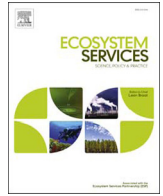


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Revealing spatial and temporal patterns of outdoor recreation in the European Alps and their surroundings

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ABSTRACT

Outdoor recreation contributes vitally to human well-being, but spatio-temporal mapping on large scales of this ecosystem service is rarely addressed in a comprehensive manner. In this study, we aim to map recreation supply, demand, and flow, combining different approaches and data sources, including spatially explicit indicators and crowd-sourced information from social media. We analyse spatial and temporal patterns in the European Alps and their surrounding areas (Alpine Space area) and explore societal preferences. Our results indicate that especially mountainous areas provide high ecosystem service supply, while high demand is characteristic of strongly urbanised areas. The spatio-temporal pattern of flow hot spots shows two major trends: recreational landscapes around urban agglomerations are frequented all year round, whereas visitation rates in remote mountain areas depend greatly on the season. By means of a cluster analysis, we identify five types of municipalities, distinguishing municipalities with little importance for recreation, prevailing demand, or supply, and highly used areas. Further, our results suggest that societal preferences can be explained by landscape attributes and tourism infrastructure. In addition to revealing a large-scale spatio-temporal pattern, this study explores methodological possibilities to provide a basis for decision-making and landscape planning regarding recreational ecosystem services.

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1. Introduction

Outdoor recreation in natural and semi-natural environments plays a crucial role for physical and mental health and contributes substantially to human well-being (de Vries et al., 2013; Triguero-Mas et al., 2015). Especially in areas with high urbanisation rates, land degradation, and growing economic wealth, the demand for recreational environments is growing (Guo et al., 2010). Green spaces within or close to urban agglomerations with high population density represent important locations for outdoor recreation activities for many residents (Kabisch, 2015; Langemeyer et al., 2015). Further, mountain regions all over the world are attractive destinations for nature-based recreation and tourism due to their appealing landscapes, access to wilderness and wildlife, and opportunities for outdoor recreation activities like hiking, mountain biking, climbing, or skiing (Pickering and Barros, 2013; Richins & Hull, 2016).

The ecosystem service (ES) 'outdoor recreation' belongs to the group of cultural ecosystem services (CES), which are defined as

the non-material benefits that humans obtain from natural and semi-natural ecosystems (Millennium Ecosystem Assessment, 2005). Although a growing number of studies that address CES focus on recreation and tourism (Hernández-Morcillo et al., 2013; Milcu et al., 2013), a series of challenges related to its assessment remain for two reasons. First, CES depend strongly on human perceptions and subjective preferences that cannot be quantified without analysing societal values (Plieninger et al., 2013). Second, spatially explicit assessment is difficult because CES are not directly linked to ecosystem processes (Burkhard et al., 2012).

Consequently, many studies concentrate on specific environments such as urban areas (Kabisch, 2015; Larondelle & Haase, 2013), agricultural landscapes (Reed et al., 2014; van Berkel & Verburg, 2014), forests (Baerenklau et al., 2010; Verlič et al., 2015), or protected areas (Larsen et al., 2008; Schägner et al., 2016), and fewer studies assess outdoor recreation across different landscapes or at large spatial scales (Helfenstein & Kienast, 2014; Paracchini et al., 2014; Weyland & Laterra, 2014). Hence, assessment approaches often remain limited to the local or regional level (Nahuelhual et al., 2013; Peña et al., 2015; Szücs et al., 2015), which might not reflect the conditions of various landscapes or represent values throughout and across societies, which could

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better provide information for policy and decision-making. On the other hand, large-scale assessments often have to apply simple proxies that fail to account for specific environmental preconditions (Paracchini et al., 2014).

Further, only recently have studies distinguished between ES potential, demand, and actual use (flow) (Burkhard et al., 2014; Villamagna et al., 2013), and CES are less often considered in comprehensive studies due to their subjectivity (Plieninger et al., 2015). Most research focusses in fact on the recreational potential, using survey-based approaches (De Valck et al., 2016; Plieninger et al., 2013) or proxy-based methods (Grêt-Regamey et al., 2015; Helfenstein & Kienast, 2014; Paracchini et al., 2014). Fewer studies have also considered the demand side, using participatory approaches (Beeco et al., 2014; Nahuelhual et al., 2013; Palomo et al., 2013; Zoderer et al., 2016) and economic valuation techniques such as willingness-to-pay (WTP) (Nielsen et al., 2007; Rosenberger et al., 2012) or the travel cost method (Fleming & Cook, 2008). At large spatial scales, mainly empirical or expert-based approaches have been applied to map the demand for outdoor recreation (Paracchini et al., 2014). To assess ES flow in terms of visitation rates, usually costly and time-consuming surveys have been carried out in local studies (Schägner et al., 2016). At larger scales, novel approaches using social media not only provide promising results for estimating visiting frequencies (Wood et al., 2013), but also identify spatial patterns of landscape values and preferences (Sonter et al., 2016; Tenerelli et al., 2016; van Zanten et al., 2016). However, to facilitate the operationalisation of ES for management, planning, and decision-making, all principal components of the ES chain (supply, demand, and flow) should be addressed (Burkhard & Maes, 2017; Burkhard et al., 2014; Plieninger et al., 2015).

Another issue that has rarely been addressed is that of the temporal dynamics of CES (Hernández-Morcillo et al., 2013). Some examples are related to the dynamics of wildflower blooms (Graves et al., 2016), tourism developments (Guo et al., 2010), seasonality of recreational visits (Wood et al., 2013), impacts of spatio-temporal landscape dynamics on cultural services (Schirpke et al., 2016), and the relationship between the spatial distribution in landscape attributes and temporal changes of visitation rates (Sonter et al., 2016). Nonetheless, spatial and temporal aspects of CES must be considered if trade-offs with other ES and changing environmental conditions or different management scenarios are to be evaluated (Hernández-Morcillo et al., 2013).

In summary, the major challenge of mapping outdoor recreation is related to the spatio-temporal analysis at different scales and extents. Evaluations of spatio-temporal characteristics of 'big data' help to disentangle supply, demand, and flow in the CES assessment. In this study, we use a combination of assessment approaches aiming to map and analyse spatial and temporal patterns of outdoor recreation on a cross-national level. Mapping of ES supply is based on spatially explicit indicators. Local demand considers demographic data, while time-referenced metadata from social media are used as a proxy for ES flow and to explore societal preferences. We evaluate spatial patterns as well as seasonality of outdoor recreation in the European Alps and their surrounding areas (Alpine Space area), and discuss their implications for planning and policy.

2. Materials and methods

2.1. Study area

Our study area corresponds to the Alpine Space Programme cooperation area, including the European Alps and their surround-

ing foothills and lowlands. It covers a surface of about 390,000 km² and comprises Austria, Liechtenstein, Slovenia, and Switzerland as well as several regions of France, Germany, and Italy (Fig. 1, Table S2 in the supplementary material). The Alpine Space area includes 17,042 municipalities of varying size, ranging from 0.006 to 767.7 km² (mean size: 22.77 km²; standard deviation: 30.74) (Appendix Fig. A1). The mountainous core zone is characterised by natural and semi-natural ecosystems (forest, grassland, areas with little or no vegetation), whereas the surrounding lowlands are mainly covered by agricultural land and urbanised areas. In the Alpine Space area live about 70 million people, most of them in great urban agglomerations in the outer belt or peri-Alpine belt (Dematteis, 2009). The Alps are one of the most important global tourist destinations, with about 500 million visitors a year, and tourism is a major source of income from both winter sports and summer tourism (Bartaletti, 2007). The mountainous areas especially offer a variety of opportunities for outdoor recreation, depending strongly on the season, and include activities such as skiing, snowboarding, and cross-country skiing in the winter and hiking, mountain biking, climbing, rafting, and canoeing in the summer.

2.2. Definitions

In this study, we follow the definition of the Common International Classification of Ecosystem Services (CICES) (Haines-Young & Potschin, 2013) on recreation defined as 'physical use of land-/seascapes in different environmental settings', i.e., outdoor activities (e.g., hiking, biking, skiing) for recreational purposes that are practiced in natural and semi-natural ecosystems. According to recent literature (Burkhard & Maes, 2017; Burkhard et al., 2014; Villamagna et al., 2013), we differentiate between the ES supply, demand, and flow:

- Recreation supply includes two aspects: the recreation potential provided by ecosystems and the possibility to benefit from it. Recreation potential is defined as the capacity of ecosystems to provide recreation opportunities due to the natural preconditions without human input and regardless of these being actually used (Burkhard et al., 2014; Villamagna et al., 2013). The service, however, is only provided if people can reach the supply area to carry out recreational activities. Thus, the supply is related to areas providing recreation that are accessible by infrastructure such as roads, trails, and public transport (Ala-Hulkko et al., 2016).
- Demand for recreational opportunities within the society is mainly expressed through stated preferences and values or direct use, but there is no agreement on measures for assessing recreation demand (Wolff et al., 2015). Demand can be mapped considering where beneficiaries live or where the use occurs (Wolff et al., 2015). Here, we map the demand areas within the study area quantifying local beneficiaries (Schirpke et al., 2014). To contribute to the understanding of demand in terms of preferences and values, we also analyse general societal preferences in qualitative terms.
- Flow refers to the actual level of use (Burkhard et al., 2014; Villamagna et al., 2013) and can be measured by the number of people practicing outdoor activities in a defined area and time. It is determined by the population density in the vicinity as well as the capacity of tourism accommodation, as the beneficiaries' origin can be from nearby areas or from other countries or continents. Hence, the benefit of recreational outdoor experiences can be connected to very different spatial scales (Weyland & Lartera, 2014).

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