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Characteristics of the top-cited papers in species distribution predictive models

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ABSTRACT

In this study, we analyzed the characteristics of the most cited papers regarding species distribution predictive models (SDPMs). We found 173 papers on SDPMs that received at least 100 citations until 2013, according to the Thomson Reuters Web of Science database. These papers were published between 1991 and 2012, with the majority published between 2002 and 2012, indicating the rapid development of this field of research. The papers were published mainly in journals listed in the ecology category on the Web of Science. Almost half of the top-cited papers were methodological, introducing novel modeling methods and software. Applied papers on species conservation and biodiversity management, climate change, phylogeography, and biosecurity also figured out among the top-cited papers. Researchers from 174 institutions in 27 countries, with 51% of the papers being internationally collaborative and 69% inter-institutionally collaborative, published the papers. Among all 173 papers, seven papers stood out as having a great impact on the field, receiving more than 1000 citations each. Finally, the results found by analyzing the top-cited SDPMs papers support the view of a growing interest and rapid development of this research field over the past two decades. The top-cited papers primarily focused on the development and evaluation of novel methods to improve the performance of the models, and thus, to better predict the environmental suitability for species in applied studies.

1. Introduction

Species distribution predictive models (henceforth SDPMs), also known as "bioclimatic envelope models", "ecological niche models", "habitat suitability models", or "species distribution models", have become important tools for predicting environmental suitability for species in space and time (Araújo and Peterson, 2012). SDPMs have been widely applied in many areas of interest, such as biodiversity discovery, species invasions, climate change effects on species distribution, and conservation planning (see Peterson et al., 2011 for a recent list of other applications). The increase in the use of SDPMs has been accompanied by the availability of several biodiversity and environmental databases (e.g. Global Biodiversity Information Facility: http://www.gbif.org/; WorldClim: http://www.worldclim.org/) and methods for modeling (see Peterson et al., 2011; Rangel and Loyola, 2012 for reviews). However, alongside the growth in the use of SDPMs, a series of studies has been published regarding the sources of uncertainty embedded in such models (Rocchini et al., 2011; Moudrý and Símová, 2012). Moreover, a recent synthesis by Araújo and Peterson (2012) discussed the misuses of the models and the lack of a clear conceptual framework.

Given the increase in the number of published papers on SDPMs over the past two decades (Lobo et al., 2010; Guisan et al., 2013), some bibliometric studies evaluated the main trends and gaps in the use of these models concerning specific areas of interest. For instance, Cayuela et al. (2009) analyzed the use of SDPMs in tropical regions as a tool for conservation planning, while Barbosa et al. (2012) investigated the main trends related to studies on SDPMs to predict the distribution of invasive species. These studies confirmed a widespread interest in SDPMs, a current topic with a great influence on ecology and biological conservation (Lobo et al., 2010). However, to our knowledge, no bibliometric study citation-based has been done in the field of SDPMs.

Citation analysis is the field of bibliometrics that investigates the citation relationships between authors or their studies (Garfield, 1979) and there are different indicators of citation indexes

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(see Tousoulis and Stefanadis, 2014 for review). For instance, the number of citations (i.e. citation counts) received by a paper is not an indicator to measure its quality (MacRoberts and MacRoberts, 1996), but an indicator to measure its recognition within the scientific community (Tousoulis and Stefanadis, 2014). According Paladugu et al. (2002) the recognition that one paper gives to another is a reference and the recognition that one paper receives from another is a citation.

Recently, bibliometric studies citation-based have been carried to identify and analyze the papers with greater recognition (i.e. most cited papers) in some fields, such as engineering (Ho, 2012), environmental science (Khan and Ho, 2012; Ma et al., 2013), and medicine (Tao et al., 2012). We conducted a bibliometric study citation-based in the field SDPMs. Our main questions were: (i) which are most cited papers in the field of SDPMs? and (ii) which characteristics are associated with citation counts in the field of SDPMs?

2. Materials and methods

We used the Thomson Reuters Web of Science database (www.webofknowledge.com) to search for the most cited papers focusing on SDPMs. We searched the papers using the following combination of words: "bioclimatic envelope model*" or "bioclimatic model*" or "bioclimatic envelope" or "bioclimate envelope model*" or "ecological niche model*" or "niche-based model*" or "niche model*" or "geographic distributions of species" or "species spatial distributions" or "spatial prediction" or "habitat suitability model*" or "habitat model*" or "species distribution model*" or "model* distribution" or "model* distribution species" or "species distribution*" or "species distribution predictive model*" or "distribution predictive model*". We collected the data in April 2014.

We used the term "TC2013" to denote the total citations received by a paper since its publication up through the end of 2013, and "C2013" to denote the total citations received by a paper in 2013 (Chuang et al., 2011). We used TC2013 ≥ 100 as a filter to extract the most cited SDPMs papers (Ho, 2012; Khan and Ho, 2012). We then analyzed each paper according to (i) year of publication, (ii) journal of publication, (iii) Web of Science category of the journal, (iv) aim of the study (applied, methodological or theoretical), (v) research fields (only for applied studies), (vi) country and regions of the authors, (vi) research institutions, and (viii) citation life cycle. We obtained the journal impact factors (IF) from the 2013 Journal Citation Reports (JCR).

We grouped the research conducted in England, Scotland, and Wales under the United Kingdom (UK) heading. Collaboration type was determined by the addresses of the authors and each signatory on the papers was treated equally (Liu et al., 2011). We classified the papers into two types of collaboration based on authors' countries: "single country paper" if the addresses of the authors were from the same country and "internationally collaborative paper" if the papers were coauthored by researchers from different countries. Similarly, collaboration among institutions was also classified into two types: "single research institution paper" if the addresses of the researchers were from the same research institution, and "inter-institutionally collaborative paper" if the authors were from different institutions (Liu et al., 2011). In the literature, various thresholds are used to analyze the citation life cycle (e.g. Khan and Ho, 2012; Ma et al., 2013) thus, we chose the threshold of 1000 citations (i.e. papers with TC2013 ≥ 1000).

We used a regression tree to analyze whether distinct time periods could be identified in relation to the number of top-cited papers published over time. In this method, the predictor variable (i.e. year of publication) is partitioned in segments that are composed of similar values of the response variable (i.e. number of papers) (De'ath and Fabricius, 2000). We performed the regression tree using the package *rpart* (Therneau et al., 2014) in the R environment (R Core Team, 2014).

3. Results

We found 173 papers regarding SDPMs that received at least 100 citations (TC2013 ≥ 100). The first papers with TC2013 ≥ 100 were published in 1991, while the last one was published in 2012. As shown by the regression tree analysis, these papers can be partitioned into two periods according to the year of publication: before and after 2001.5. The period between 1991 and 2001 was characterized by a low number of top-cited papers, with a mean of 2.6 papers per year. Most of the top-cited papers were published during the second period, between 2002 and 2012, with a mean of 13.1 papers per year (Fig. 1).

The papers were published in 47 journals, with 31 of them listed in the ecology category in Web of Science. Half of the journals (24) contained only one paper. The eleven journals that published at least five papers accounted for 67% of the top-cited papers in the area of SDPMs. The journal *Ecological Modelling* was ranked first with 23 papers, followed by *Ecography* and *Journal of Applied Ecology*, with 15 papers each (Table 1). *Ecological Modelling* had the lowest impact factor among the 11 most-productive journals, while *Ecology Letters* had the highest impact factor among the most-productive journals (Table 1). *Nature* and *Science*, which had the two highest impact factors among all the 47 journals (IF = 42.351 and 31.477, respectively), published three top-cited papers each.

Almost half of the top-cited papers are methodological (83 papers or 48%), while applied papers represented 32% of the total, and theoretical studies represented 20%. Among the applied SDPMs papers species conservation and biodiversity management studies were the most cited, with 20 papers each, followed by papers on climate change (19 papers), phylogeography (10 papers), and biosecurity (invasive species, four papers, and diseases, two papers).

The 173 papers were published by researchers from 174 institutions in 27 countries (Fig. 2). Researchers from the United States of America (USA) contributed to almost half of all top-cited papers (85 papers), making the USA the most-productive country. Regionally, researchers from either North America

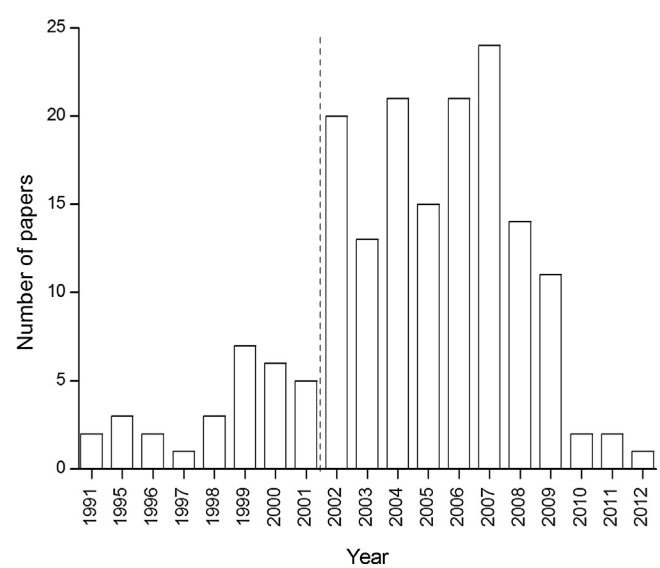

Fig. 1. Distribution of the top-cited papers (total citations ≥ 100) on species distribution predictive models according to year of publication. The dashed line indicates the year (2001.5) in which the dataset is partitioned in two segments, according to the regression tree analysis.