UNIVERSIDADE FEDERAL DE ALAGOAS
INSTITUTO DE CIÊNCIAS BIOLÓGICAS E DA SAÚDE
Programa de Pós-Graduação em Diversidade Biológica e Conservação nos Trópicos

FELIPE ALEXANDRE SANTOS VIEIRA

O PAPEL DAS ÁREAS PROTEGIDAS NA PROTEÇÃO DOS SERVIÇOS ECOSSISTÊMICOS CULTURAIS DO LITORAL BRASILEIRO

MACEIÓ - ALAGOAS
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RESUMO

As Áreas Protegidas (APs) desempenham um papel fundamental para a conservação da natureza enquanto geram uma cascata de benefícios sociais e econômicos. No Brasil, recentes mudanças no cenário político apontam para uma drástica diminuição nos investimentos para a conservação da natureza, o que deve aumentar ainda mais as constantes propostas parlamentares para *reclassificar*, *diminuir* ou até *extinguir* completamente as APs existentes no país. Uma das formas de garantir a manutenção e o investimento em APs frente as ameaças ambientais é demonstrar os benefícios culturais gerados por estas áreas. Neste estudo, foi utilizada uma ferramenta inovadora para a análise automática e a identificação de Serviços Ecossistêmicos Culturais (SECs) em milhares de fotos capturadas no litoral brasileiro e publicadas em uma rede social. Os SECs identificados nas fotos foram analisados em função de cinco (5) variáveis explicativas: grau de proteção, densidade populacional, distância aos grandes centros urbanos e acessibilidade. Os resultados mostram que as áreas protegidas fornecem, em média, mais SECs por foto e por usuário do que as áreas não protegidas. A análise temporal demonstrou uma maior ocorrência de SECs nos meses de Dezembro e Janeiro e durante os finais de semana. Os modelos estatísticos indicam que locais mais afastados de grandes centros urbanos têm maior probabilidade de fornecer *recreação social*. Apesar de algumas limitações, o método utilizado é adequado para identificar SECs de apreciação estética e recreação em larga escala. Quando aplicado ao contexto local, é esperado que esta análise forneça importantes informações sobre as preferências de usuários de áreas naturais, podendo servir de suporte para as tomadas de decisão.

Palavras-chave: Serviços Ecossistêmicos Culturais. Áreas Protegidas. Automatização.

ABSTRACT

Protected areas (PAs) are a key tool for conserving nature while generating a cascade of social and economic benefits. In Brazil, recent political changes are likely to result in a drastic decrease in investments for nature conservation as indicated by active parliamentary proposals to reclassify, diminish or extinguish the country`s PAs. One way to ensure investment in PAs in the face of such threats is to clearly demonstrate the cultural benefits generated by these areas. To this end we use an innovative machine-learning approach to automatically identify, classify and quantify the cultural ecosystem services (CES) represented in thousands of digital photos taken along the length of the Brazilian coast and uploaded onto a popular file-sharing network. Our results indicate that photos taken inside PAs portray, on average, more CES (per photo and per user) than photos from outside of PAs. Moreover, there was a higher frequency of CES portrayed in photos taken in December and January and during weekends. Distance from large urban centers was most associated with photos portraying social recreation. Despite some limitations, our method appears to be suitable for quantifying and comparing a range of CES (especially aesthetic appreciation and recreation) at large geographic scales. At finer spatial scales, our approach can provide important information about the preferences of users of natural areas, and could therefore serve as a valuable support tool for environmental planning and decision making.

Key-word: Cultural Ecosystem Services, Protected Areas, Machine Learning

SUMÁRIO

1 APRESENTAÇÃO

Serviços Ecossistêmicos Culturais (SECs) são os benefícios não materiais que as pessoas obtêm dos ecossistemas como, por exemplo, recreação, experiências estéticas e espirituais (Millennium Ecosystem Assessment 2005). Globalmente, estes benefícios são reconhecidos como fundamentais para a manutenção do bem-estar humano (De Groot et al. 2005; Millenium Ecosystem Assessment 2005; Russell et al. 2013).

Apesar da sua importância, SECs recebem pouca atenção científica em relação a outros serviços ecossistêmicos (Daniel et al. 2012) e raramente são considerados em tomadas de decisão (Satz et al. 2013). Isto acontece porque estes serviços são complexos e dinâmicos, dependentes de valores individuais contexto-específicos e que podem variar ao longo do tempo (Beery and Wolf-Watz 2014; Chan et al. 2016; Hirons et al. 2016). No cenário ideal, as decisões para a gestão da natureza (p.ex. gestão de áreas protegidas) devem ser construídas com base nos valores culturais de comunidades locais e demais grupos de usuários (Stoll-kleemann 2001; Andrade and Rhodes 2012). A inclusão de valores culturais em tomadas de decisão têm o potencial de aumentar o apoio social para a conservação da natureza e muitas vezes garantem a proteção de direitos das pessoas mais vulneráveis e sem representação (Satz et al. 2013).

Nas últimas décadas, o Brasil investiu enormemente na criação de dezenas de Áreas Protegidas (APs) (Mittermeier et al. 2005; Loyola 2014), no entanto, recentes cortes nos investimentos em pesquisa e educação e a constante elaboração de propostas parlamentares para a *reclassificação*, *redução* e *extinção* de APs têm minado os avanços ambientais e sociais ocorridos no Brasil (Bernard et al. 2014), como a demarcação de terras indígenas e o estabelecimento de Áreas Protegidas. Neste cenário de instabilidade nas políticas ambientais (Fearnside 2016), a identificação dos diversos benefícios gerados pelas APs (p.ex. SECs) e sua inclusão na gestão destas áreas se faz oportuna, uma vez que podem aumentar a resiliência e a resistência social sobre estas áreas e torna-las menos vulneráveis (Prober et al. 2011; Jepson et al. 2017).

As zonas costeiras são, reconhecidamente, *hotspots* de SECs (REF). A costa do Brasil abriga uma grande heterogeneidade de atributos biofísicos e culturais que têm uma enorme importância recreacional, estética e cultural para toda a sociedade. No entanto, pouca informação existe sobre SECs costeiros e marinhos do Brasil e do mundo (Martin et al. 2016).

Com o aumento do uso de *smartphones*, o grande número de publicações em redes sociais tem sido analisado para entender as complexas relações entre as sociedades humanas e a natureza (Ladle et al. 2016), com potencial para informar os gestores sobre as preferências dos usuários de áreas naturais (Di Minin et al. 2015; Becken et al. 2017; Hausmann et al. 2017; Vieira et al. 2018). A análise destes grandes bancos de dados surge como um complemento aos métodos tradicionais (p.ex. questionários presenciais), geralmente, dependem de investimentos em trabalhos de campo e não são adequados para avaliações em larga escala.

Neste trabalho, realizou-se uma análise automatizada do conteúdo das fotos publicadas no Flickr para a identificação de serviços culturais em todo o litoral brasileiro. Especificamente, nossos objetivos foram: (i) investigar se há diferenças significativas no fornecimento de diferentes SECs, assumindo que as categorias *paisagem*, *natureza, monumentos naturais*, *recreação social* e *recreação esportiva* são os serviços com maior potencial de serem registrados em fotos do litoral; (ii) investigar as relações entre o fornecimento de SECs e o grau de proteção da costa. Como hipótese para este objetivo, assumimos que as áreas com maior grau de proteção (p.ex. proteção integral) fornecem uma maior *riqueza* de SECs, em relação às áreas menos protegidas; (iii) identificar os padrões temporais no fornecimento de SECs, observando se existem picos de *ocorrência* de SECs entre os dias da semana, entre os meses, e entre as horas do dia; e (iv) identificar vantagens e desvantagens do uso desta metodologia como ferramenta para orientar a gestão nas APs costeiras.

Esta dissertação é compostas por 2 capítulos: no primeiro capítulo apresentamos uma revisão da literatura para embasar conceitualmente o leitor, no capitulo 2 apresentamos o artigo intitulado “Automated image recognition reveals key role of marine protected areas in safeguarding and delivering cultural ecosystem services**”** que apresenta os resultados do nosso estudo em formato de artigo a ser submetido a revista *nature sustainability*, e por fim, concluímos com uma discussão e conclusão geral.

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2 REVISÃO DA LITERATURA

2.1 Áreas Protegidas

Áreas Protegidas (APs) são reconhecidas como unidades fundamentais para a conservação da biodiversidade e dos serviços ecossistêmicos (Gaston et al. 2008; Eastwood et al. 2016). Com diferentes propósitos, as APs têm sido criadas há milênios como lugares sagrados de povos indígenas, áreas para uso comum de recursos naturais em ilhas do Pacífico ou como zonas de caça reservadas para o uso de classes sociais dominantes (Ladle and Whittaker 2011; Watson et al. 2014). Mais recentemente, a preocupação sobre a preservação de paisagens icônicas e animais selvagens ameaçados de extinção motivou a criação das primeiras áreas protegidas da idade contemporânea (Ladle and Whittaker 2011). Em 2016, cerca de 202.467 APs cobriam aproximadamente 14,7% das áreas terrestres e águas interiores, 10,2% das areas costeiras e marinhas sob jurisdições nacionais e 4,1% de todo o oceano (WNEP/WCNC and IUCN 2016).

O Brasil realizou, desde a década de 1970, grandes investimentos para a criação de uma rede de APs maior do que a de qualquer outro país tropical (Mittermeier et al. 2005), e investiu também no treinamento de técnicos e analistas ambientais, visando a proteção de sua enorme biodiversidade e variedade de ecossistemas. Devido a estes investimentos, o Brasil tornou-se uma liderança ambiental (Loyola 2014), tendo intermediado negociações internacionais (p.ex. Rio 92 e Rio +20) que deram origem a importantes tratados com objetivos para um desenvolvimento global sustentável, como a Convenção sobre Diversidade Biológica.

Assim como em várias partes do planeta, APs brasileiras têm sido convertidas em plantações e pastos, sobre o argumento de que a preservação destas áreas compete com o desenvolvimento econômico e a segurança alimentar (Dobrovolski et al. 2011; Bernard et al. 2014). Isto tem ameaçado o status de liderança ambiental conquistado pelo país e sua riqueza biológica (Loyola 2014). De fato, a extensificação da agricultura pode aumentar a produção de alimentos, no entanto, os danos ambientais associados a esta expansão territorial de monoculturas e pastos geram efeitos negativos, inclusive sobre a própria produção alimentar (Foley 2005). Por exemplo, a conversão de áreas naturais frequentemente ocasiona o desequilíbrio populacional de insetos polinizadores importantes para a agricultura (p.ex. abelhas), diminuindo a produtividade das colheitas (Gallai et al. 2009; Potts et al. 2010).

De acordo com os preceitos legais, a decisão final sobre a implementação e manutenção das Áreas Protegidas recai sobre políticos cuja opinião é, geralmente, influenciada pela opinião pública, relatórios técnicos, lobistas, debates públicos, etc. Frequentemente, propostas parlamentares tentam *reclassificar* (flexibilizar a permissibilidade de acesso aos recursos naturais), *reduzir* (diminuir a área geográfica) ou até *extinguir* completamente as APs (do inglês: Protected Area Downgrading, Downsizind and Degazettement, ou *PADDD*) (Mascia and Pailler 2011; Bernard et al. 2014; Pack et al. 2016; Symes et al. 2016). No Brasil, estas ações têm sido propostas sem a realização de consultas públicas e se intensificaram a partir do ano 2001, atingindo PAs de diversas categorias sob jurisdição federal e estadual .

As APs marinhas do Brasil são especialmente vulneráveis, uma vez que mais de 50 milhões de pessoas vivem na zona costeira (IBGE, 2010). Adicionalmente, a falta de efetividade na gestão (Oliveira Júnior et al. 2016a) e recorrentes conflitos entre gestores e comunidades locais evidenciam a desconsideração de valores culturais dos usuários destas áreas e aumentam sua susceptibilidade a eventos PADDD (Stoll-kleemann 2001; Reed 2008; Andrade and Rhodes 2012). Em contraponto, a identificação dos valores culturais e sua inclusão em tomadas de decisão podem elevar a resistência social de APs, diminuir conflitos e aumentar o apoio popular sobre estas áreas (Infield 2001; Mugisha and Infield 2009).

2.2 Serviços Ecossistêmicos Culturais

Serviços Ecossistêmicos Culturais (SECs) são os “benefícios não-materiais que as pessoas obtêm dos ecossistemas através de enriquecimento espiritual, desenvolvimento cognitivo, reflexão, recreação e experiências estéticas” (Millennium

Ecosystem Assessment 2005). Tais serviços são amplamente reconhecidos como cruciais para as sociedades humanas, uma vez que estão diretamente ligados aos componentes do bem-estar (p.ex. segurança, saúde, relações sociais) (Millenium Ecosystem Assessment 2005).

Estes SECs são gerados a partir da complexa relação entre as pessoas e os ambientes naturais que, por fim, geram benefícios culturais como inspiração, saúde física e mental e senso de pertencimento (Fish et al. 2016). Esta complexa interação entre estrutura ecossistêmica, valores, práticas e benefícios culturais torna a valoração de SECs desafiadora (Hirons et al. 2016). Como resultado, o tardio desenvolvimento conceitual e a pouca atenção científica dedicada aos SECs (Chan et al. 2012; Daniel et al. 2012) têm contribuído para a desconsideração destes serviços em avaliações ambientais, planejamentos urbanos, tomadas de decisão em áreas protegidas e zoneamento costeiro (Satz et al. 2013; Hirons et al. 2016).

As zonas costeiras estão entre os ecossistemas mais produtivos e ameaçados, uma vez que produzem mais serviços ecossistêmicos do que a maioria dos ecossistemas terrestres (Agardy et al. 2005). Estes serviços ecossistêmicos incluem alimentos (p.ex. frutos do mar), proteção contra erosão do solo (p.ex. manguezais) e contra o avanço do mar (p.ex. restinga), assim como uma grande diversidade de serviços culturais: recreação, apreciação de paisagens, inspiração, entre outros. Estudos têm demonstrado que os habitantes de áreas costeira experienciam um maior bem-estar do que moradores do interior dos continentes (Agardy et al. 2005), no entanto, pouca informação existe sobre a distribuição de SECs nestas áreas.

O primeiro estudo global especificamente focado em serviços ecossistêmicos culturais de áreas costeiras realizou uma análise comparativa para identificar padrões na distribuição destes serviços (Brown and Hausner 2017). No Brasil, alguns estudos recentes elucidaram a importância de SECs em contextos espaciais específicos como manguezais (Queiroz et al. 2017) e áreas protegidas (Ribeiro and Ribeiro 2016).

2.2.1 Avaliação de Serviços Ecossistêmicos Culturais

Tradicionalmente, a avaliação de SECs tem sido realizada a partir de questionários baseados nas ciências sociais, que permitem sua identificação e o mapeamento de valores culturais (Brown 2004; McLain et al. 2013; Brown et al. 2014). O mapa destes valores podem então ser utilizados para entender o fornecimento de SECs e informar tomadores de decisão, ao ser comparados com mapas geofísicos, de uso do solo e de biodiversidade (Nelson et al. 2009; Sherrouse et al. 2011; Plieninger et al. 2013; Sherrouse et al. 2017).

Embora as pesquisas com o uso de questionários tradicionais sejam adequadas para a identificação de SECs (Chan et al. 2012; Gould et al. 2015), elas são necessariamente limitadas a áreas geográficas relativamente pequenas e dependentes de consideráveis quantidades de recursos humanos e financeiros para trabalho de campo. Recentemente, o aumento do uso de smartphones e de publicações de textos e imagens em redes sociais na internet têm alimentando enormes bancos de dados que podem ser utilizadas para desvendar os sentimentos das pessoas em relação à natureza (Ladle et al. 2016; Sherren et al. 2017). Estes bancos de dados, quando disponíveis, podem ser acessados através das Interfaces de Programação de Aplicativos (APIs) e sua análise tem servido para informar gestores de Áreas Protegidas e tomadores de decisões sobre como as pessoas interagem com o ambiente natural e quais suas preferências, através da identificação de SECs (Di Minin et al. 2015; Richards and Friess 2015; Becken et al. 2017; Hausmann et al. 2017; Soriano-Redondo et al. 2017; Tenkanen et al. 2017; Vieira et al. 2018).

Estes métodos inovadores possuem vantagens e desvantagens em relação aos métodos tradicionais. Por exemplo, algumas categorias de SECs podem não ser bem representadas em publicações da internet (p.ex. espiritualidade ou senso de pertencimento) (Vieira et al. 2018), enquanto entrevistas pessoais podem, eventualmente, revelar valores mais sensíveis (Tyrväinen et al. 2007). Dessa forma, a análise de grandes bancos de dados provenientes da internet surge como uma alternativa de baixo custo, rápida e independente de limitações geográficas. No entanto, estas novas metodologias podem ser combinadas com métodos tradicionais para gerar análises mais holísticas que podem orientar tomadas de decisões que consideram a perspectiva de diversos grupos de usuários (p.ex. visitantes que publicam na internet e moradores locais entrevistados) (Vieira et al. 2018).

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3 AUTOMATED IMAGE RECOGNITION REVEALS KEY ROLE OF MARINE PROTECTED AREAS IN SAFEGUARDING AND DELIVERING CULTURAL ECOSYSTEM SERVICES

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3.1 Abstract

Protected areas (PAs) are a key tool for conserving nature and delivering sustainable development. However, in many parts of the world they are under increasing threat from development due to the perception of some politicians that PAs represent opportunity costs. This broadly describes the current situation in Brazil, where recent political changes are likely to result in a drastic decrease in investments for nature conservation in general and PAs in particular. One way to defend PAs in the face of such political threats is to clearly demonstrate the enormous societal benefits generated by these areas. Until recently, such demonstrations were necessarily performed at small spatial scales and relied on costly social surveys. However, the increasing reach of the internet and the widespread availability of sophisticated tools for capturing, collating and classifying digital data (‘digital exhaust’) generated from human interactions with nature offers exciting possibilities for large scale demonstrations of the cultural benefits of PAs. To this end we adopt an innovative machine-learning approach to automatically identify, classify and quantify the cultural ecosystem services (CES) represented in thousands of digital photos taken along the length of the Brazilian coast and uploaded onto a popular file-sharing network. Our results indicate that photos taken inside PAs portray, on average, more CES (per photo and per user) than photos from outside of PAs. Moreover, there was a higher frequency of CES portrayed in photos taken in December and January and during weekends. Distance from large urban centers was most associated with photos portraying social recreation. Despite some limitations, our method appears to be suitable for quantifying and comparing a range of CES (especially aesthetic appreciation and recreation) at large geographic scales. At finer spatial scales, our approach can provide important information about the preferences of users of natural areas, and could therefore serve as a valuable support tool for environmental planning and decision making.

Keywords: cultural ecosystem services, marine protected areas, automatic analysis

3.2 Introduction

Cultural ecosystem services (CES) are defined as the non-material benefits people receive from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences (Millennium Ecosystem Assessment 2005). CES are often framed as essential for human wellbeing (Millenium Ecosystem Assessment 2005), though such a connection, when it exists, is complex and multifaceted (Raudsepp-Hearne et al. 2010) emerging from the interplay between cultural values and biophysical characteristics. This is because CES are context-specific and strictly relational, being dependent on individual values and the complex and dynamic (sedimented) histories of interactions between people and the environment (Chan et al. 2016).

The complex and relational characteristics of CES pose considerable challenges for their quantification, especially at larger scales. Although a broad variety of assessment methods have been proposed, most indicators lack conceptual clarity (Hernández-morcillo et al. 2013), are inadequate to capture multiple interconnected benefits (or bundles of CES) (Bieling 2014) and fail to address the incommensurability of CES with other ecosystem services (Satz et al. 2013). These limitations have arguably held back the development of the wider research area and compromised the integration of CES into environmental management and decision making (Satz et al. 2013).

One of the most potentially important applications of the CES concept is to demonstrate the cultural value of protected areas (PAs) to the public and, especially, politicians and decision-makers who may view them as opportunity costs. PAs are typically rich in CES, frequently providing opportunities for nature-based recreation, enjoyment of scenic beauty/natural spectacles and providing unique opportunities to encounter wild/iconic animals within their natural setting. Such opportunities are particularly associated with the National Park designation, since these were typically created to safeguard natural spaces and to promote specific cultural values such as recreation and aesthetic appreciation of nature (Ladle et al. 2011). More broadly, PAs are the main policy tool for the conservation of biodiversity and ecosystem services, protecting natural areas from habitat destruction, over-exploitation and the effects of climate change (Andam et al. 2008; Acosta Salvatierra et al. 2017) while potentially contributing to local economic development (Watson et al. 2014) and poverty reduction (Andam et al. 2010). Less frequently discussed is the potential contribution of PAs to the physical and mental health of users, ultimately generating collective benefits such as increased social cohesion (Sugiyama et al. 2008; Bowler et al. 2010; Romagosa et al. 2015) and, potentially, lessening the burden on health and social services (Terraube et al. 2017).

In summary, protected areas have the potential to generate diverse CES, enriching the lives of individuals and communities and strengthening the case for conservation in the face of competing land uses. However, much of this value is currently obscured due to the challenge of quantifying CES at scale. Here, we aim to directly address this challenge by proposing a novel procedure for measuring CES over large geographic areas. Specifically, we employ an automated approach for data collection and analysis of publicly available digital photo archives and apply this methodology to the entire Brazilian coast. We then use these data to explore the drivers of CES provision, assessing the influence of land protection status, accessibility, population density, local touristic capability and distance to densely populated areas.

3.3 Material and methods

3.3.1 The Brazilian Protected Area System

Brazil has a mature and comprehensive system of Protected Areas that has been developed over the last century (Rylands and Brandon 2005). The current policy landscape is described in the Strategic Plan of Protected Areas (PNAP) (Law 5.758/2006), which encompasses conservation units (CUs), indigenous areas and *quilombos* (a Portuguese term denoting an area once occupied by escaped slaves). The different designations of CUs are defined by the National System of Conservation Units (SNUC), which establishes criteria and norms for the creation, implementation and management of Brazilian Conservation Units (CUs) (Law 9.985/2000). The SNUC has strong structural similarities with the IUCN's PA classification system (Dudley 2008) and divides Brazilian CUs into two broad categories: *integral conservation units* (ICUs), where "only the indirect use of natural resources" is allowed, and *sustainable use conservation units* (SUCUs) which seek to align sustainable development with nature conservation goals (Law 9.985/2000).

Brazil's PA network is the largest in the world, benefitting from enormous federal investment in the 1970s and 1980s (Mittermeier et al. 2005) in the run up to achieve the Aichi Targets of the Convention on Biodiversity set in 1992. However, the entire network is increasingly subject to political pressure as reflected in national environmental policy decisions that have both called into question Brazil's role as an environmental leader (Dobrowolsky et al. 2018) and have resulted in an increased frequency of PA downgrading, downsizing and degazettement (Bernard et al. 2014). Brazilian marine protected areas (MPAs) are especially vulnerable for at least three reasons: i) more than a quarter of Brazil's population lives in coastal areas (IBGE, 2010), a high proportion of whom are involved with natural resource exploitation (MMA, 2018); ii) they are often ineffectively managed and governed (Jameson et al. 2002; Oliveira Júnior et al. 2016b), and; iii) conflicts between PA staff and local communities are frequent (Lopes et al. 2013) as recently created MPAs often impinge on customary patterns of exploitation.

As with most other areas of the World (Martin et al. 2016), there is a very limited understanding about the meanings and values that Brazilians assign to their coastal ecosystems. In this context, research about coastal CES are crucial to advance our social-ecological understanding of coastal ecosystems and, critically, to demonstrate and raise public support for Brazilian MPAs as Brazil enters yet another phase of extreme political uncertainty (Artaxo 2019).

3.3.2 Study region

At roughly 8,500 km, Brazil has one of the longest coastlines in the world (MMA, 2018) that hosts a mosaic of both Integral (38 ICUs) and sustainable use (64 SUCUs) protected areas. These have diverse objectives including protecting the habitat of iconic and endangered species (e.g. reproductive areas for Humpback Whales and Antillean manatees), maintaining unique reef systems (e.g. the Coral Coast Environmental Protected Area's bank reefs), outstanding natural monuments (e.g. Jericoacoara National Park's iconic "stone with a hole") and places of high cultural importance (e.g. the natural swimming pools of the northeast coast).

3.3.3 Cultural Ecosystem Services

Coastal zones produce disproportionately more ecosystem services than other systems (Agardy et al. 2005), including food production, biological control and nutrient cycling. These services have an estimated global economic value of US$ 10.6 trillion yr-1 (Costanza et al. 1997). While recreation is perhaps the most recognized CES generated by coastal ecosystems, they also generate a range of less visible services associated with, for example, sacred values, cultural heritage and traditional knowledge systems (Gould et al. 2014; Pike et al. 2015; Queiroz et al. 2017).

CES have been traditionally assessed through questionnaire-based social surveys in which a limited sample of people are asked why (and sometimes how much) they value a particular place (Enriquez-Acevedo et al. 2018; Vieira et al. 2018). Although such traditional social survey techniques are eminently suitable for identifying CES and associated values (Chan et al. 2012; Gould et al. 2015), they are inevitably limited to a relatively small geographic scale, are costly and frequently difficult to compare due to differences in methodology and selection of methods (Bragagnolo et al. 2016). To overcome these limitations, we employed an automatized classification of crowd-sourced geotagged images that enabled the identification of CES at low-cost and in a national scale.

3.3.4 Data collection

Brazilian law defines the coastal zone as “the geographical space of interaction of the air, the sea and the land”, including their resources, and covering a sea and a land band (Law 7661/1988). We adopted this definition of coastal zone for analytical purposes, using the border between the terrestrial and the sea realms of Brazil (from the far north of Amapá to the far south of Rio Grande do Sul states) to create a 100m buffer (50 m in sea and 50 m in land). A 100 m x 100 m grid was then drawn superimposed on the buffer and loaded along with an updated Brazilian Protected Areas shapefile (available from https://www.protectedplanet.net/c/world-database-on-protected-areas) using a Geographical Information System (GIS) software. Each of the grid squares (hereafter sample units) were then classified into one of three categories: strictly protected (> 90% of its area covered by ICUs), sustainable use (> 90% covered by SUCUs) or unprotected (> 90% outside CUs). We then randomly selected a representative sampling of 50% of sample units in each category of protection, a subset still large enough to optimally reduce bias associated with insufficient sampling.

The final grid was composed of 45,468 protected (in ICUs or SUCUs) and 53,176 unprotected sample units, which were subsequently utilized for location-based searches for photos on the image hosting service, Flickr (www.flickr.com). We used the Google Earth software (version 7.3.2) to build the initial coastal zone *shapefile* and QGIS software (version 2.14.1) to perform all geoprocessing and data visualization procedures.

3.3.4.1 Photographic data from Flickr

Flickr (www.flickr.com) is one of the most globally popular image hosting services, with billions of photos uploaded by users across the world (Flickr, 2018). Critically, Flickr images have already been used for assessing CES at various scales (Wood et al. 2013; Richards and Friess 2015; Figueroa-Alfaro and Tang 2016; van Zanten et al. 2016; Richards and Tunçer 2017) due to the availability of metadata on location, date and time of publicly available photos through the Flickr Application Programming Interface (API). We used the Flickr API to carry searches for all photos taken between 01/01/2013 and 31/12/2017 in all sampling units of the final grid. We collected and compiled the following information for each photograph we retrieved: location (latitude and longitude coordinates), date taken, date uploaded, photographer's username, and image URL.

3.3.4.2 Machine learning classification of CES: Google Cloud Vision

We used the Google Cloud Vision API (Google Cloud Vision, 2018) to classify the photos in our study. The API uses a machine learning algorithm to identify objects, localities, activities, species of animals, and products in images (https://cloud.google.com/vision/docs/labels). In our study, the algorithm allocated up to five keywords to each photo gathered from Flickr. CES were then assigned to all keywords considered allusive to: (I) nature, (II) landscapes, (III) natural structures and monuments, (IV) social recreation, (V) sport recreation, (VI) religious, spiritual or ceremonial activities and monuments, (VII) historical monuments, (VIII) art and culture and (IX) research and education. Keywords that did not fit in any of the above categories were assigned to "others". Thus, each photo was assigned a minimum of 0 and a maximum of 5 CES. The procedure was independently carried out by two researchers following a detailed protocol (Appendix 1) - a visual check revealed a high level of agreement between their classifications. 'RoogleVision' R software (R Core team, 2018) package was utilized for assessing the Google Cloud Vision API (Teschner, 2016).

3.3.5 Data analysis

We performed summary statistics on CES per level of protection, including the total users and photographs and the average count of CES per user and per photograph. Additionally, we utilized the date in which photographs were taken to explore temporal distributions of photos and user activity. Specifically, percentage of total photos and users were calculated for each month, day of the week and hour of the day in the different levels of protection.

We tested the influence of four explanatory variables (section 2.4.2) on the occurrence, richness and count of our automatically derived CES in sample units by using a hurdle model for count data. A hurdle model was chosen because it is better able to deal with data with a lot of zeros than more classical models (e.g. generalized linear models) (Zeileis et al. 2008). A multi-model inference approach (Burnham and Anderson 2004; Burnham et al. 2011) was adopted to estimate of the relative effect of each explanatory variable based on the most plausible hypothesis. Models for all combinations of explanatory variables were then generated and the most plausible models were identified according to AIC corrected for small sample size (AICc) - we considered all models with a □AICc ≤ 5 in relation to the best model for a conditional-model averaging process. The continuous variables were standardized before its inclusion in the models (Schielzeth 2010) to compare their relative effect size. All model assumptions were tested prior to analysis (Zuur et al. 2010). Hurdle regression models were used through the 'hurdle' function of the 'pscl' R package and model combinations were analysed with the 'MuMIn' R package.

3.3.5.1 Response variables

We considered the count, occurrence and richness of services as indicators of CES in the study area. Here, occurrence is defined as the presence/absence of a given CES, richness is the sum of different categories of CES and count is the sum of all CES records.

3.3.5.2 Explanatory variables

We expected the level of protection to influence the occurrence, richness and count of CES assessed. Specifically, we reasoned that ICUs would generate higher numbers of photos in average due to their role in promoting visitation (e.g. parks and wildlife refuges). Also, a high number of photos depicting appreciation of nature, landscape and natural monuments were expected to occur in ICUs as they usually contain outstanding biophysical assets. A high number of photos representing cultural heritage were expected to occur in SUCUs, since they are often associated with the maintenance of traditional ways of life and culture (e.g. sustainable development reserves and extractive reserves).

Factors associated with the amount of people who might visit an area (and therefore utilize one or more CES) was also considered. Specifically, we tested for the influence of accessibility, distance to large cities and human population size. Accessibility was calculated by measuring the distance of the sample units' centroids to the nearest road. The roads' GIS information were assessed through a line *shapefile* of all Brazilian official roads. The distance to large cities is the distance of each sample unit to the nearest state capital. Human population is the population size of the nearest municipality. Number of photos were included as a proxy for visitation in the widely scattered sampling units.

3.2 Results

We identified a total of 21,819 photos taken by 3,634 individuals within 3,335 samples units along Brazilian coast, and described an average cultural ecosystem services richness of 1.54 per photograph and an average CES occurrence of 3.31 per photograph (72,272 occurrences in total). The most common CES were aesthetic-related values (nature, landscape and natural monuments), representing 81% of all CES occurrences (Table 1). Social recreation (N = 8,605), sports recreation (N = 3,437) and culture and arts (N = 1,592) were reasonably well represented in the photos while spiritual values (N = 106), historical monuments (N = 134), and education (N = 16) had a relatively low frequency in the overall data set.

CES CATEGORY	COUNT	PERCENT OF TOTAL OCCURRENCES
NATURE	7,615	11%
LANDSCAPE	40,663	56%
NATURAL MONUMENTS	10,104	14%
SOCIAL RECREATION	8,605	12%
SPORTS RECREATION	3,437	5%
SPIRITUALITY	106	0%
HISTORICAL MONUMENTS	134	0%
CULTURE & ARTS	1,592	2%
RESEARCH & EDUCATION	16	0%

Table 1: Count of CES in the overall dataset (max. 5 CES/photo)

Our analysis of CES per level of protection indicates a generally higher occurrence of CES in ICUs and SUCUs in relation to unprotected areas (Table 2). Interestingly, while count of aesthetic-related values (*nature, landscape* and *natural monuments*) was higher in ICUs and SUCUs, *sports recreation* was more represented in unprotected areas. The other sub-categories of CES were also higher in unprotected areas despite their low overall occurrence in the data set.

Cultural Ecosystem Services	ICU (Average/SD)	SUCU (Average/SD)	Unprotected (Average/SD)
Nature	0.48 ± 1.35	0.42 ± 1.28	0.32 ± 1.26
Landscape	2.31 ± 1.20	2.37 ± 1.23	1.71 ± 1.32
Natural monuments	1.03 ± 0.74	0.66 ± 0.59	0.38 ± 0.59
Social recreation	0.54 ± 0.86	0.35 ± 0.75	0.40 ± 0.79
Sports recreation	0.03 ± 0.33	0.07 ± 1.13	0.18 ± 1.22
Spirituality	0	0.003 ± 0.71	0.01 ± 0.61
Historical monuments	0	0.003±0.29	0.01 ± 0.59
Culture & arts	0	0.02 ± 0.98	0.09 ± 1.09
Research & education	0	0	0

Table 2: Count of CES per level of protection

The average CES per photo and per user was considered as a measure of cultural engagement with the different areas. As expected, both ICUs and SUCUs had more CES per photo than unprotected areas (Table 3). Also, individuals in protected areas seem to benefit from a higher richness of CES while users of unprotected areas appear to utilize a more limited set of CES.

	ICU (Average/SD)	SUCU (Average/SD)	Unprotected (Average/SD)	TOTAL (Average/SD)
Photos/user	6.14 ± 22.52	4.42 ± 9.53	5.52 ± 16.35	6.0 ± 17.86
CES/photo	2.04 ± 0.69	1.76 ± 0.74	1.45 ± 0.83	1.54 ± 0.82
CES/user	2.27 ± 1.04	2.27 ± 1.10	2.21 ± 1.35	2.30 ± 1.34
Users	134	1,018	3,018	3,634
Photographs	824	4,323	16,672	21,819

Table 3: Photos, users and CES in photos of the Brazilian coast

Temporal analysis suggests that CES are temporal specific. Percentages of total photographs taken and active users were generally higher in the months of December and January (Figure 1). Also, weekends registered a higher percentage of the total photos and users (Figure 2) and on a daily basis, highest records were found in the period from 9 AM to 5 PM, with a slight decrease at 2 PM (Figure 3).

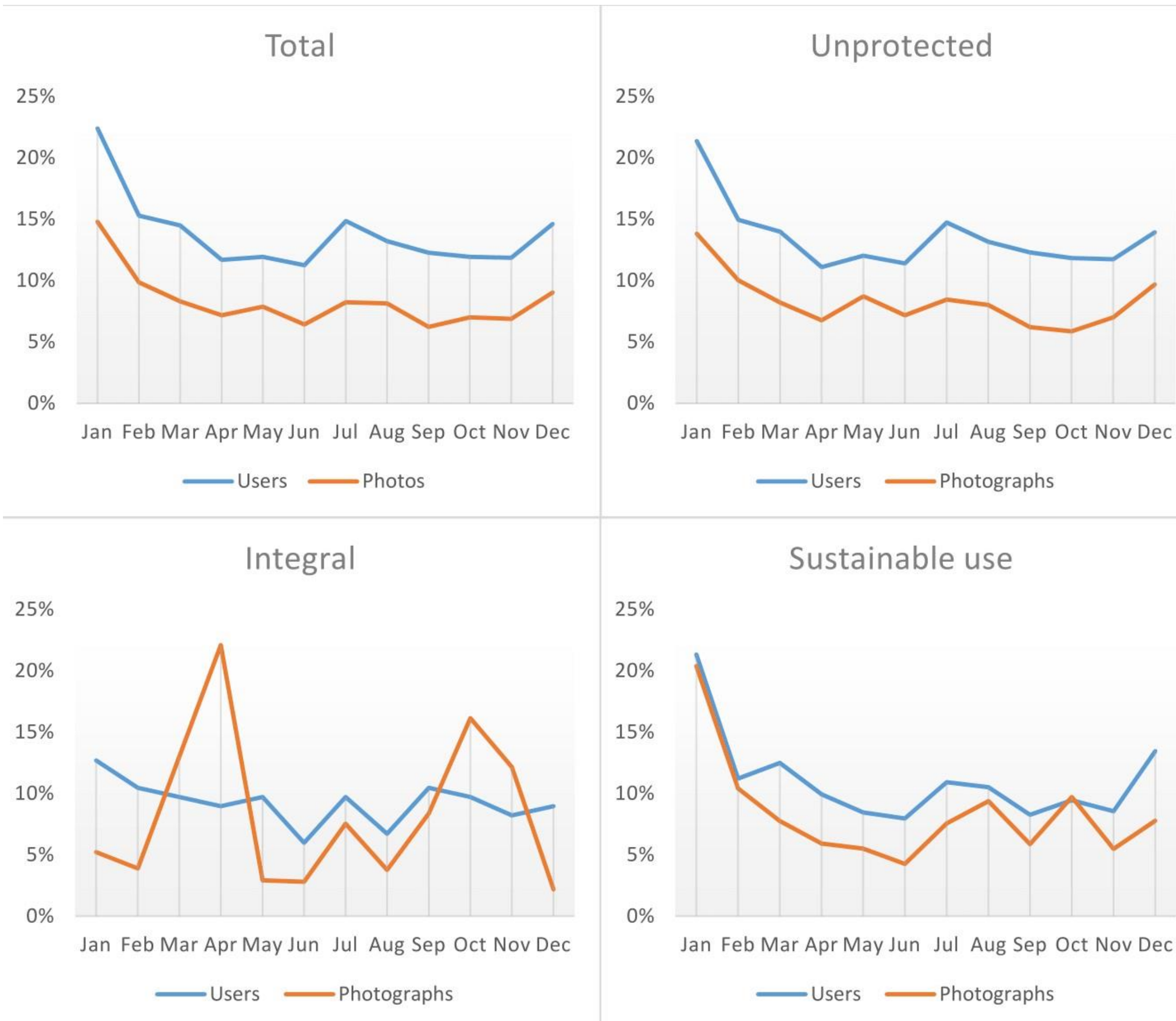

Figure 1: Percentage of total users (blue line) and photographs (orange line) per month

Figure 2: Percentage of total users (blue line) and photographs (orange line) per days of the week

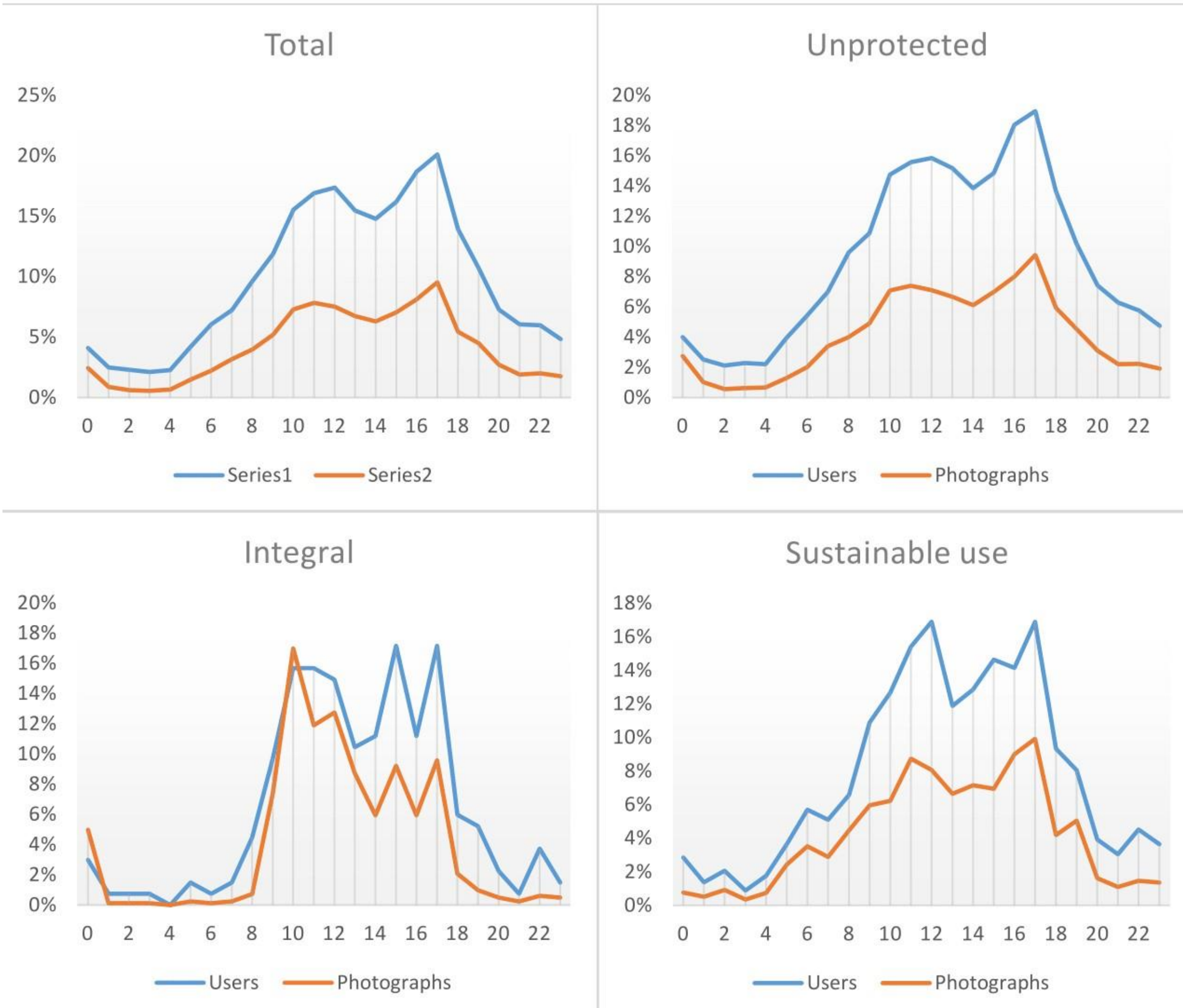

Figure 3: Percentage of total users (blue line) and photographs (orange line) per hours of the day

Our models indicate that statutory protection was significantly associated with CES, with both ICUs and SUCUs having a positive effect on the richness of services. Accessibility, human population and distance to capital did not affect CES richness (Figure 4). The number of photos was, as expected, the strongest predictor for occurrence of all categories of CES (Figure 4 a, b, c, d, e, f). SUCUs were positively associated with the occurrence of landscape (Figure 4 b). On the other hand, SUCUs had an unexpected negative association with social recreation and art and culture services (Figure 4 e, f). Accessibility was positively associated with the occurrence of some CES, including nature and landscape (Figure 4 a, b), indicating that distant places are more likely to generate these CES. The other predictor variables were not significantly associated with CES occurrence and, due to lack of data, spirituality, historical monuments and research were not modelled.

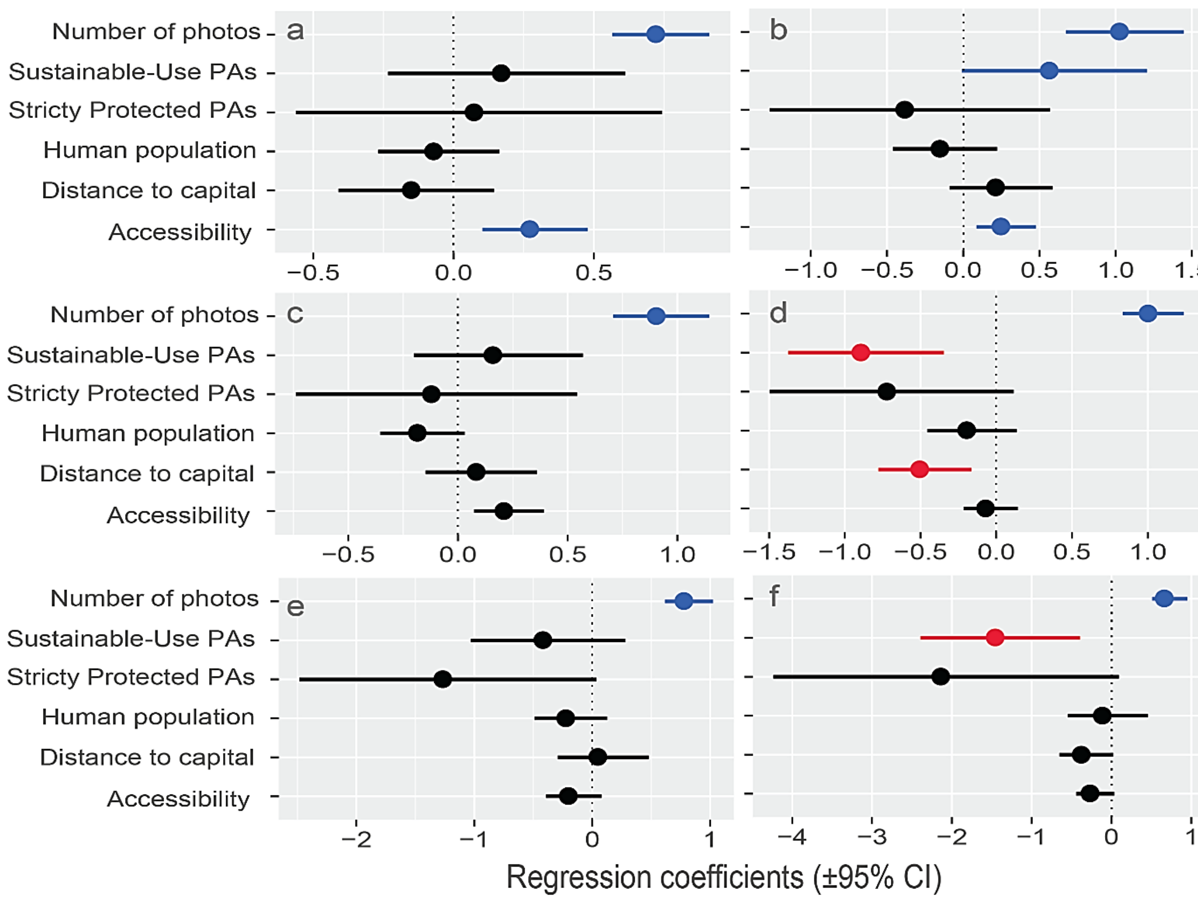

Figure 4: Standardized size effect for all predictors of cultural ecosystem services occurrence. (a) nature; (b) landscape; (c) natural monument; (d) social recreation; €sport recreation; and (f) art and culture. The mean estimates are represented by dots, and horizontal lines represent 95% confidence intervals (CI). For significant variables, CIs do not cross the vertical dotted line at zero. Blue and red estimates indicate significant positive and negative effects, respectively

As anticipated, number of photos was the strongest predictor of the count of all categories of CES. However, levels of protection influenced count of CES differently. Specifically, SUCUs were positively associated with counts of nature, landscape and art and culture services (Figure 5 b, c) and negatively associated with counts of the social recreation service (Figure 5 d). Interestingly, ICUs were positively associated with counts of landscape and natural monuments services (Figure 5 d) and negatively associated with counts of the sports recreation service (Figure 5 b, c). Human population was negatively associated with counts of nature, landscape, natural monuments and social recreation services (Figure 5 a,b,c,d) and positively associated with the sports recreation service (Figure 5 e). Distance to capital was positively associated with the landscape service (Figure 5 b) and negatively associated with counts of the social recreation and art and culture services (Figura 5 d, f), indicating that proximity to big cities promotes a higher delivery of this services. Accessibility had a positive association with counts of nature, natural monuments and sports recreation services (Figure 5 a, c, e), suggesting that these services are delivered mainly in remote areas.

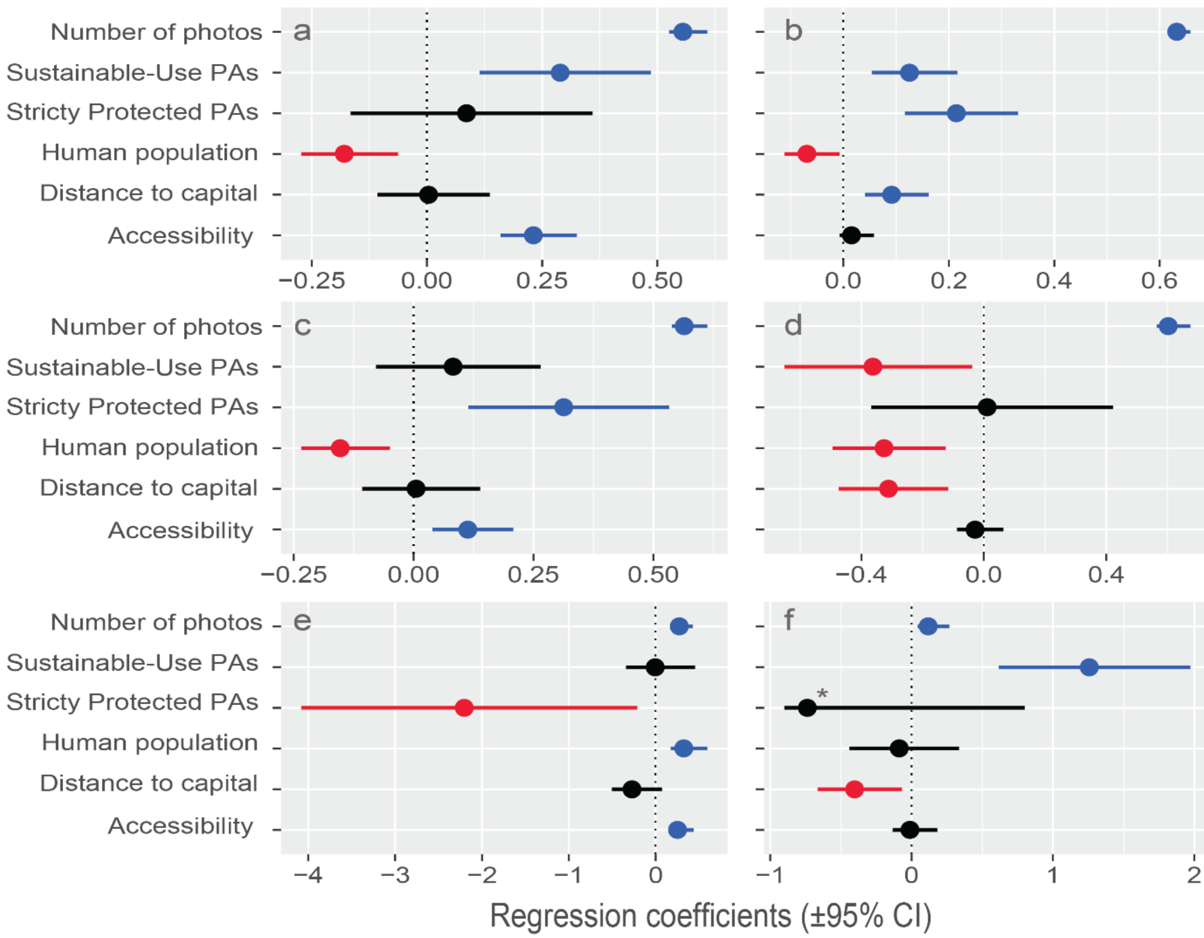

Figure 5: Standardized size effect for all predictors of cultural ecosystem services counts. (a) nature; (b) landscape; (c) natural monument; (d) social recreation; €sport recreation; and (f) art and culture. The mean estimates are represented by dots, and horizontal lines represent 95% confidence intervals (CI). For significant variables, CIs do not cross the vertical dotted line at zero. Blue and red estimates indicate significant positive and negative effects, respectively

3.2 Discussion and conclusion

Despite increasing scientific interest in cultural ecosystem services (CES), their assessment is still heavily skewed towards marketable services (e.g. tourism) and the use of methods suitable for smaller spatial scales (Hernández-morcillo et al. 2013; Plieninger et al. 2013; Van Berkel and Verburg 2014). A potential solution to these shortcomings may be found in the application of culturomics, an emerging field of study that infers cultural trends from the analysis of digital text corpora (Ladle et al. 2016) and which can be extended to incorporate the content analysis of digital-images (Ladle et al. 2017; Sherren et al. 2017). Significantly, culturomic methods are particularly suitable to investigate public interest and sentiment towards nature at larger spatial scale, from regional to global.

Culturomic analysis is typically based on the analysis of word frequencies in large digital corpora (Michel et al. 2010). Nevertheless, it can also be applied to images, either through the use of associated meta-data or by allocating the photo to one or more labelled categories (Ladle et al. 2017). Such allocation can be done manually (Richards and Friess 2015), though this is both time-consuming and can introduce elements of human error. A more effective solution would be to automate the classification process through the use of machine learning algorithms (Sherren et al. 2017). Such an approach has recently become feasible due to the rapid improvement and wide availability of machine learning tools (e.g. Google Cloud Vision, Microsoft Computer Vision, Clarifai) which are potentially able to distinguish complex photographic content such as representations of different forms of CES.

In this sense, our study provides a clear demonstration of the potential utility of automatized assessment of CES at large scale using a machine learning approach - first proposed by Richards and Tunçer (2017). Nevertheless, like every method, there are distinct advantages and disadvantages. The main advantages of using machine learning for CES assessments (in relation to manual classification) is that it is: (i) very fast; (ii) cheap; (iii) can be applied at any spatial scale, and; (IV) does not depend on the highly subjective human interpretation of images. However, this does not resolve biases that may arise from the sub-set of citizens (e.g. tourists) who take and share photos on file-sharing sites (Tufekci 2014). Ideally, robust assessment of CES requires a multiple-user perspective (e.g. tourists, local residents, researchers) and multiple-method (e.g. photo analysis and semi-structured questionnaires) approach (Hausmann et al. 2017; Vieira et al. 2018). Furthermore, only a limited subset of CES are likely to be represented in a photograph. This is because the act of sharing a photo is dependent on the individuals' personal perspective (e.g. as a traveller, an adherent of a religion or an artist) and the digital platform they use to share their photo (e.g. photo sharing patterns in Flickr may differ from Panoramio) - a comprehensive comparison between social media platforms with different characteristics has not yet been performed (van Zanten et al. 2016).

In our Flickr analysis, the high proportion of photographs and active users in the months of December and January (which coincides with the high season for tourism in Brazil) strengthens the hypothesis that the user group assessed in this study is mainly composed by visitors during vacation trips. We also observed an over-representation of aesthetic-related CES, while other potentially common CES in the study area such as social relations and personal satisfaction (Queiroz et al. 2017) were generally misrepresented. The prominence of certain CES was even stronger when accounting for the level of protection. Specifically, we found strong associations of photographic representations of nature, landscape and natural monuments services with both ICUs and SUCUs. This may be due to the fact that MPAs are created in areas where aesthetic-related features already exist and are socially recognized (as indicated by the guidelines for the creation of PAs of the Brazilian SNUC). Nevertheless, MPAs may also increase aesthetic-related CES delivery (nature, landscapes and natural monuments appreciation) by preserving natural features and actively promoting opportunities for people to interact with, and thus, receive CES in the long-term (e.g. controlling the number of visitors to natural swimming pools may decrease reef degradation and maintain opportunities to appreciate rare fish species).

Interestingly, CES delivery differed between ICUs and SUCUs. The occurrence of social recreation and art and culture services were negatively associated with SUCUs. This was somewhat unexpected, as SUCUs are generally inhabited by local communities, whose cultural expressions are appealing elements for visitors to photograph ~~e~~ share in the social media. Furthermore, SUCUs often permit a wide range of recreational activities. Our model also indicated that counts of natural monuments and landscape services were positively associated with ICUs. Nevertheless, ICUs were negatively associated with sports recreation. In general, these results indicate that marine ICUs limit sportive recreational opportunities, while providing visitors with good access to beautiful landscapes and natural monuments.

In general, our model reflects an overlap between spatial distribution of CES and the people who benefit from these services. It is interesting to note that local residents (e.g. fishers and artisans) are probably utilizing different CES from the same area. For example, a person who is unfamiliar with a certain natural spectacle (e.g. a turtle mating assemblage) would probably photograph during a visit, while a local resident who had seen it many times before would be unlikely to record it or post it.

Most broadly, our data clearly highlights the enormous cultural value of Brazilian Marine Protected Areas, despite their generally low levels of management effectiveness and poor governance (Oliveira Júnior et al. 2016b). However, the observed lack of an association between CES and human population, for example, suggests that many of the values we perceived are being captured by tourists from distant places, and may not be very representative of other groups of users such as local residents. In this context, additional evaluations should be carried for more in-depth analysis of local contexts (e.g. traditional social surveys) as such information is invaluable for MPA policy development and governance. Nevertheless, even though our data is biased towards a sub-set of the study area users, it still provides powerful support for continued investment in Brazil's MPA system and provides a clear baseline for future studies of CES in this region.

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4 Discussão geral

Apesar da reconhecida importância das áreas costeiras como provedoras de Serviços Ecossistêmicos Culturais, poucos estudos abordaram o tema com enfoque na costa do Brasil. Queiroz e colaboradores (2017), por exemplo, demonstraram a importância da consideração de percepções de usuários locais nas tomadas de decisões e em políticas de conservação a partir de uma avaliação socio-cultural de SECs em manguezais. Daminello e colaboradores (2014) constatou que a identidade de lugar (*sense of place*) é tão importante quanto alguns serviços ecossistêmicos clássicos (p.ex. serviços de provisão) para os moradores de uma comunidade litorânea no sudeste do Brasil.

Por outro lado, algumas avaliações de SECs foram realizadas em áreas não-costeiras, contribuindo para um melhor entendimento sobre os SECs no Brasil. Ribeiro e Ribeiro (2016) realizaram uma avaliação e mapeamento dos SECs percebidos por grupos distintos de usuários no maior Parque Estadual urbano do Brasil, enfatizando a importância deste parque quanto fornecedor de serviços de *apreciação estética* e *ecoturismo*. Vieira e colaboradores (2018), por sua vez, realizaram uma avaliação de SECs utilizando diversas metodologias para diferentes grupos de usuários de um Parque Nacional na *caatinga* e criaram um índice de saliência para comparar diretamente os dados obtidos a partir das diferentes abordagens.

Uma das grandes limitações da avaliação de SECs *in situ* é a disponibilidade de uma quantidade considerável de recursos humanos e financeiros. Um outro fator limitante para a aplicação de questionários presenciais sobre SECs é a necessidade de um período de familiarização ou do auxílio de um 'guia' que conheça a região de estudo (idealmente, um morador local), visando conseguir uma maior receptividade da comunidade e, consequentemente, uma maior confiança na autenticidade das respostas obtidas. Dessa forma, a análise de grandes bancos de dados disponíveis na internet (*big-data analysis*) surge com uma boa alternativa para a avaliação de SECs de forma rápida e com custo financeiro relativament baixo, em comparação com os métodos tradicionais (p.ex. questionários).

Teoricamente, esta abordagem pode ser realizada em qualquer área geográfica desejada. As limitações, por sua vez, estarão relacionadas (i) à capacidade de processamento e armazenamento dos computadores utilizados para a coleta e análise destes grandes bancos de dados, (ii) treinamento de recursos humanos para sistematizar grandes quantidades de informações associadas às fotos e utilizá-las em tarefas de geoprocessamento em softwares de Sistemas de Informações Geográficas (p.ex. QGIS, ArcGIS) e (iii) disponibilidade de recursos financeiros para a utilização de algoritmos de reconhecimento de imagens (aproximadamente R$ 6,00 para cada 1,000 fotos analisadas).

Em nosso estudo, foi possível realizar o download e a análise de informações associadas a todas as fotos georreferenciadas capturadas em uma enorme fração da área costeira do Brasil e publicadas no Flickr (aproximadamente 986.44 km^2). Estas informações foram cruzadas com os limites espaciais de todas as unidades de conservação de proteção integral (UCPI) e de uso sustentável (UCUS) costeiras, revelando padrões espaço-temporais de SECs em toda a área de estudo. Dessa forma, o banco de dados utilizado pode representar a distribuição espacial e temporal de SECs costeiros do Brasil com grande robustez, além de ser representativo do grupo de usuários avaliado.

Especificamente, foi observado que, enquanto a contagem de SECs relacionados à apreciação estética (p.ex. *natureza*, *paisagem* e *monumentos naturais*) foi maior em UCPI e UCUS, *recreação esportiva* foi mais representada em áreas não protegidas (ANP). As médias da contagem de SECs por fotos e por usuários de áreas com diferentes níveis de proteção também foram calculadas para mensurar a saliência dos SECs. Como esperado, UCPI e UCUS apresentaram uma maior quantidade de SECs por foto. Da mesma forma, a riqueza de SECs foi maior para os usuários de áreas com algum grau de proteção, enquanto os usuários de áreas não protegidas parecem usufruir de um repertório mais limitado de SECs.

Adicionalmente, a análise temporal da distribuição de SECs demonstrou que o grupo de usuários avaliado recebe SECs em meses, dias da semana e horas específicas. A grande concentração da ocorrência de SECs nos meses de Dezembro e Janeiro endossou a hipótese de que o grupo de usuários acessado através da análise de fotos do Flickr é, majoritariamente composto por visitantes, uma vez que este período coincide com a alta temporada turística no Brasil.

A modelagem estatísticas mostrou que UCUS exercem um efeito positivo significativo sobre a *ocorrência* do SEC *paisagem*. A associação negativa encontrada entre UCUS e *recreação social* e *arte e cultura* foi inesperada, uma vez que, teoricamente, as fotos representando comunidades/atividades tradicionais (comumente presentes nestas unidades de conservação) refletiriam numa maior ocorrência de *arte e cultura*. No entanto, sugere-se que a ocorrência destes SEC em fotos de UCUS seja baixa no geral devido à enorme extensão de algumas Áreas de Proteção Ambiental (APAs) (p.ex. APA Costa dos Corais – AL/PE; e APA da Plataforma Continental do Litoral Norte – BA). Foi observado também que a variável *distância até a capital mais próxima* está positivamente associada com a ocorrência de *recreação social*, sugerindo que locais mais afastados dos grandes centros populacionais oferecem mais oportunidades de recreação não-esportiva. A variável *população humana* não influenciou a ocorrência de SECs.

O modelo apontou, ainda, que UCPIs influenciam positivamente a *contagem* dos SECs *paisagem* e *monumentos naturais*. Este resultado reflete os objetivos de criação dos *parques* (nacionais, estaduais e municipais), que são a categoria mais representativa de ICUS e visam a “preservação de ecossistemas naturais de grande (...) beleza cênica” (Brasil, 2000). De forma inesperada, UCPIs também influenciaram negativamente a contagem de *recreação social*, atividade igualmente prevista nos objetivos de criação de parques.

Referências

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5 Conclusões

O presente estudo demonstra a potencialidade da análise automatizada de fotos publicadas em redes sociais como uma alternativa de baixo custo às avaliações tradicionais de Serviços Ecossistêmicos Culturais (p.ex. questionários), podendo ser aplicada em praticamente qualquer escala espacial desejada. O grande volume de dados coletados permitiu uma análise robusta e pioneira sobre o importante papel das unidades de conservação integral e de uso sustentável da costa brasileira para o fornececimento de SECs.

Apesar de todas as nove (9) categorias de SECs avaliadas terem sido identificadas, nota-se que este método não é adequado para avaliar o *valor espiritual*, de *educação* e de *herança cultural* de uma determinadas área, uma vez que estes serviços não estão bem representados em fotos publicadas em redes sociais. Por outro lado, este tipo de análise captura de forma robusta o fornecimento ecossistêmico de serviços relacionados à apreciação de *natureza*, *paisagens* e *monumentos naturais*, além de *recreação social* e *recreação esportiva*.

A aplicação deste método em contextos específicos deve gerar informação com alta resolução sobre onde e quando os usuários de uma área usufruem de SECs. Assim, os gestores de áreas naturais (p.ex. áreas protegidas) podem identificar facilmente os locais de grande beleza cênica ou com grande potencial para recreação, por exemplo, e assim realizar ações direcionadas, considerando as percepções e valores dos usuários. Além disso, estes gestores poderão identificar lacunas e *hotspots* de SECs em suas respectivas APs.

Ainda que os dados utilizados neste estudo não sejam representativos de todos os grupos de usuários de áreas costeiras, nossos resultados podem ser utilizados para justificar investimentos para a criação de novas áreas protegidas, além de servir como base para futuras pesquisas sobre SECs.

APÊNDICE

1 Metodologia de classificação de palavras em Serviços Ecossistêmicos Culturais

Categorias:

A. **Natureza** (Aesthetic appreciation, MEA 2005; Nature appreciation, Richards & Friess 2015; Species assets, Jepson et al. PA Asset Guidebook): Nesta categoria consideram-se todas as palavras que referem-se a animais, plantas e fungos (ou a seus atributos) ou a classes de organismos (p.ex. bico, brânquia, concha, invertebrado, inseto, ocycopodidae).

B. **Paisagem** (Aesthetic appreciation, MEA 2005; Landscape, Richards & Friess 2015, Scenic beauty, Jepson et al. PA Asset Guidebook): Nesta categoria consideram-se todas as palavras que se referem a uma visão ampla da paisagem (p.ex. horizonte, ecossistema, oceano, mar).

C. **Monumentos naturais** (Aesthetic appreciation, MEA 2005; Scenic beauty, Jepson et al. PA Asset Guidebook): Nesta categoria incluem-se todas as palavras que se referem a estrtuturas naturais específicas e bem-definidas (e.g. cachoeira, caverna, montanha).

D. **Recreação social** (Recreation and tourism, MEA 2005; Social recreation, Richards & Friess 2015; Regular visitors and recreation enthusiasts Jepson et al. PA Asset Guidebook): Nesta categoria incluem-se todas as palavras que se referem a grupos de pessoas em situação de recreação não esportiva (p.ex. lazer, aventura, diversão, turismo).

E. **Recreação esportiva** (Recreation and tourism, MEA 2005; Social recreation + Fishing, Richards & Friess 2015; Regular visitors and recreation enthusiasts Jepson et al. PA Asset Guidebook): Nesta categoria incluem-se todas as palavras que se referem a atividades ou equipamentos esportivos (e.g. bicicleta, longboard, atleta, surf).

F. **Atividades e monumentos religiosos e espirituais** (Spiritual services, MEA 2005; Monument and public artwork, Jepson et al. PA Asset Guidebook): Nesta categoria incluem-se todas as palavras que se referem a monumentos ou atividades religiosas ou espirituais (p.ex. igreja, templo, capela, sagrado).

G. **Monumentos historicos** (Heritage values, MEA 2005; History, Richards & Friess 2015; Monument and public artwork, Jepson et al. PA Asset Guidebook): Esta categoria considera todas as palavras que se referem a infraestruturas historicas (p.ex. castelo, ruinas, pinturas rupestres, sitio arqueologico).

H. **Expressões artisticas e culturais** (Cultural Identity and Inspiration, MEA 2005; Creative interpretations Jepson et al. PA Asset Guidebook): Nesta categoria incluem-se todas as palavras que se referem a pessoas em atividades artisticas (p.ex. pintor, escultor, fotografo), atividades culturais (p.ex. pesca artesanal, dança tradicional) ou seus produtos (p.ex. pintura, escultura).

I. **Pesquisa e educação** (Cultural identity, MEA 2005; Educational values, MEA 2005; Research, Richards & Friess 2015; Researchers, Jepson et al. PA Asset guidebook): Nesta categoria incluem-se todas as palavras que se referem a atividades ou equipamentos relacionados a pesquisa ou educação (p.ex. pesquisador, escola, camera trap, microscopio).

J. **Outros**: Consideram-se nesta categoria todas as palavras que não se enquadram em nenhum dos criterios acima.