

Research Article

Outdoor sport apps: wrong routes are shared unintentionally

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ABSTRACT

The popularity of outdoor recreation and the rise of digital planning platforms (often called “outdoor apps”) featuring user-generated content have introduced new challenges for nature conservation. Given that user-shared route descriptions often conflict with protected area regulations, this study examines whether these non-compliance results from intentional behavior or information deficits, and if compliance differs between voluntarily protected areas and those regulated by law. Descriptions of 142 winter tours in the Bavarian Alps, Germany, that did not comply with two types of protected areas, Wald-Wild-Schongebiete (voluntary agreements) and Wildschutzgebiete (legal restrictions), were identified. Users who had shared non-complying content ($n = 18$) and a control group ($n = 50$) were surveyed and subsequently compared. Indicate that both groups display positive attitudes toward nature conservation but possess limited knowledge of protected area regulations; only 54 % of the respondents recalled relevant rules mostly correctly (seasonal aspects were often not mentioned). Analysis revealed that non-compliance was notable less frequent in areas governed by voluntary agreements (0.30 problematic routes/km²) compared to those regulated by law (0.42 problematic routes/km²). These findings suggest that most non-compliance arises from information deficits rather than intentional non-compliance. Presenting conservation rules at critical touchpoints along the digital visitor journey may therefore improve compliance considerably. Furthermore, the greater effectiveness of voluntary agreements highlights the potential benefits of collaborative management strategies. Future research should investigate how targeted digital communication strategies, including real-time feedback to authors when sharing problematic routes, may contribute to reducing non-compliance.

Management Implications

This study addresses a critical challenge in sustainable tourism management: the conflict between user-generated content on digital outdoor planning platforms and nature conservation rules. By examining the knowledge and attitudes of platform users who share route descriptions in protected areas, the findings reveal that most rule violations stem from an information deficit rather than intentional disregard. The findings provide actionable insights for visitor management, emphasizing the importance of enhancing communication strategies at key touchpoints to improve compliance with conservation. Additionally, the study identifies protected areas governed by voluntary agreements with sport representatives as less prone to conflicting route descriptions, suggesting the value of collaborative and participatory approaches to conservation management. This research advances

understanding of recreationists' behavior and offers directly applicable implications for policymakers, platform providers, and conservation managers seeking to mitigating environmental impacts of outdoor recreation.

1. Introduction

1.1. Growing popularity and digitalization of outdoor recreation

Outdoor sports in nature are gaining popularity (BMWi. & BISP, 2017; Manning et al., 2017; White et al., 2016). In Germany, memberships in the largest mountain and nature sports association, the German Alpine Club (DAV) increased by 60 % from 2010 to 2021, while other sports associations show much smaller changes over the same period (5 % German Football Association; −6 % German Gymnastics Federation;

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11 % German Tennis Federation; DOSB, 2010, 2021). COVID 19 changed the number of recreationists regionally (Schweizer et al., 2021) and it is furthermore anticipated that outdoor sports will continue to generate considerable enthusiasm in the future (Auer et al., 2021; Hammit et al., 2015; Schwartz et al., 2016).

Simultaneously, with the advancement of digitalization in recent years, the number of users of outdoor sport planning applications such as [outdooractive.com](#) (further referred to as Outdooractive), [alltrails.com](#), or [komoot.de](#) has grown steadily (ADFC, 2020, 2023; BTE, 2018; Schwietering et al., 2023). But outdoor platforms are not only digital counterparts to printed guidebooks. They additionally offer users to plan outdoor activities by themselves and share route descriptions with a large number of other users. These data are per definition User-generated content (UGC), as UGC is any kind of text, data, or action created by users of online digital systems and published or shared by them through independent channels, producing an expressive or communicative effect, either individually or in combination with other contributions from the same or other sources (Santos, 2022). This UGC shifted human activity patterns in landscapes with consequences for nature conservation authorities who now face significant challenges to manage people that follow digital route descriptions that do not comply with rules (Loosen et al., 2023; Schwietering et al., 2024; Stefán et al., 2025; Zink et al., 2022). While platforms such as OpenStreetMap, an entirely UGC-based system with a structure similar to Wikipedia, have in some cases demonstrated higher accuracy and completeness than authoritative datasets (Jokar Arsanjani et al., 2015), recreational platforms pose different risks. For instance, 30% of the route descriptions for bike tours in the Bavarian Forest National Park shared mostly via Bikemap and a few via Outdooractive directed visitors to destinations where access was not permitted (Zink et al., 2024).

1.2. Protected areas

One of the most important means for nature conservation are protected areas, which cover 16 % of earth's mainland, 28 % of the European Alps and 37 % of Germany (Alparc, 2024; Hoffmann, 2021; *Protect the Planet*, 2024). Protected areas offer substantial social and environmental value by contributing to conserve biodiversity, mitigate climate change and ensure an elevated quality of life (Pörtner et al., 2021). Only a few areas have rules in place that are relevant to visitors. But due to the large number of different categories of protected areas and the differing rules even within categories, nature visitors are usually not familiar with the applicable rules and not aware of their disturbance of wildlife (*Digitize the Planet e.V.*, 2024; Gruas et al., 2020; *Protect the Planet*, 2024). While all protected areas aim to preserve nature or landscapes, various mechanisms are used to ensure that they are respected. The active participation of stakeholders in governing protected areas (PAs) is even widely recognized as a pivotal component of conservation (European Commission, 2020; Huber et al., 2023) and participatory voluntary agreements among relevant stakeholders should enhance compliance by reinforced peer group pressure (Heywood, 2002; Immoos & Hunziker, 2014, 2015; Reese et al., 2015). At the same time, recent scientific reviews examining the effectiveness of participatory approaches compared to protected areas established by law and enforced by governmental authorities reveal a lack of substantiating empirical evidence (Zhang et al., 2023). Only a very small proportion of protected areas include rules that prohibit public access, sometimes on a seasonal basis, in order to protect endangered species from disturbances caused by recreationists.

1.3. Activity management

Recreation is seen by some as the greatest threat for species at risk (Ballantyne & Pickering, 2013; Larson et al., 2016; Rosenthal et al., 2022; Wraith & Pickering, 2017), even though others state that negative effects of recreation on wildlife are overreported (Bateman & Fleming,

2017). Activity management aims to mitigate the negative effects of recreation by applying visitor management tools, such as directing visitors to specific areas or restricting access to sensitive zones, thereby helping to protect vulnerable species from disturbance (Petrić & Mandić, 2014; Zelenka & Kacetyl, 2013).

Activity management measures include designating protected areas, constructing facilities for visitors, offering and promoting attractive tours, and establishing protected areas with rules such as access restrictions for all or certain activities (Hadwen et al., 2007; Josef & Kacetyl, 2013; Leung et al., 2018). These measures are more effective when communicated in a way that is accepted by recreationists. The most accepted form varies depending on the recreationist, considering the stage of the journey (planning phase, during the activity, after the activity), the type of activity, the time available, and the attitude and knowledge regarding the addressed matter. Information output encompasses various criteria, including the selection of impact mechanisms (e.g., textual, visual, or auditory), as well as considerations of scope, language, and visual design (Esfandiar et al., 2022; Josef & Kacetyl, 2013; Leung et al., 2018).

Digital information sources, such as outdoor planning platforms, are now commonly utilized by most recreationists (ADFC, 2023; BTE, 2018; Schwietering et al., 2023). The capabilities for optimizing visitor guidance have significantly evolved with digitalization, as digital media allows for providing the information at the right time, in an appropriate format, and tailored specifically to each recreational activity (Esfandiar et al., 2022; Schmücker et al., 2023; Zejda & Josef, 2019). Particularly during the planning phase, which is the most important phase for effective activity management, outdoor platforms present an exceptional opportunity for disseminating information on nature conservation (Esfandiar et al., 2022; Immoos & Hunziker, 2014, 2015; Schwietering et al., 2024). Digital media also provide additional monitoring opportunities due to visitor movement data (Hausmann et al., 2017; Heikinheimo et al., 2017; Horst et al., 2023; Norman & Pickering, 2017). These opportunities are also being acknowledged by the majority of national parks worldwide (Mangold et al., 2024).

However, digital (social) media also poses a significant challenge for nature conservation as it weakens the effect of traditional visitor management, particularly due to user-generated content. This type of content does not always comply with (legally binding) nature conservation (rules) and is difficult to regulate through conventional nature conservation management (Arndt, 2023; Job et al., 2016; Schwietering et al., 2024; Zink et al., 2022).

1.4. Aim of the study

Communication strategies and effective management strongly depend on whether recreationists do not comply with nature conservation rules knowingly or as a result of insufficient information. While previous work mainly quantified the relevance of platforms for navigation (Mangold et al., 2024; Schwietering et al., 2023, 2024; Zink et al., 2022) or surveyed the proportion of tours that were non-compliant to regulations (Zink et al., 2024), this study evaluates why private users of outdoor platforms disregard rules for nature conservation. In addition, the study compares the effectiveness of protected areas based on statutory regulations with those relying on voluntary agreements. Even though participation of non-governmental local structures is often positively linked to higher legitimacy, compliance and enhanced information exchange (Birnbbaum, 2016; Hausner et al., 2021; Rist et al., 2007), recent reviews have highlighted the lack of sufficient comparable studies to establish a definitive link between participatory approaches and compliance (Huber et al., 2023; Zhang et al., 2023). Therefore, this study seeks to address the following questions:

1. Do private authors share route descriptions that do not comply with the rules of protected areas on purpose or by accident?

2. Are protected areas based on voluntary agreements more respected than those regulated by law?

2. Methods

2.1. Study area and object of investigation

To determine whether private users of outdoor platforms share non-compliant route descriptions with protected areas deliberately or unintentionally, we compared their attitudes and knowledge regarding nature conservation with those of a control group.

To do so, 142 winter route descriptions were identified that intersect with at least one protected area that restricts the entry of recreational users. The routes were published by private, non-official authors on the Outdooractive platform. The route descriptions were divided in two categories: Possible GPS artifacts (unrealistically long straight sections) and those that only traversed the edges of the protected areas, which could have resulted from technical tracking errors due to an imprecise GPS signal ($N = 71$); and route descriptions that clearly do not comply with nature conservation rules by crossing directly through at least one protected area ($N = 71$, see [appendix 1](#)).

Protected areas under focus were *Wald-Wild-Schongebiete* (WWS) and *Wildschutzgebiete* (WS) in the Bavarian Alps and near the Nationalpark Bayerischer Wald. WWS and WS aim to protect endangered species from disturbances caused by recreationists during sensitive retreat periods in winter. While WWS are based on voluntary agreements between the Alpine Club of the country (DAV in Germany) and nature conservation association, WS are governed by hunting laws and entail fines up to 5.000€ ([Arlettaz et al., 2015](#); [BayJG, 2022](#); [Patthey et al., 2008](#)).

2.2. Reason for non-compliance with nature conservation

To determine whether private users of outdoor platforms share non-compliant route descriptions with protected areas deliberately or unintentionally, we compared their attitudes and knowledge regarding nature conservation with those of a control group. The control group shared winter routes in the same area respecting the WWS and WS. A survey (see [appendix 2](#)) was distributed to 67 private users whose shared route descriptions did not comply with nature conservation rules in WWS or WS (non-compliant group). Some authors shared multiple route descriptions that did not comply with the rules of WWS or WS. Additionally, the survey was distributed to 283 private users who shared winter routes in the same area respecting the WWS and WS, the control group. This approach resulted in a non-compliant group of 18 authors (with a response rate of 26,9 %) and a control group of 50 authors (with a response rate of 17,7 %). Since private messaging was unavailable on Outdooractive, the authors were contacted through comments on the published content on the platform, visible for all users. While we perceive the chance of additional users, beyond the addressed authors, completing the anonymous survey to be low, it remains possible. We anticipate high data quality, given that all responding authors participated voluntarily, presumably motivated by intrinsic interest. The survey was conducted via SoSci Survey from November 16, 2022, to May 20, 2023 ([Leiner, 2021](#)). In accordance with the Code of Ethics of the German Educational Research Association (DGfE), participants were required to actively provide informed consent prior to participation, and all responses were collected anonymously. All reported ages of tour authors were over 20 years.

2.3. Survey design

To ensure a high level of participation and minimize dropouts, the survey (69 questions including 33 likert-scale items) addressed the motivation of authors to share route descriptions in general. Questions assessing the attitude towards nature conservation (4 questions), their feelings of criticism due to route descriptions not complying with rules

for nature conservation, and their knowledge and detailed description of the restrictions of WS and WWS (4 questions) were intermixed with similar questions about the motivation and importance of tour description attributes (29 questions in total) and knowledge (15 questions in total; see [appendix 2](#)). For statistical analyses the answers were converted into numbers with 1 = "Highly important" or "Strongly agree" up to 6 = "No importance at all" or "Strongly disagree".

The rules quoted by the respondents for WS and WWS in free-text responses were categorized into three groups. Category 1 includes correct statements regarding the protected area's access restriction (such as "Entering the area is restricted [or discouraged] seasonally [or during winter]" without differentiating between WS and WWS). Category 2 consists of statements that, while not entirely accurate, would guide to follow the restriction (such as "Entering the area is forbidden"). Category 3 includes incorrect descriptions of the rules, which would lead respondents to disregard rules (such as "The area is not important for me; it affects only hunters"). Each response category was assigned a numerical value corresponding to its category number (Category 1 = 1, Category 2 = 2, Category 3 = 3), enabling statistical analysis to quantify overall knowledge levels. Respondents were permitted to omit questions. The survey was conducted in German.

2.4. Comparison of voluntary agreements and protection by law

A spatial analysis was implemented to test if rule compliance differs between protected areas with voluntary agreements (WWS) and protected areas with mandatory regulations (WS). In the study area (Southern Germany), restrictions in WWS are based on voluntary agreements between the DAV and nature conservation. In contrast, the mandatory regulations in WS are part of the hunting protection law with penalties of up to 5.000€ ([BayJG, 2022](#); [DAV, 2021](#)). Differences between the two categories were quantified using an index (entitled: problematic route descriptions per km²) that divides the number of route descriptions not complying with the rules of the protected area by its spatial territory.

2.5. Statistical data analyses

Data analyses examined whether attitudes towards nature conservation and knowledge of protected area regulations are associated with whether tour authors were compliant (group 0) or non-compliant (group 1) with conservation regulations. To do so, responses to items related to nature conservation (four questions) were averaged to form a composite attitude score (ranging from 1 to 6 with 1 indicating highest attitude towards nature conservation). A similar composite score for knowledge of protected area regulations was calculated, using the established categories ranging from 1 (correct answers) to 3 (incorrect answers). We then addressed two related but distinct research questions:

- A) First, we tested whether compliant and non-compliant authors differed in their average attitude or knowledge scores using independent samples t-tests. We report Cohen's d with corresponding 95% confidence intervals as a measure of effect size. To assess whether the relatively small sample size ($N = 68$ regarding answers related to attitudes towards nature conservation; $N = 58$ for answers regarding knowledge on rules of the protected areas) was sufficient to detect small effects, we conducted a power analysis using the R package *pwr* version 1.3-0 ([Champely, 2020](#)).
- B) Second, we examined whether attitudes and knowledge could predict the likelihood of non-compliance with nature conservation regulations. For this, we used logistic regression models (generalized linear models with binomial error distribution), with group membership (0 = compliant, 1 = non-compliant) as the dependent variable and either attitude or knowledge as the

predictor. We report odds ratios (ORs) with corresponding 95% confidence intervals as a measure of effect size.

Finally, in order to test if voluntary agreements (as in WWS) differ from mandatory regulations (as in WS), we tested if knowledge of authors on regulations differed between the two types of protected areas using paired *t*-tests.

Analyses were performed with R (v 4.5.1 "Great Square Root"; R Core Team, 2025). OpenStreetMap data of September 2024 and QGIS version 3.22 were used to calculate the areas of the WWS and WS (OpenStreetMap contributors, 2015; QGIS.org, 2023).

3. Results

Results indicated that (1) authors of tour descriptions not complying with protected area rules have the same attitudes and slightly higher knowledge of WS and WWS as authors of the control group and (2) that regulations in protected areas based on voluntary agreements are better known and show relatively fewer route descriptions not complying with rules of these areas than protected areas based on law.

3.1. Attitudes towards nature conservation

For attitudes towards nature conservation ($N = 68$), the independent samples *t*-test revealed no meaningful difference between authors of non-compliant tours ($M = 2.51$, $SD = 1.03$, $n = 18$) and the control group ($M = 2.37$, $SD = 1.13$, $n = 50$; $p = 0.615$, 95% CI for the mean difference: 0.74 to 0.44, Fig. 1). Lower *M*-values indicate more positive attitudes towards nature conservation. The effect size was negligible (Cohen's $d = -0.13$, 95% CI: 0.68 to 0.42). Based on this effect size, a two-sided *t*-test with $\alpha = 0.05$ would require a total sample size of approximately 1766 participants (883 per group) to achieve 80% power. These results suggest that, although the limited sample size prevents firm conclusions about very small effects, the observed difference is minimal and likely of limited practical relevance. Consistent with this, the logistic regression model with group membership as the dependent variable and attitude as the predictor revealed no significant association ($OR = 1.13$, 95% CI: 0.70 to 1.83, $p = 0.624$), indicating that attitudes towards nature conservation are not a meaningful predictor of non-

compliance.

3.2. Knowledge of protected area regulations

For knowledge regarding the rules of protected areas ($N = 58$), the independent samples *t*-test indicated a negligible (Cohen's $d = 0.17$, 95% CI: 0.42 to 0.76) non-statistically significant difference between the two groups ($p = 0.543$, 95% CI for the mean difference: 0.24 to 0.44; non-compliant tour-authors $M = 2.22$, $SD = 0.55$, $n = 16$; control group $M = 2.32$, $SD = 0.62$, $n = 42$). A power analysis indicated that a total sample size of 1086 participants (543 per group) would be required to detect an effect of this magnitude with 80% power at $\alpha = 0.05$. Logistic regression supported this finding and revealed a non-significant effect of knowledge on group membership ($OR = 0.75$, 95% CI: 0.29 to 1.95, $p = 0.558$). The wide confidence interval reflects considerable uncertainty and, as it includes 1, indicates that the result is not statistically significant. These results indicate that local knowledge is not a meaningful predictor of non-compliance either.

Overall, 54 % of the surveyed authors knew the correct (category 1 or 2) mandatory regulations of the PAs. Interestingly with 39 % recalling the WS ($M = 2.47$, $SD = 0.73$, n of valid responses 57), while 67 % could correctly name regulations of WWS, based on voluntary agreements ($M = 2.10$, $SD = 0.69$, n of valid responses 58). Paired *t*-test indicated that this difference is significant ($p < 0.001$) with a medium effect size (Cohen's $d = -0.54$, 95% CI: 0.87 to -0.22). Even though the effect might be partly due to question order, as respondents answered WWS items first and may have mistaken the two protected area types as equivalent and may got confused.

3.3. Compliance levels by protection type: voluntary vs. enforced by law

The proportion of route descriptions not complying with the rules of the area concerned is lower in protected areas with voluntary agreements (WWS; 0.30 problematic route descriptions/km²), compared to protected areas with mandatory regulations (WS; 0.43 problematic route descriptions/km²). Out of 71 not complying route descriptions, 41 (58 %) crossed WWS while 30 (42 %) crossed WS. A larger part of the study area was covered by WWS (135 km², 64 % of the respected protected area), representing 75 % (246) of the total number of protected

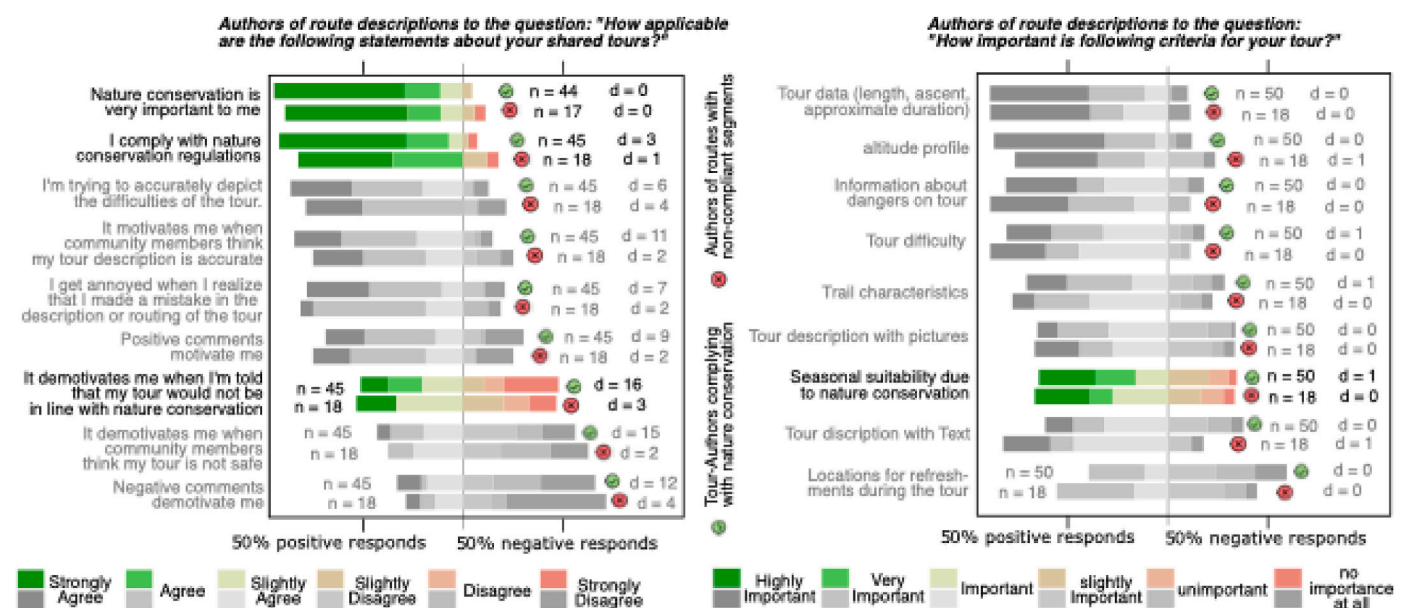


Fig. 1. a) Investigation of authors' attitudes towards statements about their route description. b) The importance of 10 out of 12 criteria for route descriptions for the authors surveyed. The colored segments of both graphics are connected to nature conservation, the grey colored questions show the framework in which they were placed. While 'n' indicates the number of respondents, 'd' reveals the number of "don't know [how to answer that question]".

areas. Less area was covered by WS (69 km², 36 % of the respected protected area), constituted 25 % (82) of the total number of areas (see Table 1 and appendix 1).

4. Discussion

4.1. Why some user-generated content on outdoor sport planning platforms does not comply with nature conservation

Results suggest that outdoor platform users do not intentionally share route descriptions that do not comply with rules in protected areas, but rather by mistake. Nearly half of the tour authors could not name the correct behavior in the area while both surveyed groups showed similar positive attitudes towards nature conservation (see Fig. 1). The results can be considered robust despite the small size of the non-compliant group (n = 18), in the sense that any differences, if present, are minimal. In fact, over 1000 respondents would be required to test whether the small differences in terms of nature conservation attitudes and knowledge between the two groups present a robust pattern or random variability. Familiarity of rules is a prerequisite for conscious compliance, even though knowledge and environmental education is not always strictly connected to equivalent behavior (McKenzie-Mohr et al., 2012, p. 237). At the time this study was conducted (June 2023), WWS and WS were only visible on the Outdooractive map if users manually activated the corresponding layer. It is therefore possible that many users did not notice the protected areas when sharing their route descriptions. Also, some of the WS and WWS have only recently been integrated in the Outdooractive map layer. Therefore, some route descriptions may have been published at a time when these areas were not yet visible on Outdooractive. In such cases, the authors would have had to inform themselves elsewhere about existing rules (including local information like signposts) to take them into account when publishing the route description.

Various studies have shown that humans tend to respond to questions in a way that is consistent with societal expectations but does not necessarily reflect their actual behavior (Esfandiar et al., 2022; John et al., 2010; Wolf-Watz, 2014). As this applies equally to both author groups, results clearly indicate that tour descriptions not complying with rules of protected areas are mostly shared due to unawareness. This aligns with other studies in winter outdoor sports, who also identified the lack of knowledge as the most decisive reason for disregarding rules (Immoos & Hunziker, 2014, 2015). Research focusing on recreationists familiar with nature conservation restrictions reported a wide range of compliance depending on the region, communication strategies, and type of restriction (Bradford & McIntyre, 2007; Duncan & Martin, 2002; Moczek et al., 2024). If all tour authors had been aware of conservation restrictions, most problematic route descriptions likely would not have been shared, as only about 20% of recreationists knowingly do not comply with such rules in similar situations (Moczek et al., 2024).

4.2. Voluntary agreements are more frequently adhered to by recreationists than those regulated by law

This study provides a valuable spatial extension to existing research

Table 1
WWS, WS and route descriptions not complying with these areas in numbers.

	WWS	WS
Number	246	82
	75 %	25 %
Area	134,5 km ²	69,4 km ²
	64 %	36 %
Number of problematic route descriptions	41	30
	58 %	42 %
Problematic route descriptions/Area	0.30 route descriptions/km ²	0.43 route descriptions/km ²

on compliance with protected areas (Andrade & Rhodes, 2012; Birnbaum, 2016; Huber et al., 2023). Even though WS are occasionally utilized as a more stringent restriction when WWS do not achieve the desired effect (DAV, 2021), outdoor platform users appear unaffected by the imposed penalties. As studies indicate that appreciated values have a big effect on behavior, acceptance of the hunting protection law (WS) could be lower among nature sports enthusiasts compared to the voluntary agreement via the DAV (WWS), probably due to the involvement of all stakeholder groups and the stronger connection of the recreationists to the DAV than to hunters (Hunziker et al., 2021; Immoos & Hunziker, 2014, 2015; Reese et al., 2015). Studies also indicate that participatory approaches (e.g. supported by internal social pressure) achieve better results in terms of compliance with desired behavior than penalties (Duncan & Martin, 2002; Heywood, 2002; Huber et al., 2023). Protected areas are also more likely to be respected if their exact purpose and the consequences of non-compliance are known (Baldauf, 2020; Cornelisse & Duane, 2013; Hubschmid & Hunziker, 2018). As in other cases of participatory approaches the DAV probably provides more extensive and comprehensive information about the WWS than is provided for the WS (López-Rodríguez et al., 2020; Rist et al., 2007). Protected areas established through voluntary agreements involving sport representatives may thus be more widely known, which could explain the better knowledge of the WWS observed in this study, in addition to potential question order effects in our survey. This greater level of knowledge could, in turn, reduce the number of non-complying tour descriptions that are unintentionally shared.

5. Management implications

5.1. Transfer of information

Given that some private tour description authors appear to be insufficiently informed about current regulations, enhanced information transfer could foster greater awareness of protected areas. Effective and comprehensive information transfer along the customer journey is essential to give all recreation seekers information on correct behavior to avoid unintentional non-compliance with rules. Informing recreationists during the planning phase is also more effective for activity management than on-site measures (Immoos & Hunziker, 2015; Schmücker et al., 2023). Since most nature visitors use digital media and outdoor platforms to plan their tours, enhancing the visibility of protected areas and their restrictions on these platforms appears to be a very effective tool for visitor guidance (Schwietering et al., 2023; Zink et al., 2022). The way in which restrictions are visually presented on maps may also play a crucial role in effective communication. Clear visualizations in an intuitive, map-based format of the spatial extent of protected areas and their rules would help users make better decisions during the planning and navigation process. There are several channels and touchpoints to inform outdoor platform users about (nature conservation) rules. Within the three stages of the customer journey, four main touchpoints can be identified (see Fig. 2; Huertas & Orden-Mejía, 2022; Kang et al., 2020; Schmücker et al., 2023; Shen et al., 2020; Zheng et al., 2018):

In the **planning phase**, outdoor platform users could be reached through the platform depending on whether they route an activity on the map independently or looking for route descriptions shared by others (touchpoint 1 and 2). While routing, restrictions could be automatically applied to avoid passing through restricted areas if they lie within the optimal connection, while also providing optional information about the area to raise awareness. Users attempting to plan a route through a restricted area should be required to confirm that they understand such a route would result in non-compliance with protected area rules. For shared routes, descriptions not complying with protected areas could remain invisible to other users until the author either updates the description or explicitly confirms the intention to share content that does not align with nature conservation. This combination of design

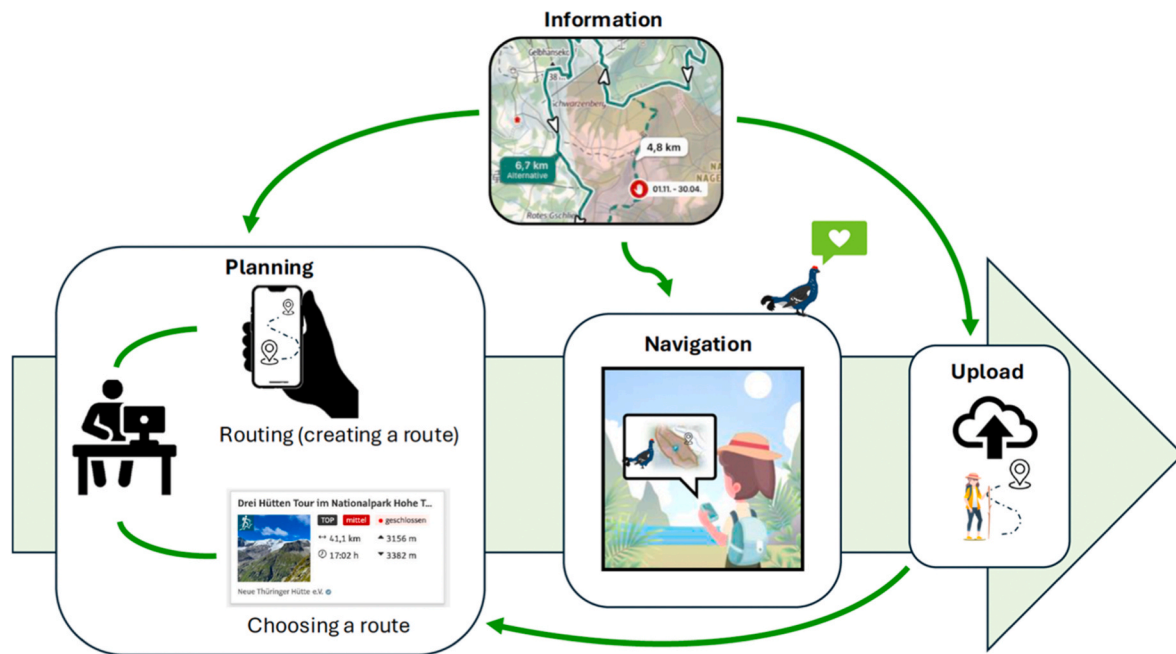


Fig. 2. Several touchpoints enable outdoor platforms to comprehensively inform their users about nature friendly behavior. Providing alternatives and reasons for limited access is one possibility to foster compliance in restricted protected areas.

interventions and awareness prompts strengthens both platform responsibility and user education.

During the tour, while navigating, GPS location-based pop-ups could help users to avoid entering restricted areas unintentionally and inform them about the reasons of the protected area and connected rules (touchpoint 3).

After the tour, when a user is in the process of sharing a tour, route sections that do not comply with nature conservation rules could be automatically highlighted. The user could be provided with additional information on the protected area and asked to change the sections of the tour that do not comply with rules or could have to confirm that they are aware the uploaded content might encourage others to break those rules when following the same route (touchpoint 4). Since there are various ways for users to plan, record and upload routes, it is important to place information about the existence of and the reasons behind areas restricted for nature conservation at all relevant touchpoints. In this way, users who plan and navigate activities via an outdoor platform, as well as those who use another app or a GPS-enabled device to record a route and afterwards upload to the description to the outdoor platform, are reached. It requires not only technical cooperation but also ongoing dialogue with local stakeholders to align conservation objectives with visitor expectations. An important prerequisite for the digital communication of nature conservation rules is their digital availability. For many countries, including Germany, this is only partially the case (Schwietering et al., 2024; Zink et al., 2022).

6. Conclusion on protected area types

Preserving landscapes, animals, or plants can be crucial and primordial goals in protected areas. As most non-compliant behavior seems to arise due to a lack of awareness, clear communication via information tools that are used by the recreationists is key. Digital media now play a dominant role, with outdoor platforms like Komoot, Outdooractive, AllTrails, Strava, and similar services being widely used (Schwietering et al., 2023). Additionally, protected areas tend to be more respected by recreationists when they are defined in collaboration with relevant stakeholders, though this effect may be influenced by factors that have not yet been thoroughly examined (e.g., visibility, enforcement,

awareness campaigns, or user familiarity with DAV agreements vs. hunting laws, Hunziker et al., 2021; Immoos & Hunziker, 2014). The participatory approach is complex and demanding, requiring significant time and energy, and typically results in a compromise. Nevertheless, this process leads to an agreement approved by the stakeholders, with each party making an effort to ensure compliance. Consequently, in the given setting, WWS are better publicized by the sport federation and therefore more widely known and followed by recreationists. Assuming that our findings are based on this premise and not significantly influenced by other factors, a shift from centrally regulated, law-based protected areas to areas governed by negotiated agreements involving all stakeholders could lead to improved compliance with conservation rules. Such an approach may also enhance effectiveness in other (nature conservation) sectors that involve stakeholders. The question remains whether the potential benefits justify the increased effort required.

7. Further research

Especially in the view of advancing digitalization, research on robust digital information transfer for effective nature conservation is becoming crucial yet remains insufficient. Similar studies examining why user-generated digital route descriptions fail to comply with rules of other protected areas, countries and in other contexts and outdoor platforms could provide valuable, more comprehensive insights into the role of user-generated content (UGC). Studies investigating when and how users of outdoor platforms need information, and how information on nature conservation rules can be communicated effectively could significantly improve the impact of nature conservation measures.

Although participatory approaches are already commonly applied in nature conservation, their effectiveness compared to other regulatory measures and documentation of best practice examples deserve further attention.

CRediT authorship contribution statement

Arne Schwietering: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation,

Conceptualization. **Leon Rade:** Writing – review & editing, Investigation. **Simon Reuter:** Writing – review & editing, Methodology, Conceptualization. **Sofie Paulus:** Writing – review & editing, Methodology. **Manuel J. Steinbauer:** Writing – review & editing, Supervision, Methodology, Conceptualization.

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.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jort.2026.101023>.

Data availability

Data will be made available on request.

References

- ADFC. (2020). ADFC-Radreiseanalyse 2020. ADFC Allgemeiner Deutscher Fahrrad-Club e. V. <https://www.adfc.de/artikel/adfc-radreiseanalyse-2020>.
- ADFC. (2023). ADFC-radreiseanalyse 2023. ADFC Allgemeiner Deutscher Fahrrad-Club e. V. <https://www.adfc.de/artikel/adfc-radreiseanalyse-2023>.
- Alparc. (2024). <https://alparc.org/de/the-protected-areas>. URL.
- Andrade, G. S. M., & Rhodes, J. R. (2012). Protected Areas and Local Communities: An Inevitable Partnership toward Successful Conservation Strategies? *Ecology and Society*, 17(4). <https://doi.org/10.5751/ES-05216-170414>
- Arlettaz, R., Nusslé, S., Baltic, M., Vogel, P., Palme, R., Jenni-Eiermann, S., Patthey, P., & Genoud, M. (2015). Disturbance of wildlife by outdoor winter recreation: Allostatic stress response and altered activity-energy budgets. *Ecological Applications*, 25(5), 1197–1212. <https://doi.org/10.1890/14-1141.1>
- Auer, J., Schöffel, V. R., Achenbach, L., Meffert, R. H., & Fehske, K. (2021). Indoor Bouldering - A Prospective Injury Evaluation. *Wilderness & Environmental Medicine*, 32(2), 160–167. <https://doi.org/10.1016/j.wem.2021.02.002>
- Arndt, S. (2023). Social media as a contributor to conflicts in protected areas: Experiences, problems, and potential solutions. *PARKS*, 29.2, 85–93. <https://doi.org/10.2305/ULMJ5060>
- Baldauf, C. (Ed.). (2020). *Participatory Biodiversity Conservation: Concepts, Experiences, and Perspectives*. Springer International Publishing. <https://doi.org/10.1007/978-3-030-41686-7>.
- Ballantyne, M., & Pickering, C. M. (2013). Tourism and recreation: A common threat to IUCN red-listed vascular plants in Europe. *Biodiversity and Conservation*, 22(13–14), 3027–3044. <https://doi.org/10.1007/s10531-013-0569-2>
- Bateman, P., & Fleming, P. (2017). Are negative effects of tourist activities on wildlife over-reported? A review of assessment methods and empirical results. *Biological Conservation*, 211, 10–19. <https://doi.org/10.1016/j.biocon.2017.05.003>
- BayJG. Bayerisches Jagtgesetz (BayJG), in the consolidated version published in the Bavarian Law and Ordinance Gazette (BayRS 792-1-L), last amended by Article 11 of the Act of April 22, 2022 (GVBl. <https://www.gesetze-bayern.de/Content/Document/BayJG>.
- Birnbaum, S. (2016). Environmental Co-governance, Legitimacy, and the Quest for Compliance: When and Why Is Stakeholder Participation Desirable? *Journal of Environmental Policy & Planning*, 18(3), 306–323. <https://doi.org/10.1080/1523908X.2015.1077440>
- BMWi. & BISP. (2017). *Wirtschaftsfaktor Outdoorsport: Aktuelle Daten zur Sportwirtschaft*. https://www.bisp.de/SharedDocs/Downloads/SSK/Wirtschaftsfaktor_Outdoorsport.pdf.
- Bradford, L. E. A., & McIntyre, N. (2007). Off The Beaten Track: Messages As A Means Of Reducing Social Trail Use At St. Lawrence Islands National Park. *Journal of Park and Recreation Administration*, 25(1), 1–21.
- BTE, D. W. (2018). *Wandertourismus in Deutschland*. https://www.bte-tourismus.de/wp-content/uploads/2019/01/BTE_Wandertourismustudie-2018_final.pdf.
- Champely, S. (2020). *pwr: Basic functions for power analysis (Version 1.3-0) [R package]*. Comprehensive R Archive Network (CRAN). <https://CRAN.R-project.org/package=pwr>.
- Cornelisse, T. M., & Duane, T. P. (2013). Effects of Knowledge of an Endangered Species on Recreationists' Attitudes and Stated Behaviors and the Significance of Management Compliance for Ohlone Tiger Beetle Conservation. *Conservation Biology*, 27(6), 1449–1457. <https://doi.org/10.1111/cobi.12117>
- DAV. (2021). *Schutzgebiete in bayerns bergen*. https://www.alpenverein-muenchen-oberland.de/uploads/images/BUPU6WHzf61624PP58QOHQ/213662_flyer-schutzgebiete-pdf.pdf.
- Digitize the Planet e.V.. (2024). <https://www.digitizetheplanet.org/>. URL.
- 2021 DOSB. (2021). *Bestandshebung 2021. Deutscher Olympischer Sportbund e. V.* <https://www.dosb.de/medienservice/statistiken>.
- DOSB. (2010). *Bestandshebung 2010. Deutscher Olympischer Sportbund e. V.* <https://www.dosb.de/medienservice/statistiken>.
- Duncan, G., & Martin, S. (2002). Comparing the Effectiveness of Interpretive and Sanction Messages for Influencing Wilderness Visitors. *Intended Behavior. International Journal of Wilderness*, 8.
- Esfandiari, K., Pearce, J., Dowling, R., & Goh, E. (2022). Pro-environmental behaviours in protected areas: A systematic literature review and future research directions. *Tourism Management Perspectives*, 41. <https://doi.org/10.1016/j.tmp.2022.100943>
- European Commission. (2020). *EU biodiversity strategy for 2030: Bringing nature back into our lives*. Publications Office of the European Union. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0380>.
- Gruas, L., Perrin-Malterre, C., & Loison, A. (2020). Aware or not aware? A literature review reveals the dearth of evidence on recreationists awareness of wildlife disturbance. *Wildlife Biology*, 2020. <https://doi.org/10.2981/wlb.00713>
- Hadwen, W. L., Hill, W., & Pickering, C. M. (2007). Icons under threat: Why monitoring visitors and their ecological impacts in protected areas matters. *Ecological Management and Restoration*, 8(3), 177–181. <https://doi.org/10.1111/j.1442-8903.2007.00364.x>
- Hammit, W. E., Cole, D. N., & Monz, C. A. (2015). *Wildland Recreation: Ecology and Management* (3rd ed.). John Wiley & Sons.
- Hausmann, A., Toivonen, T., Slotow, R., Tenkanen, H., Moilanen, A., Heikinheimo, V., & Di Minin, E. (2017). Social media data can be used to understand tourists' preferences for nature-based experiences in protected areas. *Conservation Letters*, 11. <https://doi.org/10.1111/conl.12343>
- Hausner, V. H., Engen, S., Muñoz, L., & Fauchald, P. (2021). Assessing a nationwide policy reform toward community-based conservation of biological diversity and ecosystem services in the Alpine North. *Ecosystem Services*, 49, 101289. <https://doi.org/10.1016/j.ecoser.2021.101289>
- Heikinheimo, V., Di Minin, E., 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, 85. <https://doi.org/10.3390/ijgi6030085>
- Heywood, J. L. (2002). The Cognitive and Emotional Components of Behavior Norms in Outdoor Recreation. *Leisure Sciences*, 24(3–4), 271–281. <https://doi.org/10.1080/01490400290050727>
- Hoffmann, S. (2021). Advances in conservation biogeography: Towards protected area effectiveness under anthropogenic threats. *Frontiers of Biogeography*, 13(2), 1–23. <https://doi.org/10.21425/F5FBG49679>
- Horst, L., Taczanowska, K., Porst, F., & Arnberger, A. (2023). Evaluation of GNSS-based volunteered geographic information for assessing visitor spatial distribution within protected areas: A case study of the Bavarian forest national park, Germany. *Applied Geography*, 150, Article 102825. <https://doi.org/10.1016/j.apgeog.2022.102825>
- Huber, J. M., Newig, J., & Loos, J. (2023). Participation in protected area governance: A systematic case survey of the evidence on ecological and social outcomes. *Journal of Environmental Management*, 336, 117593. <https://doi.org/10.1016/j.jenvman.2023.117593>
- Hubschmid, E., & Hunziker, M. (2018). *Wildtierfreundliches Freeriden von -Wintersportlerinnen und -sportlern - Eine Analyse der Wirkung persuasiver Lenkungsinstrumente. Naturschutz und Landschaftsplanung*, 50(04), 120–126.
- Huertas, A., & Orden-Mejía, M. (2022). Do tourists seek the same information at destinations? Analysis of digital tourist information searches according to different types of tourists. *European Journal of Tourism Research*, 32, 3211. <https://doi.org/10.54055/ejtr.v32i.2492>
- Hunziker, M., Hubschmid, E., & Solèr, R. (2021). Wildtier-orientierte Besucherlenkung im Schneessport – die Kampagne «Respect Wildlife» und deren Evaluation. *Forum für Wissen*, 63–68. https://www.dora.lib4ri.ch/wsl/islandora/object/wsl%3A28936/datastream/PDF/B%3C3%B%3C3%BCrgi-2021-Erholsame_Landschaft-%28publish_ed_version%29.pdf#page=65.
- Immoos, U., & Hunziker, M. (2014). Wirkung von Lenkungsmaßnahmen auf das Verhalten von Freizeitaktivisten. *Naturschutz und Landschaftsplanung*, 46, 5–9.
- Immoos, U., & Hunziker, M. (2015). The effect of communicative and on-site measures on the behaviour of winter sports participants within protected mountain areas—Results of a field experiment. *Eco.Mont*, 7(1), 17–25. <https://doi.org/10.15553/eco.mont-7-1s17>
- Job, H., Schamel, J., & Butzmann, E. (2016). Besuchermanagement in Großschutzgebieten im Zeitalter moderner Informations- und Kommunikationstechnologien. *Natur und Landschaft*, 91(1), 32–38. <https://doi.org/10.17433/1.2016.50153378.32-38>
- John, F. A. V. S., Edwards-Jones, G., Jones, J. P. G., John, F. A. V. S., Edwards-Jones, G., & Jones, J. P. G. (2010). Conservation and human behaviour: Lessons from social psychology. *Wildlife Research*, 37(8), 658–667. <https://doi.org/10.1071/WR10032>
- Jokar Arsanjani, J., Zipf, A., Mooney, P., & Helbich, M. (Eds.). (2015). *OpenStreetMap in GIScience: Experiences, research, and applications*. Springer International Publishing. <https://doi.org/10.1007/978-3-319-14280-7>.
- Josef, Z., & Kacel, J. (2013). Visitor management in protected areas. *Czech Journal of Tourism*, 2, 5–18. <https://doi.org/10.2478/cjot-2013-0001>

- Kang, S., Jodice, L., & Norman, W. (2020). How do tourists search for tourism information via smartphone before and during their trip?. 45, 57–68. <https://doi.org/10.1080/02508281.2019.1627076>
- Larson, C. L., Reed, S. E., Merenlender, A. M., & Crooks, K. R. (2016). Effects of recreation on animals revealed as widespread through a global systematic review. *PLoS One*, 11(12), 1–21. <https://doi.org/10.1371/journal.pone.0167259>
- Leung, Y.-F., Spenceley, A., Hvenegaard, G., & Buckley, R. (Eds.). (2018). *Tourism and visitor management in protected areas: Guidelines for sustainability* (1st ed.). IUCN, International Union for Conservation of Nature. <https://doi.org/10.2305/IUCN.CH.2018.PAG.27.en>
- Leiner, D. J. (2021). SoSci Survey (Version 3.2.31). [Software]. Available at <https://www.sosicisurvey.de>
- Loosen, A., Capdevila, T. V., Pigeon, K., Wright, P., & Jacob, A. L. (2023). Understanding the role of traditional and user-created recreation data in the cumulative footprint of recreation. *Journal of Outdoor Recreation and Tourism*, Article 100615. <https://doi.org/10.1016/j.jort.2023.100615>
- López-Rodríguez, M. D., Ruiz-Mallén, I., Oteros-Rozas, E., March, H., Keller, R., Lo, V. B., Cebrián-Piqueras, M. A., & Andrade, R. (2020). Delineating participation in conservation governance: Insights from the Sierra de Guadarrama National Park (Spain). *Environmental Science & Policy*, 114, 486–496. <https://doi.org/10.1016/j.envsci.2020.09.019>
- Mangold, M., Schwietering, A., Zink, J., Steinbauer, M. J., & Heurich, M. (2024). The digitalization of outdoor recreation: Global perspectives on the opportunities and challenges for protected area management. *Journal of Environmental Management*, 352, Article 120108. <https://doi.org/10.1016/j.jenvman.2024.120108>
- Manning, R. E., Anderson, L. E., & Pettengill, P. R. (2017). *Managing outdoor recreation: Case studies in the national parks*. CABI Publishing. <https://www.nhbs.com/managing-outdoor-recreation-book>
- McKenzie-Mohr, D., Lee, N. R., Schultz, P., & Kotler, P. A. (2012). *Social marketing to protect the environment: What works*. <https://doi.org/10.4135/9781483349466>. p. 237.
- Moczek, N., Theis, A., & Richter, A. (2024). Wie wirken Besucherlenkungsanlagen? *Natur und Landschaft*, 99(11), 540–547. <https://doi.org/10.19217/NuL2024-11-03>
- Norman, P., & Pickering, C. M. (2017). Using volunteered geographic information to assess park visitation: Comparing three on-line platforms. *Applied Geography*, 89 (June), 163–172. <https://doi.org/10.1016/j.apgeog.2017.11.001>
- OpenStreetMap contributors. (2015). Planet dump [Data file from 2024]. Retrieved from. <https://planet.openstreetmap.org>
- Patthey, P., Wirthner, S., Signorelli, N., & Arlettaz, R. (2008). Impact of outdoor winter sports on the abundance of a key indicator species of alpine ecosystems. *Journal of Applied Ecology*, 45(6), 1704–1711. <https://doi.org/10.1111/j.1365-2664.2008.01547.x>
- Pörtner, H. O., Scholes, R. J., Agard, J., Archer, E., Arneth, A., Bai, X., Barnes, D., Burrows, M., Chan, L., Cheung, W. L., Diamond, S., Donatti, C., Duarte, C., Eisenhauer, N., Foden, W., Gasalla, M. A., Handa, C., Hickler, T., Hoegh-Guldberg, O., Ichii, K., Jacob, U., Insarov, G., Kiessling, W., Leadley, P., Leemans, R., Levin, L., Lim, M., Maharaj, S., Managi, S., Marquet, P. A., McElwee, P., Midgley, G., Oberdorff, T., Obura, D., Osman, E., Pandit, R., Pascual, U., Pires, A. P. F., Popp, A., ReyesGarcía, V., Sankaran, M., Settele, J., Shin, Y. J., Sintayehu, D. W., Smith, P., Steiner, N., Strassburg, B., Sukumar, R., Trisos, C., Val, A. L., Wu, J., Aldrian, E., Parmesan, C., Pichs-Madruga, R., Roberts, D. C., Rogers, A. D., Díaz, S., Fischer, M., Hashimoto, S., Lavorel, S., Wu, N., & Ngo, H. T. (2021). In IPBES, & IPCC (Eds.), *IPBES-IPCC co-sponsored workshop report on biodiversity and climate change*. https://ipbes.net/sites/default/files/2021-06/20210609_workshop_report_embargo_3pm_CEST_10_june_0.pdf
- Protect the Planet. (2024). <https://www.protectedplanet.net/en>. URL
- R Core Team. (2025). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing [Software] Version 4.5.1. <https://www.R-project.org/>
- Reese, G., Fritsche, I., Wiersbinski, N., Mues, A., & Römpke, A.-K. (2015). *Psychologie in der Naturschutzkommunikation—Einblicke in die aktuelle Forschung und Praxis*, 21–24. Bundesamt für Naturschutz.
- Rist, S., Chidambaranathan, M., Escobar, C., Wiesmann, U., & Zimmermann, A. (2007). Moving from sustainable management to sustainable governance of natural resources: The role of social learning processes in rural India, Bolivia and Mali. *Journal of Rural Studies*, 23(1), 23–37. <https://doi.org/10.1016/j.jrurstud.2006.02.006>
- Rosenthal, J., Booth, R., Carolan, N., Clarke, O., Curnew, J., Hammond, C., Jenkins, J., McGee, E., Moody, B., Roman, J., Rossi, K., Schaefer, K., Stanley, M., Ward, E., & Weber, L. (2022). The impact of recreational activities on species at risk in Canada. *Journal of Outdoor Recreation and Tourism*, 40, Article 100567. <https://doi.org/10.1016/j.jort.2022.100567>
- Santos, M. L. B. D. (2022). The “so-called” UGC: An updated definition of user-generated content in the age of social media. *Online Information Review*, 46(1), 95–113. <https://doi.org/10.1108/OIR-06-2020-0258>
- Schmücker, D., Keller, R., Reif, J., Schubert, J., & Sommer, G. (2023). Digitales Besuchermanagement im Tourismus – Konzeptioneller Rahmen und Gestaltungsmöglichkeiten. In M. A. Gardini, & G. Sommer (Eds.), *Digital Leadership im Tourismus: Digitalisierung und Künstliche Intelligenz als Wettbewerbsfaktoren der Zukunft* (pp. 293–315). Springer Fachmedien. https://doi.org/10.1007/978-3-658-37545-4_13
- Schwartz, F., Taff, B. D., Pettebone, D., & Lawhon, B. (2016). Boulderers’ Attitudes and Beliefs. *International Journal of Wilderness*, 22(3), 25–32.
- Schweizer, A.-M., Leiderer, A., Mitterwallner, V., Walentowitz, A., Mathes, G. H., & Steinbauer, M. J. (2021). Outdoor cycling activity affected by COVID-19 related epidemic-control-decisions. *PLoS One*, 16(5), Article e0249268. <https://doi.org/10.1371/journal.pone.0249268>
- Schwietering, A., Mangold, M., Sarx, S., Sand, M., Adolf, H., Audorff, V., Berkmann, U., Campsheide, M., Finger, M., Gareis, N., Hallermann, M., Heintz, F., Heurich, M., Joa, B., Marth-Busch, M., Mitterwallner, V., Pukall, K., Pilloni, S., Reuter, S., ... Steinbauer, M. (2024). Digitale Outdoorplattformen: Potenziale und Herausforderungen für Naturschutz und Aktivitätsmanagement. *Natur und Landschaft*, 99(8), 384–396. <https://doi.org/10.19217/NuL2024-08-03>
- Schwietering, A., Steinbauer, M., Mangold, M., Sand, M., & Audorff, V. (2023). Digitalization of planning and navigating recreational outdoor activities. *German Journal of Exercise and Sport Research*. <https://doi.org/10.1007/s12662-023-00927-1>
- Shen, S., Sotiriadis, M., & Zhang, Y. (2020). The Influence of Smart Technologies on Customer Journey in Tourist Attractions within the Smart Tourism Management Framework. *Sustainability*, 12(10), Article 10. <https://doi.org/10.3390/su12104157>
- Stefán, F., Ciesielski, M., Weber, A., Choromański, K., Gotlib, D., & Taczanowska, K. (2025). Understanding generational differences in digital skills and recreational behaviour for effective visitor management in forest destinations. *Scientific Reports*. <https://doi.org/10.1038/s41598-025-02036-5>
- White, E. M., Bowker, M., Askew, A. E., Langner, L. L., Arnold, J. R., & English, D. (2016). Federal outdoor recreation trends: Effects on economic opportunities. *Gen. Tech. Rep., PNW-GTR-945*. <https://doi.org/10.2737/PNW-GTR-945>
- Wolf-Watz, D. (2014). Traveling for nature? On the paradox of environmental awareness and travel for nature experiences. *Tourism*, 62(1), 5–18.
- Wraith, J., & Pickering, C. (2017). Tourism and recreation a global threat to orchids. *Biodiversity and Conservation*, 26(14), 3407–3420. <https://doi.org/10.1007/s10531-017-1412-y>
- Zeida, D., & Josef, Z. (2019). The Concept of Comprehensive Tracking Software to Support Sustainable Tourism in Protected Areas. *Sustainability*, 11, 4104. <https://doi.org/10.3390/su11154104>
- Zelenka, J., & Kacetyl, J. (2013). Visitor management in protected areas. *Czech Journal of Tourism*, 2(1), 5–18. <https://doi.org/10.2478/cjot-2013-0001>
- Zhang, Y., West, P., Thakholi, L., Suryawanshi, K., Supuma, M., Straub, D., Sithole, S. S., Sharma, R., Schleicher, J., Ruli, B., Rodríguez-Rodríguez, D., Rasmussen, M. B., Ramenzoni, V. C., Qin, S., Pugley, D. D., Palfrey, R., Oldekop, J., Nuesiri, E. O., Nguyen, V. H. T., ... Agyei, F. K. (2023). Governance and Conservation Effectiveness in Protected Areas and Indigenous and Locally Managed Areas. *Annual Review of Environment and Resources*, 48(1), 559–588. <https://doi.org/10.1146/annurev-environ-112321-081348>
- Zheng, X., Luo, Y., Sun, L., Zhang, J., & Chen, F. (2018). A tourism destination recommender system using users’ sentiment and temporal dynamics. *Journal of Intelligent Information Systems*, 51(3), 557–578. <https://doi.org/10.1007/s10844-018-0496-5>
- Zink, J., Mangold, M., Porst, F., Steinbauer, M., & Heurich, M. (2024). Towards a digital ranger: Using data from outdoor platforms to detect rule violations in protected areas and improve visitor management. *Journal of Outdoor Recreation and Tourism*, 48, Article 100835. <https://doi.org/10.1016/j.jort.2024.100835>
- Zink, J., Porst, F., Leibl, F., & Heurich, M. (2022). Digitalisierung in Erholungsnutzung und Outdoorsport als Herausforderung—Auf dem Weg zu einem digitalen Besuchermanagement in Schutzgebieten. *Naturschutz und Landschaftsplanung*, 54, 20–29. <https://doi.org/10.1399/NuL.2022.07.02>