Ecological Indicators 86 (2018) 1–8

Contents lists available at ScienceDirect

Ecological Indicators

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

Original Articles

Does a correlation exist between environmental suitability models and plant population parameters? An experimental approach to measure the influence of disturbances and environmental changes

Mauro Fois[a], Alba Cuena-Lombraña[a,b,*], Giuseppe Fenu[a], Donatella Cogoni[a], Gianluigi Bacchetta[a,b]

[a] Centro Conservazione Biodiversità, Dipartimento di Scienze della Vita e dell'Ambiente, Università degli Studi di Cagliari, Viale S. Ignazio da Laconi, 13, Cagliari 09123, Italy

[b] Hortus Botanicus Karalitanus (HBK), Università degli Studi di Cagliari, Viale Sant'Ignazio da Laconi, 9–11, Cagliari 09123, Italy

ARTICLE INFO

Key-words:
Gentiana lutea
Human-induced threats
Maxent
Mediterranean mountain environments
Plant demography
Species distribution models

ABSTRACT

Due to increasing human pressures, there is a need to understand how environmental and anthropogenic disturbances could affect the conservation status of endangered plant species. When information on distribution or population parameters is poor, Species Distribution Models (SDMs) may offer a valuable additional source to assess threats and to evaluate conservation options. In this sense, if the output of SDMs represents the relationships between habitat features and species occurrence, SDM results can also be related to other key parameters of population. For the endangered yellow gentian, we tested the relationship between six field population parameters and the suitabilities obtained by SDMs with natural and limiting parameters (i.e. proxies of disturbances). Specifically, the six population parameters were the surface area covered by each population, the number of vegetative and reproductive individuals per population, the density of reproductive and all individuals per plot and the proportion of reproductive individuals. Thus, threats were evaluated by testing if relationships between population parameters and suitabilities increased when proxies of disturbances were included in models.

Best-fitting models resulted when all natural and human disturbance variables were included. In addition, results show relationships between suitability and population parameters only when disturbance parameters were used for SDMs. When the index related to the sensitivity to climate change was included in SDMs, the density of all individuals and number of reproductive plants were lower than in low suitability sites, suggesting that climate change is likely already challenging the ability of yellow gentian to bloom and germinate. Otherwise, we observed a decrease of the extent of localities in areas with higher suitability obtained through the index related to trail intensity. This confirmed the positive effect of conservation activities, which were mainly implemented in the proximity of trails.

Using a thoroughly studied plant species as a straightforward example, we showed the potentiality of SDMs to inform on population parameters instead of only discriminate species presence or absence. This information can suggest the use of disturbance parameters when specific SDMs aim to support strategic decisions in management and conservation.

1. Introduction

It is frequently assumed, but rarely tested, that models of environmental suitability ('Species Distribution Models', hereafter SDMs) may provide useful indices of environmental quality or other species-specific information, either from an ecological or conservation perspective (Bean et al., 2014). In general, SDMs correlate species occurrence with environmental data (e.g., topography, soil, climate) in order to predict the probability of presence on a map and thus to inform about potential species' spatial occurrence (e.g. Sousa-Silva et al., 2014; Koch et al., 2017), guide field surveys (e.g. Pearson et al., 2007; Fois et al., 2015), predict impacts of climate and habitat changes (e.g. Fois et al., 2016; López-Tirado and Hidalgo, 2016; Bosso et al., 2017), species invasions (Pěknicová and Berchová-Bímová, 2016; Bosso et al., 2016; Dullinger

* Corresponding author at: Centro Conservazione Biodiversità, Dipartimento di Scienze della Vita e dell'Ambiente, Università degli Studi di Cagliari, Viale S. Ignazio da Laconi, 13, Cagliari 09123, Italy.

E-mail addresses: mfois@unica.it (M. Fois), albacuena@gmail.com (A. Cuena-Lombraña), gfenu@unica.it (G. Fenu), d.cogoni@unica.it (D. Cogoni), bacchet@unica.it (G. Bacchetta).

https://doi.org/10.1016/j.ecolind.2017.12.009
Received 6 June 2017; Received in revised form 21 November 2017; Accepted 3 December 2017

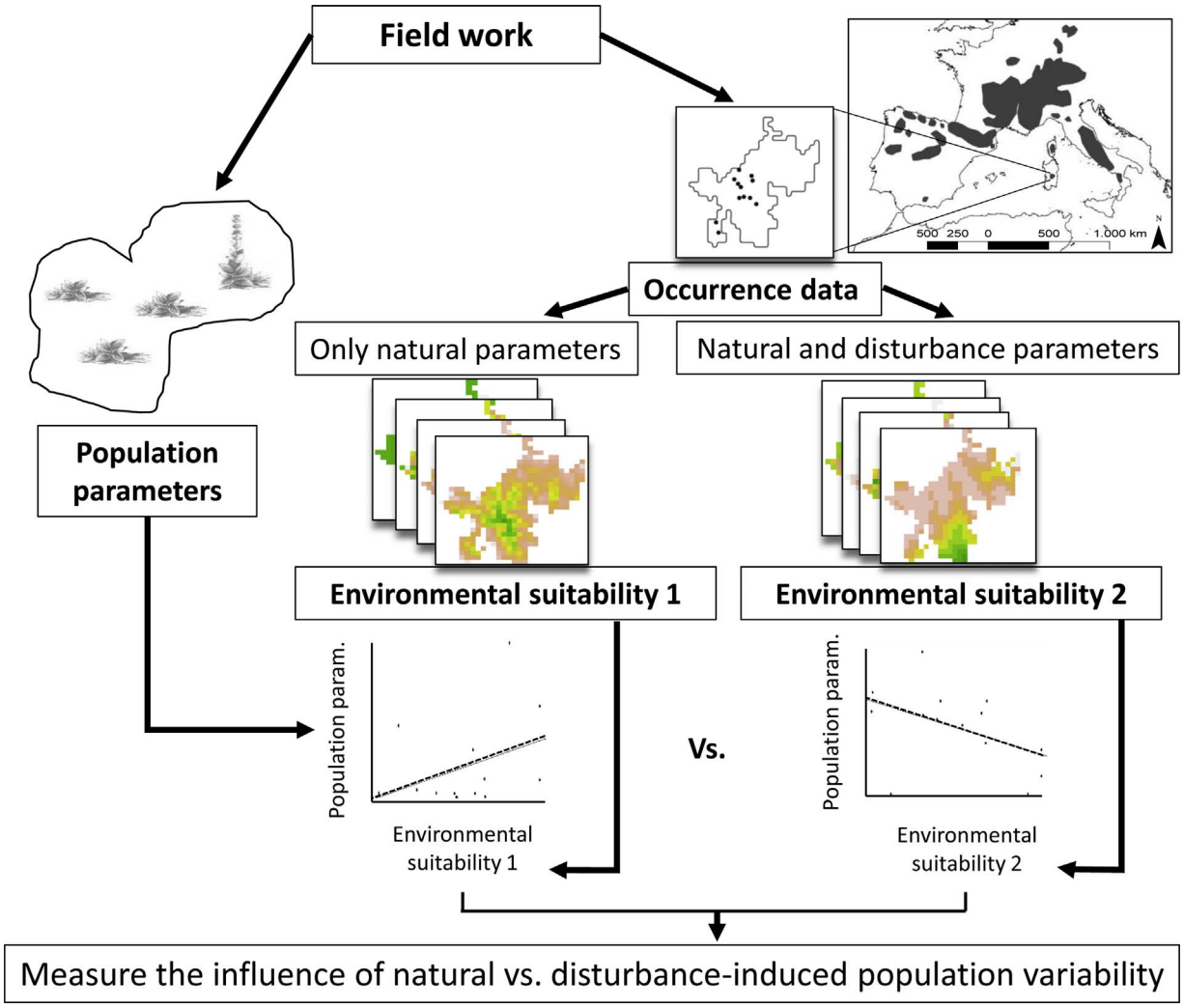

Fig. 1. Flow chart of the proposed methods. In a first step, occurrence data and population parameters were recorded in the field. Occurrence data were used to model (with or without disturbance parameters) the environmental suitability. Population parameters were then correlated with model suitabilities in order to evaluate the influence of disturbance parameters, which were stepwisely added to models. Included are also maps showing the European distribution of *G. lutea* susp. *lutea* (image modified from Rossi et al., 2015) and the locations of sampled populations in Sardinia.

et al., 2017) and support strategic decisions in management and conservation (e.g. Unglaub et al., 2015; Fois et al., 2016; Smeraldo et al., 2017).

For practical applications, the numerical outputs of statistical SDMs have often been simplified to indices of environmental suitability, ranging from 0 (unsuitable) to 1 (optimal). Otherwise, if the output of SDMs represents a relationship between a species and its environment, it would be possible that SDM results were related not only to the probability of occurrence, but also to other key parameters of populations. Being based on environmental characteristics, such indices of suitability can easily and interestingly be compared with measures in the field. For instance, some authors demonstrated that environmental suitability, obtained through presence-only SDMs, can also be associated to demographic and population parameters such as abundance (e.g. VanDerWal et al., 2009; Bean et al., 2014), reproductive success (e.g. Brambilla and Ficetola, 2012; Swab et al., 2015) and apparent survival (e.g. Weber and Grelle, 2012; Bean et al., 2014). Otherwise, because several studies did not find the expected link between environmental suitability and species demography, such tests should be more in deep evaluated (Thuiller et al., 2010; Unglaub et al., 2015; Weber et al., 2017). Indeed, several ecological processes can lead to deviations from this relationship between demographic parameters and the environmental suitability (Pulliam, 2000; Thuiller et al., 2014). Competitive interactions could, for example, exclude a weak competitor from its optimal environmental conditions, while it might persist in more extreme environments that the dominant competitors cannot occupy (Pulliam, 2000; McGill, 2012).

In the Mediterranean Basin, where this study is focused, plant diversity particularly shares its heritage with several human activities that have had profound, often negative consequences for plant species distribution, abundance and dynamic (Lavergne et al., 2005; Fois et al., 2017). In particular, climatic anomalies (e.g. Malcolm et al., 2006; López-Tirado and Hidalgo, 2016) and human related factors, such as land use change, overgrazing and overharvesting, have been identified as main threats leading to extinction or population decreases in narrowly distributed plant species (Lavergne et al., 2005; Fenu et al., 2017).

According to previous authors (e.g., Tôrres et al., 2012; Weber and Grelle, 2012; Weber et al., 2017), a relationship between population parameters and outputs of SDMs is common; also, it was proved that such relationship could increase if key limiting parameters (i.e. proxies of disturbances) were added to natural environmental variables (Weber et al., 2017). Nonetheless, it is still unclear which method and predictors will provide better population parameters predictions (Thuiller et al., 2010; Weber et al., 2017). Accordingly, we contributed to the validation of simple and easily applicable SDMs as a predictive tool for