sciendo

Environmental & Socio-economic Studies

DOI: 10.2478/environ-2019-0008

Environ. Socio.-econ. Stud., **2019, 7, 2: 10-20**

Original article

Can trail characteristics influence visitor numbers in natural protected areas? A quantitative approach to trail choice assessment

Kamila Svobodova[1, 2]*, Luis Monteiro[2], Jiri Vojar[2], Katerina Gdulova[2]

[1] Centre for Social Responsibility in Mining, Sustainable Mineral Institute, The University of Queensland, St Lucia Campus, QLD, 4072, Australia
[2] Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamycka 1176, 16521 Prague 6, Czech Republic
*E–mail address (*corresponding author): k.svobodova@uq.edu.au; ORCID iD: http://orcid.org/0000-0002-9501-7221*
ORCID iD: Jiri Vojar: https://orcid.org/0000-0002-6824-9449; Luis Monteiro: https://orcid.org/0000-0002-6894-0432; Katerina Gdulova: https://orcid.org/0000-0002-6943-9172

ABSTRACT

Planning for recreational activities in protected areas involves an understanding of multiple and complex factors. Trails constitute the main recreation facility in protected areas. They are an important and common infrastructure that concentrates visitor movement. Their sustainable planning and management requires an understanding of how the visitors made their selection. The aim of this study was to identify the effect of trail attributes on visitor numbers in the Krkonoše Mountains National Park in the Czech Republic. The methods used in this study present an analytical approach involving geographic information system analysis, field monitoring and data analyses using generalised linear models. The results showed the preferential tendencies among visitors to certain trail attributes. Marginal significance and a rather strong variability in preferences (over 10%) were identified for five trail characteristics: the amount of local attractions; diversity of land cover types; dominant land cover along a trail; soil erosion; and the type of trail surface. In our study, we illustrate an analytical framework for the assessment of trail characteristics that can help guide trail analyses and management efforts. On the other hand, our findings raise new research questions and point to the requirements for further research in order to better understand how environmental attributes influence visitor choice and to use this knowledge for trail planning and management.

KEY WORDS: tourism, route attributes, trail research, nature conservation, Krkonoše Mountains National Park

ARTICLE HISTORY: received 26 September 2018; received in revised form 3 April 2019; accepted 8 April 2019

1. Introduction

In recent decades the time available for leisure has increased and the number of tourists visiting protected natural areas has grown dramatically as a result of social and economic changes in global society (PIGRAM & JENKINS, 1999; BUCKLEY, 2009; NEWSOME ET AL., 2013; BALMFORD ET AL., 2015). One of the main reasons for this rapid growth in nature-based tourism is the fact that natural areas offer various environmental services (MILLENNIUM ECOSYSTEM ASSESSMENT, 2005; CHIOU ET AL., 2010). For instance, the value people place on experiencing nature, feelings of well-being and the physical, emotional and mental benefits received from engaging in this type of tourism (KENTER ET AL., 2011; DALLIMER ET AL., 2012). On the other hand, the increasing number of visitors in natural areas has serious consequences for their management (D'ANTONIO ET AL., 2013; HAUSNER ET AL., 2017). This highlights the urgency of improving our understanding of how visitors use these areas and what specific management strategies should be applied (D'ANTONIO ET AL., 2013; HAUSNER ET AL.,

2017). Strategies implemented to attract visitors are often balanced with methods to manage recreational problems, including the development of a recreational infrastructure such as formal trail systems (WIMPEY & MARION, 2011; NEWSOME ET AL.; 2013).

Although protected natural areas are managed in part for the provision of recreational opportunities, the monitoring of visitor use is a difficult measure, particularly due to the visitors' spatial and temporal dispersion based on their different motivations and satisfactions (TAYLOR, 2015; MILLER ET AL., 2017). Trails are an important infrastructure concentrating human movement and have been targeted for visitor use monitoring efforts (LEUNG & MARION, 2000; CESSFORD ET AL., 2002). However, the relationship between visitor use and the physical characteristics of the trails in protected areas is not well understood. Existing research has examined trail attributes with the focus on two subjects: nature protection and tourist motivations. The first approach concentrates on the protection of the natural qualities and notes the impact of visitor use on an individual trail feature (e.g., LI ET AL., 2005; PELLETIER, 2006; MARION ET AL., 2011; D'ANTONIO ET AL., 2013; ÓLAFSDÓTTIR & RUNNSTRÖM, 2013; WOLF & CROFT, 2014; BALLANTYNE & PICKERING, 2015; PESCOTT & STEWART, 2015; MILLER ET AL., 2017). In detail, ÓLAFSDÓTTIR & RUNNSTRÖM (2013) assessed trail conditions in the Icelandic highlands as a function of tourism use and such physical properties as trail elevation, gradient and ecological sensitivity. WIMPLEY & MARION (2010) evaluated the influence of use as well as managerial and environmental factors on trail width in Acadia National Park, USA and found a significant correlation between landform grade, position and trail width. BALLANTYNE & PICKERING (2015) assessed the impacts of different recreational trails in urban forests in Australia when comparing the condition of the trail surface, loss of forest strata and changes in tree structure. WOLF & CROFT (2014) quantified the strengths and spatial extent of tourism impacts along recreational tracks when examining the edge-effect on vegetation communities. The second approach presents motivations and focuses on the importance of trails in tourists' decisions when planning their trips (e.g., GOBSTER, 1995; JORGENSEN AT AL., 2002; FARÍAS TORBIDONI ET AL., 2005; DRÁBKOVÁ & ŠIŠÁK, 2013; KELLEY ET AL., 2016; KOEMLE & MORAWETZ, 2016). For instance, DRÁBKOVÁ & ŠIŠÁK (2013) investigated preferences for trail facilities and found out that maintained trails without equipment were the most preferred by tourists. GOBSTER (1995) found that vegetation management, trail surfacing, maintenance and other factors can affect a recreationist's preferences. Similarly, FARÍAS TORBIDONI ET AL. (2005) examined a significant link between visitor's socio-demographic categories, preferences and motivations on the one hand and a trail's location, climate and elevation range on the other. Further, KOEMLE & MORAWETZ (2016) investigated attributes of mountain bike trails in Austria such as trail length, vertical climb or management intensity in a choice experiment assessing the trail preferences of their users. KELLEY ET AL. (2016) demonstrated that infrastructure attributes are the most important aspects associated with trail users' demands.

Although the experimental studies presented above have demonstrated findings that contribute towards trail research from various perspectives, there is a significant gap in the complex investigations of the relationships between visitor use and the characteristics of the trails. Therefore, the present study aims to identify the effect of trail attributes on visitor numbers in protected natural areas. We hypothesise that particular physical characteristics present along the tourist trails such as type of surface, food service or scenic vistas significantly affect visitor numbers on these recreational infrastructures. The findings may help managers to design tourist trails in protected areas with the aim to reflect visitor preferences and to manage user conflicts and environmental degradation.

2. Methods

2.1. Study area

The study is based in the Czech Republic where the demand for outdoor recreation activities in protected areas and national parks has increased dramatically in the past few decades. Most of these outdoor activities have been concentrated in formal trail systems and have resulted in impacts on natural and cultural resources that have reduced the quality of the visitor experience (ZAHRADNÍK ET AL., 2012; TOMCZYK & EWERTOWSKI, 2013). Although the Czech Republic is home to one of the world's best-marked and well-connected tourist trail networks in the European Union, the existing research on trail visitation in protected areas is very limited.

The survey was conducted in the Krkonoše Mountains, one of the most valuable natural areas in Central Europe. The Mountains are situated in the north-eastern Czech Republic and in the south-west of Poland as part of the Sudetes mountain system. The main ridge runs along the Czech-Polish border. The survey is only located in the Czech part of the mountains called the Krkonoše

Mountains National Park (KRNAP). The National Park covers almost all of the Czech highest mountain range (total area of 425 km²; Fig. 1), and includes the Czech highest peak Sněžka (1,603 m a.s.l.).

KRNAP was founded in 1963 with the purpose of maintaining and improving its unique environment, especially the conservation or renewal of self-controlling functions of natural systems, strict protection of wild animals and plants, preservation of the typical landscape appearance, the fulfilment of scientific and educational objectives and the sustainable use of the national park for tourism and recreation (GOVERNMENT OF CZECHOSLOVAKIA, 1963). Nature in KRNAP is recognised as being of global importance due to its protection under the UNESCO Transboundary Biosphere Reserve, CORINE Biotopes, Natura 2000 network and Ramsar Wetlands designations. Despite its relatively small area, KRNAP is one of the most-visited national parks in the world (FOUSEK ET AL., 2007). With approximately 700 km of marked trails for pedestrians and/or cyclists, available during the summer and winter seasons, well-established infrastructure, natural attractiveness and relatively easy accessibility, the Krkonoše Mountains attracts approx. 11 million people annually (DRAHNÝ, 2018). The high number of visitors together with the problem of industrial emissions during the past few decades poses a threat for the future development of this protected area. For this reason, KRNAP was registered in the list of the most endangered national parks of the world (INTERNATIONAL UNION FOR CONSERVATION OF NATURE, 1984). In spite of these existing problems, tourism represents an important source of prosperity which is ensured only when natural value is well-preserved. For this reason, the KRNAP Administration has been monitoring tourist numbers in the most-visited areas. Until 2011, visitors were monitored occasionally by a field observer using recording forms. Since October 2011, 27 on-site counters (23 on-site counters monitor pedestrians and cyclists, and 4 devices monitor cars) have been installed and monitor visitors at selected locations within KRNAP (ŠŤASTNÁ, 2013).

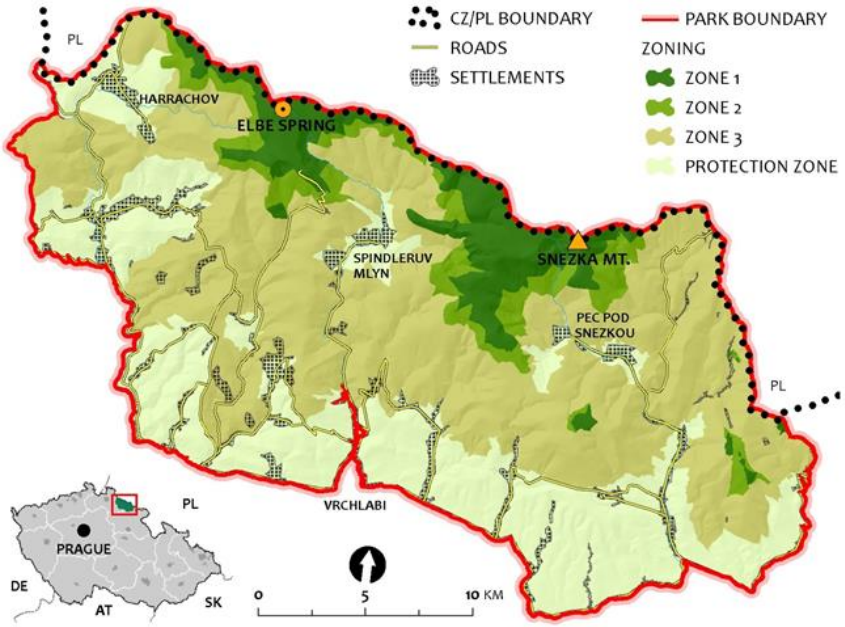

Fig. 1. The study area of Krkonoše Mountains National Park

In addition to the efforts of the KRNAP Administration, the National Park has been the centre of attention of several research projects in the Czech Republic and in Poland. For instance, ROGOWSKI (2016), ROGOWSKI ET AL. (2013) and KVAPIK ET AL. (2011) investigated the potential of the National Park for geotourism, considering an establishing a geotourist cluster in the European tourism market. CIHAR ET AL. (2002) conducted a questionnaire survey and interviews with visitors to the KRNAP to find out their preferences and motivations to visit to the National Park. BRAUN KOHLOVÁ ET AL. (2017) summarized their experience with tracking visitors into a methodology for monitoring visitor numbers in protected areas. Similarly, ZELENKA ET AL. (2013) described the basic approaches to the sustainable management of protected areas such as, consistent strategic, visitor and participative management based on the respect of the local knowledge, inhabitants' engagement and the carrying capacity of the area, in the connection with monitoring the impacts of tourism.

2.2. Trail characteristics

As in FARÍAS TORBIDONI ET AL. (2005), we assume that the characteristics of recreational trails have a major impact on their visitors. To identify the most important trail attributes, we conducted rigorous literature research, preliminary field research and short interviews with KRNAP managers on their opinion about key trail characteristics influencing visitor numbers on trails. The final list of 17 attributes can be found in Table 1.

Table 1. Surveyed and analysed trail segment characteristics

Trail characteristic	Description and scoring scheme [units]
Characteristics analyzed in geographic information system (GIS)	
Segment length	number of meters along the segment [m]
Trail type	hiking (a); cycling and hiking (b)
Dominant type of land cover (CORINE)	coniferous forest (a); moors and heathland (b); natural grassland (c); transitional woodland – shrub (d)
Number of land cover types (CORINE)	number of land cover types along the segment (1–4 types)
Average segment slope	slope parallel to the direction of travel (greater degrees = higher slope) [degrees]
Degree of shading	illumination of a surface according to a specified azimuth and altitude for the sun (values ranging from 0 to 255, with 0 representing areas in shadow and 255 the brightest areas); calculated using GIS Hillshade tool [degrees]
Water stream intersecting or running parallel to the trail segment	no stream (a); stream intersecting the trail (b); stream following the trail (c)
Characteristics evaluated directly in the field	
Trail width	trail segment width between outer trail boundaries (median) [m]
Dominant surface type	sand (a); gravel (b); stones (c); asphalt (d)
Presence of soil erosion	yes (a); no (b)
Presence of stairs along the segment	yes (a); no (b)
Number of info panels along the segment	number of information panels per meter
Number of resting places along the segment	number of resting places per meter
Food services along the segment	yes (a); no (b)
Accommodation possibility along the segment (hotels, mountain lodges, etc.)	yes (a); no (b)
Number of local attractions[1] along the segment	number of attractions per meter
Scenic vistas	dominant closed vistas along the segment (a); dominant open vistas along the segment (b); open vistas along the entire segment (c)

These trail characteristics were exclusively investigated on trails where automated visitor counters had been installed (see Figures 2 and 3). A spatial analysis was conducted whereby each trail was reduced to a segment, defined as the continuous part of the trail containing a counter between crossings with other trails in both directions. Trails were reduced into segments in order to obtain precise visitor numbers for parts of the trails. A total of 22 trail segments were designated representing the basic spatial units where all subsequent analyses were conducted (see Fig. 3).

As shown in Table 1, we divided the surveyed attributes into two groups according to the methods for their evaluation: characteristics directly evaluated in the field and characteristics analysed using the geographic information system (GIS) (see Table 1). The field survey and GIS analyses of selected trail segment characteristics were conducted by four field staff working in pairs between June and August 2014. Simultaneously, visitor numbers provided by on-site counters were selected only for the previous summer's tourist season from May to October 2013, which corresponds to the period of the year when visitation is at its highest. Field staff assessed all field characteristics while carrying a GPS unit (Garamin Dakota 20) along each surveyed trail segment. GPS points were recorded for all characteristics in order to define their geographical locations and cumulative distances from the trail. The accuracy and precision in assessing each characteristic were improved using colour photographs and supervision. Trail segment width was documented by measuring the trail width each 200 m following a GPS waypoint. For resource condition characteristics (e.g. soil erosion), only problematic occurrences that exceeded a linear distance of 2 m were assessed. All human-constructed features, such as info panels and benches, were documented. Survey data were stored and analysed in ArcGIS 10.2 software.

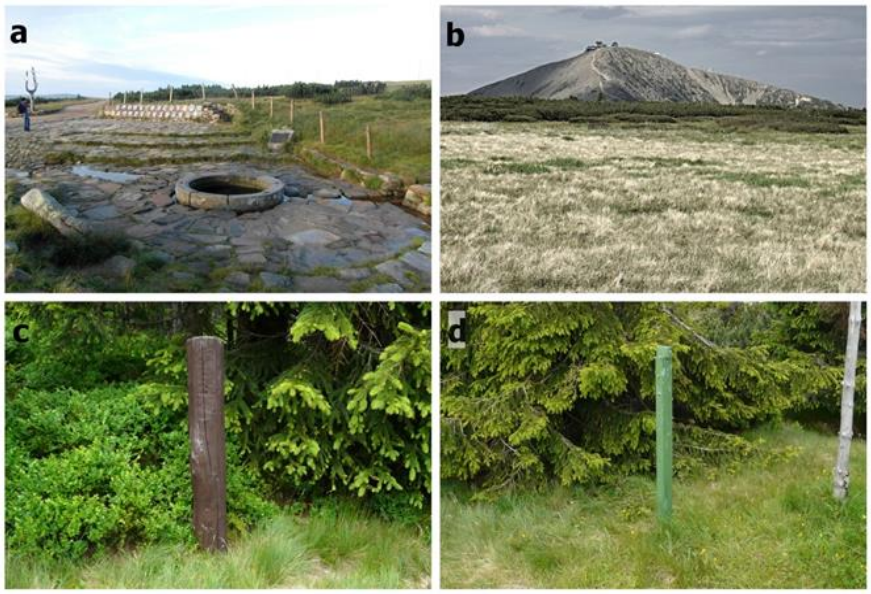

Fig. 2. The most visited sites in Krkonoše Mountains National Park (KRNAP): the Elbe River spring (a) and the highest peak, Sněžka (b). Photographs of differently designed on-site counters located in KRNAP, both use PYRO temperature change sensors (c, d)

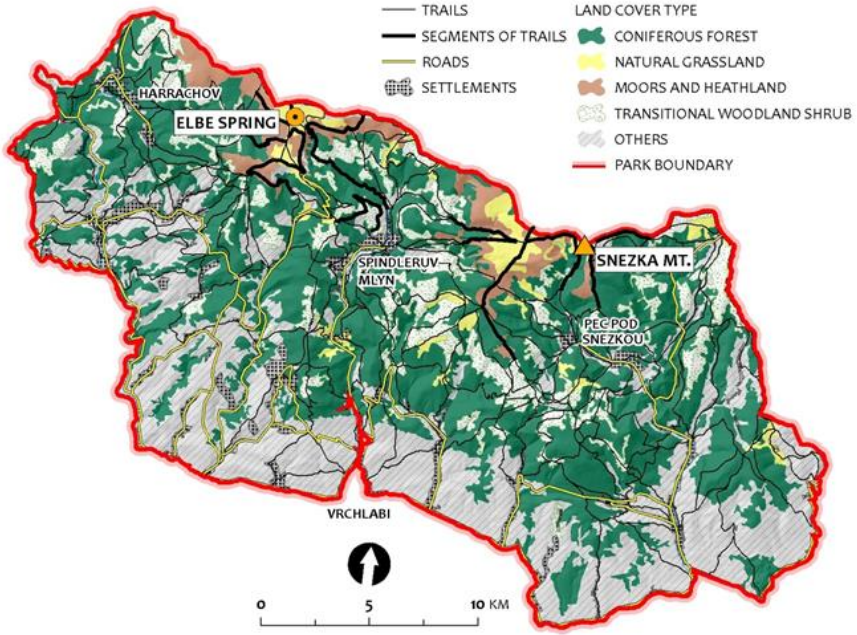

Fig. 3. Location of assessed trail segments within Krkonoše Mountains National Park.

2.3. Statistical analysis

Generalised linear models were employed to analyse the effects of the 17 selected trail characteristics (independent variables) on the number of trail visitors (dependent variable). Because the statistical distribution of visitation numbers was strongly skewed from the normal and the variance of this variable greatly exceeded the mean (a sign of overdispersion), models with quasi-Poisson distributions of errors were used (CRAWLEY, 2007). As the first step, a separate test of each independent variable was carried out to determine its significance and the proportion of variability in tourist visits it explained. In the next step, all significant variables within these partial tests ($p < 0.05$) were gradually added into the model according to their significance and tested by the *F*-test using a forward selection statistical procedure (CRAWLEY, 2007). Because none of the analysed variables were significant within the partial test, the forward selection procedure was not performed and only the results of particular tests are presented. All of the statistical analyses described above were performed in R, version 3.0.2 (R DEVELOPMENT CORE TEAM, 2013).

3. Results

GIS descriptive data analyses demonstrated that only six of the 22 evaluated trails were accessible to cyclists. The dominant land cover types along segments were natural grasslands (predominant along 36% of segments) and moors & heathland (27% of segments) (Fig. 4). The majority of the segments (36%) were located through four different land cover types and a water stream was absent along 60% of the segments. The results of GIS analyses are summarised in Table 2.

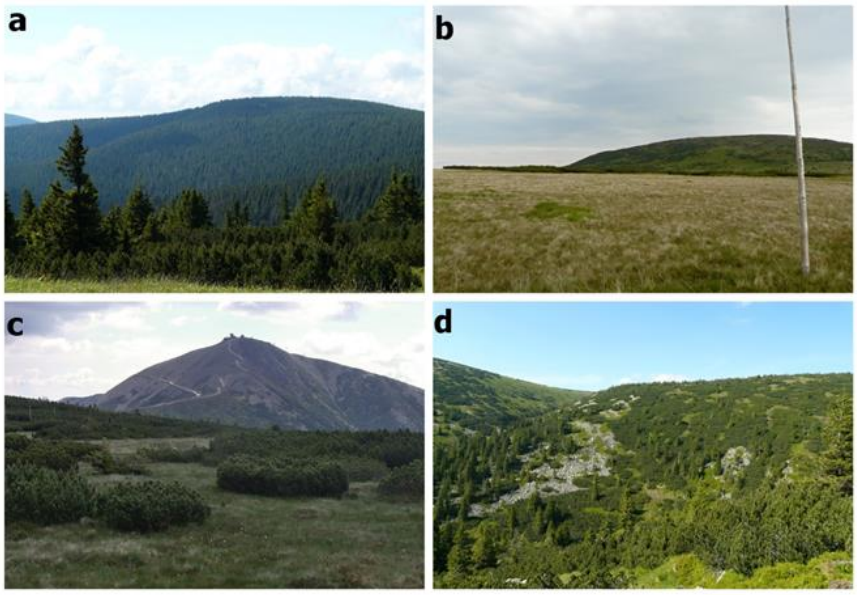

Fig. 4. Photographs from the study area depicting CORINE land cover types indicated along evaluated segments: coniferous forest (a), natural grassland (b), moors and heathland (c), transitional woodland – shrub (d)

Table 2. Results of the GIS analyses of trail characteristics (codes and scoring are explained in Table 1)

Counter/ segment no.	Segment length (m)	Trail type	Number of land cover types	Dominant type of land cover type	Average segment slope (°)	Degree of shading (°)	Water stream
1	2,249	a	2	c	9.72	151.07	a
2	2,765	a	4	d	12.05	152.24	b
3	1,863	a	4	b	15.57	146.92	a
4	3,049	a	4	b	20.36	148.73	b
5	441	a	1	c	3.59	149.05	a
6	1,234	a, b	2	c	4.74	147.56	a
7	2,099	a	2	c	11.12	135.98	b
8	1,321	a	1	c	5.63	147.87	a
9	966	a	3	b	11.83	152.05	a
10	2,563	a	3	d	14.64	152.33	b
11	7,236	a, b	4	a	14.02	133.59	c
12	5,138	a, b	3	d	14.07	136.60	a
13	3,515	a	4	a	23.64	109.23	c
14	2,751	a	4	c	18.16	141.39	b
15	806	a	3	c	2.35	146.81	a
16	2,363	a	4	b	4.71	148.44	a
17	2,397	a, b	2	c	9.16	146.67	a
18	1,293	a	1	b	7.39	146.36	b
19	2,875	a	4	d	4.33	146.68	a
20	3,319	a	3	a	8.42	140.46	a
21	3,274	a, b	3	a	21.88	139.23	c
22	3,212	a, b	2	b	16.82	150.08	a

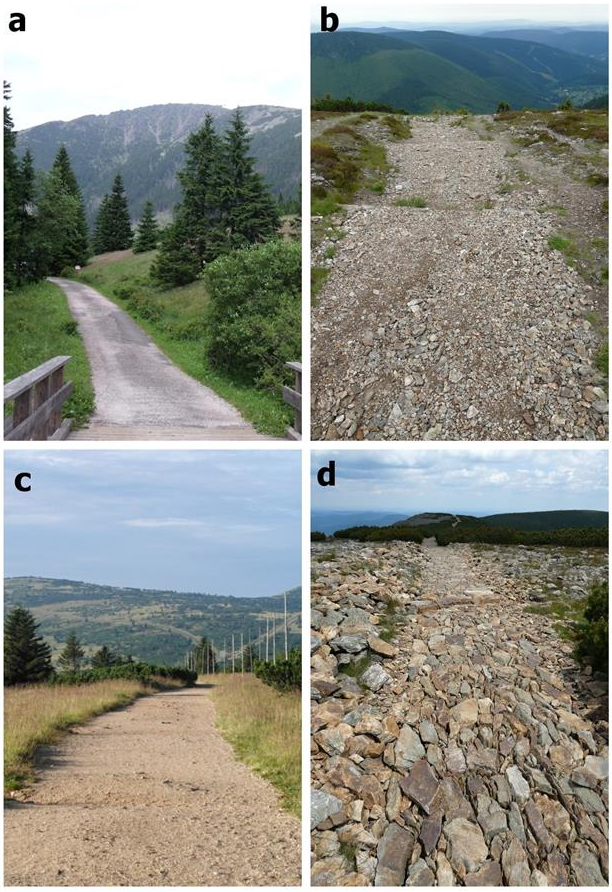

Fig. 5. Surface types determined in the study area: asphalt (a), gravel (b), sand (c), and stones (d)

Field evaluation of segments showed that the most common surface types were fine gravel (32% of segments) and stones (27% of segments) (Fig. 5). Almost half of the trail segments were affected by soil erosion processes and 32% of segments included steps. Facilities along segments were satisfactory, with food services identified along 64% of the segments and accommodation possibilities available on half of the evaluated segments. On the other hand, local attractions were absent along 27% of segments. Closed scenic vistas predominated in 45% of segments, while open vistas were dominant in 23% of segments. Detailed results of the field survey are presented in Table 3.

The results show that all 17 analysed trail characteristics have no significant effect on visitor numbers as presented in Table 4. However, the number of local attractions along the segment provided a marginally significant effect. The most visited segments were those that contained the highest number of attractions, drawing twice as many visitors as segments without attractions. Trail characteristics such as dominant land cover type, dominant surface type, number of land cover types and presence of soil erosion accounted for more than 10% of variability of visitor numbers in the statistical analysis, which suggests their potential effect on the number of visitors.

Table 3. Trail segment characteristics evaluated in the field (codes and scoring are explained in Table 1)

Counter/ segment no.	Trail widh (median)	Dominant surface type	Soil erosion	Stairs	Info panels	Resting places	Food services	Accommodation possibiity	Local attractions	Scenic vistas
1	1.30	c	b	b	0.00	0.44	a	a	0.00	a
2	1.70	a	a	b	1.45	0.72	a	b	0.00	a
3	1.85	a	a	b	1.07	2.15	b	b	0.54	b
4	1.00	c	a	a	0.00	0.98	b	b	0.66	a
5	2.70	a	b	b	2.27	9.07	b	b	2.27	c
6	3.30	d	b	b	0.00	1.62	b	b	0.00	b
7	2.55	a	a	b	1.91	4.29	b	b	3.33	c
8	1.90	a	b	b	0.00	0.76	b	b	1.51	c
9	1.05	c	b	b	0.00	8.28	a	a	0.00	a
10	1.10	c	a	a	0.39	1.17	a	a	0.78	c
11	2.60	d	b	b	1.93	1.66	b	b	0.55	a
12	3.40	d	b	b	0.19	0.39	a	b	0.78	a
13	1.20	c	a	a	0.28	0.28	a	a	0.00	a
14	1.80	b	b	a	1.09	0.73	b	b	0.36	b
15	2.50	a	b	b	4.96	2.48	a	a	1.24	c
16	2.40	a	a	b	1.69	0.85	a	a	1.27	c
17	3.40	d	b	b	2.09	1.67	a	a	1.67	c
18	2.85	b	b	b	1.55	1.55	a	a	1.55	b
19	2.25	b	b	b	1.04	0.70	a	a	0.35	a
20	1.30	c	b	a	1.21	1.21	a	a	0.90	b
21	2.30	b	a	a	1.53	1.53	a	a	1.53	a
22	2.50	b	a	a	0.00	0.00	a	b	0.00	a

Table 4. Results of statistical analyses. Trail characteristics explaining more than 10% of variability in trail visitation data are in bold. Only the number of local attractions along the segment could be considered as marginally significant. df = degrees of freedom, % dev = proportion of explained variability within partial tests, F = F-statistic, p = obtained probability

Trail characteristic	Number of visitors	df	% dev	*F*	*p*
Number of local attractions along the segment		**1**	**21.71**	**4.1232**	**0.0558**
0	5,582				
1	4,630				
2	8,787				
3	11,668				
Number of land cover types		**1**	**10.55**	**2.2584**	**0.1485**
1	8,076				
2	10,044				
3	5,445				
4	4,722				
5	6,414				
Presence of soil erosion		**1**	**10.07**	**2.2467**	**0.1495**
Yes	8,544				
No	5,361				
Dominant land cover type		**3**	**24.93**	**1.8957**	**0.1665**
Coniferous forest	7,924				
Natural grassland	6,423				
Moors and heathland	8,972				
Transitional woodland – shrub	2,419				
Dominant surface type		3	19.97	1.4246	0.2684
Asphalt	4,166				
Gravel	9,704				
Sand	7,683				
Stones	4,604				
Trail width		1	4.25	0.8456	0.3688
Presence of stairs along the segment		1	3.70	0.7168	0.4072
Trail type		1	2.34	0.4552	0.5076
Scenic vistas		2	6.37	0.5559	0.5826
Number of info panels		1	1.43	0.2578	0.6172
Food services		1	0.32	0.0589	0.8106
Accommodation possibility		2	2.18	0.1954	0.8242
Degree of shading		1	0.06	0.0109	0.9178
Number of resting places		1	0.01	0.0026	0.9596
Segment length		1	0.01	0.0012	0.9726
Average segment slope		1	0.01	0.0012	0.9732
Water stream intersecting or running parallel to the trail		2	0.01	0.0001	0.9993

4. Discussion

Management for outdoor recreation in protected natural areas requires an understanding of the visitor interests and their use of protected parts in order to avoid conflicts. In protected natural areas worldwide, trails are an important and common infrastructure that concentrates visitor movement (MILLER ET AL., 2017). Our study applied a quantitative approach to investigate the determinants of visitors' trail choice and how trail characteristics influence visitor numbers on the trails.

4.1. Preferential trends for trail characteristics

The results of our research indicate preferential tendencies for particular trail characteristics among visitors in the KRNAP. Although our findings are not statistically significant, marginal significance and a rather strong relationship to variability (over 10%) for five trail characteristics were identified. While also giving consideration to findings by existing research, the following section provides theoretical background for the trail characteristics showing preferential tendencies of KRNAP visitors.

Number of local attractions. Our results showed marginal significance of local attractions in trail visitations. Trails with three local attractions were visited twice as often as those without or with only one attraction. This finding resonates with DRÁBKOVÁ & ŠIŠÁK (2013), who indicated that local attractions on trails, such as cultural landmarks, affect visitor preferences for trails; moreover, they similarly identified only a marginal influence.

Furthermore, our findings support the importance of tourist attractions in management strategies as pointed out by PIGRAM (1983), MANNING ET AL. (1995) and BECKEN & SIMMONS (2002).

Number of land cover types. Our results suggested the potential importance of landscape type diversity in trail visitation. This is in accordance with JUNGE ET AL. (2009), who indicated human preferences for landscape biodiversity. These preferences can be connected with the aesthetic value of biodiversity as discussed by KIESTER (1997) and WALZ (2011).

Presence of soil erosion. We found that the consequences of erosion processes on trails could be a factor influencing a trail's visitation rate. While soil erosion was identified in highly visited trails, the less visited trails did not contain soil erosion impacts. In this way, it is evident that soil erosion can be both the reason and the consequence of a trail visit. This suggestion supports the observation made by ROGGENBUCK ET AL. (1993), who stated that evident forms of trail impact, such as soil erosion, eroded ruts, and exposed tree roots, can affect visitor preferences.

Dominant land cover type. Our study indicated that land cover along trails could have a tendency to affect their visitation. This finding is in accordance with authors who found an effect of land use or land cover on human preferences and perception of landscape (e.g., BULUT & YILMAZ, 2008; CAÑAS ET AL., 2009; BARROSO ET AL., 2012; MOLNAROVA ET AL., 2012; SVOBODOVA ET AL., 2012). Our study found that the most visited trails were placed in localities where moors, heathlands and natural grasslands dominated. This supports observations made by JORGENSEN ET AL. (2002) that the height and compactness of surrounding land cover plays a significant role in people's feeling of safety. Particularly, visual openness and visibility are considered to be very important factors influencing human preferences for landscape (ULRICH, 1986).

Dominant trail surface type. Our study suggested that the type of trail surface could affect visitor numbers on trails. The results showed that the most visited trails contained a gravel or fine gravel surface. This is in accordance with ARNBERGER & EDER (2011), who indicated that visitors prefer non-natural surfaces (asphalt and gravel) to natural surfaces (dirt, rocks, and tree roots). On the contrary, our findings are contrary to GOBSTER (1995), who indicated dominant preferences among visitors for asphalt-paved trails.

4.2. Study limitations and recommendations

We are aware of limitations in this study that influenced our findings. The crucial limitation of our study is the lack of significant effects. This might be a consequence of the tests' low power due to the low number of segments in the analyses (n = 22). The limited sample size was caused by a limited number of installed visitor counters in the KRNAP that provided data on trail visitation. We suggest that it was mainly this fact that led to the results wherein just one characteristic was noticed as being marginally significant and another four only point to relationships to visitor variability (>10%). If we had had a larger input data set, these four characteristics might very well have been significant.

On the other hand, although our study identified no clear influence of the selected trail characteristics on trail visitation, the investigation of the effect of trail characteristics on visitor numbers provides valuable insight into trail research. The value of this study lies in its analytical approach. We identified trail characteristics with possible effects on visitor numbers based on rigorous literature and field research, short interviews with national park managers and we developed a methodology of trail attribute assessment that can help guide trail analysis and management efforts. It is particularly notable that the trail characteristics influencing trail visitation can vary in regards to different landscape types, trail categories, groups of users and the types of dominant activities on trails. The settings have to be taken into account when applying the analytical approach.

We highly recommend that additional research is undertaken to examine the effects of other trail characteristics, particularly the multiple-use of a trail and the popularity of the start and end points of a trail. As GOEFT & ADLER (2009) showed, sharing the trail with other users, especially with motorised vehicles, can cause conflicts and significantly decrease visitor numbers on the trail. FARÍAS TORBIDONI ET AL. (2005) demonstrated that visitor preferences for trails differ when considering trails ending on a peak. Only adventurous visitors preferred these trails.

A potential area for further research also lies in applying our methodological framework to various landscapes and along trails leading outside protected natural areas or national parks. The comparison of trail choice made by visitors in protected areas with different protection purpose (e.g. historical sites, natural areas, urban zones) could provide deeper insight into trail research. Another challenge for future research is to involve the motivations, preferences and needs of the visitors themselves. This could be applied via a quantitative or qualitative survey focused on visitors' preferences of existing or proposed trail

characteristics, the motivation behind their trail choice, and their needs during the trail visit. The survey on visitors' choice should be conducted directly in the field with the aim of exploring the link between trail environments and visitors.

5. Conclusion

The purpose of this study was to study the effect of trail character on park visitors' numbers in protected natural areas. Nevertheless, significant gaps remain in understanding the process of visitors' choice in selecting particular trails. Our study presented an analytical approach and developed a methodology for trail characteristic assessment; however, the findings also raised new research questions and pointed to needs for further research. We believe that understanding the importance of environmental attributes in trail design and management is a fundamental issue, which necessitates further investigation as discussed above.

Acknowledgments

The authors thank the KRNAP staff members for their assistance and support in providing available data. Additionally, and most importantly, we thank Alena Wranova for her great, kind and very helpful assistance in the field research. This study was funded by the Internal Grant Agency of the Faculty of Environmental Sciences, CULS, grant no. 20144221 "Monitoring of trail visitation in Krkonoše Mountains National Park, Czech Republic".

References

Arnberger A., Eder R. 2011. The influence of age on recreational trail preferences of urban green-space visitors: A discrete choice experiment with digitally calibrated images. *Journal of Environmental Planning and Management*, 54: 891–908.

Ballantyne M., Pickering C.M. 2015. The impacts of trail infrastructure on vegetation and soils: Current literature and future directions. *Journal of Environmental Management*, 164: 53–64.

Balmford A., Green J.M.H., Anderson M., Beresford J., Huang C., Naidoo R., Walpole M., Manica A. 2015. Walk on the Wild Side: Estimating the Global Magnitude of Visits to Protected Areas. *PLoS Biology*, 13, *2:* 1–6.

Barroso F.L., Pinto-Correia T., Ramos I.L., Surová D., Menezes H. 2012. Dealing with fuzziness in user preference studies: Photo based questionnaires in the Mediterranean context. *Landscape and Urban Planning*, 104: 329–342.

Becken S., Simmons D.G. 2002. Understanding energy consumption patterns of tourist attractions and activities in New Zealand. *Tourism Management*, 23, 4*:* 343–354.

Braun Kohlová M., Melichar J., Kaprová K. 2017. *Methodology for monitoring of visitors to protected areas*. Prague, Nature Protection Agency of the Czech Republic.

Buckley R. 2000. Neat trends: current issues in nature, eco- and adventure tourism. *International Journal of Tourism Research*, 2: 437–444.

Buckley R. 2009. *Ecotourism: Principles and Practices*. CABI, Oxford.

Bulut Z., Yilmaz H. 2008. Determination of landscape beauties through visual quality assessment method: A case study for Kemaliye (Erzincan/Turkey). *Environmental Monitoring and Assessment*, 141: 121–129.

Cañas I., Ayuga E., Ayuga F. 2009. A contribution to the assessment of scenic quality of landscapes based on preferences expressed by the public. *Land Use Policy*, 26: 1173–1181.

Cessford G., Cockburn S., Douglas M. 2002. Developing new visitor counters and their applications for management. Paper presented at the First Monitoring and Management of Visitor Flows in Recreational and Protected Areas Conference, Vienna. Available at: http://mmv.boku.ac.at/downloads/mmv1-proceedings.pdf

Cihar M., Stursa J., Trebicky V. 2002. Monitoring of Tourism in the Czech National Parks. [in:] A. Arnberger, C. Brandenburg, A. Muhar (eds.) *Monitoring and Management of Visitor Flows in Recreational and Protected Areas*. *Conference Proceedings*. Institute for Landscape Architecture and Landscape Management, BOKU – University of Natural Resources and Applied Sciences, Vienna: 240–245.

Crawley M. J. 2007. *The R book.* John Wiley and Sons, Chichester.

Dallimer M., Katherine N.I., Andrew M.J.S., Zoe G.D., Paul R.A., James R.R., Lorraine L.M., Philip H.W., Kevin J.G. 2012. Biodiversity and the feel-good factor: understanding associations between self-reported human well-being and species richness. *BioScience*, 62, 1*:* 47–55.

D'antonio A., Monz, C., Newman P., Lawson S., Taff D. 2013. Enhancing the utility of visitor impact assessment in parks and protected areas: A combined social–ecological approach. *Journal of Environmental Management*, 124: 72–81.

Drahný R. 2018. *We exactly know it now – Czech part of the Krkonoše Mountains are visited by 11 million visitors per year.* Available at: https://www.krnap.cz/aktuality/tz-ted-uz-to-vime-presne-ceske-krkonose-maji-pres-11-milionu-navstev-rocne (07.12.2018).

Drábková A., Šišák L. 2013. Forest visitors' opinion of recreational facilities and trails in forests in the Blaník Protected Landscape Area – a case study. *Journal of Forest Science*, 59: 185–190.

Farías Torbidoni E. I., Grau H. R., Camps A. 2005. Trail preferences and visitor characteristics in Aigüestortes i Estany de Sant Maurici National Park, Spain. *Mountain Research and Development*, 25: 51–59.

Fousek J., Hartmanová O., Štursa J., Potocki J. 2007. *Krkonoše: Nature, history, life* (in Czech). Prague, Baset.

Gobster P. H. 1995. Perception and use of metropolitan greenway system for recreation. *Landscape and Urban Planning*, 33: 401–413.

Goeft U., Alder J. 2001. Sustainable mountain biking: a case study from the southwest of Western Australia. *Journal of Sustainable Tourism*, 9(3): 193–211.

Government Of Czechoslovakia 1963. *Government Regulation No. 41/1963 Coll., on establishing Krkonoše Mountains National Park.* Prague, Ministry of Justice [in Czech].

Hausner V.H., Engen S., Bludd E.K., Yoccoz N.G. 2017. Policy indicators for use in impact evaluations of protected area networks. *Ecological Indicators*, 75: 192–202.

International Union For Conservation Of Nature (Iucn) 1984. *Proceedings from the 16th Session of the General Assembly of IUCN and 16th IUCN Technical Meeting.* Gland, IUCN.

Jorgensen A., Hitchmough J., Calvert T. 2002. Woodland spaces and edges: Their impact on perception of safety and preference. *Landscape and Urban Planning*, 60: 135–150.

Junge X., Jacot K. A., Bosshard A., Lindemann-Matthies P. 2009. Swiss people's attitudes towards field margins for biodiversity conservation. *Journal for Nature Conservation*, 17: 150–159.

Kelley H., Van Rensburg T.M., Jeserich N. 2016. Determinants of demand for recreational walking trails in Ireland. *Tourism Management*, 52: 173–186.

Kenter J.O., Hyde T., Christie M., Fazey I. 2011. The importance of deliberation in valuing ecosystem services in developing countries—Evidence from the Solomon Islands. *Global Environmental Change*, 21: 505–521.

Kiester R. A. 1997: Aesthetics of biological diversity. *Human Ecology Review*, 3: 151–157.

Knapik K., Migoń P., Szuszkiewicz A., Aleksandrowski P. 2011. Geopark Karkonosze – geopark i geoturystyka. *Przegląd Geologiczny*, 59, 4: 1065–1108.

Koemle D.B.A., Morawetz U.B. 2016. Improving mountain bike trails in Austria: An assessment of trail preferences and benefits from trail features using choice experiments. *Journal of Outdoor Recreation and Tourism*, 15: 55–65.

Leung Y.-F., Marion J. L. 2000. Recreation impacts and management in wilderness: a state-of-knowledge review. Paper presented at the Wilderness Science in a Time of Change Conference, 5: Wilderness Ecosystems, Threats, and Management, Ogden 23–27.05.1999. Available at: https://www.fs.fed.us/rm/pubs/rmrs_p015_5.pdf (17.05.2017).

Li W., Ge X., Liu C. 2005. Hiking trails and tourism impact assessment in protected area: Jiuzhaigou Biosphere Reserve, China. *Environmental Monitoring and Assessment*, 108: 279–293.

Manning R. E., Lime D. W., Hof M., Freimund W. A. 1995. The Visitor Experience and Resource Protection (VERP) process: The application of carrying capacity to Arches National Park. *The George Wright Forum*, 12, 3: 41–55.

Marion J.L., Leung Y.-F. 2004. Environmentally sustainable trail management. [in:] R. Buckley (ed.) *Environmental Impacts of Ecotourism*. CABI Publishing, Wallingford: 229–243.

Marion J.L., Wimpey J.F., Park L.O. 2011. The science of trail surveys: Recreation ecology provides new tools for managing wilderness trails. *Park Science*, 28, 3: 60–65.

Miller A.B., Leung Y., Kays R. 2017. Coupling visitor and wildlife monitoring in protected areas using camera traps. *Journal of Outdoor Recreation and Tourism*, 17: 44–53.

Molnarova K., Sklenicka P., Stiborek J., Svobodova K., Salek M., Brabec E. 2012. Visual preferences for wind turbines: Location, numbers and respondent characteristics. *Applied Energy*, 92: 269–278.

Newsome D., Moore S.A., Dowling R.K. (eds.) 2013. *Natural area tourism: Ecology impacts and management*. Channel View Publications: Clevedon.

Ólafsdóttir R., Runnström M.C. 2013. Assessing hiking trails condition in two popular tourist destinations in the Icelandic highlands. *Journal of Outdoor Recreation and Tourism*, 3–4: 57–67.

Pelletier F. 2006. Effects of tourist activities on ungulate behaviour in a mountain protected area. *Journal of Mountain Ecology*, 8: 15–19.

Pescott O.L., Stewart G.B. 2014. Assessing the impact of human trampling on vegetation: a systematic review and meta-analysis of experimental evidence. *PeerJ*, 2: e360.

Pigram J.J. 1983. *Outdoor recreation and resource management*. Croon Helm, London.

Pigram J.J., Jenkins J.M. 1999. *Outdoor recreation management*. Routledge, London.

R Development Core Team. 2013. *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna.

Rogowski M. 2016. The potential of Karkonosze Mountains in creating geotourism cluster. [in:] A. Szponar, S. Toczek-Werner (eds.) *Geotourism. Organization of the tourism and education in the geoparks in the Middle-Europe Mountains*. University of Business in Wrocław, Wrocław: 63–79.

Rogowski M., Bronowicki S., Machnicka M. 2013. Atrakcyjność turystyczna geostanowisk Geoparku Karkonosze. *Studia Periegetica*, 2, 10: 109–126.

Roggenbuck J.W., Williams D.R., Watson A.E. 1993. Defining acceptable conditions in wilderness. *Environmental Management*, 17: 187–97.

Swarbrooke J. (eds.) 1995. *The development and management of visitor attractions.* Butterworth–Heinemann, Oxford.

Šťastná P. 2013. How many tourists are in Krkonoše Mountains? *Journal Krkonoše – Jizerské hory,* 9, 22–23 [in Czech].

Svobodova K., Sklenicka P., Molnarova K., Salek M. 2012. Visual preferences for physical attributes of mining and post-mining landscapes with respect to the socio-demographic characteristics of respondents. *Ecological Engineering*, 43: 34–44.

Taylor P. 2015. What factors make rail trails successful as tourism attractions? Developing a conceptual framework from relevant literature. *Journal of Outdoor Recreation and Tourism*, 12: 89–98.

Tomczyk A.M., Ewertowski M. 2013. Planning of recreational trails in protected areas: Application of regression tree analysis and geographic information systems. *Applied Geography*, 40: 129–139.

Ulrich R. S. 1986. Human responses to vegetation and landscapes. *Landscape Urban Planning*, 13: 29–44.

Walz U. 2011. Landscape structure, landscape metrics and biodiversity. *Living Reviews in Landscape Research*, 5: 1–35.

Wimpley J.F., Marion J.L. 2010. The influence of use, environmental and managerial factors on the width of recreational trails. *Journal of Environmental Management*, 91: 2028–2037.

Wimpey J.F., Marion J.L. 2011. A Spatial Exploration of Informal Trail Networks Within Great Falls Park, Virginia. *Journal of Environmental Management*, 92, 3: 1012–1022.

Wolf I.D., Croft D.B. 2014. Impacts of tourism hotspots on vegetation communities show a higher potential for self-propagation along roads than hiking trails. *Journal of Environmental Management*, 143: 173–185.

Zahradník, D., Banaš M., Jirásková E. 2012. Back and front of visitor monitoring – Examples of good and less successful visitor monitoring in the Czech protected areas. *Journal of Landscape Management*, 3: 14–17.

Zelenka J., Těšitel J., Pásková M., Kušová D. 2013. *Sustainable Tourism: Tourism Management in Protected Areas*. Hradec Králové, Gaudeamus [in Czech].