



Research article

The digitalization of outdoor recreation: Global perspectives on the opportunities and challenges for protected area management

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ABSTRACT

The increasing popularity of digital media among protected area visitors poses challenges to protected area management. It alters the way visitors move and behave in the area, potentially increasing disturbance of nature, and it might also affect their expectation prior to the visit and their reflection on it. Simultaneously, digital media allow protected area managers to develop and implement new methods of digital visitor management (DVM). This may help to avoid conflicts and ensure compliance with rules and regulations and may have much further reaching positive consequences. Based on an online survey across 131 parks in 46 countries covering all continents, this study examined for the first time how protected areas view DVM. The results showed that the majority of park managers see digitalization as an opportunity, with 91% agreeing that it enables them to reach larger numbers of visitors and to provide real-time information. The advantage of integrating digital media into visitor monitoring was recognized. However, some park managers perceived digitalization as problematic, with 42% agreeing that it increases visitor load in sensitive areas and 40% agreeing that it leads to more off-trail activity. A clear majority of the respondents (61–91%) saw the proposed methods of DVM as effective or very effective. Accordingly, 70% of them envisioned using DVM in the future. Our findings suggest that the effects of digitalization in outdoor recreation are largely similar across the globe, with no significant influence of economic status or region. They offer insights into the potential of DVM for protected area management, but also its main obstacles. Adoption will be facilitated by increasing staff and funding for DVM. Additionally, knowledge exchange between protected areas can ease the successful implementation of new digital tools.

1. Introduction

In recent decades, digital technologies have found their way into almost every aspect of human activity, transforming the functioning of entire industries and organizations, not to mention the daily life of most individuals (Matt et al., 2019; Reis et al., 2018). Consistent with this global trend, digital technologies are playing an increasingly larger role in outdoor recreation (Anderson et al., 2017; Jepson and Ladle, 2015), as they are used by visitors of protected areas not only for pre-visit planning and inspiration, but also during their visit, for navigation and information purposes, and after their visit, to share their experience on various platforms (Schwietering et al., 2024). For the managers of protected areas, using digital technologies can present opportunities and challenges. On the one hand, digital media can be used to monitor visitor

activity and to deliver information about the area and its rules directly to potential visitors via frequently used platforms (Barros et al., 2021; Wilkins et al., 2020). On the other hand, digitalization might lead to changes in visitor behavior, with negative impacts on the protected area (Arts et al., 2021; Zink et al., 2022). For example, sharing digital content (e.g. photos, text, or route tracks) on social media can promote the use of informal or illegal trails and lead to higher visitor numbers in some areas (Campelo and Nogueira Mendes, 2016; Job et al., 2016; Norman et al., 2019). Increased levels of recreational activities may cause the disturbance of wildlife as well as erosion and loss of vegetation due to trail widening (Kuwaczka et al., 2023; Larson et al., 2016; Salesa and Cerdà, 2020; Wilson et al., 2020). The reliance of visitors on digital tools might also reduce the effectiveness of conventional, non-digital forms of visitor management, similar to the reduced impact of traditional vs. social

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media marketing campaigns and of newspapers vs. online news (Bruhn et al., 2012; Trusov et al., 2009). Nonetheless, for the managers of protected areas, such as national parks, social media and digital media, for instance mobile applications for outdoor and fitness activities (hereafter, outdoor apps), can be actively exploited to improve visitor management. Examples include verifying the information provided on geospatial databases such as OpenStreetMap to ensure that the data used by outdoor apps comply with protected area regulations (Hennig, 2017; Zink et al., 2022). In fact, communicating information about a park or other recreational area via social media is already a widely adopted practice (Miller et al., 2019; Wilkins et al., 2020). In this article, these methods will be referred to as digital visitor management (DVM).

DVM has the potential to extend and enhance visitor management in protected areas, but the impact of the digitalization on outdoor recreation on visitation is unclear (Miller et al., 2019; Zink et al., 2022). Neither the type of DVM tools already in use in protected areas nor their efficacy has been determined. Research conducted thus far on DVM has primarily addressed visitor monitoring (Ghermandi, 2022; Teles da Mota and Pickering, 2020). Several studies showed moderate to high correlations between visitor number determined using data from outdoor apps and trail counter data (Corradini et al., 2021; Horst et al., 2023; Norman and Pickering, 2017; Venter et al., 2020). The use of social media platforms such as Instagram, Flickr, and Twitter by visitors has also been examined (Becken et al., 2017; Heikinheimo et al., 2017). In addition to visitor density in protected areas, topics of interest to park managers include the motivation driving visits to protected area, the socio-demographic backgrounds of visitors, and visitor sentiment. Miller et al. (2019) found that protected area administrations already use social media as part of their visitor management. However, they argue that there is a need for research on the effectiveness of social media use by protected areas. One of the few studies investigating this topic surveyed the communication preferences of national park visitors and concluded that the most effective approach is to use different platforms and publish content optimized for the respective outlet (Wilkins et al., 2020). However, uncertainty remains regarding the impact of digitalization on outdoor recreation in protected areas, especially in terms of visitation, and how protected area managers can best make use of DVM. Both topics were the focus of the present study and they were investigated by surveying the managers of national parks and similar protected areas around the world. According to the International Union for Conservation of Nature (IUCN) national parks are protected areas “managed mainly for ecosystem protection and recreation” (Dudley, 2013). To balance this two-fold purpose, national parks are generally active in visitor management and are therefore more likely to have greater experience with the digitalization in outdoor recreation than smaller protected areas or areas less accessible to the public.

The research questions specifically addressed by our study were:

1. How does the digitalization of outdoor recreation affect park management?
2. What strategies are used by park managers to leverage the digitalization of outdoor recreation to facilitate visitor management?
3. What are the obstacles hindering the adoption of new methods of DVM?

Our methodology consisted of a global online survey in which national park managers were asked about the digitalization of outdoor recreation as well as the opportunities and challenges of DVM. The survey also included items on the perceived effectiveness of DVM, the likelihood that park managers would make use of it in the future, and the potential obstacles that might impede its implementation in national parks.

2. Methods

This study consisted of a cross-sectional survey of how national

parks, as representative protected areas, assess and react to the use of digital tools in outdoor recreation. An online questionnaire was designed and sent to park managers globally.

2.1. Survey design

The survey was designed to acquire information on the attitudes of national park managers regarding the digitalization of outdoor recreation and visitor management. The questionnaire included assessments of new digital-media-based tools of visitor management and services as well as the strategies developed to counteract the negative impacts of digitalization. The survey was available in Chinese, English, French, German, and Spanish. A copy of the questionnaire is provided in the Supplementary Information.

Given the lack of previous research on this topic, most questionnaire items were newly developed for this survey. This was done using input from national park managers and by transferring non-DVM concepts to a digital context. The primary source for the latter were the guidelines for visitor management published by the IUCN (Eagles et al., 2002; Leung et al., 2018). Questions related to DVM tools were also derived from the publications of Zink et al. (2022) and Hennig (2017). The effects of digitalization on outdoor recreation and the potential obstacles to implementing DVM were queried on a five-point (1–5) Likert scale, except for of items regarding the effectiveness of DVM, in which a four-point (1–4) Likert scale was used.

2.2. Sample selection

To ensure the comparability of the sample population, the questionnaire was mainly sent to managers of those protected areas classified as IUCN category II (Dudley, 2013). Only terrestrial national parks >10 km² in size were contacted. Parks were selected based on the World Database on Protected Areas (www.protectedplanet.net). If a country lacked a category II protected area but had a protected area with similar characteristics, it was contacted as well. To increase the outreach of the survey, it was also disseminated via different umbrella organizations such as the EUROPARC Federation, The International Ranger Association, and IUCN regional offices. The survey was designed using the tool www.socisurvey.de and was sent to recipients as an online questionnaire.

Not all national parks feature the same rules and regulations. Depending on their legal framework and the type of landscape preserved within them, access might be more or less restricted such that visitation is likely to follow different patterns. However, in our survey of the general characteristics of the participating parks, we found several similarities, with hiking being frequent in 88% of them, followed by guided group tours (66%) and wildlife observation (61%). Half of the parks had fewer than 0.5 million visitors annually. There were also no significant differences concerning the assessment of digitalization in our survey. Our results can therefore be considered representative of national parks around the world. Nonetheless, the online nature of the survey may have introduced biases towards a greater inclusion of those parks more active in digital media and better acquainted with DVM.

2.3. Statistics

The survey results were analyzed using the R software (R Core Team, 2023) and visualized using the Likert package version 1.3.5 (Bryer and Speerschneider, 2016). The overall rate of agreement across multiple items was measured by computing mean indices for the Likert scales used to query the challenges and opportunities linked to the digitalization of outdoor recreation. Only complete responses were included in the mean computation. This resulted in 120 and 110 observations, respectively, for the items describing opportunities and challenges of the digitalization of outdoor recreation. The mean inter-item correlation was computed using Spearman's rank correlation, as provided in the

performance package version 0.10.3, to test for item redundancy of the scales (Lüdtke et al., 2021; Revelle, 2022).

Pattern in the assessments of the digitalization of outdoor recreation were tested by implementing a non-metric multidimensional scaling (NMDS) analysis of the Likert scales. The output of the NMDS is provided in Supplementary Fig. 1. An analysis of similarities (ANOSIM) was conducted to check for statistical differences in the parks concerning their assessments of the digitalization of outdoor recreation (Supplementary Table 1). For this purpose, the parks were grouped according to their continent and according to the human development indexes (HDIs) of the respective countries for the reference year 2021. Established by the United Nations Development Program, the HDI classifies human development into four categories: low (HDI <0.550), medium (HDI 0.550–0.699), high (HDI 0.700–0.799), and very high (HDI ≥0.800) (United Nations Development Programme, 2022). Differences among the groups in the items of the Likert scales were tested. NDSM and ANOSIM were done using the R package vegan version 2.6–4 (Oksanen et al., 2022).

3. Results

The survey was conducted between September 2022 and May 2023. Managers of 131 national parks in 46 countries from all continents (except Antarctica) completed the questionnaire (Fig. 1). Most participants were managers of protected areas defined according to IUCN category II. One was from a category Ia area and one from an area uncategorized at the time of the survey. The participation of both was included as national parks in the respective countries are currently being established.

3.1. Effects of digitalization

There was a strong consensus regarding the positive aspects of digitalization in outdoor recreation, as indicated by a mean index of 4.1 (SD 0.5) for the answer options *Strongly Disagree* (ranking of 1) to *Strongly Agree* (ranking of 5) (Fig. 3A). The pertinent items mostly referred to novel means of sharing information and reaching out to visitors. A clear majority of the respondents agreed that digitalization

allows them to reach more visitors (91%) and to inform potential visitors about the current conditions in the park (94%). Most participants (85%) also agreed or strongly agreed that digitalization allows them to target specific groups. A large majority (85%) of those surveyed also agreed that, in addition to offering new avenues of communication, digitalization creates new data sources for visitor monitoring.

Challenges related to the digitalization of outdoor recreation received a mean index of 3 (SD 0.7), indicative of less agreement with the items among respondents. That digitalization brings more visitors into sensitive areas and creates more off-trail movement was the opinion of 42% and 40%, respectively. While 39% agreed or strongly agreed that the inability of visitor management to influence the content of social media and outdoor apps poses its own challenges, 49% expressed trust in non-DVM tools and disagreed with the statement that traditional means of visitor management would become less effective due to digitalization. However, 22% agreed with that statement. The item scales for positive and negative items had a mean inter-item correlation of 0.30 and 0.26, respectively, indicating that the items are reasonably homogeneous but possessed enough diversity to avoid being isomorphic with one another (Briggs and Cheek, 1986).

The results from the NMDS did not reveal a strong pattern in the assessment of digitalization (Supplementary Fig. 1). Parks in Africa, Asia, and countries with a lower HDI had slightly lower ratings (Supplementary Fig. 2), although an ANOSIM found no significant HDI-based or continent-based differences (Supplementary Table 1). These findings suggest that the effects of digitalization in outdoor recreation are largely similar across the globe, with little influence of economic status or region.

3.2. The present state of digital visitor management

When asked about specific tools of DVM, managers from the majority of parks rated them as effective or very effective (Fig. 3B). The use of social media to post information was rated as effective by 92%, and the promotion of official trails via the parks' own websites or mobile apps and via general outdoor apps by 89%. The active editing of geographic databases, such as OpenStreetMap, to integrate the rules of national parks was found to be effective by 90% of respondents. It is important to

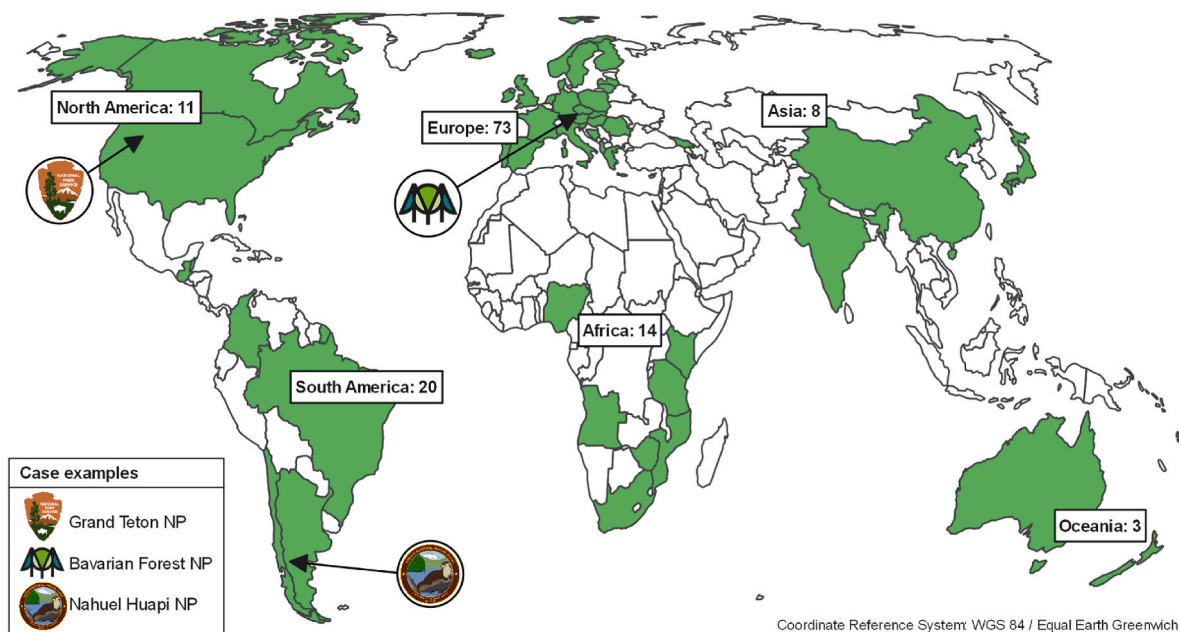


Fig. 1. The countries (indicated in green) of the national parks that participated in the survey. The numbers indicate the number of participating parks per continent. The three parks indicated by their logos served as case examples in the Discussion. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

point out that, regarding this topic, for the four items with the lowest ratings more than a third of the participants stated that they had no experience using the respective measure. Nevertheless, these methods were rated as rather effective or very effective (61–69%) by the majority of the respondents. The item scale had a mean inter-item correlation of 0.36. The types of digital platforms used to disseminate information to visitors consisted mostly of the large social media platforms as well as own homepages (Fig. 2). This pattern does not vary considerably between the respondents from different continents (Supplementary Fig. 3).

3.3. The future of digital visitor management

At the time of the survey, 39% of the responding park managers had staff specifically responsible for DVM, with a similar pattern across all continents except Latin America where this value was 21% (Supplementary Fig. 4). In the future, this number is likely to increase as almost half of the participants agreed that there is a need to implement DVM in their parks. A majority (82%) thought that they would likely or very likely use digital visitor monitoring and 70% that they will eventually use DVM. Those parks that stated that they already had personnel for DVM were almost exclusively from countries with a high or very high HDI (>0.7) whereas those that lacked such staff represented countries with the entire range of HDI. However, this difference is not significant (Mann-Whitney U test: $P = .6284$; Supplementary Fig. 5).

Participants were also asked about potential obstacles to the implementation of DVM in their national park (Fig. 3C). Insufficient staff was cited by 74%, followed by a lack of expertise (69%). Half the respondents disagreed or strongly disagreed with the statement that there would be no legal basis for DVM (52%) and 42% disagreed with the statement that there would not be enough digital data available to implement DVM.

4. Discussion

Our global survey of national park administrations evaluated the effects on park management of the digitalization of outdoor recreation. The willingness to incorporate digital tools and media into visitor management and monitoring in national parks was also examined. The results showed that managers from most parks perceive digitalization in outdoor recreation positively. The DVM tools queried in the survey were mostly considered effective, but the level of experience with them differed considerably. Most respondents indicated that they plan to apply DVM and digital visitor monitoring in the future.

4.1. Opportunities and challenges of digitalization

There was a clear consensus regarding the opportunities to use DVM

in national parks. The respective items referred mainly to opportunities for visitor communication. These findings support related research demonstrating the benefits of using digital media for external communication in national parks (Gruas et al., 2022; Miller and Freimund, 2017; Wilkins et al., 2020). The potential benefits identified in our study were enhanced information about current conditions in the park and the possibility to reach specific groups of visitors. For this the participants are using mostly large social media platforms such as Facebook and Instagram but also their own homepages (Fig. 2). The respondents also agreed that digitalization enables them to provide information to visitors independently of locally installed infrastructure such as signposts or info boards. Our survey also showed that park managers do not believe that the conventional visitor management tools become less effective due to the digitalization of outdoor recreation. This contrasts with the study by Immoos and Hunziker (2015), who found that information provided online might be more effective in terms of visitor guidance, as outdoor recreationists tend to follow information delivered during the planning phase more than information provided during the activity. Ultimately, a context-dependent combination of digital and non-digital tools will likely be the most efficient approach to modern visitor management. However, one must bear in mind that based on our survey we can only draw conclusions about the effectiveness of digital and traditional tools from a management perspective. What tools are actually used by different user groups and for which purpose may depend largely on socio-demographics and personal preferences. Investigating this should be the subject of future research.

The potential of DVM extends beyond digital communication, evidenced by the agreement among the surveyed park managers that digital media provides a new data source for visitor monitoring. Geotagged social media data can be used to derive spatial visitation patterns in protected areas. The utility of related methods has been thoroughly demonstrated in previous studies. For instance, data from several outdoor apps have been used to gain detailed insights into visitors' spatial behavior (Norman and Pickering, 2017; Rota et al., 2019; Zink et al., 2022). The greater spatial detail of GPS track data is an advantage over data from trail counters or cameras. Track data created by participatory GIS, for instance, was used to identify conflicts between different types of recreational activities on multi-use trails (Wolf et al., 2018). These types of data have the additional advantage of being cheaper to acquire and of higher temporal resolution than data obtained from other monitoring approaches. Many social media posts include various types of data that can be used in monitoring. Metadata, profiles, and text analysis can be used to gain insights into the socio-demographics of visitors (Ghermandi, 2022; Heikinheimo et al., 2017), and text and hashtags can be studied in sentiment analysis (Becken et al., 2017). Content analysis of photos is another useful tool. For example, photos from social media have been used to quantify the cultural values of

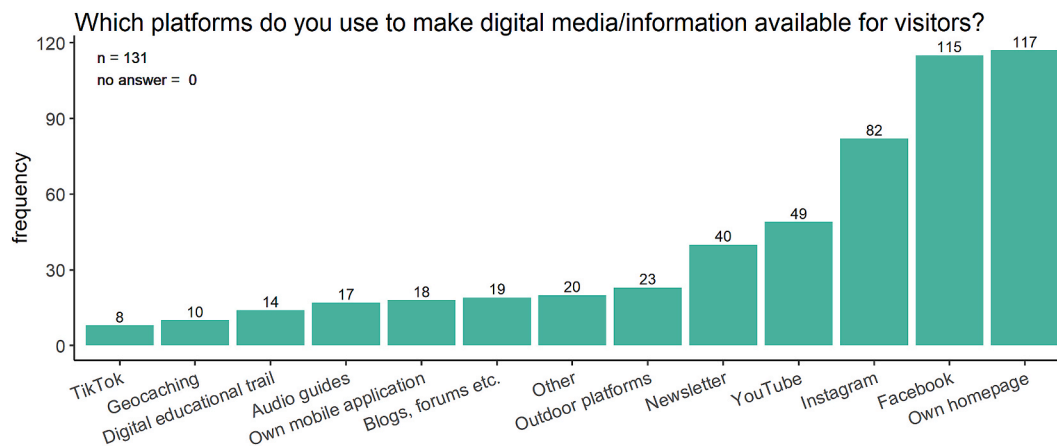


Fig. 2. Digital platforms used by protected area management to share information with their visitors.

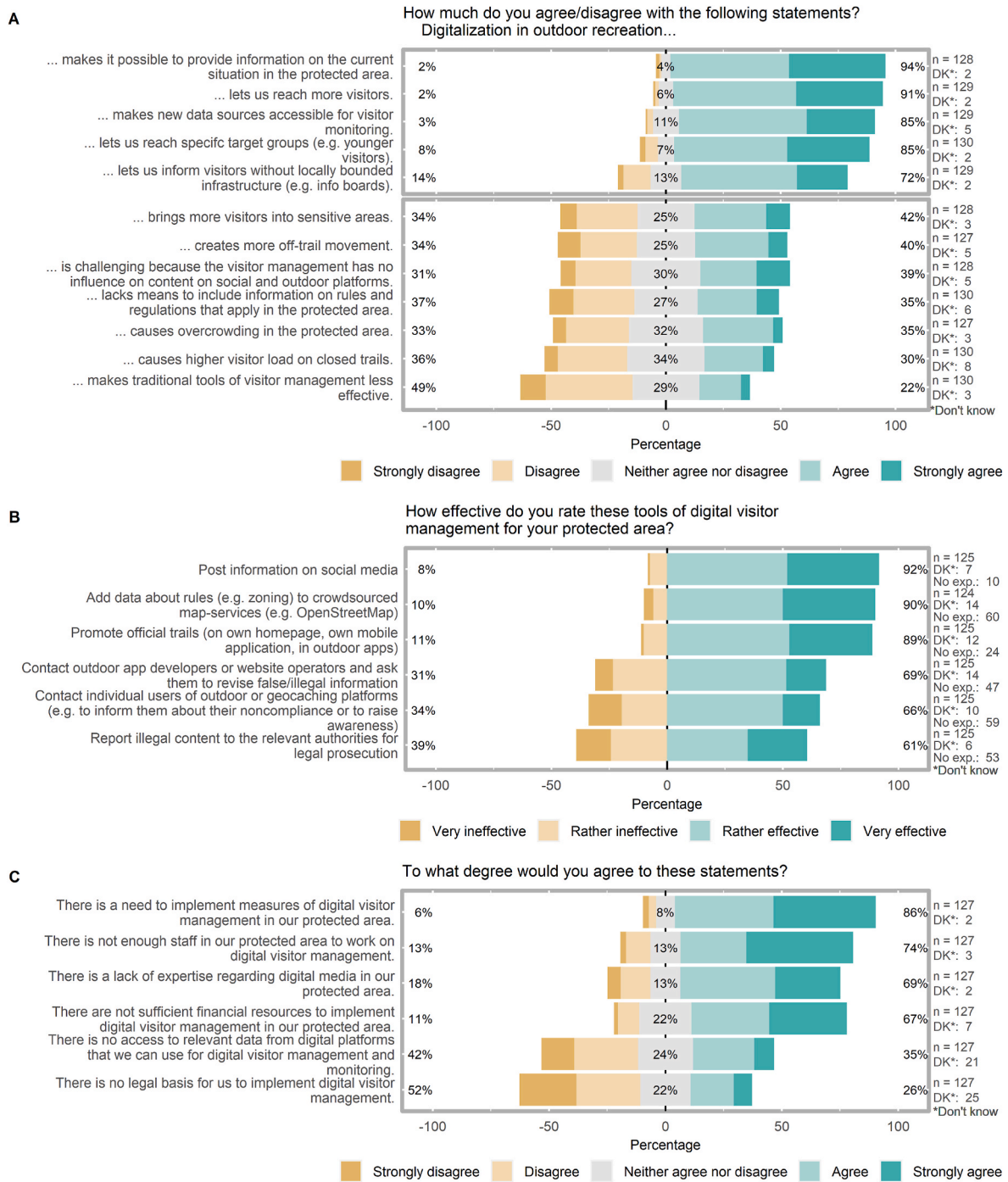


Fig. 3. A) National park managers had a higher rate of agreement for opportunities (upper scale) than for challenges (lower scale). Spearman's rank correlation was used to test the Likert scale for item redundancy, by computing the mean inter-item correlation. Items about opportunities had a correlation of 0.30 and challenge related items a correlation of 0.26. B) Participants rated the proposed methods of digital visitor management (DVM) mostly as effective. The mean inter-item correlation, had a value of 0.36. C) The respondents were asked to rate their agreement to statements regarding potential challenges in the adoption of DVM. According to them, the main obstacle was a lack of staff and financial resources whereas neither data availability nor an adequate legal framework was seen as an obstacle.

red-listed species in African national parks (Willemen et al., 2015). Photos have also been used to estimate the size of visitor groups (Heikinheimo et al., 2017).

Respondents did not agree on whether the problems caused by the digitalization of outdoor recreation impact park management, as 31–49% disagreed with the relevant statements, 25–34% had a neutral opinion, and 22–42% agreed with them. The factors that explain whether a respondent had a more skeptical or optimistic sentiment

towards the digitalization of outdoor recreation could not be determined based on the survey results. Our results also did not reveal strong geographic differences in the respondents' assessment of the effects of DVM on outdoor recreation in general (Supplementary Fig. 1).

Previous research reported a predominantly skeptical perspective, voiced in several publications, toward the digitalization trend in national parks (Miller et al., 2019). Social media posts may cause overcrowding by increasing the popularity of specific locations within a

natural area, potentially leading to environmental disturbances or risks to human safety (Bergman et al., 2022). In addition to reports in scientific publications, news outlets such as the *New York Times*, the US National Public Radio, and the German magazine *Stern*, followed this narrative (Hegyí, 2019; Holson, 2018; Wüstenberg, 2021). Such news coverage might have led to the more negative perception of digital media in the context of natural and protected areas. Our findings, however, suggest that park managers generally have fewer negative perceptions of digitalization.

Only 22–42% of respondents agreed to some degree with negative statements, resulting in a mean index of 3.4, indicating a slight skew towards an agreement with negative statements. Frustration with their inability to influence content spread on digital platforms was expressed by 39%. This supports Zink et al. (2022), who voiced concerns regarding visitors’ increasing use of social media and outdoor platforms, especially the risk of the uncontrolled spread of content that conflicts with the rules and regulations that apply in a protected area.

Along with potential negative effects on conservation, a reliance on digital services can pose risks for visitors. This was not directly queried in the survey but respondents mentioned it in a free text box. A potential risk associated with digital outdoor navigation is that visitors might select trails that are too demanding for their skill or fitness level. The use of outdoor apps without adequate area knowledge also increases the risk of accidents, as demonstrated by several recent events in which hikers had to be rescued or fatalities occurred (Anchan, 2022; Kühne, 2022).

4.2. Effectiveness of digital visitor management

DVM already plays a role in at least half of the parks that responded to the survey. These parks employ personnel specifically responsible for DVM. As many park managers also see potential in using digital media for communication, it is not surprising that, over the past decade, many protected areas have created social media accounts which they use actively (Garrison and Li, 2014; Luque-Martínez et al., 2019). Argentina’s Nahuel Huapi National Park, for example, maintains social media accounts and uses them to inform the public about conservation efforts, wildlife, how to behave safely in the park, and how to avoid causing damage during their stay. The US National Park Service has gone even further and developed a mobile app on which it promotes hiking routes as well as amenities and other activities at its sites (Fig. 5). The assumption that most parks have used DVM to distribute information to their visitors was also supported, as most of survey participants stated that they had experience with posting information on social media and promoting official trails on online platforms. However, >36% replied they had no experience with the other queried methods. This illustrates that the full potential of DVM is far from being utilized.

Integrating notice of the rules that apply in protected areas in the geospatial database OpenStreetMap, as proposed by Hennig (2017), has the potential to further develop DVM. Most respondents that have already done this rated it as effective or very effective. Rules can be added to OpenStreetMap using tags (OpenStreetMap Wiki contributors, 2022). OpenStreetMap’s US chapter has even formed an initiative to improve the tagging of trails in its database to include information that aligns with the official trail system (OpenStreetMap US, 2022). Similar efforts have been undertaken by individual national parks, such as the Bavarian Forest National Park in Germany (Fig. 4).

4.3. Challenges in the adoption of digital visitor management

Most respondents are confident that DVM will be used in their parks in the future. However, obstacles to its implementation were also noted (Fig. 3C), in particular, insufficient personnel to work on DVM (74%) and a lack of financial resources (67%). This may be why protected areas from countries with a high HDI more commonly employed staff for DVM, since these countries are likely to have higher funding capabilities. Asked to rate the DVM capabilities of their parks, 69% of respondents reported insufficient expertise. Research on the successful digital transformation of public organizations has shown that one of the crucial success factors is the access of staff to training resources that provide them with the proficiency needed to deal with new digital formats (Jonathan, 2020). Policymakers will have to address these issues in order to facilitate the establishment of DVM in the national parks under their authority. As pointed out by Leung et al. (2018), the development of new technologies brings new challenges for protected area managers and will require new means of visitor management. Building up DVM now will likely increase the ability of park managers to react appropriately to these developments in the future.

Most respondents identified neither an adequate legal framework nor data availability as problematic. However, 26% were unsure whether DVM can be legally implemented in their parks. Legal uncertainty can be addressed in a joint effort by protected area officials and the responsible authorities. As experience seems to differ considerably, an exchange of knowledge via workshops or methods manuals would be a promising approach to deepen and extend expertise in the use of DVM.

It should be noted that although this study mainly focused on national parks, its results can be transferred to other protected areas. Digitalization is not restricted to a single type of nature reserve but happens simultaneously across most areas of society. For smaller national parks and other types of protected areas that might lack the resources needed to take advantage of the different DVM tools, our findings can guide the selection of those most likely to be effective.

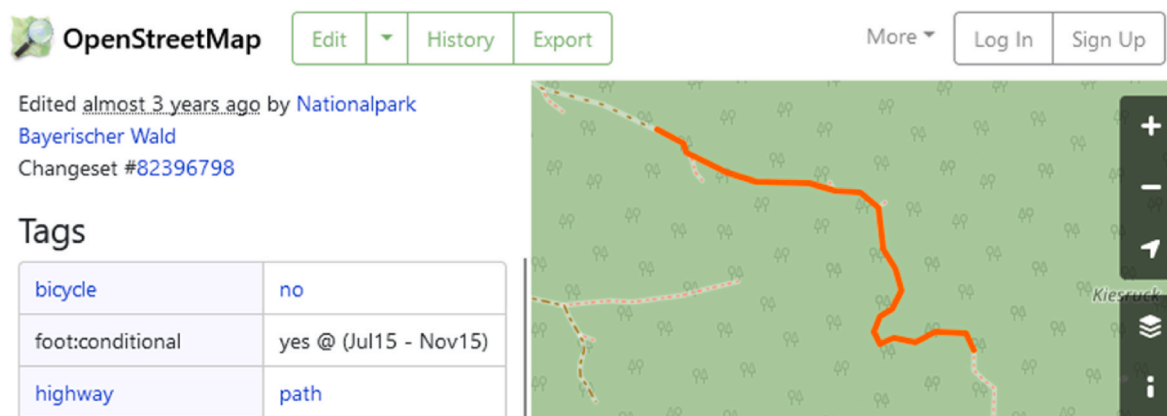


Fig. 4. Trail segment edited by the Bavarian Forest National Park so that the tags contain correct information about the rules that apply regarding its use. The attribute “foot:conditional = yes @ (Jul15 – Nov15)” specifies that hikers may use the trail during the stated period. Tags specifying other rules and regulations and/or web links to relevant laws or further information can be added.

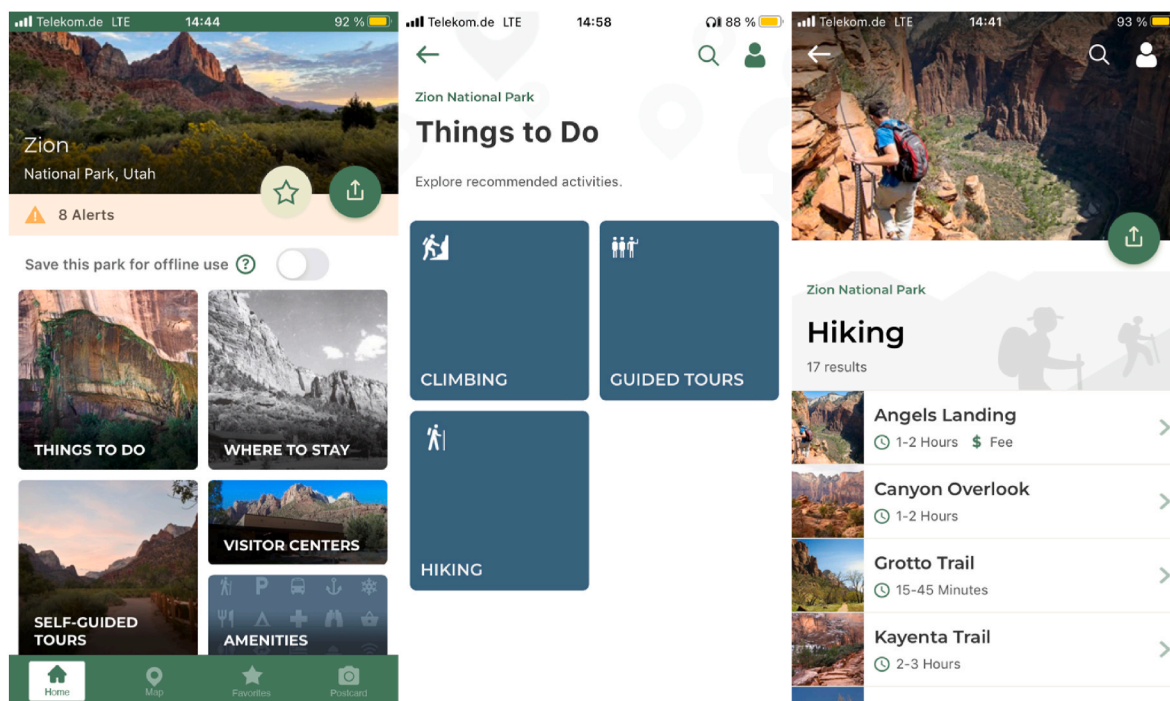


Fig. 5. Screenshots of the US National Park Service's mobile application. The app provides information about activities, amenities, and current alerts in the country's national parks. Suggestions regarding various hiking routes are complemented by information on their duration, accessibility, and level of difficulty. An interactive map is also available for each hike (United States National Park Service, 2023).

4.4. Further considerations

A clear majority (86%) of the participating park managers saw a need to implement DVM but 49% did not think that digitalization lowers the effectiveness of traditional visitor management methods. This suggests an interest in retaining conventional visitor management, complemented by the additional use of DVM and the use of digital media in visitor monitoring. A major limitation of social media and outdoor apps is that they are not used by all members of society equally; hence communication using these formats will not reach all visitors and monitoring results will not necessarily be representative of all visitors (Ghermandi, 2022; Wilkins et al., 2020). Liang et al. (2023), suggested using social media only as a complementary data source in demographic analyses of visitors to protected areas. However, Miller and Freimund (2017) found that the socio-demographic characteristics of visitors to the Facebook page of Yellowstone National Park were similar to those of the actual visitors. This indicates that data from digital platforms can be valuable for digital visitor monitoring, but possible bias in the sample population must be kept in mind.

The potential of DVM in protected areas has yet to be fully exploited. Future research could explore the use of the gamification of outdoor experience inherent to many nature apps, such as AI-driven species identification apps described by Jepson and Ladle (2015). This could be used to create new, interactive methods of nature education. The potential tools mentioned by respondents to our survey included QR codes to access digital content and collaborations with map providers to ensure a high-quality map content. In a diverse and continuously developing landscape of digital platforms and services for outdoor recreation, common standards would be useful, as noted by several respondents. Digitize the Planet e.V., an initiative to develop a database for storing rules and regulations specific to protected areas, was mentioned as an example for this. Map providers and app developers can access this platform to integrate it into their services (Digitize the Planet e.V., 2023). Future research should investigate both the full potential of DVM and the role of digital media in supporting the development and adoption of common standards for protected areas.

5. Conclusions

The digitalization presents opportunities for protected area management. New means of communications and better outreach to specific groups of visitors can improve the parks communication. The usage of digital media has, furthermore, the potential to improve visitor monitoring. In contrast to earlier findings, however, less evidence of a strong negative effect of digital media on park management was found. These challenges related to digitalization seem to arise only in some protected areas while others have not experienced them until now. However, the survey reveals generally a similar pattern in the assessment of digitalization in outdoor recreation across the respondents with no significant influence of economic status or region. The fact that most of the parks stated that they will adopt DVM in the future illustrates this point clearly. An increase in financial and staff resources is likely to facilitate this process as they were identified as the main obstacles in an implementation of DVM.

CRediT authorship contribution statement

Max Mangold: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. **Arne Schwietering:** Conceptualization, Writing – original draft, Writing – review & editing. **Julia Zink:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Manuel J. Steinbauer:** Conceptualization, Methodology, Writing – review & editing, Writing – review & editing, Supervision. **Marco Heurich:** Conceptualization, Methodology, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvman.2024.120108>.

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