Contents lists available at ScienceDirect

Ecological Indicators

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

A rapid indicator of cultural ecosystem service usage at a fine spatial scale: Content analysis of social media photographs

Daniel R. Richards *, Daniel A. Friess

Department of Geography, National University of Singapore, 1 Arts Link, Singapore 117570

ABSTRACT

Cultural ecosystem services (CES) are an important benefit that habitats provide, particularly in the fragments of natural ecosystems that remain in urban areas. To manage CES we need to understand what people use habitats for, and where different activities take place. It is challenging to assess CES provision, as surveys and interviews are time consuming and can be expensive. Social media data, particularly geo-tagged photographs, are spatially explicit and contain visual information that can be used to infer cultural use. Indicators of CES derived from social media make use of existing data so may contribute useful information for rapid, cost-effective assessments of CES. In this study we develop an indicator of CES usage that is derived from photographs from an image-sharing website, at two different scales. First, we compare four small (<150 ha) urban mangrove sites in Singapore, using photograph content to classify sites according to predominant cultural use. Second, the spatial distribution of different CES was modelled within one site using MaxEnt. A resampling simulation was conducted to identify the sensitivity of the photograph classification to the number of photographs classified. Photographs of social recreation, organisms and landscapes occurred most commonly. The proportional occurrence of photograph types differed between sites depending on their characteristics. Within one site, the probability of occurrence of social recreation photographs was highest around built focal points, while photographs of organisms were more likely in the mangrove and terrestrial habitats. Classifying more than 50–70 photographs (which would take approximately 30 minutes) gave only small increases in categorisation accuracy. This tool for CES assessment rapidly provided information that would be useful for managing Singapore's mangroves. The approach could be widely applied to assess CES provision across a range of habitats and settings, helping CES to become more commonly considered in ecosystem service evaluations.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

The concept of ecosystem services – the benefits that people gain from nature (MA, 2005) – has been proposed as a framework for managing and conserving habitats. An ecosystem can provide a range of provisioning, regulating, supporting and cultural services, and the subset of services that are provided is affected by the way that people manage the environment. There are commonly trade-offs between the provision of different ecosystem services, so decisions must be made about how to balance their provision (Bennett et al., 2009), an understanding of which will help managers make more informed decisions (Fish, 2011). For ecosystem service frameworks to become widely used in environmental decision making, it must be straightforward and cost-effective to analyse service provision, especially at the local scales (e.g. within

a nature reserve) at which many decisions are made (Peh et al., 2013). Multiple methodological and modelling frameworks have now been developed to assist with ecosystem service assessment [e.g. ARIES (Villa et al., 2009), InVEST (Guerry et al., 2012), TESSA (Peh et al., 2013), and the benefit transfer approach applied by Burkhard et al. (2009)]. Such frameworks typically focus on provisioning and regulating services, with fewer options available for assessing cultural ecosystem services (CES) (Crossman et al., 2013).

CES are a broad subset of services that are nonmaterial, such as the existence value of a species, or the opportunities for wildlife recreation, social recreation in public spaces, or education that habitats can provide (Hernández-Morcillo et al., 2013). When assessing CES usage there is a trade-off between the level of detail (both spatial and in terms of differentiating between CES) that an assessment can provide, and the amount of time required to make the assessment. Traditional sociological approaches such as surveys (Pleasant et al., 2014), interviews (Plieninger et al., 2013) and focus groups (Norton et al., 2012) can provide detailed information on relative CES usage, but are time consuming to carry out and

* Corresponding author. Tel.: +65 65163851.
E-mail address: d.r.richards@nus.edu.sg (D.R. Richards).

Table 1
Summary information describing the four study mangroves in Singapore.

Site	Protection status	Approximate mangrove area (ha)	Accessibility	Key amenities
Berlayer Creek	Nature Reserve[a]	3	Public access, free, good transport link	Playground and fitness, historical sites, mangrove and ocean boardwalks
Chek Jawa	Nature area[b], previously threatened by reclamation	2	Public access, free, longer journey from mainland followed by hike, bicycle, or bus	Mangrove and ocean boardwalks, viewing tower, adjacent coastal forest, seagrass
Sungei Buloh Wetland Reserve (SBWR)	Nature Reserve[a] – designated for birdlife	133	Public access, free, longer journey from main urban areas	Nature trail and wildlife information, viewing points, bird hides, mangrove boardwalk
Mandai	State land – no legal protection	3	No public access	None

[a] Highest legal conservation protection status in Singapore.
[b] Managed by the governmental National Parks organisation. Unclear legal protection.

rarely provide spatially explicit information (Hernández-Morcillo et al., 2013). More recent indices derived from geographic data have been proposed for mapping CES rapidly and with high spatial accuracy over wide geographic areas. For example, the volume and spatial distribution of geo-tagged photographs that have been uploaded to social media may indicate recreational value (Wood et al., 2013) and, by extension, aesthetic quality (Casalegno et al., 2013; Nahuelhual et al., 2013). This approach has now been implemented in InVEST, a popular modelling and mapping framework for ecosystem services assessment (InVEST, 2014).

Existing social media indices of visitor pressure as quantified by photograph density can be used for broad-scale analyses of CES provision, as they indicate popular areas for visitors. However, photograph density does not help us to assess the cultural role of a site, or the reasons why it may be appreciated by society. To add this important detail for site management, we must understand the activities that people are engaged in when they take photographs, and which features of the environment attract their attention. Content analysis of social media photographs could allow indicators of individual CES to be identified, and their spatial patterns to be mapped. Content coding (classification) of photographs taken in the field by survey subjects has previously been used to identify factors that impact recreational enjoyment (e.g. Dorwart et al., 2010). However, such a classification has not been applied to online datasets of existing geo-tagged photographs.

The aim of this study is to present a methodological framework for assessing different CES uses through the content analysis of photographs, using the freely accessible photo-sharing website Flickr. We analyse photograph content at two spatial scales (between sites and within-site) to compare an indicator of CES provision in the context of coastal mangrove forest habitat patches that remain in Singapore. The specific objectives of this study were to: (1) compare CES provision between four mangrove sites in Singapore, by downloading and classifying images hosted on Flickr; (2) analyse spatial variation in cultural usage within one mangrove site, by modelling the distribution of different types of photographs in relation to habitat characteristics and; (3) assess the time required to implement this method, by analysing the sensitivity of the photograph classification to the number of photographs classified.

2. Materials and methods

2.1. Case study system: mangroves in Singapore

Singapore is a suitable location to analyse social media photographs due to a high population density of ~7600 people per km² (Singapore Department of Statistics 2013), and high rate of mobile phone usage. In 2012 there were around 1.5 phones per person (Singapore Department of Statistics 2013; IDA, 2014), many of which are smartphones that are capable of capturing and uploading geo-tagged photographs. Singapore is also a useful location to understand the importance of CES in mangrove conservation and management, as the city-state has undergone rapid urbanisation in recent decades, with a concomitant areal decline in key habitats such as mangrove forests (Yee et al., 2010). Current patches of mangrove habitat in Singapore are small and fragmented, and variable in terms of their public accessibility and their amenities (Table 1).

We analysed CES provision at four mangroves in Singapore; two nature reserves, one natural area, and one undeveloped area of state land (Table 1). Three of the sites are located on Singapore's mainland, with a further site on the offshore island of Pulau Ubin (Fig. 1b). The area of mangrove at each site is relatively small, and because mangrove habitat is not found independently, adjacent habitats such as mudflat, seagrass, coastal forest and open ocean were also assessed. All but one of the mangrove sites are publicly accessible (Table 1), but there is variation in the travel time from the main urban areas (Table 1). One site, Mandai, is not accessible to the general public but is utilised extensively for academic research purposes (Friess et al., 2012). There is variation in the amenities that are available at, or adjacent to, the sites (Table 1). Berlayer Creek is set within a recreational park environment, while Sungei Buloh Wetland Reserve (SBWR) and Chek Jawa have more educational content (Table 1).

2.2. Assessment workflow

This study presents a methodological framework for differentiating between CES uses at a fine spatial scale, using social media data. The resulting index of CES use may be used within a larger CES assessment to assist habitat management. Under this framework, photographs must first be accessed from Flickr using a geographic search. Second, the content of the photographs must be classified using an objective coding approach that distinguishes between different types of CES usage by the public. The proportions of different types of photographs can then be compared between sites. Finally, the detailed geospatial data attached to each image can be used within a distribution modelling tool such as MaxEnt to investigate the relationships between environmental factors and cultural usage, and map indices of spatial variation in different cultural uses across a single mangrove site.