Ecological Indicators 96 (2019) 59–68

Contents lists available at ScienceDirect

Ecological Indicators

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

# Combining social media photographs and species distribution models to map cultural ecosystem services: The case of a Natural Park in Portugal

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ARTICLE INFO

*Keywords:*
Cultural ecosystem services
Social media photos
Photoseries analysis
Maxent
Spatial distribution

ABSTRACT

Developing spatially explicit models of Ecosystem Services (ES) distribution and diversity across the territory has been increasingly attracting the interest of researchers and policy-makers due to its potential to operacionalize and mainstream the ES concept into existing planning and policy tools.

In this paper we explore the use of social media photographs to model the spatial distribution of people preferences for cultural ecosystem services (CES), map their hotspots, identify the determinant variables as well as the spatial correlation between CES. This research was applied in the Sudoeste Alentejano and Costa Vicentina Natural Park (PNSACV) located in Southwestern Alentejo, Portugal.

A collection of 1378 geo-tagged digital images taken inside the Park and posted in the Flickr web platform between 2004 and 2015 were analyzed and classified according to a tailored list of CES. To model CES spatial distribution it was used a species distribution model – Maxent – adapted to combine the observation of CES occurrence with biophysical and infrastructural variables.

This method allowed us to identify and map the social preferences for CES in this area. The distance to the ocean and distance to touristic and cultural infrastructure were the most determinant variables to explain CES distribution in PNSACV. Another relevant result of this study was the identification of pairs of CES (such as Recreation & Aesthetics services) with a significant spatial overlap.

Using social media data can be an expedite and cost-effective way to identify and map CES, although this approach embodies some challenges and biases that need to be considered. The use of species distribution models, such as Maxent, can be particularly valuable to support the design of future scenarios and assist decision-making on land use planning.

## 1. Introduction

The concept of Ecosystem Services (ES), understood as "the benefits people obtain from ecosystems" (Millennium Ecosystem Assessment, 2005), has been increasingly attracting the interest of scientific literature and policy-making (García-Nieto et al., 2013; Palomo et al., 2013). The concept of ES may potentially respond to the demand for a more integrated approach to ecosystems management and for a balance between human needs and nature conservation, as it stands in the interaction of ecological and social spheres. However, the implementation of the ES concept faces problems due to data deficiencies (Burkhard et al., 2009; Dick et al., 2014) and lack of appropriate methodologies.

The development of spatial models to measure and value the distribution and diversity of ES across the territory is becoming a more common approach, showing great potential as a support tool for landscape management and environmental decision-making (Burkhard et al., 2012; Martínez-Harms and Balvanera, 2012; García-Nieto et al., 2013; Palomo et al., 2013). ES mapping has been able to provide spatial identification of ES hotspots, spatial trade-offs and synergies between ES (Martínez-Harms and Balvanera, 2012). To mainstream these assessments it is necessary to find cost-effective techniques for mapping and analysing the spatial distribution of ES (Anderson et al., 2009; Egoh et al., 2009). Such efforts typically focus on provisioning and regulating services, with fewer options available for assessing Cultural Ecosystem

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https://doi.org/10.1016/j.ecolind.2018.08.043
Received 21 October 2017; Received in revised form 15 August 2018; Accepted 17 August 2018

Services (CES) (Crossman et al., 2013).

CES are recognized as a main pillar in existing conceptual frameworks for ES classification. Definitions and classifications vary across different frameworks. In the Common International Classification of Ecosystem Services (CICES), CES are defined as non-material ecosystem outputs that have symbolic, cultural or intellectual significance (Haines-Young and Potschin, 2012). They include both the direct benefits people obtain from ecosystems, such as recreation or aesthetic experience, as well as other benefits resulting from the interaction of natural and human/cultural capital, such as cultural heritage (Hernández-Morcillo et al., 2013). More recently the understanding of CES has evolved in a way that explicitly acknowledges the importance of the relationships between people and places, landscapes and species, and recognises CES as a co-produced and co-created outcome of people's interaction with ecosystems (Fish et al., 2016; Chan et al., 2011).

Assessing all types of CES is particularly challenging due to their intangible and subjective nature (Daniel et al., 2012; Kirchhoff, 2012). Several authors have tested different methods, most of them based on monetary valuation and socio-cultural preferences assessments through interviews (Klain et al., 2014), face-to-face surveys (Iniesta-Arandia et al., 2014; Oteros-Rozas et al., 2014), participatory mapping (Plieninger et al., 2013) and focus groups (Norton et al., 2012). Most of these studies have been performed at local scale; therefore, the spatial distribution patterns of CES at wider spatial scales (e.g. regional) remain understudied.

New methodological approaches are needed to assess the social importance of CES beyond monetary metrics. A trending approach, following the exponential development of social networks, is to use crowd sourced geospatial data, namely photographs (Richards and Friess, 2015). The volume and spatial distribution of geo-tagged photographs uploaded to online social media global platforms, like Instagram, Panoramio or Flickr, can provide a fertile source of data for new mapping methodologies (Cao and O'Halloran, 2014; Hollenstein and Purves, 2010; Li et al., 2013; Sun et al., 2013). The main advantages of using geo-tagged photographs as a proxy for people's preferences are i) using observed preferences (Hollenstein and Purves, 2010) and ii) having precise information on the real provision of the service provided by the exact location where the photos were taken (Bagstad et al., 2014).

The analysis of photoseries from social platforms has already been shown to be a suitable proxy to assess and map CES in diverse contexts (Martínez Pastur et al., 2016; Keeler et al., 2015; Willemen et al., 2015). Tenerelli et al (2016) designed and implemented a protocol for photoseries analysis of CES, which was used in this research to retrieve, organize and classify the photos. Beyond the mapping of social preferences for CES it is also important to identify the landscape settings and variables that explain CES distribution as well as the correlation between CES in the same area (Tenerelli et al., 2016; Oteros-Rozas et al., 2016; van Zanten et al., 2016). For that purpose, it is necessary to use complex methodological approaches. A maximum entropy (Maxent) technique commonly used to model species distributions using presence-only data (Elith et al., 2011) will be used to model each type of CES. Species distribution models are numerical tools that combine observations of species occurrence or abundance with environmental estimates. In the scope of CES assessments, Maxent is used combining the observation of CES occurrence (photographs) with biophysical and infrastructural variables. An application – SolVES (Sherrouse et al., 2011) which now integrates Maxent, has already been developed (https://solves.cr.usgs.gov/) to quantify the perceived social values of ES based on responses to public preference surveys.

The aim of this article is to explore the use of social media photographs to model the spatial distribution of people preferences for cultural ecosystem services in a coastal region, using as study area the Southwestern Alentejo coast, Portugal. This research intends to map, at the regional scale, a wide range of CES, namely cultural heritage and spiritual services, that are commonly absent in CES mapping research. The ultimate goal of this research is to promote the integration of CES into decision making and regional planning by identifying their hotspots, the determinant variables as well as the spatial correlation between CES.

In the following sections we first present the methodological design, followed by a description of the case study area, data collection strategy and identification of explanatory variables. The adopted model is briefly described before presenting the results of this research. The final sections include a critical discussion of the results and a reflexion on the suitability of these methods to identify and map social preferences of CES, and some concluding remarks.

## 2. Methods

This research uses social media photos instead of species occurrences in a framework of species distribution modelling for understanding the spatial distribution of people preferences for CES. To combine the observation of CES occurrence (spatially referenced and validated photographs) with biophysical and infrastructural layers (variables), this methodology followed a three-step process: (1) database preparation and variable selection, (2) modeling, and (3) interpretation and discussion of the model results.

At first, a spatially geo-referenced database of social media photographs was created, validated and classified according to a list of CES, tailored for the research area. The second step was to investigate and model the spatial distribution of each CES, using Maxent. This model worked with a set of socio-biophysical factors, together with a set of sample locations where CES photographs had been observed. The model outputs, such as CES maps, provided the material for the analysis of spatial CES provision in the research area, including spatial correlations among CES and relationships between environmental/infrastructural factors and cultural use.

### 2.1. Research area

Located in the Southwestern corner of Portugal, the Sudoeste Alentejano and Costa Vicentina Natural Park (PNSACV) covers a coastal strip composed of 60567 ha of land and 28858 ha of marine waters (see Fig. 1). This coastline with elevated cliffs, deep ravines, small beaches, temporary watercourses, estuaries and marshes, hosts a large diversity of habitats. This protected area, created in 1995, represents one of the few remaining well-preserved coastlines in Western Europe. This area faces several pressures, such as the spread of invasive species (e.g. acacia and hottentot-fig) and growing polluting activities, namely large areas of irrigated agriculture located within the Natural Park and some industries in its vicinity, contributing to the degradation of some habitats.

In a region with low population density, but with strong traditions and cultural identity namely linked to fisheries, recreational tourism has been a key driver for human pressure in some parts of the park. During high seasons (summer and hiking seasons) the number of visitors is massive, overcoming the number of local inhabitants. The restrictions imposed by the Park regulations and the advent of the economic crisis; seem to be slowing down the development of massive tourism infrastructure towards the promotion of an "all season" nature-based model. To enforce and develop this strategy, both regional/local authorities and companies are interested in learning about visitors' preferences to increase the diversity of touristic attractions by promoting other natural and cultural values beyond recreation.

### 2.2. Database retrieval and interpretation

The key elements for this research are social media geo-tagged photographs. These free-access resources provide a large amount of spatially explicit information that allows inferring visitors' preferences for cultural values through content analysis. For the process of