Global Ecology and Conservation 2 (2014) 226–237

Contents lists available at ScienceDirect

Global Ecology and Conservation

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

Original research article

Improving the assessment and reporting on rare and endangered species through species distribution models

Rita Sousa-Silva [a,*], Paulo Alves [a], João Honrado [a,b], Angela Lomba [a,c]

[a] *Centro de Investigação em Biodiversidade e Recursos Genéticos (CIBIO), Campus Agrário de Vairão, 4485-661 Vairão, Portugal*

[b] *Faculdade de Ciências da Universidade do Porto, Departamento de Biologia, Edifício FC4, Rua do Campo Alegre, s/n, 4169-007 Porto, Portugal*

[c] *Alterra Wageningen University and Research Centre, 6708 Wageningen, The Netherlands*

ARTICLE INFO

Article history:
Received 10 June 2014
Received in revised form 25 September 2014
Accepted 26 September 2014
Available online 13 October 2014

Keywords:
Conservation
Habitats directive
Monitoring
Predictive modeling
Range Tool
Suitable habitat

ABSTRACT

Species distribution models (SDMs) are increasingly used to understand rare and endangered species distributions, as well as the environmental pressures affecting them. Detailed knowledge of their distribution is critical for reporting its conservation status, and SDMs are potential tools to provide the relevant information to conservation practitioners. In this study, we modeled the distribution of *Veronica micrantha*, a vulnerable plant whose conservation status has to be periodically assessed under Article 17 of the Habitats Directive.

The objective was to highlight the potential of SDMs for the assessment of threatened species within the periodical report on their conservation status. We used a spatially explicit modeling approach, which predicts species distributions by spatially combining two SDMs: one fitted with climate data alone and the other fitted solely with landscape variables. A comparison between the modeled distribution and the range obtained by classical methods (minimum convex polygon and *Range Tool*) is also presented. Our results show that while data-based approaches only consider the species known distribution, model-based methods allow a more complete evaluation of species distributions and their dynamics, as well as of the underlying pressures. This will ultimately improve the accuracy and usefulness of assessments in the context of EU reporting obligations.

1. Introduction

Halting the decline of biodiversity worldwide is acknowledged as one of the greatest challenges facing Humanity (CBD, 2010) and achieving this will require an unprecedented effort (Wolinsky, 2011). In the European context, the EU reporting obligations under the Article 17th of the Habitats Directive (92/43/EEC) resulted from the pressing need to assess the overall conservation status of species and habitats of community interest (European Commission, 1992). Habitats Directive aims to promote the maintenance of biodiversity by requiring Member States (MS) to take measures to maintain or restore natural habitats and wild species listed on the Annexes to the Directive at a favorable conservation status, introducing robust

* Correspondence to: Department of Earth and Environmental Sciences, KU Leuven, BE-3001 Leuven, Belgium.
E-mail addresses: silva.as.rita@gmail.com, anarita.silva@kuleuven.be (R. Sousa-Silva).

http://dx.doi.org/10.1016/j.gecco.2014.09.011

protection for those habitats and species of European importance. MS are thus required to report every six years, providing extensive data regarding the conservation status of species and habitats classified as favorable, inadequate, unfavorable, or unknown. Reporting includes several relevant parameters for species assessment such as range, number and dimension of populations, suitable habitat and future prospects (ETC/BD, 2011). Overall, as a result from the 2007 report, a significant percentage of species (27%) and habitats (13%) was considered to be data deficient, meaning that the information available does not allow the assessment of their conservation status (European Commission, 2009). Further, the lack of data is more acute in southern countries, such as Portugal and Spain, where more than 50% of the species assessments were classed as 'unknown'.

Rare species may be at greater risk of extinction because of their small geographic ranges, low abundances, and greater susceptibility to environmental changes (Pimm et al., 1995; Broennimann et al., 2005; Lavergne et al., 2005; Lomba et al., 2010). Further, incomplete information on their distributions, often gathered over long periods of time and with limited spatial accuracy, makes the assessment of these species particularly challenging (Engler et al., 2004; Lomba et al., 2010; Gogol-Prokurat, 2011; Marcer et al., 2013). Consequently, and according to the International Union for Conservation of Nature (IUCN) guidelines, the estimation of the extent of species distributions constitutes the core of most assessment schemes (IUCN, 2001). Even if both Article 17 and Red Listing aim to assess the conservation status of species and habitats, they rely on related but rather distinct criteria. Article 17 of the Habitats Directive places particular emphasis on the assessment of species ranges and areas of potentially suitable habitat (ETC/BD, 2011). In former reporting periods, the standard approach to determine a species' distribution was the minimum convex polygon (MCP; (IUCN, 2001)), and as a result the quality of reported ranges wan uneven (Urda and Maxim, 2012). More recently, the European Topic Centre on Biological Diversity (ETC/BD, 2011) developed a tool to make the assessment of the conservation status for European biodiversity features easier and more accurate. Known as *Range Tool*, it computes the range for the selected species or habitat types and creates standardized outputs that could be used for the reports on the implementation of the Directive (Maxim, 2013). On the other hand, the IUCN has recently recommended the development of techniques that better reflect threats to species' persistence than those from predicted range changes, emphasizing the potential of species distribution models (IUCN, 2011; Fordham et al., 2012). Moreover, European Union (EU) guidelines highlight modeling the habitat used by a species and its potential suitable habitat as an important tool for periodic assessments and reporting (ETC/BD, 2011).

Species distribution models (SDMs; Guisan and Zimmermann, 2000; Guisan and Thuiller, 2005) are being increasingly used to inform monitoring programs and thus conservation policies (Guisan et al., 2013). These models have been successfully applied to locate new populations of rare and threatened species (e.g Guisan et al., 2006), prioritize areas for conservation (e.g. Carvalho et al., 2011), evaluate potential effects of global change in species distribution (e.g. Thuiller et al., 2005), and to infer extinction risk of species (e.g. Benito et al., 2009). In such context, climate change has been considered one of the major drivers of species distributions at a large spatial extent (Pearson et al., 2004; Soberón and Nakamura, 2009; Bellard et al., 2012) and species are assumed to be mainly constrained by their physiological tolerance to temperature and humidity. Land-use changes have also been assessed as they may affect biodiversity and ecosystem services at several relevant scales, from wide assessments across Europe (e.g. Reidsma et al., 2006; Verburg et al., 2006), to local studies of landscape-level changes of biodiversity (e.g. Lomba et al., 2012; Pompe et al., 2008). Thus, anticipating the combined impacts of climate change and land-use, which can lead to dramatic declines in biodiversity, is critical to prioritize conservation planning and effectively protect biodiversity under conditions of environmental change (Riordan and Rundel, 2014).

Supported by the growing availability of data and from conceptual and technical advances in SDMs, there is an emerging recommendation to simultaneously apply several methods (ensemble modeling; Araújo and New, 2007) within a consensus modeling framework (Thuiller, 2004; Marmion et al., 2009). Such cutting-edge modeling framework is known to reduce the predictive uncertainty of single-models by combining their predictions (Buisson et al., 2010; Grenouillet et al., 2011), thus increasing the accuracy of species distribution forecasts (Marmion et al., 2009).

In this paper, we investigate SDMs as tools to provide relevant information needed for reporting under the Article 17 of the Directive. To approach this issue, we present a tailored modeling framework to tackle the combined effects of climate and land-use changes on the distribution of focal species. Such framework is based on a multi-scale approach that acknowledges that different factors act more strongly at different spatial and temporal scales (Wu and Smeins, 2000; Pearson et al., 2004; Milbau et al., 2008). At a regional scale, climate strongly influences the distribution and abundance of plant species, while at local scales, topography and soil typically become important in influencing floristic variability (Pearson et al., 2004; Luoto et al., 2007; Milbau et al., 2008; Riordan and Rundel, 2014). We illustrate our modeling approach with *Veronica micrantha*, an Iberian endemic plant listed in Annex II of the EU Habitats Directive. As the distribution of *V. micrantha* remains poorly understood, SDMs were considered an ideal tool for predicting locations of additional, as of yet unknown, populations (Guisan et al., 2006). This work explores the potential of this novel modeling approach for the assessment of the distribution of rare and endangered species in the context of the EU Article 17 report, in the line of Attorre et al. (2012) and Marcer et al. (2013). We described the general approach and compared it thereafter to the range estimate provided by convex polygons and range maps generated using the latest *Range Tool*. Further, we performed a sensitivity test to the proposed framework to assess whether it is able to capture the effects of future environmental changes on the potential suitable habitat available for *V. micrantha*. The results are discussed in light of their influence upon the development of adequate conservation strategies and implications for conservation.