da SPEA (GTAN-SPEA) realizou um programa voluntário de monitorização (NOCTUA-Portugal) para determinar a tendência populacional de sete espécies de aves de rapina noturnas à escala nacional. Usámos modelos de equações de estimação generalizadas para avaliar tendências populacionais. Adicionalmente, usámos dados de distribuição de atlas das aves nidificantes, observações enviadas por colaboradores e dados inseridos na base de dados online PortugalAves/eBird para detetar alterações na distribuição durante um período de quatro décadas (1978-2017). Definimos quatro períodos para estudar mudanças potenciais na distribuição das aves de rapina noturnas em Portugal: 1978-1984 (1º atlas das aves nidificantes); 1999-2005 (2º atlas das aves nidificantes); 2006-2014 (intervalo entre o 2º e o 3º atlas das aves nidificantes); e 2015-2017 (3º atlas das aves nidificantes, em curso). Três espécies apresentam tendências negativas de distribuição e população: coruja-das-torres (*Tyto alba*), mocho-d'orelhas (*Otus scops*) e mocho-galego (*Athene noctua*). O bufo-real (*Bubo bubo*) aparentemente apresenta tendências de distribuição e população ligeiramente positivas, enquanto a coruja-do-mato (*Strix aluco*) parece estável ou em ligeiro declínio. A tendência da população bufo-pequeno (*Asio otus*) é desconhecida uma vez que apresenta grandes flutuações e, devido ao baixo número de registros, não foi possível determinar a tendência populacional para a coruja-do-nabal (*Asio flammeus*).

Palavras-chave: alterações na distribuição, aves de rapina noturnas, ciência cidadã, Portugal, tendência populacional

Introduction

Owls are cryptic, exist at low densities, and are mostly nocturnal or crepuscular birds. Consequently their distribution and population status are often less well known when compared to other groups of birds (Vrezec et al. 2012). Owls are top predators within food webs, being important monitors to ecosystem health (Lourenço et al. 2011, Espín et al. 2016, Movalli et al. 2017). Monitoring owls requires specific methods (e.g. Redpath 1994, Zuberogoitia & Campos 1998, Hardey et al. 2009) and this group is under sampled by general bird atlas, census and other such programs (Palma 2012, Lourenço et al. 2015). This affects the quality of information on owls to inform conservation and management programs.

Many European owl species are threatened by human persecution, infrastructures like roads and powerlines, agriculture intensification and environmental contamination (Burfield 2008, BirdLife International 2004). As a result, many of the seven owl species that occur regularly in Portugal are at risk. According to the most recent Portuguese vertebrate red list (Cabral et al. 2005) the

Short-eared Owl (*Asio flammeus*) is endangered, the Eurasian Eagle-owl (*Bubo bubo*) is nearly threatened, the Eurasian Scops-owl (*Otus scops*) and Northern Long-eared Owl (*Asio Otus*) are data deficient, and only three species are of least concern: the Common Barn-owl (*Tyto alba*), the Little Owl (*Athene noctua*) and the Tawny Owl (*Strix aluco*). All species are resident, except the Eurasian Scops-owl, which only occurs during breeding period, and the Short-eared Owl, which is a winter migrant (Lourenço et al. 2015).

While information on owl population status and distribution in Portugal has increased in the last two decades, it is still limited due to insufficient spatial coverage and a lack of atlas and monitoring programs using methods to detect less common species (Palma 2012, Lourenço et al. 2015). Owl populations in Portugal are not cyclical (Lourenço et al 2015), however monitoring efforts are important to detect annual variations due to irruptions or nomadism (e.g. Northern Long-eared Owls). In the last decade knowledge of owls in Portugal has improved from the creation of the long-term monitoring program NOCTUA-Portugal (Lourenço et al. 2015, GTAN-SPEA 2017), the completion of the 1st wintering and migration bird atlas, the initiation of the 3rd breeding bird atlas, and increased information from birdwatchers from eBird and other on online data portals. Citizen science is a useful tool that can collect widespread data and contribute to the conservation of owls (Sullivan et al. 2017). This paper used available information to estimate owl population and distribution trends in Portugal.

Methods

This study covered continental Portugal, but not the archipelagos of Madeira and Azores (for additional information see Lourenço et al. 2015).

Estimating population trends of owls

The NOCTUA-Portugal is a long-term (2010-2017) monitoring program aimed at assessing the population trends of nocturnal birds in continental Portugal (GTAN-SPEA 2017; methods and annual reports available at www.spea.pt/pt/participar/grupos-de-trabalho/aves-noturnas/) that used 10 x10 km sampling units derived from a UTM grid. A subset of sampling units was visited once during each of the three periods (1 Dec - 31 Jan; 1 Mar - 30 Apr; 1 May - 15 Jun) each year. During each visit, the same five point count locations, separated by at least 1.5 km, were sampled during 10 minutes of passive listening. Point counts were performed in the first 2 hours after sunset, in days with favourable weather conditions. Individual owls detected were recorded to estimate the minimum number of breeding pairs. As of 2017, 81 sampling units (8% of the total number of units in continental Portugal) have been sampled: two in each of 8 years, six in 7 years, four in 6 years, five in 5 years; six in 4 years; 11 in 3 years; 19 in 2 years; and 28 in 1 year (total = 230 sampling units × year).

To estimate population trends (2010-2017) we produced generalized estimating equations models (GEE-GLM) with Poisson distribution, using the minimum number of breeding pairs detected per sampling unit in each year. We only considered those units in which the species was detected at least once over the sampling period. Year was the only explanatory variable included in the models. We used the identifier of each sampling unit as clusters in the GEE-GLM and considered an auto-regressive correlation structure (AR1). GEE models were computed in the software R 3.4.3 (R Core Team 2017) with the package "geepack" (Højsgaard et al. 2006).

Estimating long-term trends in the distribution of owls

We identified four periods during which a representative sampling effort capable of

Table 1 - Eight-year population trend estimates for the owl species in Portugal (2010 – 2017). Results from generalized estimating equations models (GEE-GLM): estimate, SE, Wald and P. Categorical trends defined based on the estimate, SE, significance level, and sample size (number of squares where each species was present).

Tabela 1 - Estimativas de oito anos da tendência populacional das aves de rapina noturnas em Portugal (2010 – 2017). Resultados dos modelos de equações de estimação generalizadas (GEE-GLM): coeficiente, erro padrão, parâmetro de Wald, P. As tendências categóricas foram definidas com base no coeficiente, erro padrão, nível de significância e tamanho da amostra (número de quadrículas onde a espécie esteve presente).

	ESTIMATE	SE	WALD	P	N SQUARES	TREND
Common Barn-owl (*Tyto alba*)	-0.09	0.05	3.474	0.06	36	Decrease
Eurasian Scops-owl (*Otus scops*)	-0.13	0.10	1.878	0.17	24	Decrease
Eurasian Eagle-owl (*Bubo bubo*)	0.02	0.04	0.208	0.6	17	Slight increase
Little Owl (*Athene noctua*)	-0.24	0.09	6.529	0.01	65	Decrease
Tawny Owl (*Strix aluco*)	-0.07	0.07	0.829	0.36	58	Slight decrease
Northern Long-eared Owl (*Asio otus*)	-0.004	0.07	0.005	0.9	13	Unknown

Table 2 - Distribution trend estimates for the owl species in Portugal (1978 – 2017). Percentage of the sampling units with breeding/presence information; in brackets – variation in the distribution percentage in relation to the immediately preceding sampling period. BBA1 – 1st breeding bird atlas, BBA2 – 2nd breeding bird atlas; inter-atlas – period between 2nd and 3rd breeding bird atlases; BBA3 – 3rd breeding bird atlas.

Tabela 2 - Estimativas da tendência da distribuição para as aves de rapina noturnas em Portugal (1978 – 2017). Percentagem das unidades de amostragem com informação de nidificação/presença; entre parêntesis – variação da percentagem de distribuição em relação ao período de amostragem imediatamente anterior. BBA1 – 1º atlas de aves nidificantes, BBA2 – 2º atlas de aves nidificantes; inter-atlas – period entre o 2º e o 3º atlas de aves nidificantes; BBA3 – 3º atlas de aves nidificantes.

	1978-1984 (BBA1)	1999-2005 (BBA2)	2006-2014 (INTER-ATLAS)	2015-2017 (BBA3)
Common Barn-owl (*Tyto alba*)	68%	59% (-9%)	43% (-16%)	36% (-8%)
Eurasian Scops-owl (*Otus scops*)	54%	33% (-21%)	15% (-18%)	16% (0%)
Eurasian Eagle-owl (*Bubo bubo*)	22%	22% (0%)	30% (+8%)	22% (-7%)
Little Owl (*Athene noctua*)	92%	74% (-18%)	64% (-9%)	65% (+1%)
Tawny Owl (*Strix aluco*)	62%	61% (0%)	51% (-10%)	58% (+7%)
Northern Long-eared Owl (*Asio otus*)	7%	9% (+2%)	9% (0%)	10% (+1%)
Short-eared Owl (*Asio flammeus*)	--	--	7%	7% (0%)

providing a general picture of the distribution of the owl species was carried out in continental Portugal. The first period (1978-1984) was the first breeding bird atlas of Portugal (Rufino 1989; hereafter designated as BBA1), which sampled 20 x 32 km rectangles (total of 180 rectangles). The second period (1999-2005) was the second breeding bird atlas of Portugal (Equipa Atlas 2008; hereafter designated as BBA2), which sampled 10 x10 km UTM squares (total of 947 squares). These two atlases did a complete census of continental Portugal, although it is assumed that they under sampled owls, especially in remote rural and interior areas of the country, with relatively low census effort (Rufino 1989, Equipa Atlas 2008). All categories of presence reported in the atlas (possible, probable and confirmed breeding) were used to quantify owl distribution.

The third period (2006-2014) was an "inter-atlas" period, when there was no country-wide owl census. The distribution data for this period was gathered from several sources: (1) NOCTUA-Portugal program (started in 2010); (2) additional records sent by NOCTUA-Portugal collaborators; (3) records from a public online database called PortugalAves/eBird (SPEA, Audubon, Cornell Lab of Ornithology; ebird.org/content/portugal/; Sullivan et al. 2009); (4) records sent to the newsletter of SPEA (Noticiário Ornitológico, www.spea.pt); and (5) published literature on owl studies, particularly regional atlases and monitoring studies (Tomé et al. 2008, Aguiar et al. 2010, Lourenço et al. 2011, Grilo et al. 2012, Silva et al. 2012, Santos et al. 2013, Lourenço et al. 2015). As in the BBA2, we used 10 x10 km UTM squares as sampling units. To determine the distribution of owls during this period we used all records for resident and wintering species. For the Eurasian Scops-owl (breeding but absent in winter) we only included records from April to August. There was incomplete coverage of all census units during this period, and therefore we only considered 740 sampling units that had at least one owl record.

The fourth period (2015-2017) corresponded to the ongoing third breeding bird atlas (BBA3), which used 10 x10 km ETRS squares as sampling units. We used all owl data from the PortugalAves/eBird (atlas visits and additional records) and observations sent by NOCTUA-Portugal collaborators. When this paper was prepared this atlas had not been completed and therefore we only included those sampling units with at least one owl record (n = 581) in our analysis.

To estimate the changes in the distribution of owl species in Portugal over time we calculated the percentage of sampling units censused that contained owls for each period and then determined how this varied relative to those obtained in the immediately preceding period.

Results

The Common Barn-owl population and distribution both declined (Tables 1, 2; Figs. 1, 2). The Eurasian Scops-owl population had a non-significant decline (Table 1, Fig. 3), yet it had the largest loss in distribution relative to other owl species (Table 2, Fig. 4). The Eurasian Eagle-owl population had a slight non-significant increase (Table 1, Fig. 5), accompanied by small increase in its distribution (Table 2, Fig. 6). The Little Owl population had the steepest decline (Table 1, Fig. 7), and its distribution declined from the first to the third census periods and then stabilized (Table 2, Fig. 8). The Tawny Owl population had a non-significant decline (Table 1, Fig. 9), together with an overall small reduction in its distribution (Table 2, Fig. 10). The Northern Long-eared Owl population trend is unknown since it shows considerable fluctuations (Table 1, Fig. 11) while its distribution increased slightly (Table 2, Fig. 12). It was not possible to estimate the population trend of wintering Short-eared Owls due to insufficient data but its distribution stable for the latter two periods (Table 2, Fig. 13).

Figure 1 - Annual abundance estimates (number of breeding pairs per sampled 10 x10 km square with 95% confidence intervals) for the Common Barn-owl (*Tyto alba*) in the period 2010-2017 resulting from the NOCTUA-Portugal monitoring program.

Figura 1 - Estimativas da abundância anual (número de casais reprodutores por quadrícula 10 x 10 km amostrada e intervalos de confiança de 95%) para a coruja-das-torres (*Tyto alba*) no período 2010-2017 resultantes do programa de monitorização NOCTUA-Portugal.

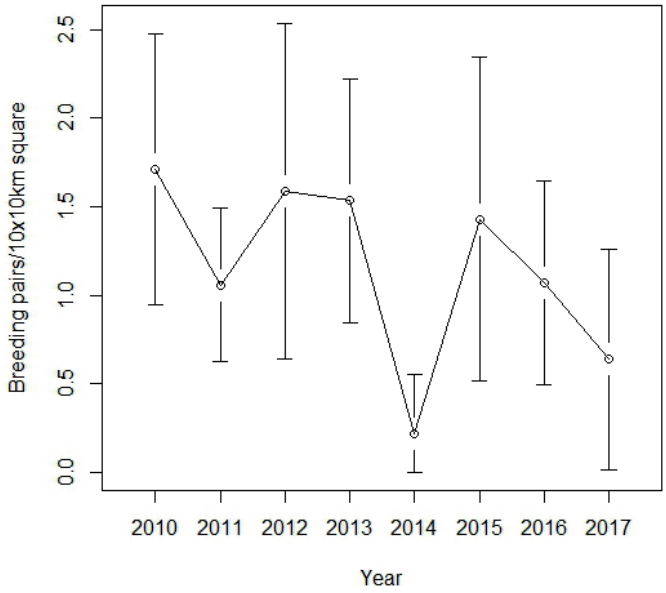


Figure 2 - Distribution of the Common Barn-owl (*Tyto alba*) in the four sampling periods: 1st breeding bird atlas BBA1 (1978-1984); 2nd breeding bird atlasBBA2 (1999-2005); period between 2nd and 3rd breeding bird atlases – inter-atlas (2006-2014); 3rd breeding bird atlas BBA3 (2015-2017).

Figura 2 - Distribuição da coruja-das-torres (*Tyto alba*) nos quatro períodos de amostragem: 1º atlas de aves nidificantes BBA1 (1978-1984); 2º atlas de aves nidificantesBBA2 (1999-2005); período entre o 2º e o 3º atlas de aves nidificantes – inter-atlas (2006-2014); 3º atlas de aves nidificantes BBA3 (2015-2017).

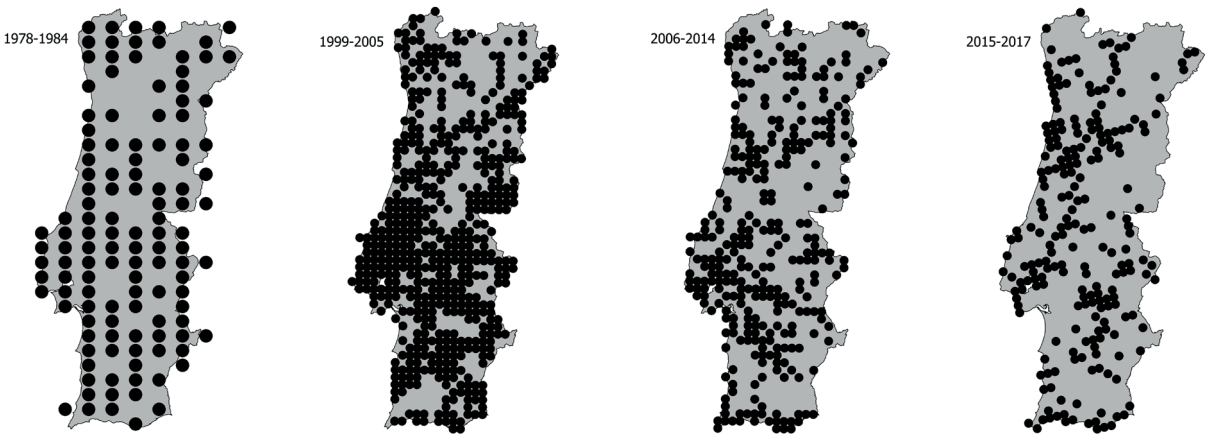


Figure 3 - Annual abundance estimates (number of breeding pairs per sampled 10 x10 km square with 95% confidence intervals) for the Eurasian Scops-owl (*Otus scops*) in the period 2010-2017 resulting from the NOCTUA-Portugal monitoring program.

Figura 3 - Estimativas da abundância anual (número de casais reprodutores por quadrícula 10 x 10 km amostrada e intervalos de confiança de 95%) para o mocho-d'orelhas (*Otus scops*) no período 2010-2017 resultantes do programa de monitorização NOCTUA-Portugal.

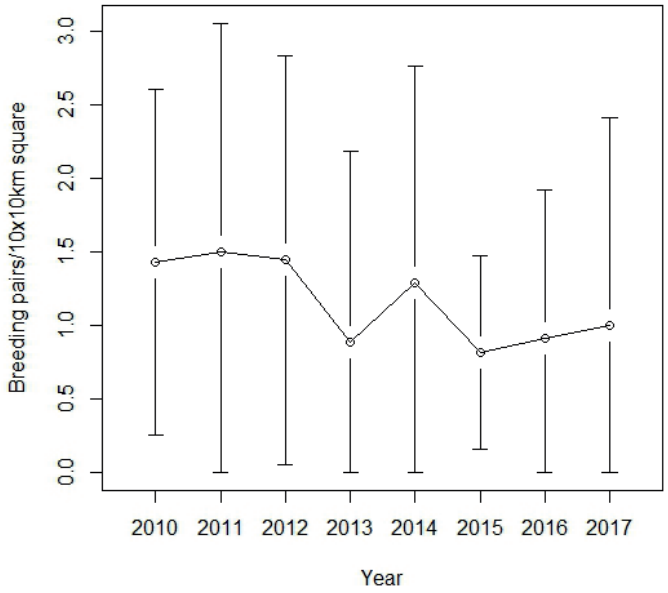


Figure 4 - Distribution of the Eurasian Scops-owl (*Otus scops*) in the four sampling periods: 1st breeding bird atlas BBA1 (1978-1984); 2nd breeding bird atlasBBA2 (1999-2005); period between 2nd and 3rd breeding bird atlases – inter-atlas (2006-2014); 3rd breeding bird atlas BBA3 (2015-2017).

Figura 4 - Distribuição do mocho-d'orelhas (*Otus scops*) nos quatro períodos de amostragem: 1º atlas de aves nidificantes BBA1 (1978-1984); 2º atlas de aves nidificantesBBA2 (1999-2005); período entre o 2º e o 3º atlas de aves nidificantes – inter-atlas (2006-2014); 3º atlas de aves nidificantes BBA3 (2015-2017).

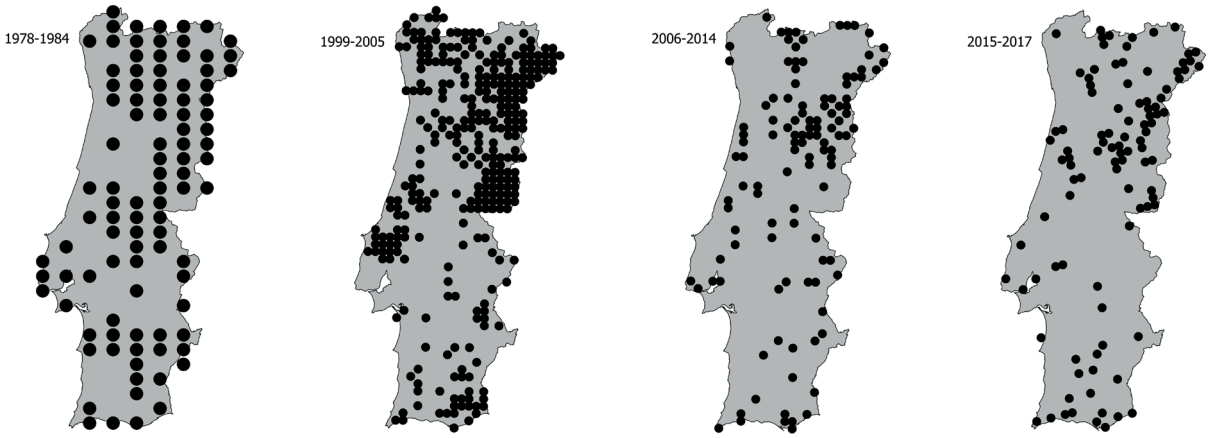


Figure 5 - Annual abundance estimates (number of breeding pairs per sampled 10 x10 km square with 95% confidence intervals) for the Eurasian Eagle-owl (*Bubo bubo*) in the period 2010-2017 resulting from the NOCTUA-Portugal monitoring program.

Figura 5 - Estimativas da abundância anual (número de casais reprodutores por quadrícula 10 x 10 km amostrada e intervalos de confiança de 95%) para o bufo-real (*Bubo bubo*) no período 2010-2017 resultantes do programa de monitorização NOCTUA-Portugal.

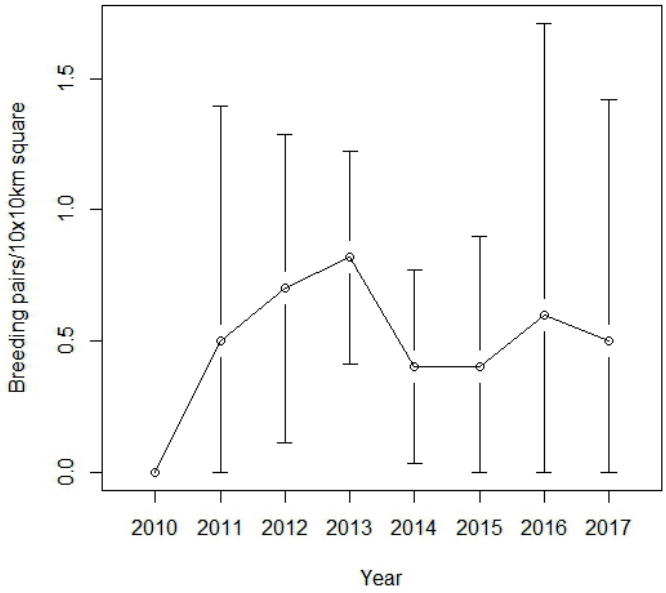


Figure 6 - Distribution of the Eurasian Eagle-owl (*Bubo bubo*) in the four sampling periods: 1st breeding bird atlas BBA1 (1978-1984); 2nd breeding bird atlasBBA2 (1999-2005); period between 2nd and 3rd breeding bird atlases – inter-atlas (2006-2014); 3rd breeding bird atlas BBA3 (2015-2017).

Figura 6 - Distribuição do bufo-real (*Bubo bubo*) nos quatro períodos de amostragem: 1º atlas de aves nidificantes BBA1 (1978-1984); 2º atlas de aves nidificantesBBA2 (1999-2005); período entre o 2º e o 3º atlas de aves nidificantes – inter-atlas (2006-2014); 3º atlas de aves nidificantes BBA3 (2015-2017).

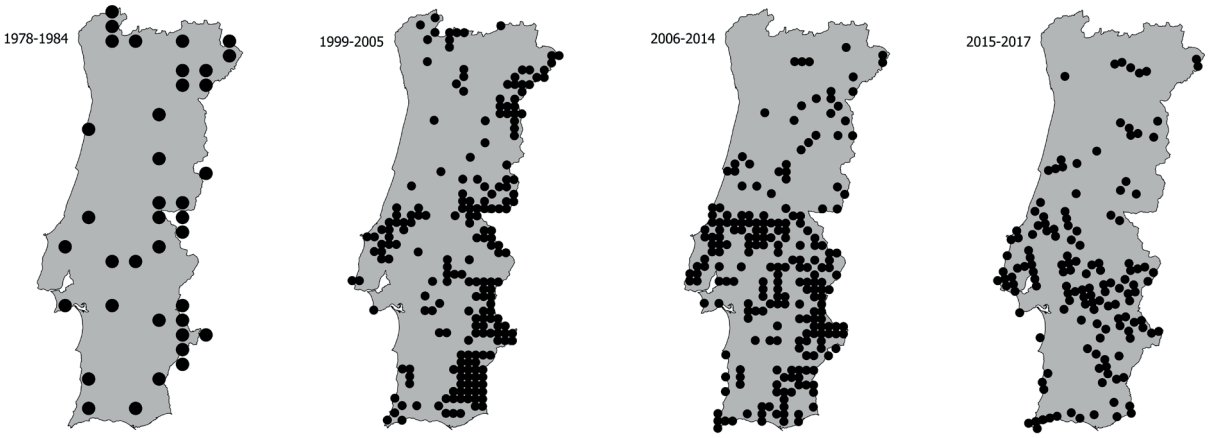


Figure 7 - Annual abundance estimates (number of breeding pairs per sampled 10 x10 km square with 95% confidence intervals) for the Little Owl (*Athene noctua*) in the period 2010-2017 resulting from the NOCTUA-Portugal monitoring program.

Figura 7 - Estimativas da abundância anual (número de casais reprodutores por quadrícula 10 x 10 km amostrada e intervalos de confiança de 95%) para o mocho-galego (*Athene noctua*) no período 2010-2017 resultantes do programa de monitorização NOCTUA-Portugal.

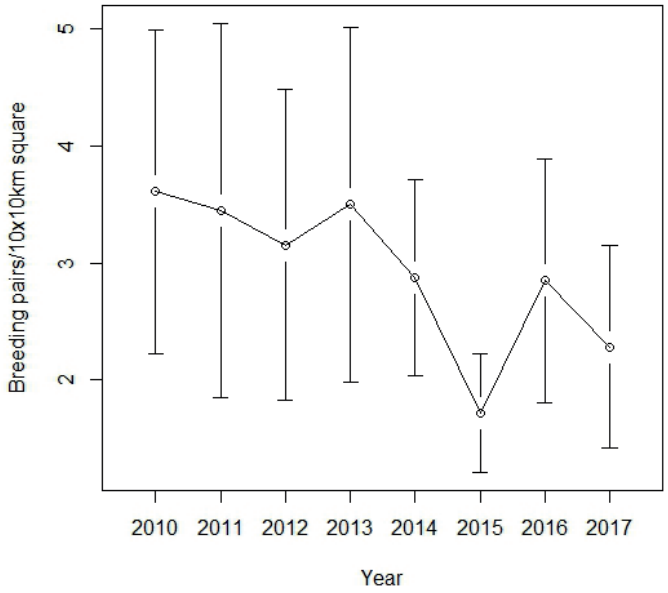


Figure 8 - Distribution of the Little Owl (*Athene noctua*) in the four sampling periods: 1st breeding bird atlas BBA1 (1978-1984); 2nd breeding bird atlasBBA2 (1999-2005); period between 2nd and 3rd breeding bird atlases – inter-atlas (2006-2014); 3rd breeding bird atlas BBA3 (2015-2017).

Figura 8 - Distribuição do mocho-galego (*Athene noctua*) nos quatro períodos de amostragem: 1º atlas de aves nidificantes BBA1 (1978-1984); 2º atlas de aves nidificantesBBA2 (1999-2005); período entre o 2º e o 3º atlas de aves nidificantes – inter-atlas (2006-2014); 3º atlas de aves nidificantes BBA3 (2015-2017).

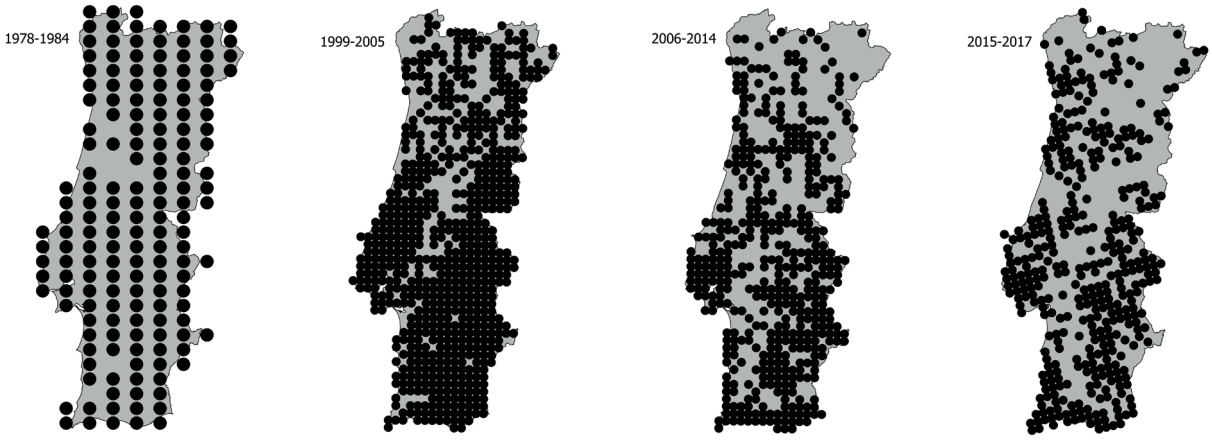


Figure 9 - Annual abundance estimates (number of breeding pairs per sampled 10 x10 km square with 95% confidence intervals) for the Tawny Owl (*Strix aluco*) in the period 2010-2017 resulting from the NOCTUA-Portugal monitoring program.

Figura 9 - Estimativas da abundância anual (número de casais reprodutores por quadrícula 10 x 10 km amostrada e intervalos de confiança de 95%) para a coruja-do-mato (*Strix aluco*) no período 2010-2017 resultantes do programa de monitorização NOCTUA-Portugal.

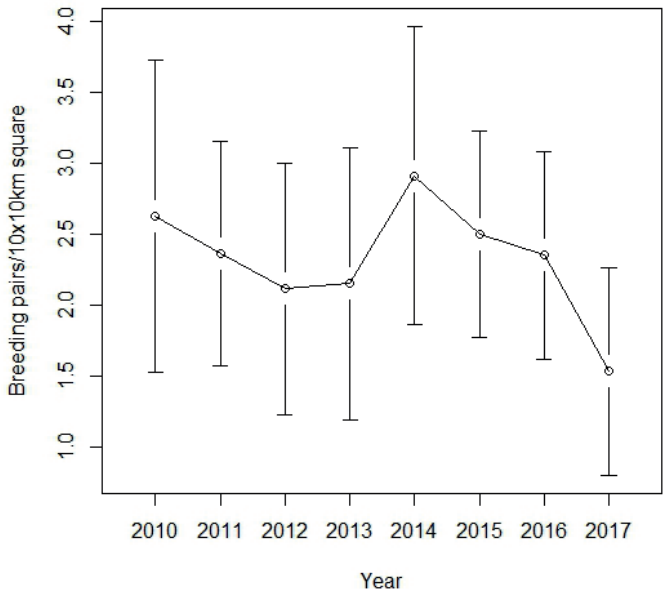


Figure 10 - Distribution of the Tawny Owl (*Strix aluco*) in the four sampling periods: 1st breeding bird atlas BBA1 (1978-1984); 2nd breeding bird atlasBBA2 (1999-2005); period between 2nd and 3rd breeding bird atlases – inter-atlas (2006-2014); 3rd breeding bird atlas BBA3 (2015-2017).

Figura 10 - Distribuição da coruja-do-mato (*Strix aluco*) nos quatro períodos de amostragem: 1º atlas de aves nidificantes BBA1 (1978-1984); 2º atlas de aves nidificantesBBA2 (1999-2005); período entre o 2º e o 3º atlas de aves nidificantes – inter-atlas (2006-2014); 3º atlas de aves nidificantes BBA3 (2015-2017).

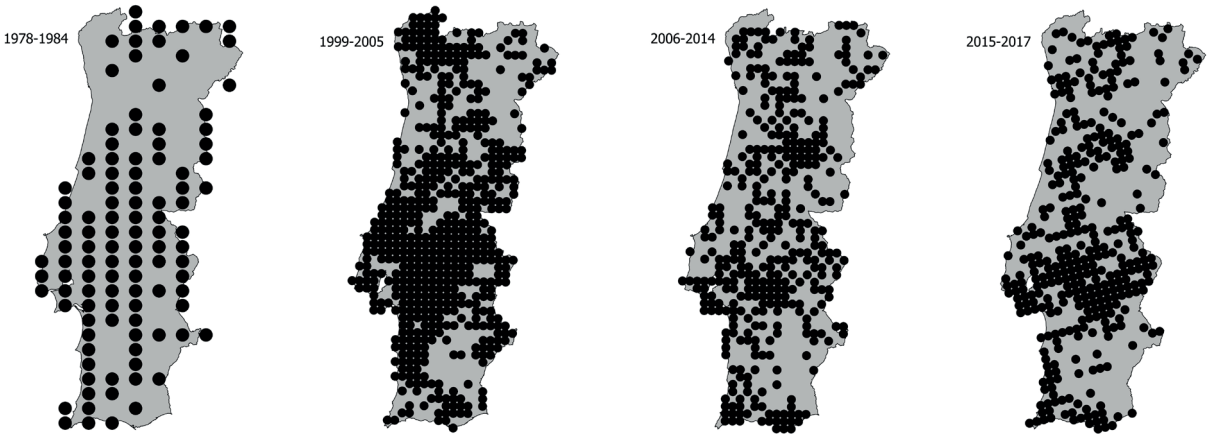


Figure 11 - Annual abundance estimates (number of breeding pairs per sampled 10 x10 km square with 95% confidence intervals) for the Northern Long-eared Owl (*Asio otus*) in the period 2010-2017 resulting from the NOCTUA-Portugal monitoring program.

Figura 11 - Estimativas da abundância anual (número de casais reprodutores por quadrícula 10 x 10 km amostrada e intervalos de confiança de 95%) para o bufo-pequeno (*Asio otus*) no período 2010-2017 resultantes do programa de monitorização NOCTUA-Portugal.

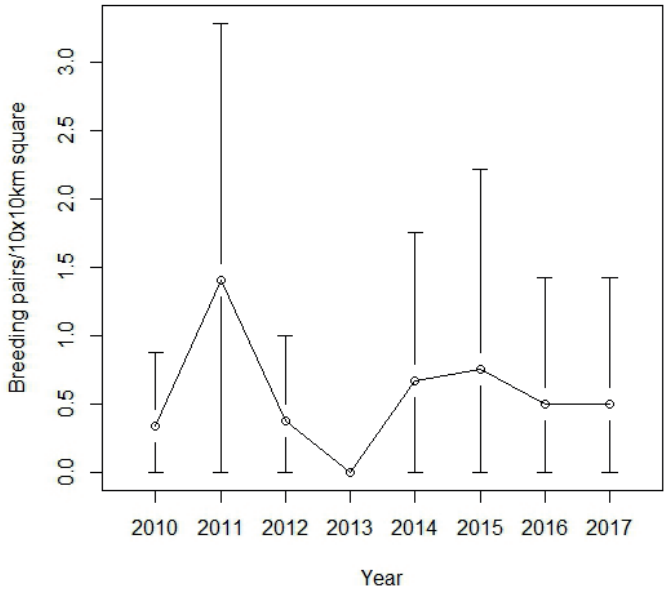


Figure 12 - Distribution of the Northern Long-eared Owl (*Asio otus*) in the four sampling periods: 1st breeding bird atlas BBA1 (1978-1984); 2nd breeding bird atlasBBA2 (1999-2005); period between 2nd and 3rd breeding bird atlases – inter-atlas (2006-2014); 3rd breeding bird atlas BBA3 (2015-2017).

Figura 12 - Distribuição do bufo-pequeno (*Asio otus*) nos quatro períodos de amostragem: 1º atlas de aves nidificantes BBA1 (1978-1984); 2º atlas de aves nidificantesBBA2 (1999-2005); período entre o 2º e o 3º atlas de aves nidificantes – inter-atlas (2006-2014); 3º atlas de aves nidificantes BBA3 (2015-2017).

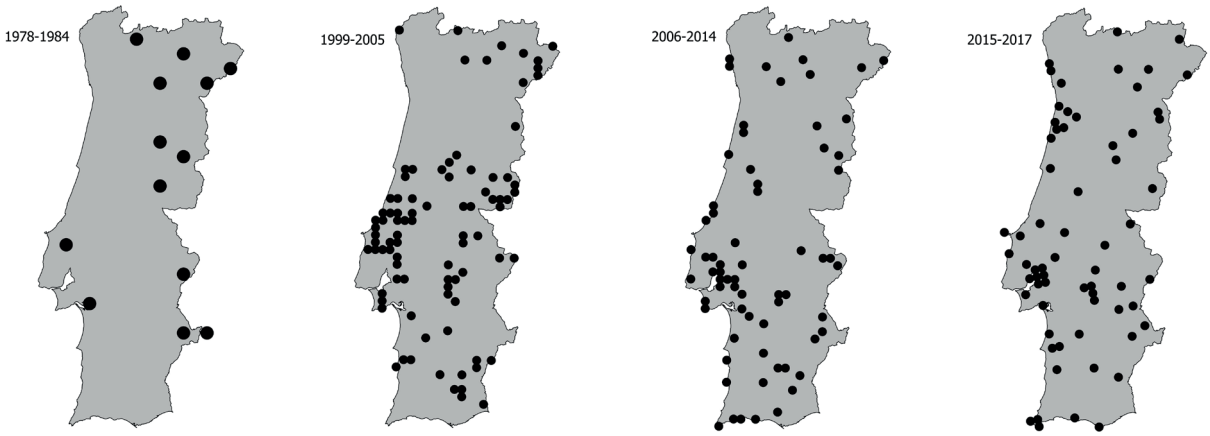
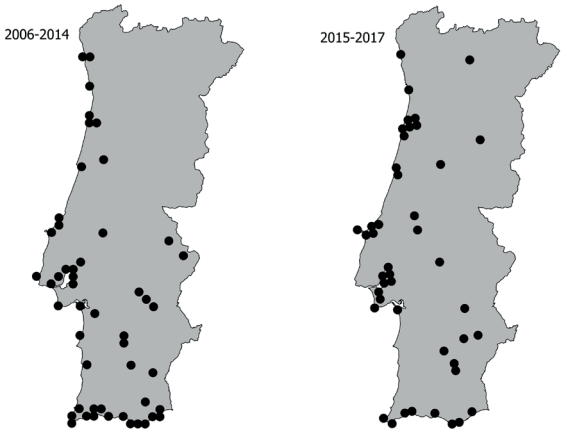


Figure 13 - Distribution of the Short-eared Owl (*Asio flammeus*) in two sampling periods: period between 2nd and 3rd breeding bird atlases – inter-atlas (2006-2014); 3rd breeding bird atlas BBA3 (2015-2017).

Figura 13 - Distribuição da coruja-do-nabal (*Asio flammeus*) nos dois períodos de amostragem: período entre o 2º e o 3º atlas de aves nidificantes – inter-atlas (2006-2014); 3º atlas de aves nidificantes BBA3 (2015-2017).



Discussion

Eight years of monitoring by NOCTUA-Portugal has provided a reasonable amount of information to estimate the short-term population trend of owls in continental Portugal. Owl population trend estimates were more reliable for the most common species, although even these should be interpreted with caution due to relatively low sampling effort. Our estimates are the most accurate available to date in Portugal. Owl population trend estimates reported here in were somewhat similar to those of NOCTUA-Spain (2006-2017; SEO/BirdLife 2018), suggesting that owl populations in the Iberian Peninsula are continuous and subject to similar threats.

Although the baseline information available to estimate long-term trends in owl distribution was relatively heterogeneous (different sampling unit size used in BBA1, and incomplete coverage in inter-atlas and BBA3), we consider that our results are an early warning for substantial distribution declines, as seen for the Common Barn-owl and Little Owl.

The Common Barn-owl is also declining in Spain (SEO/BirdLife 2018) and several other European countries (BirdLife International 2004, Burfield 2008). In Portugal, its decline may be due to changes in agricultural landscapes, namely conversion of traditional crops into intensive olive groves, irrigated fields and forestations (Lourenço et al. 2015). In contrast, in some interior areas, a reduction in human population resulted in abandoned agricultural land being replaced by scrubland less favourable to Common Barn-owls.

The slight decline of the Eurasian Scops-owl in Portugal appears to be consistent with the moderate decline shown in Spain (SEO/BirdLife 2018), although the overall population trend in Europe remains unknown (BirdLife International 2004, Burfield 2008). The Eurasian Scops-owl may also be negatively affected by the intensification in agricultural practices. This has been more pronounced in southern Portugal, coinciding with where the distribution of the Eurasian Scops-owl seems to be shrinking the most

(Lourenço et al. 2015).

The slight increase in the Eurasian Eagle-owl population in Portugal is consistent with the concurrent trend in Spain (SEO/BirdLife 2018) and in most western European countries, where the species is recovering after a large historical decline (BirdLife International 2004). In Portugal, it may be benefiting mostly from a decrease in human persecution resulting from greater environmental awareness and rural depopulation.

The decline of the Little Owl in Portugal is in line with its decline in Spain and in most European countries (Burfield 2008, van Nieuwenhuyse et al. 2008, SEO/BirdLife 2018). The main cause behind its negative status in Portugal seems to be nesting habitat loss and decreased prey availability due to agriculture intensification.

The non-significant decline of the Tawny Owl suggested it may be stable in Portugal, which is consistent with its estimated status in Spain and throughout most European countries (BirdLife International 2004, SEO/BirdLife 2017). The apparently stable long-term population trend of the Tawny Owl in Portugal (Lourenço et al. 2015) may start to decline due to degradation and management changes in habitat, e.g., in montado landscapes, shaped by human activity (Pinto-Correia & Godinho 2013). Tawny Owls are also frequent victims of collision with vehicles in Portugal (Santos et al. 2013), therefore current increases in vehicle use may also contribute to future population declines.

Large annual fluctuations in abundance associated with the very small distributional increase and relative scarcity make population estimates for the Northern Long-eared Owl unreliable. For similar reasons, the status of the Northern Long-eared Owl in Spain is unknown (SEO/BirdLife 2017), whereas across Europe it seems stable (Burfield 2008). Due to its cryptic behaviour and low abundance, a longer monitoring period and/or monitoring scheme with a much larger sampling effort or a species-specific census method is required to produce a more accurate estimate of its population and distribution trend.

The Short-eared Owl occurs in Portugal in winter concentrations mostly in large wetlands along the coast, therefore a specific and coordinated census in this habitat is required to obtain a population estimate. Still, its wintering distribution area seems stable, at least in the last decade. Likewise, its population census estimate was not available in NOCTUA-Spain, but in Europe its trend is apparently stable (Burfield 2008).

The current monitoring scheme and the bird atlases in Portugal have gathered important information on the population and distribution trends of owl species. NOCTUA-Portugal is a long-term monitoring program that will produce more reliable trends for owls and other nocturnal birds over time. Such data, combined with habitat, landscape management and other information, can be used to address and mitigate threats to owls to further their conservation in Portugal.

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