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Research paper

Culturomic assessment of Brazilian protected areas: Exploring a novel index of protected area visibility

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ABSTRACT

In a time when protected areas are under increasing societal and political pressure, ensuring their public visibility and support will be essential to guarantee their long-term maintenance. The high levels of societal participation and global reach of emerging digital technologies provide exciting new opportunities to assess the public salience of environmental and conservation related subjects, including protected areas. Here, we test the relationship between measures of public interest and internet saliency of protected areas and evaluate how the characteristics of different protected areas relate to their cultural visibility. We show there is a strong relationship between public interest in protected areas (as measured by Google Trends) and their visibility on the internet. Our results also indicate that governance sphere and protected area category are the most important factors driving internet salience, with national parks being the most visible to the public. Other important factors include the age of a protected area, its geographical extent, human population density in surrounding areas and proximity to touristic centres. Finally, our results suggest that downgrading, downsizing and degazettement (PADDD) events have targeted protected areas independently of their public visibility but they were more likely to be enacted in those protected areas with lower levels of public interest. While further studies are needed to evaluate the relationship between internet content and public sentiment towards different protected areas, our results suggest that internet saliency can be considered as a broad proxy of public awareness and engagement with protected areas.

1. Introduction

The Convention on Biological Diversity (CBD) set goals for the percentage of territory that nations should place under protection to conserve iconic landscapes, wildlife, natural resources and/or traditional ways of living. This target has grown from 10% of the world's terrestrial ecological regions in the 2000–2010 CBD strategic plan to 17% in the 2020 Aichi Biodiversity Targets (CBD, 2010). As of 2016, global protected area (PA) coverage stood at approximately 14.7% of terrestrial land and inland waters although this varies widely between major terrestrial biomes and depending on the type of PA considered (UNEP-WCMC and IUCN, 2016). However, these PA gains are coming under increasing pressure from population growth, land competition (e.g. agriculture and mining) and infrastructure (Geldmann et al., 2014). For government agencies, PAs may represent an opportunity cost constraining their ability to raise tax revenue, invest in public infrastructure and exploit natural resources to stimulate jobs and economy (Watson et al., 2014). At the same time, resources for PA management are declining as governments with struggling economies need to prioritise public funds towards core sectors such health and education. This is leading to growing incidences of Protected Area Downgrading, Downsizing and Degazettment (PADDD) across the world (Mascia and Pailler, 2011; Symes et al., 2016).

Under this scenario, if the PA gains of conservation policy are going to be assured into the future they will need broad-based societal support (Mascia and Pailler, 2011; McNeely, 2015). Part of the role of politicians and policy makers is to balance trade-offs between economic, social and environmental interests and their decisions will be informed by a mixture of technical advice and the democratic voice of their citizens expressed through elections, lobbying, opinion polls, and public debate. Hence, the level of societal interest in protected areas is likely to reflect the degree of public support for PAs as a legitimate land use (Ladle et al., 2016). In other words, public interest and support for PAs influences their ability to persist (maintain their size and status) in the face of unpredictable societal change (Cumming et al., 2015; Maciejewski et al., 2015; Newton, 2011), and therefore represents an

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important component of PA social resilience.

Traditionally, public interest in protected areas could only be measured through periodic social surveys, typically commissioned by special interest groups. However, the rise and global reach of the internet has created the possibility for developing new measures of public interest generated by big data analytics (Kitchin, 2014). Here, we present a novel internet-based metric for assessing public visibility and interest in PAs generated using culturomic techniques (Ladle et al., 2016). Using Brazilian PAs as a case study (we excluded indigenous land designations), we propose that this metric offers a proxy of public interest, and thus support, for aspects of protected area policy. Specifically, we: i) test the proposition that internet visibility can act as a robust proxy for public interest, ii) use multi-model inference to identify the most important correlates of PA internet visibility, and iii) evaluate whether Brazilian PAs with low public visibility are more vulnerable to PADDD decisions.

We chose Brazilian PAs for three main reasons. First, the nation has invested significantly in the expansion of conservation units in its PA system and now features 2029 reserves covering 1,544,833 Km^2 (MMA, 2016). In fact, the area of terrestrial conservation units in Brazil now represents approximately 12% of the global total (reported in Pack et al., 2016). Second, Brazil is subject to the developmental and population pressures outlined above. In particular, the expansion of croplands and pasture, mining and dams is ongoing (Charity et al., 2016; Ferreira et al., 2014) and may lead to an increase in development pressures on PAs. In this context, a number of studies suggest that Brazil is scaling back elements of its PA network through PADDD processes (Bernard et al., 2014; Pack et al., 2016) and that politics threaten environmental policies (Fearnside, 2016). Finally, Brazil has good internet coverage and a large amount of locally generated web content. The country has an estimated 101 million internet users, 23 million fixed broadband connections, and ranks 3rd in terms of the time user spend online. Furthermore, content portals (sites with information) are a historic preference of Brazilians and there are an estimated 525,000 domain names (Geromel, 2013; TechinBrazil, 2014).

2. Material and methods

2.1. The Brazilian protected area system

The first protected areas in Brazil were the Itatiaia (1937), Iguaçu (1939) and Serra dos Orgãos (1939) national parks inspired by the US Yellowstone model (Mittermeier et al., 2005). Subsequently, different PA agendas have gained policy prominence on several occasions. The passing of the 1965 forest code established the category of national forests (Medeiros, 2006) that nowadays constitute and significant component of the PA system, especially in the Amazon. Notable subsequent developments were the i) creation of ecological stations in the 1970s to generate scientific knowledge for environmental management (Nogueira-Neto and de Melo Carvalho, 1979), ii) the Chico Mendes rubber tapper's movement in the mid-1980s which led to creation of extractive reserves (Fearnside, 1989), iii) the 1988 federal constitution that empowered state and municipal government to establish PAs (Prates and Irving, 2015) and iv) the demarcation of indigenous lands and development of the sustainable use reserves in the 1990s (Davis and Wali, 1994; Peres, 2011). Following Brazil's hosting of the 1992 Rio Earth Summit, where the Convention on Biological Diversity was signed, the nation rapidly expanded its PA network. This expansion was guided by the three pillars of the convention: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the use of genetic resources.

In 2000, the National System of Conservation Units (*Sistema Nacional de Unidades de Conservação*, SNUC – Law 9.985/2000) consolidated these policy agendas into 12 PA categories (see Table S1), grouped into either Integral Protection Units or Sustainable Use Units. These groupings reflect two dominant policy worldviews within Brazil on the purpose of protected areas: the first sees biodiversity as an end point in itself, possessing intrinsic value that merits protection (cf. Noss, 1990) and promotes the view that human access needs to be properly regulated. The second worldview emphasises instrumental values and the sustainable use and management of natural landscapes (Prates and Irving, 2015). Furthermore, the establishment of SNUC recognised the category of private protected areas (established by presidential decree in 1998), which nowadays represent almost 1200 PAs (Pegas and Castley, 2016). This led to a large increase in the Brazilian PA estate, which accounted for 74% of the global increase in PA coverage (km^2) between 2003 and 2009, mainly due to the establishment of large PAs in Amazonia (Jenkins and Joppa, 2009).

For this work, we generated a dataset of current and historical (i.e. degazetted) Brazilian protected areas. This database comprised a total of 1023 public terrestrial PA units (i.e. excluding marine and private PAs) and was compiled from three data sources: i) the spatial database of protected areas provided by the Brazilian Ministry of the Environment (see http://mapas.mma.gov.br/i3geo/datadownload.htm, accessed 22/06/2015), ii) the spatial database of protected areas provided by the protected area observatory program of WWF Brazil (see http://observatorio.wwf.org.br/mapa/, accessed 29/03/2016), and; iii) the list of existing and historical Amazon protected areas from Pack et al. (2016).

2.2. Protected area interest – search volume

Public interest in Brazilian PAs was evaluated using freely-available data from the Google Trends platform, which returns the volume of searches for any given term on Google search engine over a defined period. Results are reported on a weekly or monthly temporal scale in terms of relative search volume: the number of searches carried out during a given week or month are shown in relation to the maximum search interest observed over the period of interest. This platform is increasingly being used by conservation and environmental scientists to assess public interest in issues such as biodiversity, climate change and ecosystem services (Lineman et al., 2015; McCallum and Bury, 2013; Proulx et al., 2014; Soriano-Redondo et al., 2017; Szymkowiak and Kuczyński, 2015).

Data were extracted from Google Trends in March 2016 following a two-step process. Firstly, we identified the PA in our database with the largest search volume in Brazil over this period, in order to act as a benchmark term (Nghiem et al., 2016). Once this PA was identified (Iguaçu National Park), we carried out simultaneous searches for the benchmark PA and each of the remaining individual PAs in our database. For each PA, we extracted the average relative search volume between 2010 and 2015. It should be noted that Google Trends was unable to retrieve any relevant search activity for the majority of PAs (961, approximately 94% of total PAs considered) over the study period because Google only records search activity above a certain (undisclosed) threshold.

2.3. Protected area visibility – internet saliency

The frequency at which certain names or concepts are mentioned on the web (internet saliency) provides a metric of public visibility on a given subject. Such metrics have already been successfully applied to studies of public visibility of biodiversity (Correia et al., 2016a; Żmihorski et al., 2013). Here we extend this approach to assess the public visibility of protected area units. However, the measurement of internet saliency requires care because vernacular names often have multiple meanings (Correia et al., 2017; Ladle et al., 2016). For example, Yosemite refers to the US National Park and a 2014 version of Apple's operating system for Macintosh computers. In this study we minimized these biases by the inclusion of additional search terms (Correia et al., 2016a). Specifically, search strings comprised the PA name and its designation in full and standard abbreviated format (e.g.