GPS-Based Visitor Monitoring in Protected Areas Using Mobile Tracking Application Data – A Case Study in Black Forest National Park

***Teresa Schallinger**, Technical University of Munich, Germany, teresa.schallinger@tum.de*
Werner Rolf, Chair for Strategic Landscape Planning and Management, Technical University of Munich, Germany
***Dr. Dominik Rüede**, Black Forest National Park, Germany*

Introduction

With increasing visitor numbers and the diversification of recreational activities in protected areas (PAs), careful visitor management is required to avoid potential visitor conflicts as well as exceeding the carrying capacity of an area (Meijles et al., 2014). To preserve the area's resources and to ensure a positive visitor experience, detailed information about visitor behavior is needed to understand how the visitors' spatio-temporal concentrations and distribution patterns affect the area and to develop appropriate visitor guidance measures (D'Antonio et al., 2010). However, since efficient visitor monitoring techniques are challenging and laborious, many PAs lack comprehensive data on their visitors (Wolf et al., 2012).

Today, due to the progress in information and communication technologies and widespread mobile internet use, new, innovative approaches involving secondary crowdsourced volunteered geographic information (VGI) data are emerging (Hennig, 2017). Within a master's thesis in cooperation with Black Forest National Park (NP) in Germany, the potential of using such publicly shared location-based, user-specific data to monitor different visitor groups was investigated. The still very young national park has only recently approved a new official trail network, closing many formerly operated paths for touristic use, which made it all the more relevant to explore the visitors' exact spatial behavior within the existing trail network. It was thus examined to what extent using online available GPS-tracked routes via mobile applications is applicable and beneficial as an alternative, cost-effective method to provide data for visitor monitoring in PAs.

Methods

In a first step, various internet platforms were screened regarding the data availability of GPS-tracked routes by different user groups. After the sports tracking provider *Strava* [www.strava.com] has been proven the most suitable for our purpose, 486 GPS tracks within the Black Forest NP were downloaded for further analysis, distinguishing between the user groups mountain biking (MTB), road biking, running and hiking.

Using statistical evaluations of the non-spatial data, qualitative visitor information as well as temporal patterns of recreational use were investigated in detail. Assessing the visitor demographics allowed to classify visitors into tourists and residents (i.e. living within a 25-km radius around the NP). The temporal behavior of each visitor group was evaluated according to season, day type (weekday vs. weekend/holiday) and time. Average track distance, speed and duration of stay were analyzed, as well.

The spatial data was examined with GIS. Density analysis was used to identify general visitor hotspots. For a more detailed visualization of visitor distribution patterns within the trail network, a raster-based analysis was carried out to determine more and less intensively used path segments. This allowed to generate a heat map with high and low visitor use of the trail network.

Results

Data analysis showed that 56% of the data available originated from MTB. Besides, about 25% of the data covered road biking and 16% running tracks. Hiking activities (3%) were hardly available. The gender distribution was one-sided with 94% of the users being male. Most data originated from activities on weekends in late spring and summer, especially around midday hours. The analyzed users generally visited the park only for a limited time, extending their workout beyond the NP borders. The available user information further allowed to make visitor-specific observations. For example, it was demonstrated that a significant number of residents visited the park after 5 pm on weekdays, concluding a comparably high activity by after-work-visitors.

Spatial analyses demonstrated that certain areas of the NP were clearly more visited than others by the separate user groups, with some highly frequented trail sections by mountain bikers and visitors on foot alike (see Figure 1). Distribution patterns partly differed according to season, day and visitor type. Besides, especially mountain bikers were shown to employ trails not intended for cycling use, thus potentially representing a concern for resource change and diminished visitor experience. The accuracy and detail of GPS data generally also allow to identify off-trail movement deviating from any existing path infrastructure (D'Antonio et al., 2010). In this study, however, the only "off-trail" behavior in the park was illustrated to take place on formerly used trails not compliant with the new trail network anymore.

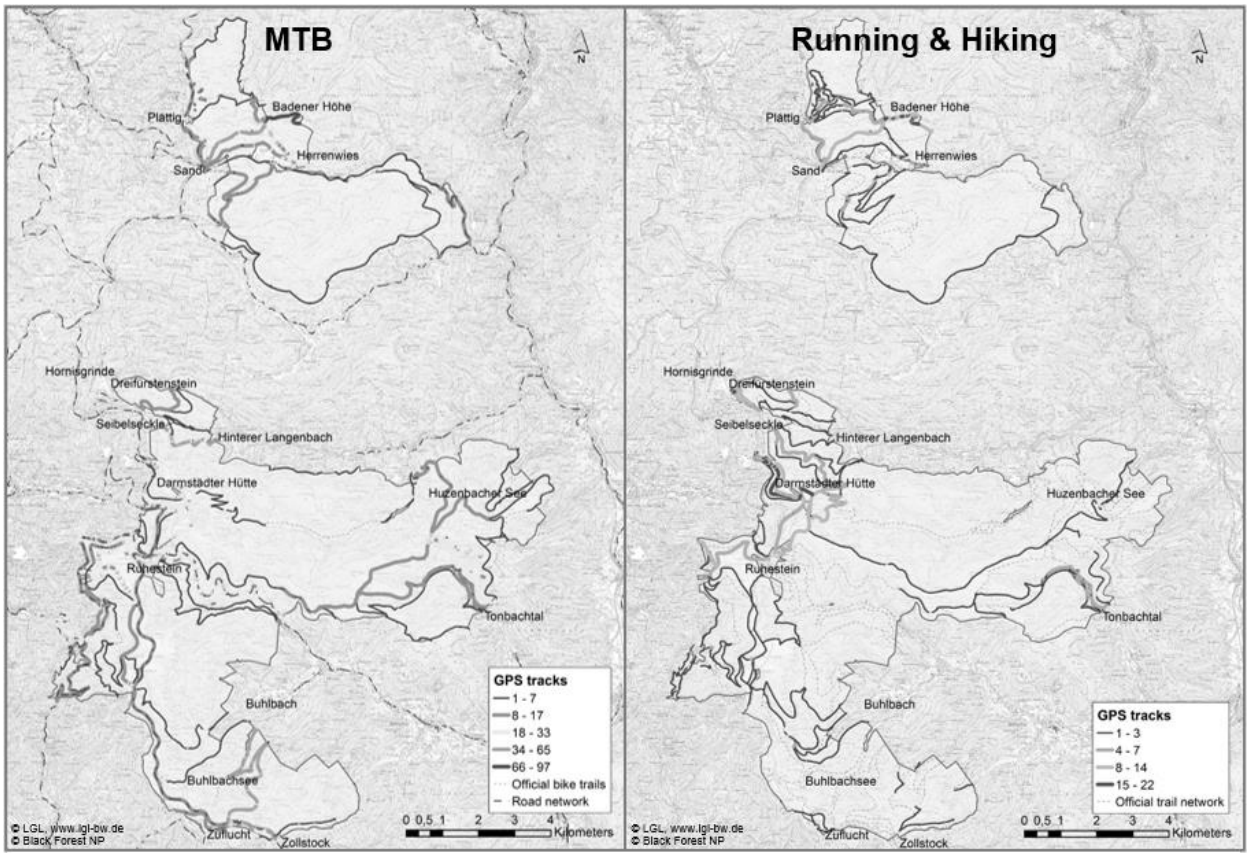

Figure 1: MTB and running/hiking use intensity of the official trail network in Black Forest NP. MTB use is depicted on official bike trails only, as well as on roads.

Discussion

The findings of the study demonstrated that valuable information can be derived from publicly available data, in this case providing a baseline assessment for Black Forest NP to help see how use patterns and resource conditions might be changing (Meijles et al., 2014). The data not only reveals closer information on the visitors themselves, but also allows to understand and anticipate some of their typical spatio-temporal behavior patterns and concentrations according to different sports activities. This knowledge can help PA managements to take preventive decisions related to designated trail management (D'Antonio et al., 2010). Further practical implications can be deduced, for example where to strategically place automatic visitor counters to determine use levels or where to place infrastructure. The data gathered on online GPS tracking depositories is thus suited for adaptive management, long-term monitoring and planning.

Still, the methodology is subject to certain limitations. The accessed track files on *Strava* proved to be fragmentary, not containing exact time information and therefore hindering specific analyses such as of the location and duration of breaks. Besides, the data and results originated from sports tracking application users only, who are generally assumed to be rather young, male and athletic (Francke & Lißner, 2017), and were thus not representative of the overall visitor distribution in the park. Nevertheless, a detailed differentiation of user-specific behavior could be deduced from the data, providing a realistic impression of cycling and running activities in the area. Combining this information with other monitoring data can help to get a more comprehensive overview about user preferences and to detect conflict potentials.

The applied approach can be a useful tool for PA management. It allows to easily acquire up-to-date temporal and spatial information about visitor behavior in possibly all PAs worldwide. More research is needed, however, to develop standardized methods and procedures. If appropriately used, though, the substantial amount of available online data represents a crucial information asset for PA management which can effectively complement data from traditional monitoring techniques and thus allow for a sustainable recreation and resource management.

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