Ecological Indicators 69 (2016) 488–499

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

A habitat quality indicator for common birds in Europe based on species distribution models

Sara Vallecillo*, Joachim Maes, Chiara Polce, Carlo Lavalle

European Commission – Joint Research Centre, Institute for Environment and Sustainability, Via Fermi, 2749, TP 270, 21027 Ispra, VA, Italy

ARTICLE INFO

Article history:
Received 5 November 2015
Received in revised form 2 May 2016
Accepted 4 May 2016

Keywords:
Species richness
Breeding habitats
Biodiversity Strategy
Habitat suitability
Downscaling
Data refinement
Maxent

ABSTRACT

The EU 2020 Biodiversity Strategy requires the gathering of information on biodiversity to aid in monitoring progress towards its main targets. Common species are good proxies for the diversity and integrity of ecosystems, since they are key elements of the biomass, structure, functioning of ecosystems, and therefore of the supply of ecosystem services. In this sense, we aimed to develop a spatially-explicit indicator of habitat quality (HQI) at European level based on the species included in the European Common Bird Index, also grouped into their major habitat types (farmland and forest). Using species occurrences from the European Breeding Birds Atlas (at 50 km × 50 km) and the maximum entropy algorithm, we derived species distribution maps using refined occurrence data based on species ecology. This allowed us to cope with the limitations arising from modelling common and widespread species, obtaining habitat suitability maps for each species at finer spatial resolution (10 km × 10 km grid), which provided higher model accuracy. Analysis of the spatial patterns of local and relative species richness (defined as the ratio between species richness in a given location and the average richness in the regional context) for the common birds analysed demonstrated that the development of a HQI based on species richness needs to account for the regional species pool in order to make objective comparisons between regions. In this way, we proved that relative species richness compensated for the bias caused by the inherent heterogeneous patterns of the species distributions that was yielding larger local species richness in areas where most of the target species have the core of their distribution range. The method presented in this study provides a robust and innovative indicator of habitat quality which can be used to make comparisons between regions at the European scale, and therefore potentially applied to measure progress towards the EU Biodiversity Strategy targets. Finally, since species distribution models are based on breeding birds, the HQI can be also interpreted as a measure of the capacity of ecosystems to provide and maintain nursery/reproductive habitats for terrestrial species, a key maintenance and regulation ecosystem service.

1. Introduction

The EU 2020 Biodiversity Strategy has as headline target to halt the loss of biodiversity and degradation of ecosystem services in the EU by 2020. The Strategy therefore calls for the gathering of comprehensive information on the status of biodiversity, ecosystems and ecosystem services and the development of coherent and robust indicators to monitor, assess and report on progress in its implementation across the EU.

The Streamlining European Biodiversity Indicators (SEBI) have been set to address the EU Biodiversity Targets (EEA, 2012). The 'abundance and distribution of selected species' (SEBI 01) is among these indicators and includes, among other groups, common birds. Common species contribute to much of the structure, biomass and energy turnover of an ecosystem, so are a determinant of ecosystem function, with the depletion of their population potentially affecting ecosystem goods and services in a significant way (McIntyre et al., 2007; Gaston and Fuller, 2008; Gaston, 2010). Moreover, birds are considered to be good proxies to measure the diversity and integrity of ecosystems as they tend to be near the top of the

Abbreviations: AUC, Area Under the receiver operating characteristic Curve; EBCC, European Bird Census Council; HQI, habitat quality indicator; LUISA, Land Use-based Integrated Sustainability Assessment modelling platform; LSR, local species richness; NM_{AUC}, null model AUC; RSR, relative species richness; SDM, species distribution models; SM_{AUC}, species model AUC; SEBI, Streamlining European Biodiversity Indicators.

* Corresponding author. Tel.: +39 0332 785738.
E-mail addresses: sara.vallecillo-rodriguez@jrc.ec.europa.eu (S. Vallecillo), joachim.maes@jrc.ec.europa.eu (J. Maes), chiara.polce@jrc.ec.europa.eu (C. Polce), carlo.lavalle@jrc.ec.europa.eu (C. Lavalle).

http://dx.doi.org/10.1016/j.ecolind.2016.05.008

food chain, have large ranges, and the ability to move elsewhere when their environment becomes unsuitable (Sekercioglu, 2006). The abundance of common birds is currently reported by the European Common Bird Index (Gregory et al., 2005; Eurostat, 2013). The negative population trends described by this indicator during recent years, particularly for farmland birds, reveal an increasing threat to those species within certain habitat types (Eurostat, 2013).

A great deal of work has been done to include data on species abundance and population trends of common birds within the framework of the SEBI 01 indicator (Inger et al., 2014), with much less of a focus on the spatial distribution of selected species. There is, therefore, a need to evaluate the spatial distribution patterns at European level of the species included in the Common Bird Index. In spite of the great usefulness of species distribution models (SDM) to map habitat suitability of species at large spatial scales (Araujo et al., 2005; Elith et al., 2011; Virkkala et al., 2013; Thuiller et al., 2014), there are, as yet, no published studies on modelling the distribution of the species listed in the widely accepted European Common Bird Index. Species distribution maps obtained through SDM indicate the probability of presence of a given species based on the spatial variation of environmental conditions. A higher probability of presence of a modelled species can be considered an indicator of habitat quality (Sergio and Newton, 2003) that will be useful to identify areas offering good habitat conditions for all the target species. Computing and overlaying the SDM for the common bird species therefore offers a unique opportunity to develop a composite indicator on the habitat quality of this group of species.

However, when assessing the species richness derived from the SDM outputs for a set of target species over a broad spatial extent, there may be an influence of the dominant distribution patterns depending on the biogeography of the species selected for the analysis. A higher species richness is expected closer to areas where most of the species have the core of distribution range, where individual species are more homogeneously distributed, and there is an increased likelihood of overlap with other species (Soberón and Ceballos, 2011). On the contrary, towards the periphery of the distribution ranges, species appear in more isolated and fragmented patches decreasing the probability of overlay, and potentially yielding lower species richness. If this hypothesis holds, the use of local species richness as an indicator would result in a biased comparison between regions, overestimating the role of species richness in those areas closer to the core ranges of the species analysed. Therefore, the indicator might be highly variable depending on the species selected and the specific location considered for the analysis.

Spatial variation in local species richness may not only be linked to variations in local environmental conditions, but also to the size of the regional species pool. Using relative species richness (RSR), expressed as local species richness in relation to the regional species pool, should help to resolve this issue (Cam et al., 2000). Relative species richness should then be independent of the geographic position in relation to the core or periphery range of the studied species, which would warrant its use as a robust indicator of habitat quality for common birds.

In this context, the general objective of this study was to develop a habitat quality indicator (HQI) based on the richness of species included in the European Common Bird Index, also grouped into major habitat types (farmland and forest). Species richness was obtained from species distribution models (SDM) using occurrence data refined according to the species ecology, allowing us to obtain downscaled habitat suitability maps. Finally, we analysed the spatial patterns of local and relative species richness throughout Europe to test the influence of the dominant pattern of species distributions, as explained above. This analysis would prove the soundness of using species richness, either local or relative, as a spatial indicator of habitat quality, allowing us to make objective comparisons between regions as required for appropriate environmental indicators (OECD, 1993; EEA, 2012).

2. Methods

2.1. Bird species data and refined species occurrences

Presence-only data on bird species occurrences were obtained from the European Bird Census Council (EBCC) Atlas of European Breeding Birds, over a grid of roughly 50 km × 50 km (Hagemeijer and Blair, 1997). Of the 148 species included in the Common Bird Index (Appendix A) (European Bird Census Council, Species classification 2012), only data on the Syrian woodpecker (*Dendrocopos syriacus*) was not available in the EBCC Atlas. A given species was considered to be breeding when a record was classified as 'confirmed breeding' (i.e. Category C from the EBCC Atlas). Species of the Common Bird Index are classified according to habitat types in Europe and include 37 farmland species, 33 forest species and a very heterogeneous group of 78 species found in other habitat types (i.e. urban, water, generalist birds). Following the Common Bird Index, we present results for all common bird species (including all three groups) and then separately for farmland and forest common birds.

The modelling of widespread and common species is challenging since these species do not show strong responses to environmental gradients leading, in some cases, to poor model performance (McPherson et al., 2004; Segurado and Araújo, 2004; Franklin et al., 2009; Aguirre-Gutiérrez et al., 2013). In fact, a large distribution range in relation to the modelled extent might result in low discriminatory power between areas where the species is present or absent (Franklin et al., 2009 Aguirre-Gutiérrez et al., 2013). Keeping the original resolution of the Atlas data we expected to face this issue for about 52% of the targeted species, whose distribution ranges cover more than half the study area (i.e. Europe). The coarse spatial resolution of the EBCC Atlas data may also yield situations in which species show similar distribution ranges (and therefore very similar explanatory variables in their SDM), even when the species have contrasting habitat requirements. For instance, *Garrulus glandarius* and *Hirundo rustica* show a Jaccard's index of similarity of their EBCC occurrences of 0.85, but have completely different habitat requirements, belonging respectively to the farmland and forest species groups. In addition, SDM based on land use usually require a finer spatial resolution than those based solely on climate, given that land use is a much more heterogeneous factor than climate at the landscape scale (Kelly et al., 2014; Sohl, 2014).

The foregoing arguments justify the development of a suitable approach to refine the available species occurrence data to model species distributions for common birds. This would also contribute towards providing downscaled distribution models for a more detailed assessment of habitat quality for the target species, improving the applicability to support policy decisions. To achieve this refinement, 10 km × 10 km cells were randomly sampled within each occupied cell of the original EBCC Atlas presence-only data (∼ at 50 km × 50 km resolution). The sampling was constrained by species habitat preferences, so that only fine-grain cells for which the extent of the preferred habitat for each species is above the 50th percentile can be selected. The downscaling of coarse occurrence data based on species habitat preferences has also been done in other studies (McPherson et al., 2006; Rondinini et al., 2011; Sardà-Palomera and Vieites, 2011; Overmars et al., 2013). Habitat preferences for each species were taken from BirdLife International (2014), where suitable breeding habitats are listed using the IUCN habitat classification scheme (IUCN, 2012). We harmonized the IUCN habitats with the Corine Land Cover (CLC)