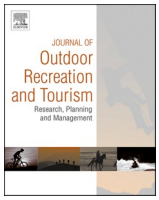
Journal of Outdoor Recreation and Tourism 44 (2023) 100642

Contents lists available at ScienceDirect

Journal of Outdoor Recreation and Tourism

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



Research Article

Spatial and temporal patterns in wildlife tourism encounters and how people feel about them based on social media data from South Africa☆

J.R. Mangachena [a,*], S. Geerts [b], C.M. Pickering [a]

[a] Centre for Planetary Health and Food Security, Griffith School of the Environment and Sciences, Griffith University, Parklands Drive, Southport, QLD, 4222, Australia
[b] Department of Conservation and Marine Sciences, Cape Peninsula University of Technology, P.O. Box 652, Cape Town, 8000, South Africa

ARTICLE INFO

Keywords:
Flickr
Hot spots
Nature-based tourism
Sentiment analysis
Textual analysis
Volunteered geographic information

ABSTRACT

With well-developed tourism infrastructure and high biodiversity, including charismatic mammals, wildlife tourism is popular in South Africa. But where and when do people encounter wildlife, how does this vary among species and land-tenures, and how do people feel about their encounters? To assess the potential of social media to provide insights into wildlife tourism, metadata from 22,002 images across South Africa posted by 9762 people to the photo-sharing platform Flickr were obtained on 15 March 2021 and analysed using standard spatio-temporal and sentiment analyses methods. Total wildlife-encounter-days, and specific hot spots of encounters varied among elephant, white and black rhinos, lion, cheetah, giraffe, leopard, zebra, buffalo, hippopotamus, hyena and African wild dog. Most encounters were in national parks and other government protected areas (59%), particularly Kruger National Park (33%), with private protected areas (25%) also important. Encounters were predominantly within the species' traditional geographic ranges. These encounters were more common in early morning and late afternoon, on major holidays, weekends and in the dry season between August and October. Words used to describe images referred to locations, species and natural features, with people mostly expressing positive sentiments and emotions such as trust, joy and anticipation about their encounters. The results reinforce the concentrated nature of wildlife tourism – in parks, such as Kruger National Park, and adjacent private protected areas. Expanding where, when and which species are encountered would be valuable for marketing and management. The results also illustrate benefits but also limitations including who posts about what, where and when from online platforms such as Flickr.

Management implications

We illustrate how metadata of images from social media can be used to examine patterns in wildlife encounters, including spatial and temporal hot spots, as well as how tourists feel about their experiences. Although spatial and temporal hot spots of encounters varied among species and with tourists generally positive about wildlife encounters, there is an opportunity to diversify wildlife tourism to focus on more species, locations and times, which could both enhance tourists' experiences and spread community benefits from wildlife tourism in South Africa. In addition, user created content on social media could expand tourism operators' and park agencies' knowledge about where tourists go, when and why over large spatial scales, such as for all of South Africa, but as with many approaches, it has important limitations.

1. Introduction

Wildlife is an important aspect of nature-based tourism with people spending considerable time and effort to encounter specific animals (Maciejewski & Kerley, 2014; Okello, Manka, & D'Amour, 2008) with some places (Valentine & Birtles, 2004; Taecharungroj & Mathayomchan, 2021; Mangachena et al., 2022) and species (Catlin et al., 2013; Macdonald et al., 2015; Mangachena & Pickering, 2021a) far more popular than others. As a result, there are global wildlife hot spots, such

☆ The authors, Joy Rumbidzai Mangachena, Sjirk Geerts and Catherine Marina Pickering, declare that they have no personal interests, financial or otherwise in the subject matter discussed in this manuscript. The authors also certify that they have no affiliations with or involvement in any organization or entity with any financial interests including educational grants, membership, employment, consultancies, stock ownership or personal or professional relationships, affiliations in the subject matter discussed in this manuscript.

* Corresponding author.
E-mail address: joy.mangachena@griffithuni.edu.au (J.R. Mangachena).

https://doi.org/10.1016/j.jort.2023.100642
Received 19 July 2022; Received in revised form 23 February 2023; Accepted 11 April 2023
Available online 1 May 2023

as South Africa, that attract millions of local and international tourists annually (Arbieu et al., 2017; Kerley et al., 2003; SANParks, 2020). Although there is a high diversity of wildlife within South Africa, tourists are keen to see specific species, particularly elephant, white and black rhinos, lion, cheetah, giraffe, leopard, zebra, buffalo, hippopotamus, hyena and African wild dog (Mangachena & Pickering, 2021a). Encounters with these animals may benefit locals through income generation and employment, as well as increasing support for conservation (Larm et al., 2018; Wardle et al., 2018). In South Africa there is also a strong focus on generating direct economic and social benefits from wildlife tourism, including in protected areas, supporting wider social justice and economic development goals (Fairer-Wessels, 2019).

Within South Africa, protected areas consist of public protected areas, such as national parks that are run by the government and cover over 5.1% of the country (Statistics South Africa, 2021). There are also private protected areas (private reserves) that are owned and managed by individuals and non-governmental organisations covering an additional ~4.1% of South Africa (Clements et al., 2019). In both public protected areas and private reserves, wildlife tourism is popular (Mangachena & Pickering, 2021a). Some wildlife tourism also occur outside these areas such as in zoos, sanctuaries, wildlife ranches and farms that breed threatened charismatic megafauna (Clements et al., 2019) where tourists can see animals in natural and/or semi-captive environments (Maciejewski & Kerley, 2014).

Those promoting and managing wildlife tourism, whether in national parks or other land-tenures, need information including where tourists visit, when and why (Hausmann et al., 2019; Spenceley et al., 2021; Wilkins et al., 2021) to enhance destination marketing and promotion by indicating which species and places tourists value (Curtin, 2010; Di Minin et al., 2013; Siikamäki et al., 2015). It can also be used to identify where wildlife tourism income is generated including from which types of land-tenures (Barnes et al., 1999; Meyer, 2015). Information about tourists' movements can be used to allocate resources such as accommodation, food outlets, roads, parking, visitor centres and viewing points (Leung et al., 2018; Spenceley et al., 2021). It can indicate where there is crowding and hence potential conflict amongst tourists (Spenceley et al., 2021), as well as times and places where wildlife may experience stress from human encounters (Larm et al., 2018; Macdonald & Wester, 2021). This can help in developing strategies to reduce and manage demand for and interest in highly popular areas and species, providing alternative tourism opportunities while minimising pressure on biodiversity (Drugova et al., 2021; Mancini et al., 2018).

Some data about wildlife tourism are available for public and private protected areas through entry fees, vehicle and trail counters, visitor surveys and direct observation (Newsome & Rodger, 2012; Wood et al., 2013). These sources of data are widely employed but can be expensive and time consuming to obtain (Garnett et al., 2018; Hausmann et al., 2018) particularly over larger areas including different land-tenures and over longer time periods (Newsome and Rodger, 2012). More recently, data about tourist movements from social media have started to be used in research and to better manage nature-based tourism (Ghermandi and Sinclair, 2019; Teles da Mota & Pickering, 2020; Toivonen et al., 2019; Wilkins et al., 2021) and this includes information from the image-sharing social media platform Flickr.

1.1. Social media and wildlife tourism

Flickr is a social media platform which was established in 2004 to share high quality images and was initially predominantly used by professional photographers. It has diversified and expanded including in terms of who posts about what and from where, with large numbers of images posted by tourists, making it a useful source of data for tourism research (Hausmann et al., 2018; Wilkins et al., 2021). Metadata associated with Flickr images have started to be harnessed in wildlife and nature-based tourism monitoring in a range of countries (Mancini et al., 2018; Monkman et al., 2018; Teles da Mota & Pickering, 2020). The majority of those using Flickr and other image sharing social media platforms are young, wealthy and highly educated (Smith, 2022). By 2018, there were over 10 billion images shared by more than 90 million people from 63 countries (Smith, 2022). Recently, the number of people using Flickr is declining but there were still 14 million images posted per month in 2020 (Michel, 2022). Unlike other platforms, such as Facebook and Instagram, researchers can use Flickr Application Programming Interfaces (APIs) remotely to freely obtain metadata about images such as volunteered geographic information, timestamps and the texts used to tag and describe images (Coleman et al., 2009, Teles da Mota & Pickering, 2020; Wilkins et al., 2021).

Spatio-temporal data from Flickr have been used for landscape management (Dunkel, 2015; Heikinheimo et al., 2020), mapping ecosystem services (Rossi et al., 2020), and assessing nature-based tourism at global (Hausmann et al., 2019), continental (Teles da Mota et al., 2022), national (Heikinheimo et al., 2017) and regional scales (Rossi et al., 2020). Flickr data have also been used to show which species and places tourists value (Hausmann et al., 2018; Willemen et al., 2015). Flickr data have been a useful proxy for the relative popularity of national parks (Tenkanen et al., 2017) and species (Hausmann et al., 2018; Mangachena & Pickering, 2021a; Willemen et al., 2015). In addition, information from Flickr has been used in combination with data obtained through traditional methods to provide more insights about popular activities (Heikinheimo et al., 2017; Moreno-Llorca et al., 2020), spatial and temporal patterns of visitation (Heikinheimo et al., 2017) and wildlife preferences in national parks (Hausmann et al., 2018).

For South Africa, research using social media to assess nature-based tourism is relatively limited considering the popularity of wildlife and the importance of tourism for the country (Mangachena & Pickering, 2021a; Teles da Mota & Pickering, 2020). Among the very few studies using social media, Hausmann et al. (2018) found that Flickr data were positively correlated with actual visitor data and thus could be used as a surrogate of actual visitation. The study also found that first time international visitors were more likely to post images of large charismatic mammals to social media, but that experienced and local tourists mostly shared images of less known wildlife such as smaller mammals and amphibians (Hausmann et al., 2018). That study in Kruger National Park, along with a broader literature review (Mangachena & Pickering, 2021a), found that tourist preferences for specific species identified in park visitor surveys were correlated with species popularity on Flickr. Although there are studies showing the benefits and limitations of using Flickr data for large scale monitoring of wildlife tourism across land-tenure and time in Africa (Willemen et al., 2015) and in other parts of the world (Lopez et al., 2020; Mancini et al., 2018, 2019), such studies have not been undertaken for South Africa. This despite the benefits that such information would have for tourism, public protected areas, private reserves and wildlife management more generally.

Although there is a high diversity of wildlife in South Africa, only a few mammals (elephant, white and black rhinos, lion, cheetah, giraffe, leopard, zebra, buffalo, hippopotamus, hyena and African wild dog) are very popular with tourists (Mangachena & Pickering, 2021a). These are among the only species regularly listed as the most popular in visitor surveys (Arbieu et al., 2017; Di Minin et al., 2013; Grünewald et al., 2016; Hausmann et al., 2018; Kerley et al., 2003; Lindsey et al., 2007; Maciejewski & Kerley, 2014), online marketing (Castley et al., 2013), social media (Hausmann et al., 2018) and wildlife auctions (Dalerum & Miranda, 2016).

The aim of this study was to assess if Flickr metadata could be used to understand spatial and temporal patterns in wildlife tourism encounters across land-tenures for the most popular wildlife species in South Africa and how people feel about such encounters. Our specific objectives were to identify i) spatial hot spots and cold spots of wildlife tourism across different land-tenures, ii) when tourists encounter wildlife, iii) what tourists valued, and iv) how they felt about their encounters using

methods that can be easily replicated by park agencies. We predicted that protected areas (Hausmann et al., 2018), particularly Kruger National Park (Ferreira & Harmse, 2014; Kruger & Saayman, 2010) would be hot spots and that species popularity may differ among land-tenures (Mangachena & Pickering, 2021a). We also expected that engagement with wildlife would occur throughout the year, but, mostly in dry seasons (Mancini et al., 2018), holidays and weekends when people have more time available for leisure. We further expected that tourists tend to share experiences they value (Rossi et al. 2019), and hence would mainly express positive feelings about their encounters. Based on our findings, we provide recommendations for how to improve wildlife tourism in South Africa.

2. Methods

2.1. Study area

South Africa (30.5595° S, 22.9375° E) is a large country (~1,220,000 km^2) with well-developed tourism infrastructure as well as high biodiversity (Driver et al., 2005). Much of this biodiversity is found in protected areas, consisting of public and private protected areas that cover ~9.2% of the country (UN-WCMC, 2018). Public protected areas include 20 national parks that are managed by the South African government through the South African Parks (SANParks) agency and one that is managed by the North-West Parks Board as well as 580 nature reserves, while private protected areas are owned by individuals and/or non-governmental organisations (UNEP-WCMC, 2018) and are mostly managed for profit (Di Minin et al., 2013). Wildlife also occurs outside protected areas including on wildlife ranches and farms (Di Minin et al., 2013) and in zoos. Across the different land-tenures, there are 299 mammal, over 850 bird, 363 reptile and 138 amphibian species native to South Africa (IUCN, 2020) with large mammals particularly popular for wildlife tourism (Goodwin & Leader-Williams, 2000; Hausmann et al., 2018; Mangachena & Pickering, 2021a).

Wildlife and other nature-based tourism in government-run protected areas attracted over seven million tourists pre-COVID-19, generating USD$207 million annually and contributing 2.8% to the Gross Domestic Product of the country (SANParks, 2019). In private protected areas, the total value of wildlife tourism amounted to USD $768.4 million (Pasmans & Hebinck, 2017). Most of this income from wildlife tourism is from entrance fees, commercial concessions, animal breeding and auctions (SANParks, 2019). However, like much of tourism globally, wildlife tourism in South Africa was severely affected by COVID-19 pandemic travel bans on international and local tourists (Giddy & Rogerson, 2021). This resulted in massive financial losses of over USD$774 million with entry to public and private parks restricted (Braczkowski & Biggs, 2021; Rogerson & Rogerson, 2020). Although a complete recovery will be difficult, the industry has started to recover with international tourist arrivals in 2022 at 60% of visitors prior to the COVID-19 pandemic (UNWTO, 2022).

2.2. Data collection and cleaning

We collected metadata from images of the 11 most popular species (elephant, white and black rhinos, lion, cheetah, giraffe, leopard, zebra, buffalo, hippopotamus, hyena and African wild dog) from Flickr. There were 392,047 images obtained using the Flickr API and R Studio (R Development Team, 2021) on 15 March 2021 by using a keyword search for all images tagged with the species' common name and the term 'South Africa' (Fig. 1, Table 1). A preliminary image content analysis on a random sample of one hundred images per species carried out using manual methods established a 92% match between what was shown in

Table 1
Details of wildlife encounters in South Africa for 11 species based on data from Flickr.

Species	Images returned by word search	Images geolocated in South Africa	Wildlife-encounter-days (WED)	Number of people posting
Elephant	101,498	20,422	4346	1886
Lion	86,930	13,922	2507	1278
Giraffe	47,060	8663	2702	1416
Zebra	34,395	8124	5809	1298
Leopard	29,563	5305	1416	756
Buffalo	22,843	5154	1423	754
Cheetah	25,825	4841	1023	652
Hippopotamus	16,040	3645	996	614
White Rhino	10,095	2280	709	383
Hyena	9046	2260	655	201
African wild dog	6527	934	274	425
Black Rhino	2225	526	142	99
Total	392,047	76,076	22,002	9762

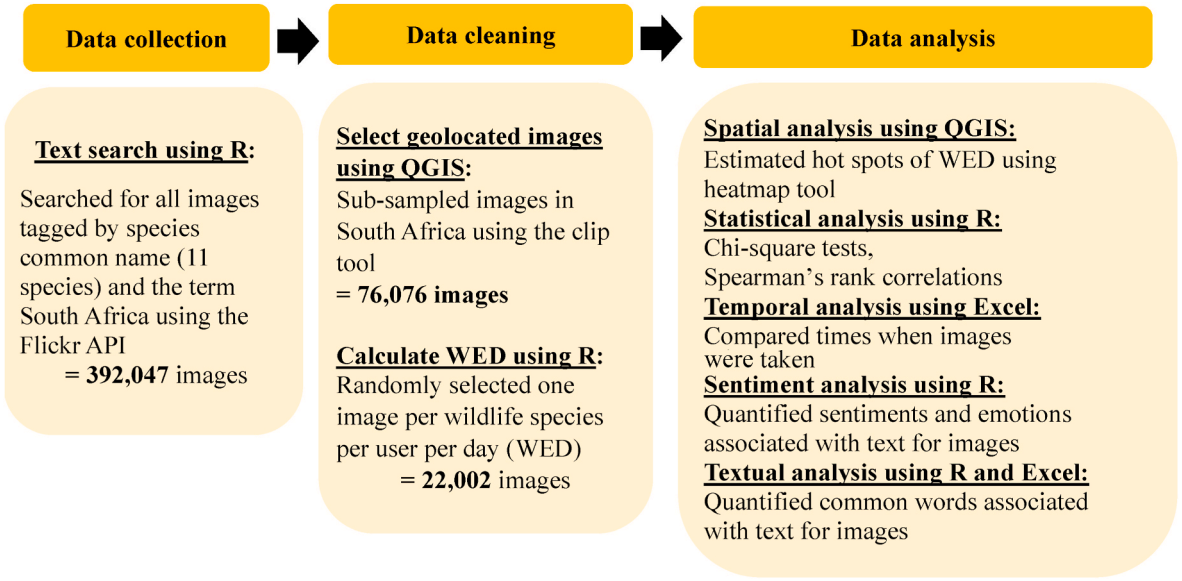


Fig. 1. Details about each of the steps involved in collecting, processing and analysing data from Flickr and the different software used to carry out the procedures. API = Application Programming Interface, WED = Wildlife Encounter Days.

images and the names in the tags. Metadata per image included user identification number, volunteered geographic information of where the image was taken (if provided), date and time when image was taken, title, tags, description and URL link.

After discarding duplicate images and those without geolocations, the remaining images were mapped using QGIS (QGIS Development Team, 2021) with those taken outside South Africa then removed, leaving 76,076 images (Fig. 1). Issues can arise with such data where a few prolific posters dominate when they post many images at the same time and place, and even of the same animal. For South Africa, 19 of the 9762 people posting wildlife encounter images posted at least 100 images each which collectively accounted for 19% of all images (Table 1). Therefore, data were sub-sampled to produce wildlife-encounter-days (WED) by randomly selecting one image per person per day using the *dplyr* function in R Studio (R Development Team, 2021). This is a common approach when using social media data to deal with over representation of some tourists (Wilkins et al., 2021; Wood et al., 2013) and allowed us to control for encounters with different species posted by the same person on the same day. Similar methods have been used in other studies that calculated photo-user-days as estimates of actual park visitation (Wilkins et al., 2021; Wood et al., 2013).

To determine the land-tenures for the remaining 22,002 encounters, we downloaded terrestrial protected areas data for South Africa from the Protected Planet website (UN-WCMC, 2018). Then we used the 'select by features' tool in QGIS to separate encounters from public protected areas, private protected areas as well as encounters outside these areas such as those from zoos, sanctuaries, wildlife ranches and farms. Due to its popularity with wildlife tourists, Kruger National Park was analysed separately from other public protected areas. We excluded biosphere reserves from protected areas as they overlap with cities and other built-up areas. To determine if encounters occurred within the species' geographic ranges, data for each species were downloaded from the IUCN Red List of threatened species (IUCN, 2020) except for hippopotamus and hyena which are currently not listed as threatened.

2.3. Data analysis

To compare patterns in wildlife encounters, we calculated the proportion of images across all land-tenures overall, and then separately for each species, with Chi-square tests and Cramer's V in R used to identify significant differences in encounters among land-tenures (R Development Team, 2021). Previous research has shown how social media data correlate with other measures of park visitation (Ghermandi, 2022; Teles da Mota & Pickering, 2020; Wilkins et al., 2021; Wood et al., 2013) so here the number of wildlife-encounter-days (WED) from Flickr was compared with 2020 actual park visitor data (SANParks, 2020) using Spearman's rank coefficient in R (R Development Team, 2021).

The spatial distribution of encounters – including hot spots for wildlife tourism – were visualised with kernel density estimations using the heatmap tool in QGIS (QGIS Development Team, 2020). Kernel density estimation is a spatial analysis technique that calculates density values for descrete geolocated points and displays them as a smooth continuous image (Silverman, 1986) and has been used to show hot spots for nature-based tourism including using data from Flickr (Kim et al., 2019; Teles da Mota et al., 2022). After testing different kernel radii depending on the number of encounters, we selected a 10 m radius for combined encounters and radii ranging between 10 m and 60 m for encounters with individual species. Based on the kernel radius size, the map layers were then divided into pre-determined grid cells, each fitted with a series of kernels (King 2016). We used the quartic smoothing function to create detailed colour-themed density maps showing hot spots of all images combined and then separately for each species including in relation to land-tenure as well as the species' geographic ranges.

To identify temporal patterns in wildlife encounters, we analysed when images were taken. Values were plotted as spider graphs in Microsoft Excel 2016 to assess trends among seasons/months, weekdays, and hours, for all encounters and each species separately, with Chi-square tests and Cramer's V used identify significant differences in temporal patterns of encounters among species.

Terms used by tourists to describe their wildlife encounters were compared using textual analysis of the words in title, tags and descriptions of the images. First, data were pre-processed using the Tidytext package in R (Silge & Robinson, 2016; R Development Team, 2021) which entails replacing all uppercase characters with lowercases, removing special characters, connecting and stop words as well as finding word stems. Words with similar meanings such as 'jaw' and 'teeth' or 'predator' and 'carnivore' were merged after which frequencies of the most common words (unigrams) were obtained for all encounters collectively and for elephant, white and black rhinos, lion, cheetah, giraffe, leopard, zebra, buffalo, hippopotamus, hyena and African wild dog separately using *dplyr* in R (R Development Team, 2021).

Emotions expressed about encounters were examined using sentiment analysis of all English words in title, tags and description for the images of each species. This involved coding the text with the 'nrc' function 'syuzhet' package in R (Jockers, 2017; R Development Team, 2021) that utilizes the National Research Council of Canada's lexicon of sentiments (positive, negative) and emotions (anger, fear, anticipation, trust, surprise, sadness, joy and disgust) associated with over 14,000 English words (National Research Council Canada, 2019). The lexicon has been used to analyse sentiments and emotions in a wide range of texts (National Research Council Canada, 2019). The text associated with an image may contain several words relating to specific emotions and/or sentiments resulting in values of greater than one for some images. Data were graphed in Excel to show specific sentiments and emotions expressed. Chi-square tests and Cramer's V in R were then used to determine any significant differences in sentiments and emotions among species (R Development Team, 2021).

3. Results

There were many encounters with wildlife across South Africa posted on Flickr, with a total of 22,002 wildlife-encounter-days (WED) for the 11 species (Table 1). Encounters varied among species ($\chi^2_{(11)} = 17988$, $p < 0.05$, Cramer's $V = 0.5$) with encounters with zebra (26%) and elephant (20%) most often seen on Flickr, while giraffe (12%) and lion (11%) had moderate numbers of encounters. Buffalo (6%), leopard (6%) and cheetah (5%) had fewer encounters on Flickr while black rhino and African wild dog were far less likely to be encountered and/or have images on Flickr (Table 1).

3.1. Where do people encounter wildlife?

As was expected, nearly all encounters (84%) were in some type of protected area (Fig. 2), with 33% in Kruger National Park (Kruger) alone. For the remaining 633 public protected areas, images were taken in 124 of them, but mainly Addo (5%), Hluhluwe-Umfolozi (5%), Pilanesberg (4%), Mountain Zebra (3%), and iSimangaliso Wetland Park (2%). Similarly, although there are >900 private protected areas, images were taken in just 70, with Sabi Sands located adjacent to Kruger with the most images (6%). Images were also taken outside of protected areas including in zoos, sanctuaries, wildlife ranches and farms.

The spatial distribution of encounters varied among species, including the proportion of encounters across land-tenures ($\chi^2_{(43)} = 2664.8$, $p < 0.05$, Cramer's $V = 0.5$; Fig. 2). Most encounters with large mammals including buffalo (47%), elephants (37%), giraffe (37%) and hippopotamus (31%) were in Kruger, but less so for cheetah (17%) and black rhino (16%). Some carnivores such as hyena (55%), African wild dog (51%), leopard (39%) and lion (30%) were also commonly seen and photographed in Kruger. In public protected areas, zebra (34%), white (29%) and black (28%) rhinos, elephant (28%), hippopotamus (25%), buffalo (20%) and giraffe (20%) were the most common wildlife posted,

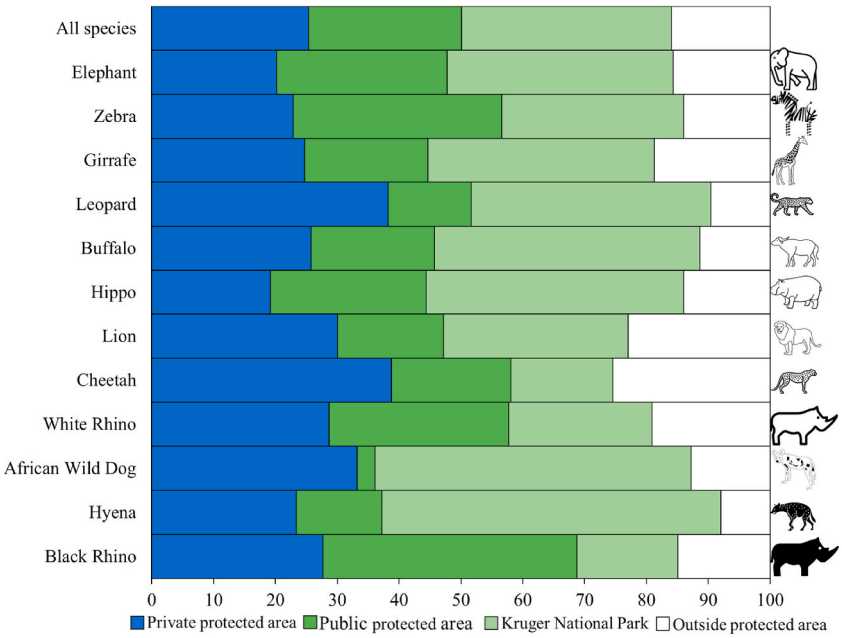


Fig. 2. Proportion of Wildlife Encounters Days (WED) for all 11 species combined and then separately for each species in private and public protected areas including in Kruger National Park and outside protected areas. Hippo = Hippopotamus.

Table 2
Differences in wildlife encounters in National Parks as a proportion of encounters per species across South Africa with ●50%, ● 41–50%, ● >31–40%, ● 21-30%, ● 11–20%, and ● < 10%. Blanks = species absent from the park, while X = no Flickr images of the species although present in the Park. Hippo = Hippopotamus. This table is based on Flickr images, noting that images from some parks were tagged with names of species which do not occur in the parks resulting in data not matching the species' geographic ranges.

	Elephant	Zebra	Giraffe	Leopard	Buffalo	Hippo	Lion	Cheetah	White rhino	African wild dog	Hyena	Black rhino
Kruger	●	●	●	●	●	●	●	●	●	●	●	●
Pilanesberg	●	●	●	●	●	●	●	●	●	●	●	●
Addo	●	●	●	●	●		●		●		●	●
Marakele	●	●	●	●	●	●	●		●		●	●
Mountain Zebra	●	●	●	●	●		●	X			X	●
Kgalagadi	●		●	●	●		●	●			●	
Golden Gate		●	●	●				●			●	
Mokala	●	●	●	●	●				●		X	X
Mapungubwe	●	●	●	X	●		●	X	X	X	X	
Agulhas		●	●	●	●	●						
Augrabies	●	●	●	●							●	
Camdeboo	●	●		●	●							
Garden Route	●		●	●	●							
Bontebok		●	●	●								
Richtersveld	●		●	●								
Table Mountain		●		●				●				
Karoo		●		●			●				X	X
West Coast		●										
Tankwa Karoo							●					

but less so for hyena (14%) and African wild dog (3%). Species more likely to be encountered in private protected areas included cheetah (39%), leopard (38%) and lion (30%), unlike elephant (20%) and hippopotamus (19%). In zoos, wildlife ranches, farms and sanctuaries, white (19%) and black (15%) rhinos as well as cheetah (25%), lion (23%) and leopard (10%) were also encountered, but less so for hyena (8%) (Fig. 2).

A total of 10,498 (47%) images were from public protected areas but some national parks were more popular than others ($\chi^2_{198)} = 25399$, $p < 0.05$, Cramer's $V = 0.4$), while WED were not correlated with actual visitation data per park (Spearman's rho = 0.3, p = 0.2). Elephant, zebra, giraffe, buffalo, hippopotamus, lion and leopard were photographed in some major parks, but not hyena despite also occurring in many of the same parks. Based on the Flickr metadata, Kruger, Pilanesberg and Addo Elephant were popular places for images of elephant, buffalo, both species of rhinos, giraffe, zebra, lion, leopard and cheetah (Table 2). The number of encounters with many species was lower in Mountain Zebra, Marakele and Kgalagadi National Parks despite quite

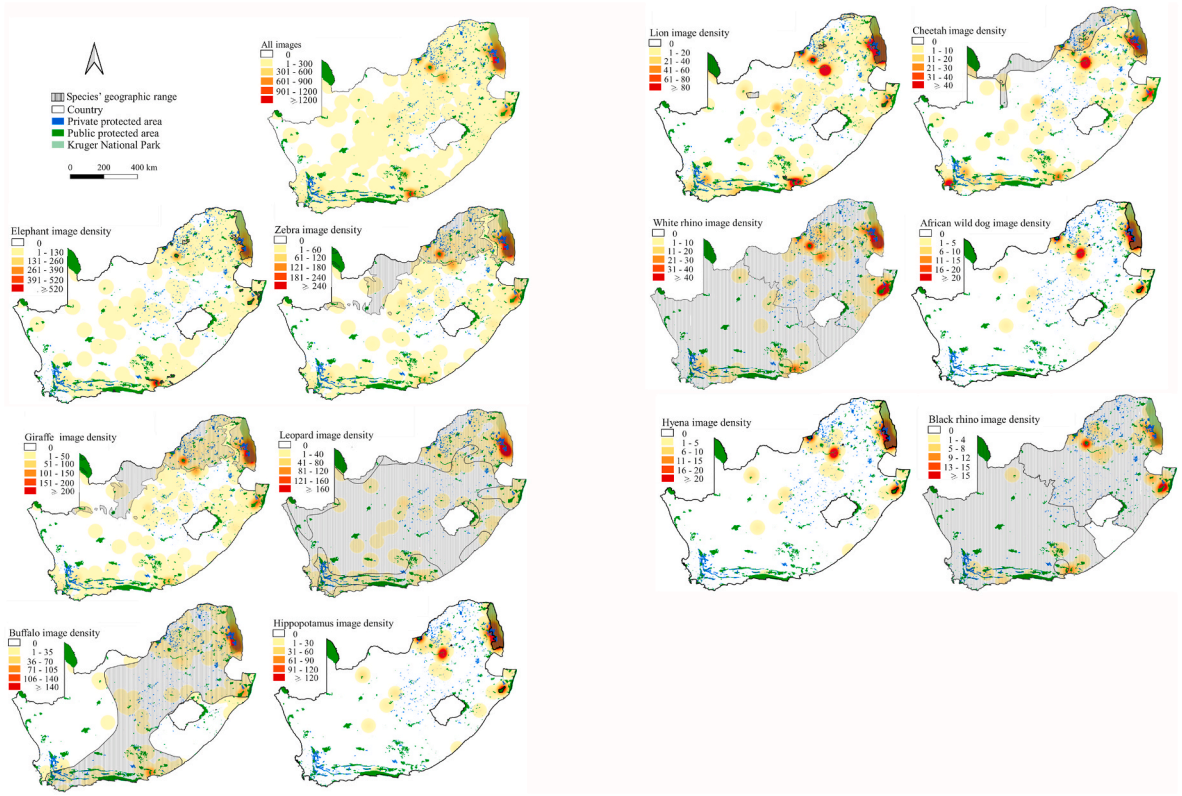


Fig. 3. Spatial distribution of WED across South Africa for all 11 species combined and then separately for each species based on geolocated images from the social media platform Flickr. Species geographic range data were sourced from the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (https://www.iucnredlist.org) and Protected area data were downloaded from Protected Planet (World Conservation Monitoring Centre [UNEP-WCMC]) site (https://www.protected planet.net/).

high visitation to these parks and the presence of most of the species. Based on Flickr data, there were few wildlife encounters in Mokala and Mapungubwe. Although some popular species occur in these parks, there were no encounters on Flickr for cheetah, leopard, hyena and African wild dog in those parks. Agulhas, Richterveld, Bontebok, Camdeboo, Augrabies, Tankwa Karoo and Karoo are generally not popular with visitors and had low numbers of wildlife encounters overall, but where there were Flickr images for these parks, they were mostly of zebra (Table 2). Total wildlife-encounter-days were also low for Table Mountain, West Coast and Garden Route National Parks, which although very popular for visitation, contain few of these species.

3.2. Where are the hot spots of wildlife encounters?

Although images were broadly spread across South Africa, there were clear hot spots in national parks, mainly Kruger, Pilanesberg, Addo Elephant and areas close by (Fig. 3). Spatial distribution and the density of images varied among species, with hot spots for elephants highly concentrated while zebra and giraffe encounters were more widely distributed (Fig. 3). Hippopotamus and buffalo encounters were widely distributed but at lower densities. Of the large cats, there were fewer leopard hot spots than for lion and cheetah although the density of images was higher. For rhino, white rhino encounters were more dispersed and at higher density than encounters with black rhino. African wild dog and hyena encounters were localised and at low densities (Fig. 3).

3.3. When do people encounter wildlife?

Overall, there were wildlife encounters all year, but most encounters were in late winter in August until spring in October (Fig. 4). However, there were temporal differences among species with few encounters with hippo, black rhino, leopard and hyena from the beginning of summer in November until May, with a slight increase in February and March. There were more encounters in February and March for black rhino and hyena (Fig. 4) while for buffalo, white rhino and African wild dog it was mainly November until January and then July, which contrasted with elephant, zebra, giraffe, lion and cheetah with limited seasonal variation. Although encounters were mainly on weekends, black and white rhinos, hippo and leopard were also encountered and photographed during weekdays (Fig. 4). Encounters were mainly either early in the day or late afternoon, the most common times for safaris and also when animals are active with few encounters in the middle of the day or at night (Fig. 4).

3.4. What words do people use to describe their wildlife encounters?

A wide range of words were used to describe wildlife encounters with 28,790 unique words across all tags, titles, and descriptions of images. People mostly captioned images of leopard (13%), lion (12%), elephant (10%) and white rhino (10%) with fewer words used for black rhino (3%), African wild dog (5%) and hyena (5%). Across all species, the most frequent words were geographical locations such as 'Africa', 'South Africa', 'Kruger' and 'park' (Table S1). Words such as 'KwaZulu', 'Natal' and 'Cape' were frequently used for encounters with rhinos and buffalo, 'sanctuary' for cheetah, 'zoo' for African wild dog, while 'lodge' and 'reserve' were common for most species. Apart from Kruger, other protected areas often referred to include Addo, Hluhluwe-Umfolozi, St Lucia, Sabi Sands and Arathusa particularly for images of elephant, the rhinos and leopard (Table S1). Besides locations, words such as 'animal', 'mammal', 'wildlife' and names of species were frequently used. The word 'elephant' was mentioned 15,067 times with 'zebra' (11,673) and

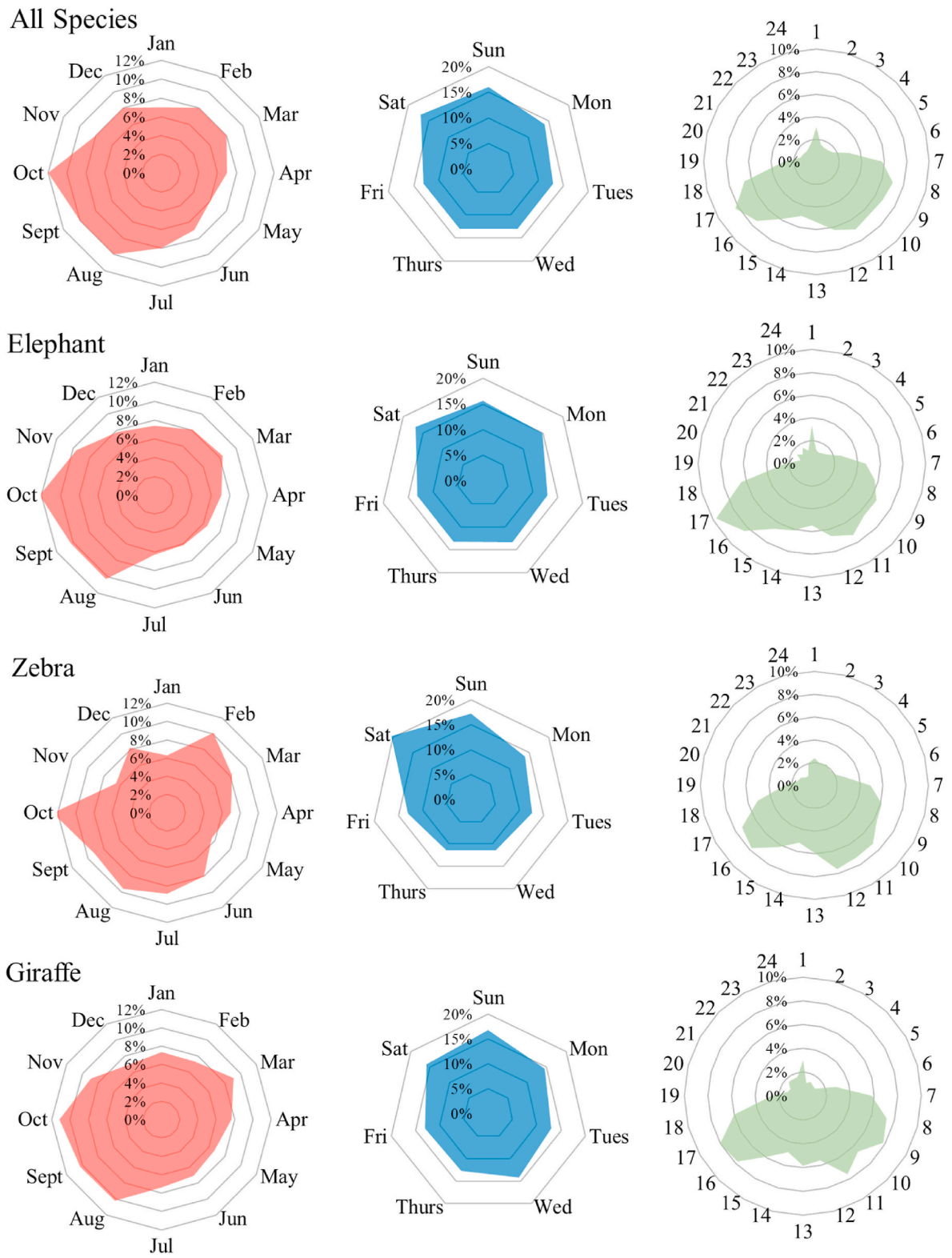


Fig. 4. Temporal patterns in WED across months, days and hours for all 11 species combined and then separately for each of species based on data from Flickr.

'lion' (10,112) also common, while 'hyena' (2015) and 'African wild dog' (2303) were less mentioned. Other animals commonly mentioned included 'birds' and 'crocodiles'. Words relating to natural features such as 'mountain', 'landscape', 'lake', 'water', 'tree', 'river', forest' were also common along with tourism terms such as 'travel', 'safari' and 'game'.

3.5. How do people feel about wildlife encounters?

Text associated with the images indicate that people felt more positive (69%) than negative (31%) about their encounters, although sentiments differed among species ($\chi^2_{(11)} = 6293.5$, $p < 0.05$, Cramer's V = 0.2). Positive sentiments were more often expressed about leopard

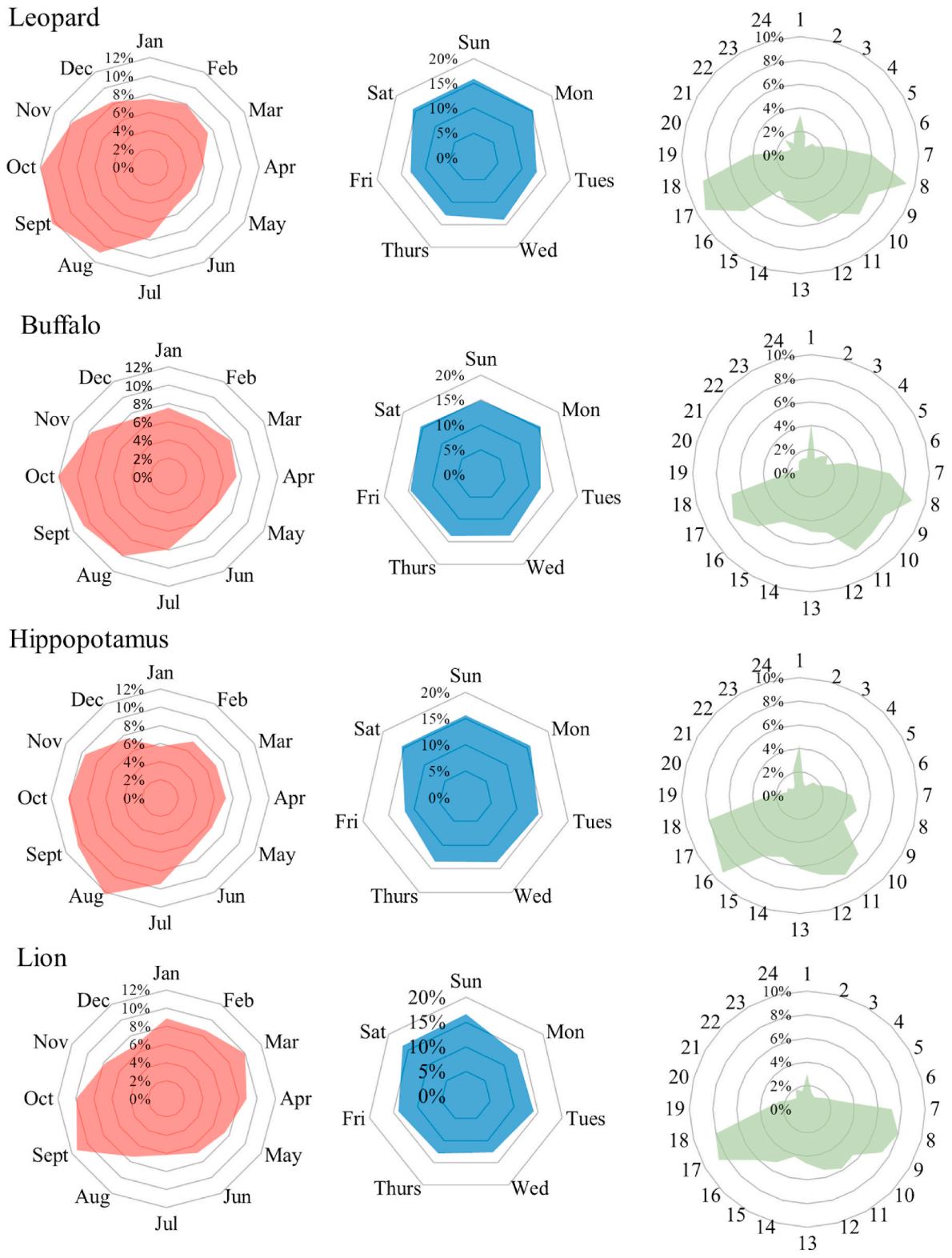


Fig. 4. (*continued*).

(14%), lion (13%), elephant (11%), zebra (11%) and white rhino (10%) than other species (Fig. 5). Emotions also differed among species ($\chi^2_{77)} =$ 106298, $p < 0.05$), with trust (20%), joy (19%) and anticipation (17%) often expressed about leopard, lion, cheetah, elephant, white rhino, giraffe or zebra (Fig. 5). Trust, joy and anticipation were often associated with words such as 'conservation', 'drinking', 'waterhole', 'family', 'calves', 'defend' and 'breeding'. Positive sentiments were also associated with activities such as vacation, holiday, outdoors, fun, sunset, safari, view and landscape. Fear (12%) was more common for images of lion (15%), leopard (13%), elephant (11%), buffalo (9%) and white rhino (9%) (Fig. 5). Although some people expressed sadness (9%), they rarely expressed disgust (6%) or anger (6%). Negative sentiments were associated with terms such as 'wild', 'fight', 'kick', 'dead', 'kill', 'poach', 'horn', 'threat', 'extinct' and 'danger'. No sentiments were

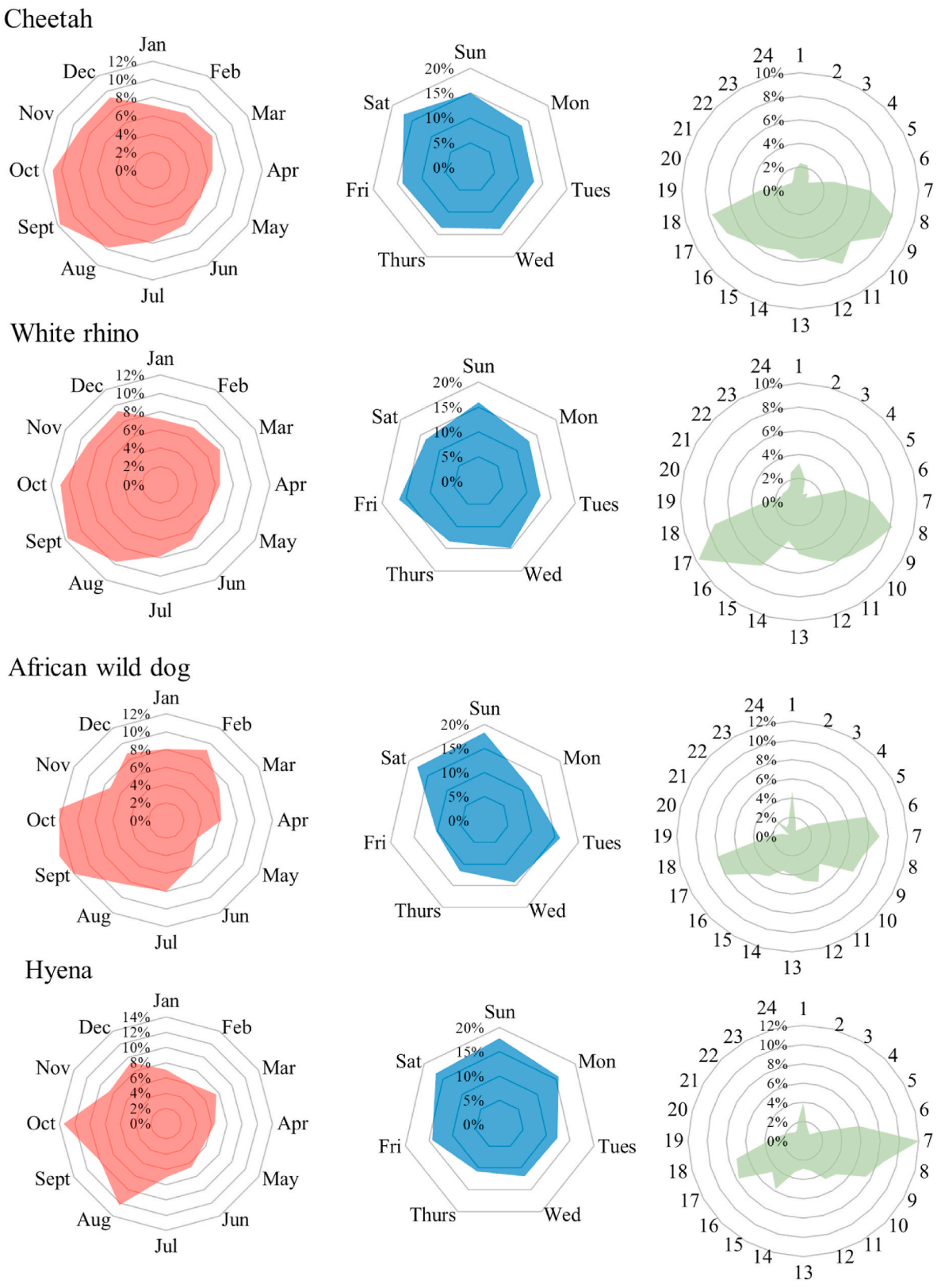


Fig. 4. (*continued*).

associated with images that only mentioned geographical locations.

4. Discussion

On Flickr there were images of wildlife encounters across most of South Africa, but mostly in a few prominent large national parks, particularly Kruger, but also Addo and Pilanesberg. The total number of encounters, and specific hot spots varied among species, in part reflecting species' geographic distributions and their relative popularity. When species were encountered appears to reflect both when people

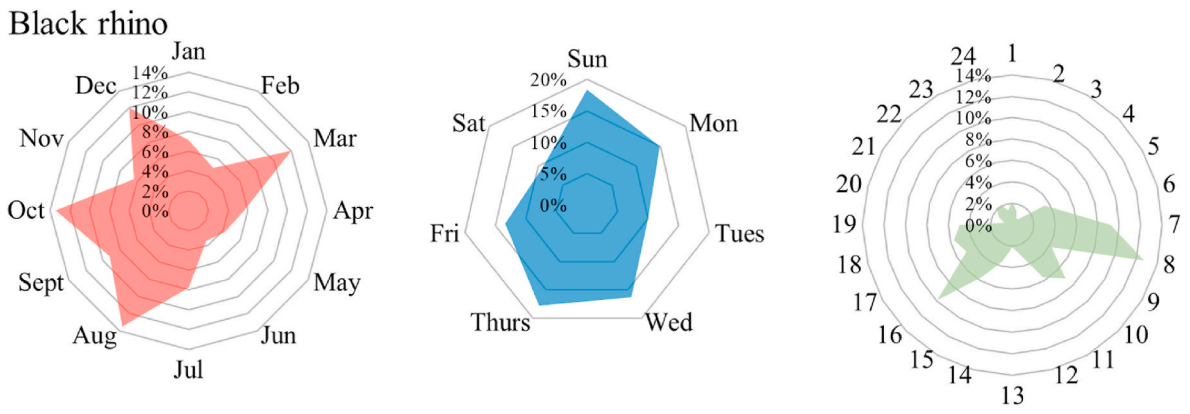


Fig. 4. (*continued*).

were most likely to be viewing wildlife, as well as when species were most likely to be easily seen. People often tagged images with information about which species they encountered, where and their experiences as tourists, often expressing trust, joy and anticipation. While other studies have examined the relative popularity of different species for wildlife tourism in South Africa (Hausmann et al., 2018; Mangachena & Pickering, 2021a; Willemen et al., 2015), our results show where and when some tourists went to view specific species and how they feel about their encounters. The results again highlight the importance of protected areas for wildlife tourism in South Africa and how wildlife encounters are shaped by the availability, visibility and desirability of specific species.

4.1. Determinants of spatio-temporal patterns of wildlife encounters in South Africa

Species popularity is affected by traits associated with visibility such that species distributions, abundance, size and behaviour all influence where and when people encounter and photograph them (Castley et al., 2013; Correia et al., 2016; Garnett et al., 2018; Macdonald et al., 2015; Mangachena & Pickering, 2021a). For instance, zebra and elephant, which were the most frequently encountered and/or photographed species in our study, are widely distributed across South Africa including in most national parks. In addition, they tend to occur in large herds in open vegetation and are active during daytime (Willemen et al., 2015; Winterbach et al., 2015), making it easy to see and photograph them. Species popularity is also determined by a range of factors such as presence of body hair, body and facial markings, bright or multiple colours, being a carnivore, dangerous to humans, threatened or rare (Correia et al., 2016; Fancovicova et al., 2022; Macdonald et al., 2015; Willemen et al., 2015). Hence, it was likely that wildlife tourists would want to photograph elephant, lion, giraffe, leopard and cheetah and share these images on social media. Although rhinos attract a lot of public attention, the low number of images available on Flickr for critically endangered black rhinos as well as near-threatened white rhinos could possibly be due to concerns surrounding the release of geotagged images onto social media (Di Minin et al., 2018). In addition, volunteered geographic information can be employed for tracking and monitoring wildlife populations for conservation, but also increases the risk of poaching and/or illegal trade (Di Minin et al., 2018). African wild dog also had few images although they are endangered, reinforcing previous findings from surveys where there was a lack of interest in this species by tourists in South Africa's protected areas (Mangachena & Pickering, 2021a). Most encounters with the African wild dog were also outside the species' natural geographic range, and included encounters in private protected areas, wildlife ranches and farms as well as in zoos, highlighting the importance of such locations for wildlife tourism (Gusset et al., 2008).

The large number of images of wildlife encounters on Flickr reflect the popularity of some species for tourism in South Africa. This adds to previous research using surveys and other measures of species' popularity, where large mammals were shown to be particularly important for wildlife tourism (Hausmann et al., 2018; Mangachena & Pickering, 2021a). Although some nature-based tourists prefer viewing landscapes and plants, larger wild mammals are often a must-see for both international and local visitors to South African parks (Castley et al., 2013; Di Minin et al., 2013; Lindsey et al., 2007) with tourists preferring to visit parks with high animal species richness, as this heightens their chance of encountering wildlife (Siikamäki et al., 2015). Both public and private protected areas were popular for wildlife viewing, accounting for over half of all the encounters on Flickr. Several national parks in South Africa contain iconic species such as the 'big five' (SANParks, 2019), contributing to their popularity. In addition, private protected areas often stock charismatic, but easy to manage species, enhancing opportunities to see wildlife and maximising profits (Di Minin et al., 2013; Maciejewski & Kerley, 2014). Iconic animals not only attract visitors to parks but are also a key part of their experiences with tourists stopping more often and spending longer viewing wildlife such as elephants and lions than other species (Grünewald et al., 2016; Maciejewski & Kerley, 2014; Okello, Manka, & D'Amour, 2008).

That Kruger National Park (Kruger) was the most popular place for wildlife encounters on Flickr was not surprising given it is a flagship national park and a magnet for wildlife tourism in South Africa (Ferreira & Harmse, 2014; Kruger & Saayman, 2010). It is the second most popular national park after Table Mountain, receiving an average of 1.48 million local and international visitors annually prior to the COVID-19 pandemic (SANParks, 2019). Wildlife, particularly charismatic megafauna, are often listed as key attractions in visitor surveys from Kruger (Ferreira & Harmse, 2014; Kruger & Saayman, 2010), and this was similar to the patterns in Flickr image data, with at least 100 images of each of the 11 species from the park. Other factors contributing to Kruger's popularity include accessibility, well-developed infrastructure, diversity of services for day and overnight visitors, and high name recognition including via inclusion on must-visit tourist destinations in South Africa (Kruger et al., 2019; Liang, Kirilenko, Stepchenkova, & Ma, 2020; SANParks, 2020). Within Kruger, there are many lookout points at waterholes as well as relatively open savannah vegetation adjacent to the roads with self or guided drives popular (Liang et al., 2020). In contrast, the other most popular national park in South Africa, Table Mountain, had few wildlife encounters on Flickr. This is not surprising since the park provides other types of nature-based tourism opportunities with few species popular with wildlife tourists found in the park (Hausmann et al., 2020). In addition, there were generally few wildlife-encounter-days (WED) in other popular parks with tourists, but where such parks contained popular species, they were often at lower abundance and hence limited the chances of tourists encountering and

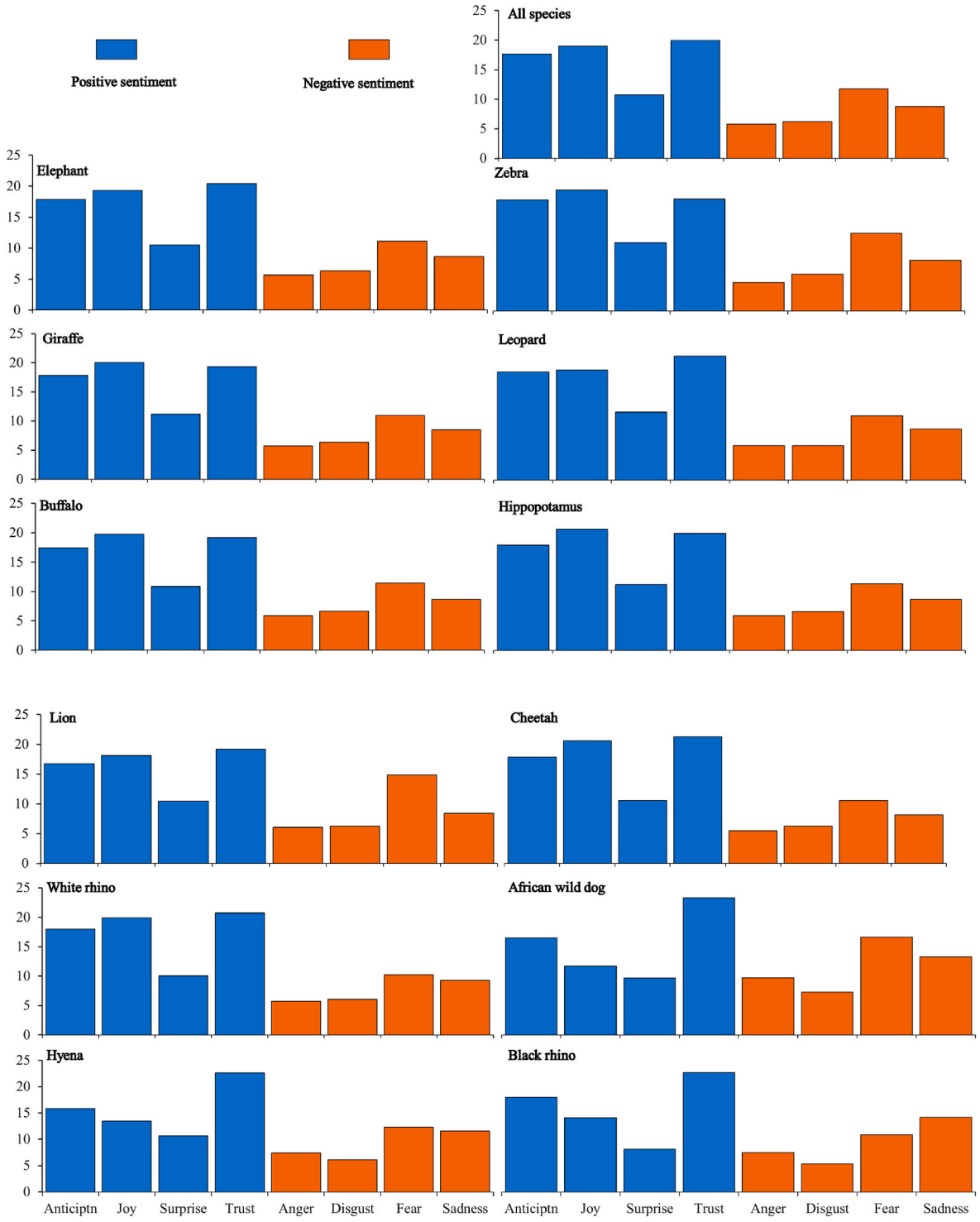


Fig. 5. Sentiments and emotions expressed in text in tags, title and description of images of encounters with all species as well as each of the 11 species wildlife. Anticiptn = Anticipation.

photographing them. These are likely to be part of the reasons there was no significant relationship between wildlife encounters based on Flickr and actual park visitation data.

Temporal patterns in wildlife encounters reflect how the period leading up to the summer rains was the best time for wildlife tourism in African savannahs (Winterbach et al., 2015), with drier conditions and limited surface water often forcing wildlife to congregate at perennial water sources, enhancing opportunities for tourists to see and photograph them (Okello, D'Amour, & Manka, 2008). In contrast, in summer, many of the most popular species remain hidden in the denser undergrowth during the day, climatic conditions are less comfortable for tourists (Okello, Manka, & D'Amour, 2008) and road access in many parks can be challenging. Although encounters across all land-tenures were generally lower in summer, tourists still encountered wildlife in parks such as Table Mountain and West Coast that have dry summers, private protected areas and in zoos, sanctuaries and wildlife farms. Unlike public protected areas, tourists can see wildlife with less effort in private protected areas where particularly popular species are stocked in

higher densities in relatively confined areas, with species dispersal often restricted by fencing (Di Minin et al., 2013; Maciejewski & Kerley, 2014). Although temporal viewing patterns differed among species, the patterns also reflect when people were most likely to be able to participate in tourism with peaks in February but also in March then from August until October coinciding in part with South African school holidays as well as Europe's long holiday seasons (Ferreira & Harmse, 2014). Similar patterns have been observed where other types of nature-based tourism are more popular on weekends and major holidays (Teles da Mota et al., 2022). In addition, encounters in public protected areas were greater on weekends, potentially reflecting visitation by South Africans whilst encounters in private protected areas were more consistent throughout the week, probably reflecting international tourism to these more expensive destinations (Di Minin et al., 2013; Ferreira & Harmse, 2014). The popularity of early morning and late afternoon for wildlife viewing could reflect favourable weather conditions for tourists and wildlife unlike the middle of the day when its hotter (Kerley et al., 2003). Night-time encounters were rare, which may reflect limitations on tourists moving around at night in many national parks (Kerley et al., 2003) and difficulties in taking good images at night, but these still were seen in some private protected areas (Di Minin et al., 2013).

4.2. Relevance of textual metadata accompanying images

Tourists used a diversity of terms to describe their encounters with wildlife and where they occurred. Often people tag images on social media using terms relating to specific places and types of nature to assist others to find images (Rossi et al. 2019). The frequency with which some experiences, places or species are mentioned in text posted with images can provide additional insights into tourists' preference, information that may not be apparent in visual representations alone (Hausmann et al., 2019) including explaining why people desire and value certain species over others (Rossi et al. 2019). In other instances, texts can reflect tourists concerns about species' safety as well as conservation programmes and activities they support (Hausmann et al., 2020). For the images of South African wildlife on Flickr, mountains, rivers and forests were mentioned showing that aside from wildlife viewing, tourists are also interested in, and value, a range of nature-based tourism attractions. Image text also provide insights into how tourists feel about their experiences (Hausmann et al., 2020). For South African wildlife on Flickr, encounters triggered different sentiments, although they were mostly positive. This included sentiments when encountering charismatic, well-known species, such as lion, that many tourists view with affection (Mangachena & Pickering, 2021b), but also negative sentiments when tourists perceive the animal as dangerous and/or when the species is threatened (Macdonald et al., 2015). Positive sentiments reflect a high public regard for wildlife and management may take advantage of such attitudes to garner further support for conservation (Correia et al., 2016). Furthermore, people often expressed positive emotions about breeding and other conservation programmes, while illegal activities such as poaching brought about negative feelings in national parks (Mangachena & Pickering, 2021b). Our results again highlight the importance of nature for human health where outdoor activities often are associated with enhanced well-being (Buckley et al., 2019; Mnisi et al., 2021).

4.3. Management implications and recommendations

Monitoring where and when people view animals, which species they encounter and how they feel about their experiences can reveal spatial and temporal hot spots among and within species: information that is important for managing and promoting wildlife tourism. The data from Flickr used here and results from other studies show how wildlife tourism opportunities could be expanded by marketing lesser-known destinations, species and times (Ferreira & Harmse, 2014; Mancini et al., 2018; Mangachena & Pickering, 2021a). For example, although Kruger is a wildlife tourism flagship destination, many of the popular species also occur in other national parks such as Addo, Mountain Zebra, Marakele, Mokala and Mapungubwe. Promoting wildlife tourism in more parks in South Africa could spread the economic benefits to additional local communities, something seen as key to South African national parks. However, rapid increases in tourism including as a result of online content on social media, can overwhelm local resources resulting in negative impacts on the environment, infrastructure and amenities (Wengel et al., 2022). For some parks, the low number of WED compared to actual visitation is likely to reflect the availability of a range of nature-based tourism attractions other than wildlife (Di Minin et al., 2013; Hausmann et al., 2020; Lindsey et al., 2007; Mangachena & Pickering, 2021b).

Managers could also use off-season marketing, highlighting other wildlife opportunities when destinations are less crowded and potentially less expensive to visit (Mancini et al., 2018). Such interventions may be less effective in some locations where there is risk of adverse weather conditions during off-season periods (Scholtz et al., 2015). Marketing repeat visitation could also be useful, focusing on different species with more experienced tourists who are often interested in greater diversity and/or different landscapes and species (Di Minin et al., 2013; Lindsey et al., 2007). Spreading wildlife tourism opportunities can also minimise negative impacts on wildlife associated with overcrowding and noise (Ferreira & Harmse, 2014; Okello, D'Amour, & Manka, 2008). Such campaigns have been successful including targeting specialised high-income tourists with interest in specific species such as bird tourists (Lindsey et al., 2007). Promoting interesting backstories and characteristics of less well-known species can also increase peoples' desire to see and conserve species, which can both enhance tourism opportunities and support for conservation (Richardson & Hogan, 2018).

4.4. Advantages and disadvantages of using social media data for wildlife tourism monitoring

This study illustrates how openly available social media metadata that can be accessed remotely, can provide insights into patterns of wildlife tourism across large spatial and temporal scales. Volunteered geographic information associated with images from Flickr highlighted a range of hot spots and cold spots of wildlife encounters in different land-tenures including when and why people participate in wildlife tourism in South Africa. Other studies already confirm how species preferences seen in social media images reflect preference listed by visitors in surveys (Hausmann et al., 2018; Heikinheimo et al., 2017; Mangachena & Pickering, 2021a; Toivonen et al., 2019). Here we go further and illustrate how texts used to describe images can provide insights into visitor experiences including why they visit specific places and how they feel (Rossi et al. 2019; Hausmann et al., 2020), with those tourists posting to Flickr generally positive about their wildlife encounters in South Africa, but also concerned about threats to animals.

Similar to data obtained with other methods, there are important limitations with social media data including using Flickr for wildlife tourism research (Mancini et al., 2018; Teles da Mota & Pickering, 2020). Some limitations with social media data are platform-specific whereby the use of sophisticated computer methods and automated tools makes it difficult to access, clean and analyse geolocated data from large social media datasets (Ghermandi and Sinclair, 2019; Toivonen et al., 2019). Although park agencies could use methods from this study to visualise spatial patterns in geographic information systems, text and sentiment analyses could be challenging to carry out for most protected area personnel. In addition, certain platforms are generally preferred in some countries and by some demographics and are popular for particular types of data (Ghermandi and Sinclair, 2019; Toivonen et al., 2019; Teles da Mota & Pickering, 2020). For instance, Flickr is popular for sharing nature-based images and hence widely used in tourism research

(Walden-Schreiner et al., 2018) but is not the most popular social media platform used by tourists visiting parks in South Africa (Hausmann et al., 2018; Tenkanen et al., 2017). Also, due to issues around ethics and privacy, some platforms such as Instagram and Facebook have put in place barriers to accessing data, but data remain publicly available from Flickr for research (Hausmann et al., 2018).

Despite global spread and broad popularity of the internet and mobile phone use, there are major biases in who uses social media with younger, wealthier and educated people from first world and English-speaking countries more active on social media, including Flickr (Ghermandi and Sinclair, 2019; Toivonen et al., 2019; Teles da Mota & Pickering, 2020). In addition, the risk of only using Flickr data for wildlife tourism monitoring is that some tourists may capture images of encounters and a fraction of them go on to share their experiences onto social media when visiting natural areas such as parks (Teles da Mota & Pickering, 2020), resulting in the content from a few tourists dominating data on the platform, biasing results. In addition, charismatic species were over-represented in our study, and this may reflect the views of inexperienced tourists from abroad, while downplaying the interests of older people and those of locals who can be interested in other types of wildlife (Hausmann et al., 2018). These limitations could be addressed by comparing the experiences of tourists from Flickr against data from other social media platforms and from park surveys as has been done in Kruger (Hausmann et al., 2018). However, there remain limitations on access to data from more popular platforms such as Instagram and major challenges with visitor surveys over large spatial and temporal scales. We also used English terms only to search for Flickr images with the potential of missing images tagged in other languages (Teles da Mota et al., 2022).

Other limitations result from user inaccuracies whereby image content does not correspond with species names used in tags. For instance, in our study, there were several instances where animals such as black and white rhinos, cheetah and leopard as well as African wild dog and hyena were misidentified. There were also errors where images from some parks were tagged with names of species which do not occur in the park, resulting in data about some species not matching the species' actual distribution. One example is that of images name tagged as giraffe and geolocated in parks where the species does not occur (see Table 2). Such issues can arise when people use the same captions for many images on Flickr. In the future, studies could explore using machine learning methods to analyse image content which would identify discrepancies between tags and image content. Use of machine learning methods also mean that it is possible to harness large datasets to obtain information about nature-based tourism (Gosal et al., 2019; Gosal & Ziv, 2020; Runge et al., 2020; Väisänen et al., 2021; Wilkins et al., 2022). Many users also do not post images with geolocation and timestamped information for images on social media (Walden-Schreiner et al., 2018), limiting the use of many images for monitoring spatial and temporal patterns in encounters.

5. Conclusion

Our study illustrates that despite its limitations, geotagged, timestamped images from Flickr and their metadata can be a cost-effective and useful tool, including in middle-income counties like South Africa, to examine wildlife tourism preferences. We found that certain parks and animals were popular while certain times were more favourable for encountering wildlife with tourists generally being positive about their experiences. These findings could inform wildlife tourism management decisions to redistribute tourism pressure from overutilised to underutilised areas. The same methods could also be used to examine tourist interest in other animal groups, which in turn can benefit local communities and wildlife conservation. This study provides baseline information and there is a clear need for future joint research with parks agencies using Flickr data for wildlife tourism management.

CRediT authorship contribution statement

J.R. Mangachena: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **S. Geerts:** Conceptualization, Writing – review & editing. **C.M. Pickering:** Conceptualization, Methodology, Writing – review & editing.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jort.2023.100642.

References

Arbieu, U., Grünewald, C., Martín-López, B., Schleuning, M., & Böhning-Gaese, K. (2017). Mismatches between supply and demand in wildlife tourism: Insights for assessing cultural ecosystem services. *Ecological Indicators, 78*, 282–291. https://doi.org/10.1371/journal.pone.0200565

Barnes, J. I., Schier, C., & Van Rooy, G. (1999). Tourists' willingness to pay for wildlife viewing and wildlife conservation in Namibia. *South African Journal of Wildlife Research, 29*(4), 101–111. https://hdl.handle.net/10520/EJC117083.

Braczkowski, A. R., & Biggs, D. (2021). What COVID-19 travel bans have done to conservation tourism in Africa. https://theconversation.com/what-covid-19-travel-bans-have-done-to-conservation-tourism-in-africa-169324. (Accessed 6 October 2022) Accessed.

Buckley, R., Brough, P., Hague, L., Chauvenet, A., Fleming, C., Roche, E., Sofija, E., & Harris, N. (2019). Economic value of protected areas via visitor mental health. *Nature Communications, 10*(1), 1–10. https://doi.org/10.1038/s41467-019-12631-6

Castley, J. G., Bennett, A., & Pickering, C. M. (2013). Wildlife visual imagery: Do pictures used to promote destinations online match on-site species visibility at two geographic destinations? *Geographical Research, 51*(1), 59–70. https://doi.org/10.1111/j.1745-5871.2012.00767.x

Catlin, J., Hughes, M., Jones, T., Jones, R., & Campbell, R. (2013). Valuing individual animals through tourism: Science or speculation? *Biological Conservation, 157*, 93–98. https://doi.org/10.1016/j.biocon.2012.07.022

Clements, H. S., Kerley, G. I., Cumming, G. S., De Vos, A., & Cook, C. N. (2019). Privately protected areas provide key opportunities for the regional persistence of large-and medium-sized mammals. *Journal of Applied Ecology, 56*(3), 537–546. https://doi.org/10.1111/1365-2664.13300

Correia, R. A., Jepson, P. R., Malhado, A. C., & Ladle, R. J. (2016). Familiarity breeds content: Assessing bird species popularity with culturomics. *PeerJ, 4*, e1728. https://doi.org/10.7717/peerj.1728

Curtin, S. (2010). Managing the wildlife tourism experience: The importance of tour leaders. *International Journal of Tourism Research, 12*(3), 219–236. https://doi.org/10.1002/jtr.747

Dalerum, F., & Miranda, M. (2016). Game auction prices are not related to biodiversity contributions of southern African ungulates and large carnivores. *Scientific Reports, 6*(1), 1–6. https://doi.org/10.1038/srep21922

Di Minin, E., Fink, C. A., Hausmann, A., Heikinheimo, V. V., Slotow, R., Tenkanen, H. T. O., & Toivonen, T. K. (2018). *Can poachers locate rhinoceroses using social media data? Abstract from savanna science network meeting, skukuza.* South Africa: Kruger National Park.

Di Minin, E., Fraser, I., Slotow, R., & MacMillan, D. C. (2013). Understanding heterogeneous preference of tourists for big game species: Implications for conservation and management. *Animal Conservation, 16*(3), 249–258. https://doi.org/10.1111/j.1469-1795.2012.00595.x

Driver, A., Maze, K., Rouget, M., Lombard, A. T., Nel, J., Turpie, J. K., Cowling, R. M., Desmet, P., Goodman, P., Harris, J., & Jonas, Z. (2005). In *National spatial biodiversity assessment 2004: Priorities for biodiversity conservation in South Africa. Strelitzia* (Vol. 17). Pretoria, South Africa: South African National Biodiversity Institute.

Drugova, T., Kim, M. K., & Jakus, P. M. (2021). Marketing, congestion, and demarketing in Utah's national parks. *Tourism Economics, 27*(8), 1759–1778.

Dunkel, A. (2015). Visualizing the perceived environment using crowdsourced photo geodata. *Landscape and Urban Planning, 142*, 173–186. https://doi.org/10.1016/j.landurbplan.2015.02.022

Fairer-Wessels, F. A. (2019). Investigating sustainable development goals, livelihoods and tourism development in a rural protected area: The iSimangaliso Wetland Park, South Africa. In M. T. Stone, M. Lenao, & N. Moswete (Eds.), *Natural resources, tourism and community livelihoods in southern Africa* (pp. 205–217). London: Routledge.

Fancovicova, J., Prokop, P., Repakova, R., & Medina-Jerez, W. (2022). Factors influencing the sponsoring of animals in Slovak zoos. *Animals, 12*, 21. https://doi.org/10.3390/ani12010021

Ferreira, S., & Harmse, A. (2014). Kruger National Park: Tourism development and issues around the management of large numbers of tourists. *Journal of Ecotourism, 13*(1), 16–34. https://doi.org/10.1080/14724049.2014.925907

Garnett, S. T., Ainsworth, G. B., & Zander, K. K. (2018). Are we choosing the right flagships? The bird species and traits Australians find most attractive. *PLoS One, 13* (6), Article e0199253. https://doi.org/10.1371/journal.pone.0199253

Ghermandi, A. (2022). Geolocated social media data counts as a proxy for recreational visits in natural areas: A meta-analysis. *Journal of Environmental Management, 317*, Article 115325. https://doi.org/10.1016/j.jenvman.2022.115325

Ghermandi, A., & Sinclair, M. (2019). Passive crowdsourcing of social media in environmental research: A systematic map. *Global Environmental Change, 55*, 36–47. https://doi.org/10.1016/j.gloenvcha.2019.02.003

Giddy, J. K., & Rogerson, J. M. (2021). Nature-based tourism enterprise adaptive responses to COVID-19 in South Africa. *Geo Journal of Tourism and Geosites, 36*, 698–707. https://doi.org/10.30892/gtg.362spl18-700

Goodwin, H., & Leader-Williams, N. (2000). Tourism and protected areas – distorting conservation towards charismatic megafauna? In A. Entwhistle, & N. Dunstone (Eds.), *Priorities for the conservation of mammalian diversity: Has the panda had its day?* (pp. 257–275). Cambridge: Cambridge University Press.

Gosal, A. S., Geijzendorffer, I. R., Václavík, T., Poulin, B., & Ziv, G. (2019). Using social media, machine learning and natural language processing to map multiple recreational beneficiaries. *Ecosystem Services, 38*, Article 100958. https://doi.org/10.1016/j.ecoser.2019.100958

Gosal, A. S., & Ziv, G. (2020). Landscape aesthetics: Spatial modelling and mapping using social media images and machine learning. *Ecological Indicators, 117*, Article 106638. https://doi.org/10.1016/j.ecolind.2020.106638

Grünewald, C., Schleuning, M., & Böhning-Gaese, K. (2016). Biodiversity, scenery and infrastructure: Factors driving wildlife tourism in an African savannah national park. *Biological Conservation, 201*, 60–68. https://doi.org/10.1016/j.biocon.2016.05.036

Gusset, M., Maddock, A. H., Gunther, G. J., Szykman, M., Slotow, R., Walters, M., & Somers, M. J. (2008). Conflicting human interests over the re-introduction of endangered wild dogs in South Africa. *Biodiversity & Conservation, 17*(1), 83–101. https://doi.org/10.1007/s10531-007-9232-0

Hausmann, A., Toivonen, T., Fink, C., Heikinheimo, V., Kulkarni, R., Tenkanen, H., & Di Minin, E. (2020). Understanding sentiment of national park visitors from social media data. *People and Nature, 2*(3), 750–760. https://doi.org/10.1002/pan3.10130

Hausmann, A., Toivonen, T., Fink, C., Heikinheimo, V., Tenkanen, H., Butchart, S. H., Brooks, T. M., & Di Minin, E. (2019). Assessing global popularity and threats to Important Bird and Biodiversity Areas using social media data. *Science of the Total Environment, 683*, 617–623. https://doi.org/10.1016/j.scitotenv.2019.05.268

Hausmann, A., Toivonen, T., Slotow, R., Tenkanen, H., Moilanen, A., Heikinheimo, V., & Di Minin, E. (2018). Social media data can be used to understand tourists' preferences for nature-based experiences in protected areas. *Conservation Letters, 11* (1), Article e12343. https://doi:10.1111/conl.12343.

Heikinheimo, V., Minin, E. D., Tenkanen, H., Hausmann, A., Erkkonen, J., & Toivonen, T. (2017). User-generated geographic information for visitor monitoring in a national park: A comparison of social media data and visitor survey. *ISPRS International Journal of Geo-Information, 6*(3), 85. https://doi.org/10.3390/ijgi6030085

Heikinheimo, V., Tenkanen, H., Bergroth, C., Järv, O., Hiippala, T., & Toivonen, T. (2020). Understanding the use of urban green spaces from user-generated geographic information. *Landscape and Urban Planning, 201*, Article 103845. https://doi.org/10.1016/j.landurbplan.2020.103845

IUCN. (2020). International union for the conservation of nature red list of threatened species. https://www.iucnredlist.org. (Accessed 13 May 2021) Accessed.

Jockers, M. (2017). Package 'syuzhet' Accessed May 2021 from https://cran.r-project.org/web/packages/syuzhet.

Kerley, G. I., Geach, B. G., & Vial, C. (2003). Jumbos or bust: Do tourists' perceptions lead to an under-appreciation of biodiversity? *South African Journal of Wildlife Research, 33*(1), 13–21. https://hdl.handle.net/10520/EJC117161.

Kim, Y., Kim, C. K., Lee, D. K., Lee, H. W., & Andrada, R. I. T. (2019). Quantifying nature-based tourism in protected areas in developing countries by using social big data. *Tourism Management, 72*, 249–256. https://doi.org/10.1016/j.tourman.2018.12.005

Kruger, M., & Saayman, M. (2010). Travel motivation of tourists to kruger and tsitsikamma national parks: A comparative study. *South African Journal of Wildlife Research, 40*(1), 93–102. https://hdl.handle.net/10520/EJC117327.

Kruger, M., van der Merwe, P., Saayman, M., & Slabbert, E. (2019). Understanding accommodation preferences of visitors to the kruger national park. *Tourism and Hospitality Research, 19*(2), 170–185. https://doi.org/10.1177/1467358417715678

Larm, M., Elmhagen, B., Granquist, S. M., Brundin, E., & Angerbjörn, A. (2018). The role of wildlife tourism in conservation of endangered species: Implications of safari tourism for conservation of the Arctic fox in Sweden. *Human Dimensions of Wildlife, 23*(3), 257–272. https://doi.org/10.1080/10871209.2017.1414336

Leung, Y. F., Spenceley, A., Hvenegaard, G., Buckley, R., & Groves, C. (2018). Tourism and visitor management in protected areas: Guidelines for sustainability. In *Best practice protected area guidelines series* (Vol. 27)Gland, Switzerland: IUCN Accessed April 2022 from https://iucn.oscar.ncsu.edu/mediawiki/index.php/Tourism_and_Visitor_ Management_in_Protected_Areas_-_Guidelines_for_Sustainability.

Liang, Y., Kirilenko, A. P., Stepchenkova, S. O., & Ma, S. (2020). Using social media to discover unwanted behaviours displayed by visitors to nature parks: Comparisons of nationally and privately owned parks in the greater kruger national park, South Africa. *Tourism Recreation Research, 45*(2), 271–276. https://doi.org/10.1080/02508281.2019.1681720

Lindsey, P. A., Alexander, R., Mills, M., Romañach, S., & Woodroffe, R. (2007). Wildlife viewing preferences of visitors to protected areas in South Africa: Implications for the role of ecotourism in conservation. *Journal of Ecotourism, 6*(1), 19–33. https://doi.org/10.2167/joe133.0

Lopez, B., Minor, E., & Crooks, A. (2020). Insights into human-wildlife interactions in cities from bird sightings recorded online. *Landscape and Urban Planning, 196*, Article 103742. https://doi.org/10.1016/j.landurbplan.2019.103742

Macdonald, E., Burnham, D., Hinks, A., Dickman, A., Malhi, Y., & Macdonald, D. (2015). Conservation inequality and the charismatic cat: *Felis felicis*. *Global Ecology and Conservation, 3*, 851–866. https://doi.org/10.1016/j.gecco.2015.04.006

Macdonald, C., & Wester, J. (2021). Public understanding of wildlife tourism: Defining terms, harms, and benefits. *Journal of Ecotourism, 20*(2), 198–209. https://doi.org/10.1080/14724049.2020.1817930

Maciejewski, K., & Kerley, G. I. (2014). Understanding tourists' preference for mammal species in private protected areas: Is there a case for extralimital species for ecotourism? *PLoS One, 9*(2), Article e88192. https://doi.org/10.1371/journal.pone.0088192

Mancini, F., Coghill, G. M., & Lusseau, D. (2018). Using social media to quantify spatial and temporal dynamics of nature-based recreational activities. *PLoS One, 13*(7), Article e0200565. https://doi.org/10.1371/journal.pone.0200565

Mancini, F., Coghill, G. M., & Lusseau, D. (2019). Quantifying wildlife watchers' preferences to investigate the overlap between recreational and conservation value of natural areas. *Journal of Applied Ecology, 56*(2), 387–397. https://doi.org/10.1111/1365-2664.13274

Mangachena, J. R., & Pickering, C. M. (2021a). Why are some animals popular with wildlife tourists: Insights from South Africa. *Journal of Ecotourism*, 1–17. https://doi.org/10.1080/14724049.2021.2019261

Mangachena, J. R., & Pickering, C. M. (2021b). Implications of social media discourse for managing national parks in South Africa. *Journal of Environmental Management, 285*, Article 112159. https://doi.org/10.1016/j.jenvman.2021.112159

Meyer, I. (2015). *The impact on visitation and the relative importance of iconic animals as tourist attraction in selected SANParks(Doctoral dissertation*. University of Pretoria.

Michel, F. (2022). Number of public photos uploaded to Flickr. https://www.flickr.com/photos/franckmichel/49788632377/. (Accessed 31 October 2022) Accessed.

Mnisi, B. E., Geerts, S., Smith, C., & Pauw, A. (2021). Nectar gardens on school grounds reconnect plants, birds and people. *Biological Conservation, 257*(1), Article 109087. https://doi.org/10.1016/j.biocon.2021.109087

Moreno-Llorca, R., Méndez, P. F., Ros-Candeira, A., Alcaraz-Segura, D., Santamaría, L., Ramos-Ridao, Á. F., Revilla, E., Bonet-García, F. J., & Vaz, A. S. (2020). Evaluating tourist profiles and nature-based experiences in Biosphere Reserves using Flickr: Matches and mismatches between online social surveys and photo content analysis. *Science of the Total Environment, 737*, Article 140067. https://doi.org/10.1016/j.scitotenv.2020.140067

National Research Council Canada. (2019). Sentiment emotion lexicon Accessed June 2021 from https://nrc.canada.ca/en/research-development/products-services/technical-advisory-services/sen.

Newsome, D., & Rodger, K. (2012). Wildlife tourism. In A. Holden, & D. Fennell (Eds.), *A handbook of tourism and the environment* (pp. 367–380). London: Routledge.

Okello, M. M., D'Amour, D. E., & Manka, S. G. (2008). Tourism attractions and satisfaction of amboseli national park, Kenya. *Tourism Analysis, 13*(4), 373–386. https://www.researchgate.net/publication/233556129_.

Okello, M. M., Manka, S. G., & D'Amour, D. E. (2008). The relative importance of large mammal species for tourism in Amboseli National Park, Kenya. *Tourism Management, 29*(4), 751–760. https://doi.org/10.1016/j.tourman.2007.08.003

Pasmans, T., & Hebinck, P. (2017). Rural development and the role of game farming in the Eastern Cape, South Africa. *Land Use Policy, 64*, 440–450. https://doi.org/10.1016/j.landusepol.2017.03.010

QGIS Development Team. (2019). Quantum geographic information system: Open source geospatial foundation project Accessed June 2021 from https://qgis.org/en/site/.

R Development Team. (2021). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing Accessed June 2021 from http://www.R-project.org/ Accessed June 2021 from.

Richardson, B. J., & Hogan, J. (2018). The 'Remarkable Tasmanian Devil': The aesthetics of persecution and protection. *Alternative Law Journal, 43*(4), 269–274. https://doi.org/10.1177/1037969X18783536

Rogerson, C. M., & Rogerson, J. M. (2020). COVID-19 tourism impacts in South Africa: Government and industry responses. *Geo Journal of Tourism and Geosites, 31*(3), 1083–1091. https://doi.org/10.30892/gtg.31321-544

Rossi, S. D., Barros, A., Walden-Schreiner, C., & Pickering, C. (2020). Using social media images to assess ecosystem services in a remote protected area in the Argentinean Andes. *Ambio, 49*(6), 1146–1160. https://doi.org/10.1007/s13280-019-01268-w

Runge, C. A., Hausner, V. H., Daigle, R. M., & Monz, C. A. (2020). Pan-Arctic analysis of cultural ecosystem services using social media and automated content analysis. *Environmental Research Communications, 2*(7), Article 075001. https://doi.org/10.1088/2515-7620/ab9c33

SANParks. (2019). South African national parks annual report. https://www.sanparks.org/assets/docs/general/annual-report-2019.pdf. (Accessed 10 August 2021) Accessed.

SANParks. (2020). South African national parks annual report. https://www.sanparks.org/assets/docs/general/annual-report-2020.pdf. (Accessed 5 May 2020) Accessed.

Scholtz, M., Kruger, M., & Saayman, M. (2015). Determinants of visitor length of stay at three coastal national parks in South Africa. *Journal of Ecotourism, 14*(1), 21–47. https://doi.org/10.1080/14724049.2015.1023730

Siikamäki, P., Kangas, K., Paasivaara, A., & Schroderus, S. (2015). Biodiversity attracts visitors to national parks. *Biological Conservation, 24*, 2521–2534. https://doi.org/10.1007/s10531-015-0941-5

Silge, J., & Robinson, D. (2016). Tidytext: Text mining and analysis using tidy data principles in R. *Journal of Open Source Software, 1*, 37.

Silverman, B. W. (1986). *Density estimation for statistics and data analysis*. New York: Chapman and Hall.

Smith, C. (2022). *Flickr statistics, user counts, facts and news*. https://expandedramblings.com/index.php/flickr-stats/. (Accessed 6 February 2022) Accessed.

Spenceley, A., Schägner, J. P., Engels, B., Thomas, C. C., Engelbauer, M., Erkkonen, J., Job, H., Kajala, L., Majewski, L., Mayer, M., Metzler, D., Rylance, A., Scheder, N., Smith-Christensen, C., Souza, T. B., & Woltering, M. (2021). *Visitors count! Guidance for protected areas on the economic analysis of visitation.* Paris, France: United Nations Educational, Scientific and Cultural Organization.

Taecharungroj, V., & Mathayomchan, B. (2021). Traveller-generated destination image: Analysing Flickr photos of 193 countries worldwide. *International Journal of Tourism Research, 23*(3), 417–441. https://doi.org/10.1002/jtr.2415

Teles da Mota, V. T., & Pickering, C. (2020). Using social media to assess nature-based tourism: Current research and future trends. *Journal of Outdoor Recreation and Tourism, 30*, Article 100295. https://doi.org/10.1016/j.jort.2020.100295

Teles da Mota, V., Pickering, C. M., & Chauvenet, A. (2022). Popularity of Australian beaches: Insights from social media images for coastal management. *Ocean & Coastal Management, 217*, Article 106018. https://doi.org/10.1016/j.ocecoaman.2021.106018

Tenkanen, H., Di Minin, E., Heikinheimo, V., Hausmann, A., Herbst, M., Kajala, L., & Toivonen, T. (2017). Instagram, Flickr, or Twitter: Assessing the usability of social media data for visitor monitoring in protected areas. *Scientific Reports, 7*(1), 1–11. https://doi.org/10.1038/s41598-017-18007-4

Toivonen, T., Heikinheimo, V., Fink, C., Hausmann, A., Hiippala, T., Järv, O., Tenkanen, H., & Di Minin, E. (2019). Social media data for conservation science: A methodological overview. *Biological Conservation, 233*, 298–315. https://doi.org/10.1016/j.biocon.2019.01.023

UN-WCMC. (2018). Protected planet report Accessed https://livereport.protectedplanet.net/pdf/Protected_Planet_Report_2018.pdf. (Accessed 21 May 2021).

UNWTO. (2022). UNWTO World tourism barometer Accessed https://www.unwto.org/unwto-world-tourism-barometer-data. (Accessed 6 October 2022).

Väisänen, T., Heikinheimo, V., Hiippala, T., & Toivonen, T. (2021). Exploring human–nature interactions in national parks with social media photographs and computer vision. *Conservation Biology, 35*(2), 424–436. https://doi.org/10.1111/cobi.13704

Valentine, P., & Birtles, A. (2004). Wildlife watching. In K. Higginbottom (Ed.), *Wildlife tourism: Impacts, management and planning* (pp. 15–34). Gold Coast: Common Ground Publishing.

Walden-Schreiner, C., Rossi, S. D., Barros, A., Pickering, C., & Leung, Y. F. (2018). Using crowd-sourced photos to assess seasonal patterns of visitor use in mountain-protected areas. *Ambio, 47*(7), 781–793. https://doi.org/10.1007/s13280-018-1020-4

Wardle, C., Buckley, R., Shakeela, A., & Castley, J. G. (2018). Ecotourism's contributions to onservation: Analysing patterns in published studies. *Journal of Ecotourism*, 1–31. https://doi.org/10.1080/14724049.2018.1424173

Wengel, Y., Ma, L., Ma, Y., Apollo, M., Maciuk, K., & Ashton, A. S. (2022). The TikTok effect on destination development: Famous overnight, now what? *Journal of Outdoor Recreation and Tourism, 37*, Article 100458. https://doi.org/10.1016/j.jort.2021.100458

Wilkins, E. J., Van Berkel, D., Zhang, H., Dorning, M. A., Beck, S. M., & Smith, J. W. (2022). Promises and pitfalls of using computer vision to make inferences about landscape preferences: Evidence from an urban-proximate park system. *Landscape and Urban Planning, 219*, Article 104315. https://doi.org/10.1016/j.landurbplan.2021.104315

Wilkins, E. J., Wood, S. A., & Smith, J. W. (2021). Uses and limitations of social media to inform visitor use management in parks and protected areas: A systematic review. *Environmental Management, 67*, 120–132. https://doi.org/10.1007/s00267-020-01373-7

Willemen, L., Cottam, A. J., Drakou, E. G., & Burgess, N. D. (2015). Using social media to measurethe contribution of red list species to the nature-based tourism potential of African protected areas. *PLoS One, 10*(6), Article e0129785. https://doi.org/10.1371/journal.pone.0129785

Winterbach, C. W., Whitesell, C., & Somers, M. J. (2015). Wildlife abundance and diversity as indicators of tourism potential in Northern Botswana. *PLoS One, 10*(8), Article e0135595. https://doi.org/10.1371/journal.pone.0135595

Wood, S. A., Guerry, A. D., Silver, J. M., & Lacayo, M. (2013). Using social media to quantify nature-based tourism and recreation. *Scientific Reports, 3*(1), 1–7. https://doi.org/10.1038/srep02976

1. Joy R. Mangachena (author for correspondence) is a PhD candidate and researcher with the Environmental Futures Research Institute, Griffith University, Australia. Her research interests include protected area management, tourism and conservation science. Address: Environment Futures Research Institute, Griffith University, Gold Coast Campus, Parklands Drive, Southport, QLD 4222, Australia. e-mail: joy.mangachena@griffithuni.edu.au

2. Sjirk Geerts is an associate professor in the Conservation and Marine Sciences department at the Cape Peninsula University of Technology, South Africa. His research interests include urban ecology, anthropogenic impacts, nature conservation and plant-animal interactions. Address: Department of Conservation and Marine Sciences, Cape Peninsula University of Technology, PO Box 652, Cape Town 8000, South Africa e-mail: geertss@cput.ac.za

3. Catherine Pickering is a professor and researcher in the School of Environment and Science, Griffith University, Australia. Her research interests include ecology, tourism, and protected area management. Address: School of Environment and Science, Griffith University, Gold Coast Campus, Parklands Drive, Southport, QLD 4222, Australia. e-mail: c.pickering@griffith.edu.au