162 Human mobility patterns in outdoor recreational areas based on GPS-tracking data

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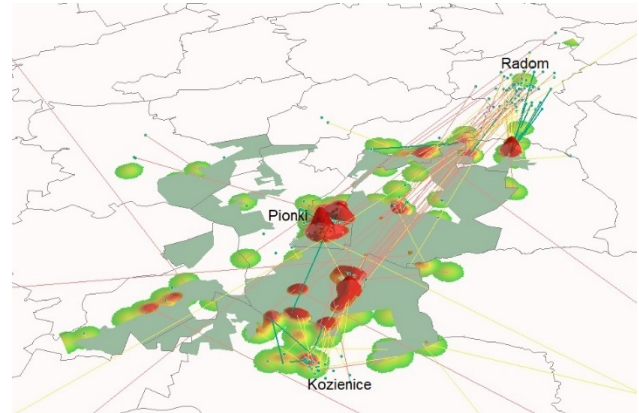## Introduction & study objectives

New trends in leisure and outdoor recreation show an increased penetration of remote areas and the development of spatially unconstrained outdoor recreational activities (Bielanski et al, 20218; D'Antonio & Monz, 2016; Meijles et al, 2014; Taczanowska et al, 2014; Taczanowska et al, 2008). Here we present the application of GPS tracking to monitor visitor behaviour in a popular nearby recreation destination located in the Kozienicka Primeval Forest, Poland. Particular focus of the study was investigation of the spatial and temporal behaviour of hikers in the forest, detection of resting locations as well as use of recreational infrastructure grouped by visitor profile.

Methods

The research is based upon empirical data. A combination of several visitor monitoring methods was simultaneously applied in the study area: long-term automatic visitor counting using pyroelectric sensors (Eco-Counter); online survey including PPGIS; manual counting and on-site visitor survey combined with GPS-tracking carried out on 8 sampling days in 2016-2017. A total sample of 284 GPS tracks of visitor groups combined with visitor group characteristics obtained via direct interview were analysed. ArcGIS and Matlab Software were used for spatial and statistical analyses.

Selected results

Our work provides detailed insights into spatial and temporal aspects of recreationists' spatial behaviour. The Kozienicka Primeval Forest (KPF) serves as nearby recreation destination mainly for surrounding cities and towns: Radom, Kozienice, Pionki (Figure 1). Accoriding to automatic counters in the field, visitation load achives up to 75302 passages per year and daily maximum of 2549 passages at most popular trail segments.

*Figure 1. Origin-destinantion analysis of nearby recreation in the Kozienicka Primeval Forest (KPF), Poland. 3D density map illustrates recreational use intensity of the forest entrances; points illustrate living places of the respondents; lines indicate origin-destination pairs during last reported recreational trip. A detailed view of a spatio-temporal animation of visitors' GPS-tracks can be found additionally **here**.*

Results of spatio-temporal analysis show significant differences of use among various visitor profiles. Especially, frequency of visits results in different use patterns. Visitors frequently visiting KPF (making almost 1/3 of a total sample) on avaerage spent 67 minutes in the forest and hiked 3.7 km. First time visitors and hikers visiting KPF ocasionally (38%) did shorter trips (AV: 3.3 km), while spending longer time in recreation destinantion (AV: 74 minutes). Larger visitor groups, especially those accompanied by children tend to be less active and use especially dedicated picnic spots, whereas single hikers and pairs spend less time in the forest and walk longer distances.

Discussion & Conclusions

Finding adequate tools enabling better understanding of visitor behaviour is crucial for an effective management of leisure activities in vulnerable environments. GPS tracking allows

registering visitors' movement trajectories to be analysed both at an individual and a collective level. The results can be practically used to improve visitor management strategies in outdoor leisure areas. We conclude that GPS tracking is a reliable tool allowing monitoring of recreational use assigned to infrastructure (such as dedicated hiking trails or picnic spots) as well as spatially unconstrained outdoor recreational activities.

References
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