

Outdoor recreation activities- Supply

General description:

The supply of outdoor recreation is collected in three steps: First, we map the recreation potential provided by ecosystems, then the accessibility is calculated, and finally both aspects are integrated into one map.

Different landscape variables serve as indicators for the recreation potential. These are all based on recent literature (see table 1). Every dataset was converted to raster data with a spatial resolution of 100 m in order to easily overlay them. Furthermore, all indicators were considered to equally contribute to the recreation potential and were rescaled to 0–100. In a last step, they were then overlaid to obtain a recreation potential index (Paracchini et al., 2014). The recreation potential index ranges from 0 (low) to 100 (high) and was further analysed considering accessibility. All calculations were performed using standard routines provided with ArcGIS 10.4. The following explanations are quoted directly from the supplementary material of Schirpke et al. (2017).

Input Data

Protected areas

- DEM
- Open street map
- Landcover

Calculation processes:

(3) Calculate recreational value of protected areas

Natural environment and high biodiversity contribute considerably to recreational value (Sonter et al., 2016) and, thus, protected areas are considered public recreation areas (Paracchini et al., 2014). The recreational value of protected areas was mapped considering the Natura 2000 network and the Common Database on Designated Areas (CDDA) (EEA, 2015a, b). The Natura 2000 network consists of sites designated under the Birds Directive (Special Protection Areas, SPAs) and the Habitats Directive (Sites of Community Importance, SCIs, and Special Areas of Conservation, SACs). The CDDA is an inventory of nationally designated areas. The database follows the IUCN (International Union for Conservation of Nature and Natural Resources) categories, classifying protected areas according to their management objectives. Protected areas from the Natura 2000 network and the CDDA were overlaid and reclassified in relation to their importance for recreational uses according to Zulian et al. (2013) (Table 1). The score ranges from 0 to 100. The highest score was assigned to the category of protected areas with the highest natural value, whereas 0 was used for sites that are inaccessible for recreation purposes (category Ia).

Table 1: CDDA categories and score for recreation potential according to Zulian et al. (2013)

Class	Description	Score
Ia	Strict Nature Reserve: protected area managed mainly	0
Ib	Wilderness Area: protected area managed mainly for wilderness protection	100
II	National Park: protected area managed mainly for ecosystem protection and recreation	80
III	Natural Monument: protected area managed mainly for conservation of specific natural features	100
IV	Habitat/Species Management Area: protected area managed mainly for conservation through management intervention	80
V	Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation	80
VI	Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystem	80
NA	Not classified	80

(4) Reclassify to hemeroby classes

The degree of environmental naturalness (hemeroby) is one of the most important factors when selecting locations for outdoor recreation (Peña et al., 2015; Willemsen et al., 2008). The hemeroby index measures the extent of human impacts on the natural environment on a scale from 1 (natural) to 7 (artificial) and can be attributed to land cover types (Steinhardt et al., 1999; Wrbska et al., 2004). The hemeroby was calculated based on CORINE land cover data (EEA, 2016a). All land cover types were attributed to the hemeroby classes as proposed by Paracchini and Capitani (2011). The index was inverted to assign highest recreational values to more natural environments and rescaled from 0 to 100.

(5) Calculate distance to water

Water offers a variety of recreational opportunities (Keeler et al., 2015) and has a high visual attraction compared with or in conjunction with surrounding areas (Arriaza et al., 2004; Ode et al., 2009). To calculate the influence of water bodies on the recreation potential, inland and marine water bodies were extracted from the CORINE land cover database (EEA, 2016a). The Euclidean distance was calculated up to 2,000 m from the coastline of seas and lakes, and the recreational potential was assessed by applying an impedance function (Paracchini et al., 2014) and subsequently rescaled from 0 to 100, resulting in high values for areas close to the coastline.

(6) Calculate number of land cover types

Diverse landscapes provide high recreational and visual attractiveness (Kienast et al., 2012; Ode et al., 2009; Schirpke et al., 2016). The landscape diversity was assessed by calculating the number of different land cover types per km² (Kienast et al., 2012) based on the CORINE land cover database (EEA, 2016a). The result was rescaled from 0 to 100. Great landscape diversity indicates high recreation potential.)

(7) Calculate Terrain roughness

Rough landscapes provide many recreational opportunities and are visually more appealing than flat landscapes (Weyland & Laterra, 2014). The Terrain Ruggedness Index (TRI) reveals the degree of topographic heterogeneity by measuring elevation differences between adjacent cells (Riley et al., 1999). We calculated the TRI based on the DEM (EEA, 2016b), which was aggregated to 100 x 100 m and classified into seven classes as proposed by Riley et al. (1999). All scores were rescaled from 0 to 100. High ruggedness suggests high recreation

potential.

(8) Calculate density of mountain peaks

Mountain peaks are very attractive for recreation, providing opportunities, for example, for mountaineering and climbing (Pomfret, 2011). Furthermore, they can be considered as a proxy for long vistas and remoteness (Kienast et al., 2012), and influence people's choices for recreational purposes due to their high visual attractiveness (D'Antonio & Monz, 2016). We used the density of mountain summits as an indicator for recreation potential, as also applied by other studies (Kienast et al., 2012; Peña et al., 2015).

To select important mountain summits on a local to regional level, several steps were applied following Podobnikar (2012):

- Calculation of local peaks by applying a moving window with the kernel of size 5 × 5 cells (focal statistics; maximum) based on the DEM (EEA, 2016b) using a spatial resolution of 100 m* Selection of local peaks above 600 m* Elimination of local peaks on flat areas (curvature > 0.2: significant concave areas; ruggedness >= moderately rugged)

The density of the identified mountain peaks was then calculated by counting the peaks per 10 km² by applying a moving window. The resulting values were reclassified from 0 to 100, with high density of mountain peaks representing high recreation potential.

(9) Calculate recreation potential

All indicators were considered to equally contribute to the recreation potential. All indicators, which were first rescaled to 0–100, were overlaid to obtain a recreation potential index (Paracchini et al., 2014) by summing all layers and dividing them by 6 (number of all layers). The recreation potential index ranges from 0 (low) to 100 (high).

(10) Calculate accessibility

Accessibility through infrastructure determines whether suitable recreation areas can be used, and proximity to residential areas is a crucial factor for the use of recreational sites (Ala-Hulkko et al., 2016; Kienast et al., 2012; Paracchini et al., 2014; Peña et al., 2015; Weyland & Laterra, 2014). We therefore identified the accessible areas as well as the level of accessibility defined by the proximity to residential areas.

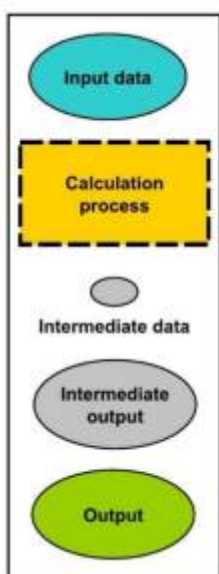
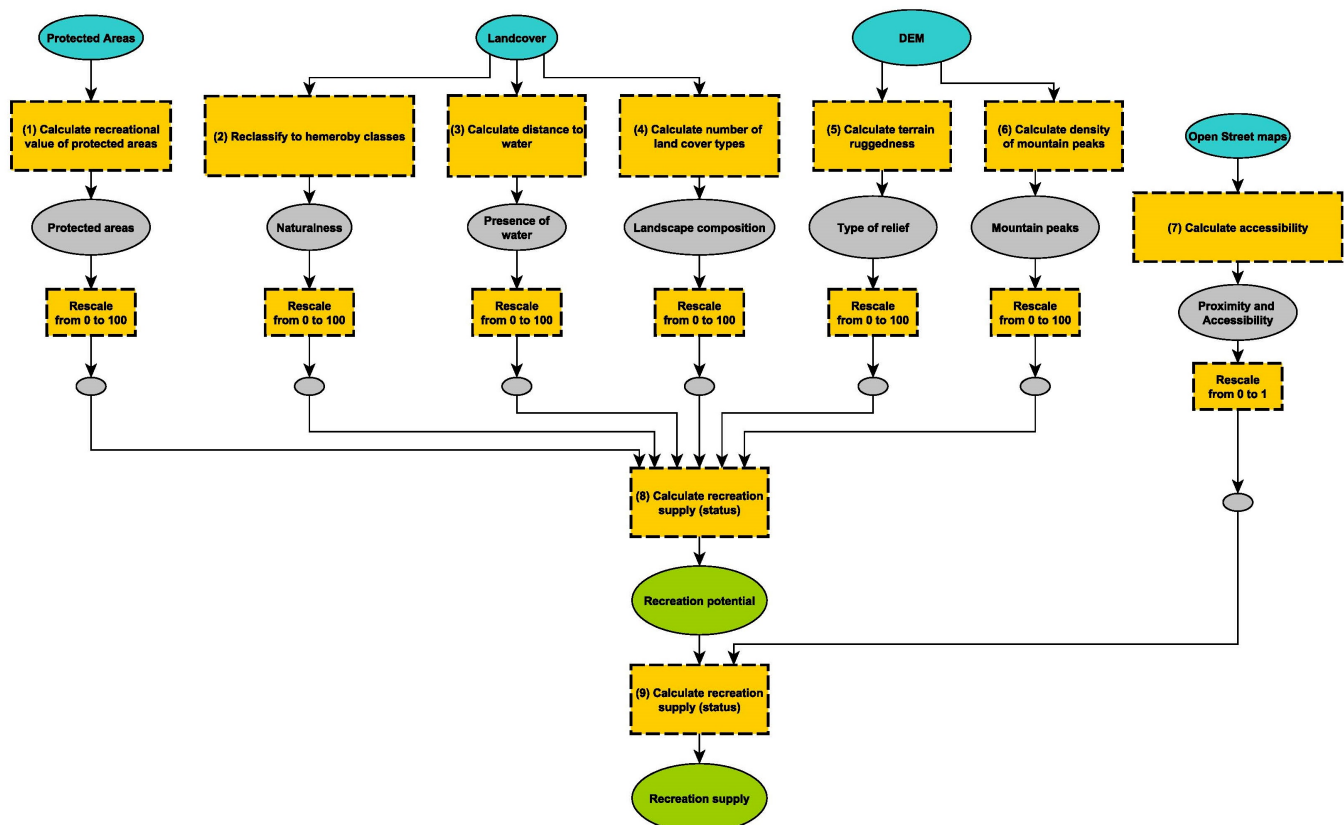
First, we identified recreational areas that are accessible through infrastructure such as paved and unpaved roads, hiking trails, and cycling paths. Information on the road network was obtained from OpenStreetMap (OSM, 2016), which was used to calculate the Euclidean distance from roads and paths. Assuming that people would rather stick to existing paths and trails for most recreational activities rather than moving off-road, accessible areas were mapped by selecting all areas up to 1,500 m distance from the road network, as this distance contributes most to visual landscape enjoyment (Schirpke et al., 2013).

To assess the level of the supply, we calculated the proximity of recreational areas from residential areas in terms of travel time by private car (on paved roads) and foot (on roads and paths closed for cars). The road network contained information on the maximum speed of most roads. Missing data were integrated by assigning each type of road a mean travelling velocity. Further, we assumed an average off-road velocity of 1 km/h, to include the whole surface of

the study area into the calculation. Residential areas were extracted from the CORINE land cover database (EEA, 2016a) (classes 'continuous urban fabric' and 'discontinuous urban fabric'). The travel time from urban areas was then estimated using the cost distance algorithm as implemented in ArcGIS 10.4 (ESRI, Redlands, CA, USA). The resulting travel time was rescaled from 0 to 1.

(11) Calculate recreation supply (status)

The recreation potential was overlaid with the level of accessibility by multiplying the two layers in order to exclude inaccessible areas and map the recreation supply.



Input data→elements that hold a value or a reference to data stored on disk. It is usually a spatial explicit information coming from official sources.

Calculation process→ the actual operation performed on the data. The number preceding the item refers to the number in the model description.

Intermediate data→ for each calculation process intermediate data is generated. This data, however, is usually not significant itself, but is used as an input for the next calculation step.

Intermediate output→ is intermediate data that has a significance for the ES evaluation.

Output→ is the result of the calculation process. It is typically one of the ES indicators, either Supply, Demand or Flow.

Table 2: Landscape variables used as indicators of outdoor recreation potential.

Landscape variable	Description	Relationship to recreation potential	Data sources	Mapping approach
Naturalness	Index of naturalness (hemeroby)	Preference for more natural environments for outdoor recreation (Peña et al., 2015; Willemen et al., 2008)	CORINE land cover (EEA, 2016a)	Attribution of hemeroby classes to land cover types (Paracchini & Capitani, 2011)
Protected areas	Presence of protected area	Natural environment and high biodiversity (Sonter et al., 2016) and public recreation areas (Paracchini et al., 2014)	Natura 2000 database (EEA, 2015b); Common Database on Designated Areas (CDDA) (EEA, 2015a)	Attribution of scores to IUCN categories (Zulian et al., 2013)
Presence of water	Distance to water bodies	Recreational opportunities (Keeler et al., 2015) and high visual attraction (Arriaza et al., 2004; Ode et al., 2009)	CORINE land cover (EEA, 2016a)	Impedance function of attractiveness (distance < 2000 m) from coastlines of sea and lakes (Paracchini et al., 2014)
Landscape composition	Landscape diversity	High recreational and visual attractiveness of diverse landscapes (Kienast et al., 2012; Ode et al., 2009; Schirpke et al., 2016)	CORINE land cover (EEA, 2016a)	Number of land cover types per km ² (Kienast et al., 2012)
Type of relief	Terrain Ruggedness Index (TRI)	Recreational opportunities and visual attraction of rough landscapes (Weyland & Laterra, 2014)	DEM (EEA, 2016b)	TRI classes (Riley et al., 1999)
Mountain peaks	Density of mountain summits	Recreational opportunities (Pomfret, 2011), overview and remoteness (Kienast et al., 2012), and visual attraction (D'Antonio & Monz, 2016)	DEM (EEA, 2016b)	Identification of mountain peaks (Podobnikar, 2012), number of summits per 10 km ²

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