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Using an aggregated remote sensing-based habitat quality index for the identification of spatially targeted conservation measures

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Abstract

The effective assessment and monitoring of habitat quality is important for conservation management decisions, especially in protected areas. To support these tasks we present a remote-sensing based index not only for the spatially explicit assessment, but at the same time for the identification of suitable conservation measures to improve habitat quality. As a case study the riparian forest of the Salzach - a Natura 2000 site near Salzburg, Austria - was chosen as riparian zones are ecosystems with a high biodiversity, but are at the same time highly threatened. Four indicators derived from a very high resolution satellite image and LiDAR data were used to assess habitat quality: (1) Tree species composition, (2) Horizontal forest structure, (3) Vertical forest structure and (4) Water regime. They were aggregated to a statistically sound composite indicator, providing an easy overview of the spatial distribution of habitat quality and highlighting cold-spots where conservation measures may be needed. Decision processes are further supported through the decomposability of the provided habitat quality index into its underlying indicators and identifying conservation measures based on the indicator(s) with the least share. Findings of this study emphasise the importance of tree species composition for the habitat quality. While in high-quality areas the occurrence of favourable tree species is mainly responsible for the good status, in low-quality areas the lack of such characteristic species, combined with poor hydrological conditions, is mainly responsible for the poor status. Suitable and spatially targeted conservation measures would thus primarily aim at restoring a more favourable tree species composition in combination with improvement of the water regime. We consider the presented methodology as a suitable complementary option to traditional methods for assessing and monitoring habitat quality, the facilitation of decision-making on spatially explicit conservation measures as well as the evaluation of such applied measures.

Keywords

Habitat quality, remote-sensing based indicators, composite indicator, riparian forest

Introduction

Management of protected areas requires detailed knowledge about the quality of occurring habitats. For assessing habitat quality the use of single indicators, but also their integration into an index is used (e.g. GEBUREK et al., 2010). Earth Observation (EO) data and remote sensing-based indicators can thereby compliment in-situ data and support the monitoring of protected areas through their advantage of area-wide coverage and the option of regular, cost-efficient updates (DURO et al., 2007; GILLESPIE et al., 2008).

Here we present a remote-sensing based index to describe the habitat quality of riparian forests. Through the integration of single indicators into a statistically sound composite index (NARDO et al., 2008), the number of single parameters are reduced while the underlying information is kept (SAISANA & TARANTOLA, 2002). As such it provides an easy to grasp overview of the spatial distribution of habitat quality. Additionally it offers the opportunity of decomposability into the single indicators. For management purposes this is especially important, as it can provide the basis for suitable targeted conservation measures.

Methods

This study was conducted in the semi-natural Natura 2000 site Salzachauen (Salzburg, Austria; UL: N 47°56'12" / E 12°56'24"; LR: N 47°52'17" / E 13°00'22"). Based on detailed literature review four indicators describing riparian forest quality and that can be derived from EO data were identified (Tab.1; RIEDLER et al., 2015; RIEDLER & LANG, in press).

These indicators were integrated into a composite indicator, representing habitat quality. For the delineation of patch boundaries the novel approach of geons was used. Thereby homogenous spatial units (geons) are built through regionalizing a multiple indicator set, thus directly representing in this case habitat quality (LANG et al., 2014; RIEDLER & LANG, in press). For illustrating the decomposability of the index, categorical classes depending on the share of the underlying indicators were formed with a threshold value of 60%.

Indicator	EO data	Derived information
Tree species composition		
Tree species	VHR satellite image (WorldView-2 [1])	object-based single tree detection including classification of main occurring tree species (PACCAGNEL, 2013; STRASSER et al., 2014) accounting for the naturalness of forest systems (sensu ELLMAUER, 2005; GEBUREK et al., 2010)
Horizontal forest structure		
Spectral heterogeneity	VHR satellite image (WorldView-2 [1])	number of classes within a 3x3 kernel moving window defined by scene-component analysis reflecting different habitat and feature types (RIEDLER et al., 2015; RIEDLER & LANG, in press) accounting for habitat heterogeneity and structural features typical for alluvial forests (sensu ELLMAUER, 2005)
Vertical forest Structure		
Canopy roughness	LiDAR data[2] Canopy height model	standard deviation of the canopy height model within a 5x5 kernel moving window (RIEDLER et al., 2015; RIEDLER & LANG, in press) accounting for differences in height and a complex vertical forest structure (sensu NOSS, 1999)
Old trees	LiDAR data[2] Canopy height model	kernel density of tree height and detection of local maxima resampling single trees (RIEDLER et al., 2015; RIEDLER & LANG, in press) accounting for old living trees
Water regime		
Terrain roughness	LiDAR data[2] Digital terrain model	standard deviation of slope within a 5x5 kernel moving window (RIEDLER et al., 2015; RIEDLER & LANG, in press) accounting for the microtopographic relief (sensu UNGER & MUZIKA, 2008)

Table 1: Remote-sensing based indicators describing habitat quality of riparian forests (modified from Riedler and Lang, in press)

Results and Discussion

The spatial distribution of the habitat quality index allows a good overview of hot-and cold spots, revealing that areas of high habitat quality are primarily found along water bodies, the main river Salzach or perennial streams in the flood plain. Maybe even more important for management purpose is to know what indicators are responsible for the either good or poor habitat quality. The decomposability of the habitat quality index offers the possibility to identify these underlying indicators (Fig.1).

Areas with good habitat quality are – independent of their location - mainly characterized by a favourable tree species composition. These findings match and are in congruence with literature, where hydrological conditions are one of the main aspects for riparian forests itself and additionally strongly influence the characteristic tree species composition (DÖRINGER & TOCKNER, 2008; ELLMAUER, 2005).

Areas with low habitat quality on contrast are mainly forest plantations, characterized by a low share of the indicator Tree species compositions - in the example of the dark blue patch on the upper left the share is even 0, as it is a forest plantation of *Picea abies* and thus no characteristic tree species can be found. Also the Water regime is below 6%, indicating that no distinct micro-topographic relief exists. Thus, for such areas suitable conservation measures can easily be identified - here logging of *Picea abies* and subsequently reforestation with characteristic tree species together with water restoration measures for a more favourable hydrological conditions.

Conclusion

Complementary to traditional in-situ based assessments of habitat quality, the presented index is a suitable method for objective and repeatable assessment and monitoring of riparian forest quality. It can not only discover areas that are especially relevant for management decisions, but also identify spatially targeted conservation measures and support the evaluation of such applied measures. The approach additionally offers a unique opportunity for the integration of field and EO data, and allows for easy transferability to similar habitats.

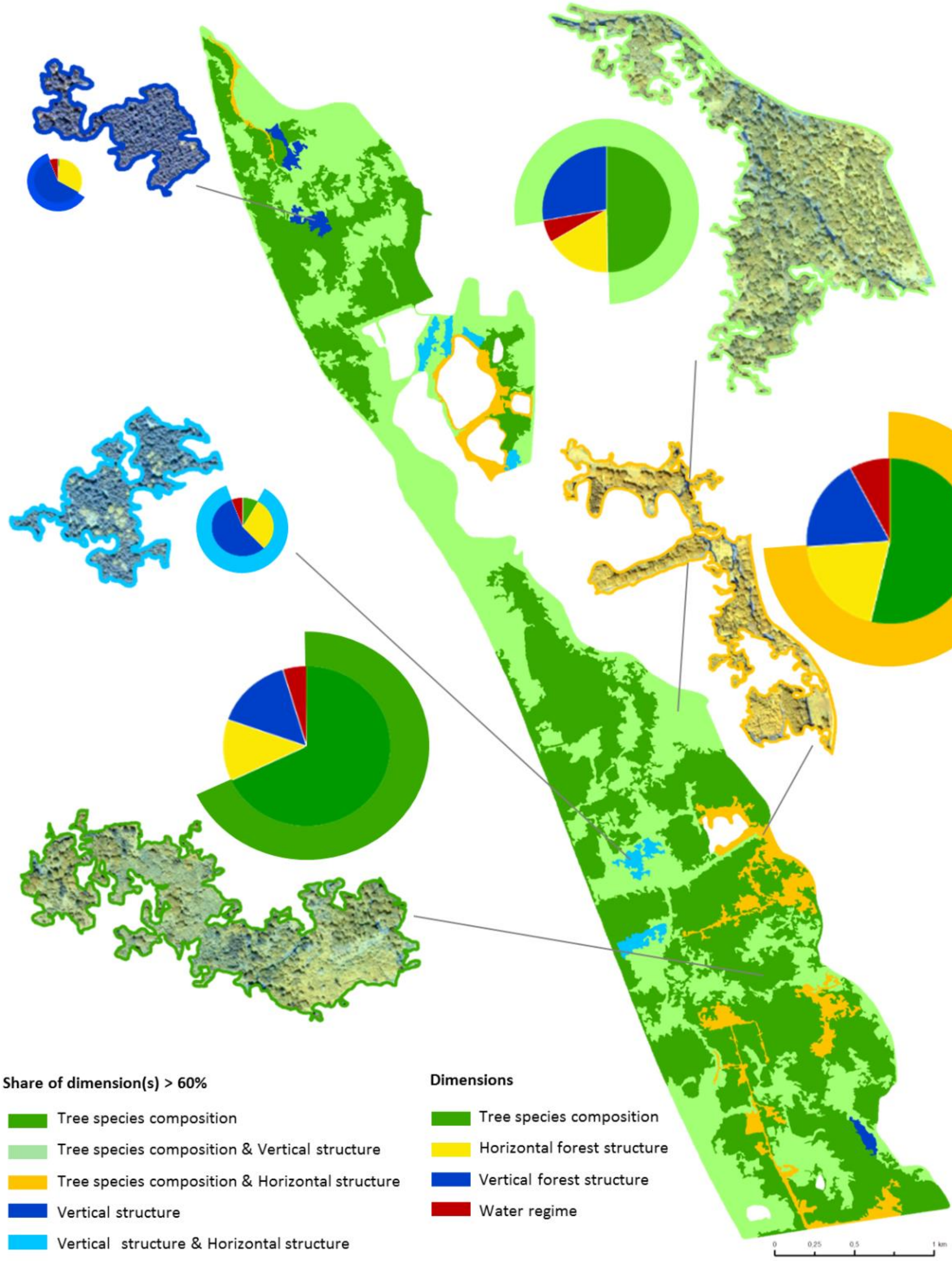

Figure 1: Decomposability of the habitat quality index. In the overview, categorical classes defined by a combined share of indicators > 60% are visualized. In the pie-chart diagrams additionally the actual contribution of each indicator is show. The size of pie charts is proportional to the habitat quality (from RIEDLER, 2015)

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