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An Approach to Mapping the Potential of Cultural Agroecosystem Services

Jarmila MAKOVNÍKOVÁ[1], Jozef KOBZA[1], Boris PÁLKA[1], Jozef MALIŠ[1], Radoslava KANIANSKA[2] and Miriam KIZEKOVÁ[3]

[1]National Agricultural and Food Centre, Soil Science and Conservation Research Institute Bratislava, Regional Station Banská Bystrica, Banská Bystrica, Slovak Republic; [2]Department of Environment, Faculty of Natural Sciences, Matej Bel University Banská Bystrica, Banská Bystrica, Slovak Republic; [3]National Agricultural and Food Centre, Grassland and Mountain Agriculture Research Institute Banská Bystrica, Banská Bystrica, Slovak Republic

Abstract

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A system for evaluating outdoor recreation as a cultural agroecosystem service is presented. Every agroecosystem presumably has the potential for providing some kind of outdoor recreation. Two approaches to mapping the recreation potential were used and compared – the Social Values for Ecosystem Services (SolVES) model and the regional model (RegMOD). From the possibilities of recreation activities, hiking, biking, and cross-country skiing were chosen. The comparison of the two approaches showed that the RegMOD incorporates a wider range of categories than the SolVES model, particularly for hiking. The robust character of the SolVES model is reflected by narrowing the spectrum of categories of this recreation activity. The differences in the map view are marked in the case of biking and cross-country skiing. Overall, the grasslands of the study area in Slovakia offer mainly medium relevant capacity (53.90% by the results of the SolVES, 64.90% by the results of the RegMOD) for providing selected outdoor recreation activities. The less productive (53.88% of all non-productive grasslands by the results of the SolVES, 48.00% by the results of the RegMOD) and non-productive grasslands represent a higher relevant capacity (41.18% of all non-productive grasslands by the results of the SolVES, 54.40% by the results of the RegMOD) for providing outdoor recreation activities. This brings about a new view of their management as well as use. The RegMOD developed in this paper is replicable and could be applied by managers mainly at the regional level on condition of their proficiency in geographical information systems.

Keywords: cultural services; cultural services potential; ecosystem services; land use cover; outdoor recreation; SolVES model

Ecosystem services have become a very popular scientific topic, especially during the last three decades (Costanza *et al.* 1997; de Groot *et al.* 2002; MEA 2005; Burghard *et al.* 2009; Crossman *et al.* 2013; Nieto-Romero *et al.* 2014; Burghard *et al.* 2014; Frélichová *et al.* 2014). Ecosystem services linked to natural capital can be divided into three main service categories (provisioning, regulating and cultural) (Dominati *et al.* 2010; Burghard *et al.* 2014). Because the provision of ecosystem services depends on biophysical conditions and changes over space and time due to human-induced changes affecting land cover, land use, and climate (Burghard *et al.* 2012), the supply and demand of services may differ geographically (Crossman *et al.* 2013). A number of recent studies have mapped the supply of services at global (Naidoo *et al.* 2008), continental (Schulp *et al.* 2012), national (Bateman *et al.*

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2009) or regional scales. The knowledge is useful for making assessments of landscape capacities and potentials to supply ecosystem services (Burghard *et al.* 2012) and to adapt the management to local conditions (Szolozzi *et al.* 2012). For this reason, it is necessary to understand better where and what services are provided by a local area (Crossman *et al.* 2013). Cultural ecosystem services, one of the three main service categories, are defined as "non-material benefits that people obtain from ecosystems" (MEA 2005). Recreation and tourism are two out of the six categories of cultural ecosystem services recognized by the Millenium Ecosystem Assessment (MEA 2005), the others being: spiritual services, heritage value, cultural identity, inspiration, aesthetic appreciation of cultural and cultivated landscape (MEA 2005). However, cultural services cannot be treated independently and depend on supply and regulating services as well as on supporting processes. Supporting processes are necessary to preserve the balance of the ecosystem. Research on mapping the ecosystem services has grown substantially in the past decade. Information based on mapping and modelling exercises have been used to analyze the spatial distribution of multiple ecosystem services at local (Lavorel *et al.* 2011), regional (Chan *et al.* 2012), and global (Naidoo *et al.* 2008) or spatial scales (Maes *et al.* 2012). The most common indicators for mapping the ecosystem services are land use cover, soils, vegetation, and nutrient related indicators. However, provisioning services are mapped more frequently than regulating and cultural services (Crossman *et al.* 2013). Cultural ecosystem services are less in the foreground to be put on the maps, because researchers must rely on proxies for their quantification (Maes *et al.* 2012). Of the group of cultural services, the most commonly mapped is the recreation service, because it is relatively simple to quantify. The methods used for mapping recreation and tourism ecosystem services involve very location-specific proxies for recreation and tourism (Willemen *et al.* 2008; Naidoo *et al.* 2011), landscape naturalness, and attractiveness (Maes *et al.* 2012). At the EU scale, there are no adequate supporting data for calculating the recreation services. Spatial information for cultural services is generally only available at a provincial level. At regional and landscape levels, maps are often considered essential for proper management of ecosystems and their services (Hauck *et al.* 2013). There exist multiple tools for quantifying the cultural ecosystem services. Bagstad *et al.* (2013) identified 17 tools that assess, quantify, model, value, and/or map the ecosystem services. Publicly available are Ecosystem Services Review (ESR), Artificial Intelligence for Ecosystem Services (ARIES), Social Values for Ecosystem Services (SolVES) or EcoMetrix (Bagstad *et al.* 2013). SolVES is a Geographic Information System (GIS) tool to quantify the social values for ecosystems. Land use and land cover are the prime input data (Crossman *et al.* 2013).

The present study is aimed at mapping the potential of outdoor recreation as an example of cultural agroecosystem services (recreation activities tied to the natural resources). Outdoor recreation was selected due to its importance for a lot of people deriving benefits in daily life.

MATERIAL AND METHODS

The presumption is that every agroecosystem has the potential (or capacity) for providing outdoor recreation. Herein, two approaches to mapping the potential of recreation agroecosystem service in the study area (the region of Gemer, Slovakia) were used and compared. Firstly, the SolVES model in a GIS application for assessing, mapping, and quantifying the social values of ecosystem services (http://solves.cr.usgs.gov) (Sherrouse *et al.* 2011;Sherrouse & Semmens 2012) and secondly, the regional model RegMOD were applied. The latter was designed based on a review of indicators and methods used to map these services in the literature, and considering the characteristics of the study area and the information available (Maes *et al.* 2011; Crossman *et al.* 2013; Kandziora *et al.* 2103a, b; Milcu *et al.* 2013; Burkhard *et al.* 2014), including the Methodological Framework for Integrated Assessment of Ecosystem Services in thetCzech Republic (Vačkár *et al.* 2013). The adaptation of the SolVES model for use in agroecosystem was performed in two steps. The first step required the validation and adaptation of the values in the study area, and the second step required the collection of data in the study area. The categories of an agroecosystem to provide outdoor recreation activity are as follows: very low relevant capacity (lower than 2 points), low relevant capacity (2.01–3.09 points), medium relevant capacity (3.10–5.09 points), high relevant capacity (5.10–7.09 points), very high relevant capacity (higher than 7.10 points).

The regional model (RegMOD). The recreation potential was evaluated through agroecosystem land-

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scape components that have a specific link with summer, winter, and year-round recreation. Because the results of this pilot study will be applied over the entire territory of Slovakia, only data which are available on National and Agriculture Food Centre, Soil Science and Conservation Research Instituet for Slovakia have been used. These include environmental data, slope and elevation data from the Digital Elevation Model (DEM) of Slovakia (raster layer), distance to roads – Euclidian distance to the nearest roads (raster layer), Natura 2000 database with sites designated under the Birds Directive, and the Habitats Directive (EEA) (vector layer), Climate – Slovakian climatic regions (vector layer). In the analysis of the area suitability in terms of recreation usage, the altitude, inclination, climate, and the distance to the roads were taken as the basis. Water recreation was not evaluated, because the graphic layer of water recreation places in the study area was not available. Factors and sub-criteria were assessed (see Table 1). The region of Gemer includes 120 303 ha of registered and classified agricultural soils. Protected areas (Natura 2000) cover an area of 98 592 ha, grasslands 76 915 ha. Productive grasslands represent 35 084 ha, less productive grasslands 37 519 ha, and non-productive grasslands 4311 ha. Agricultural soils cover the area of 62% of the total area of the region Gemer, forest covers 32.7%, and other areas (e.g. settlements, waterways) 5.3% of the total area.

The study area was divided into regular spatial simulation units (SimU). Each SimU was designed so that it represented one cell of 500 m resolution as a regular grid derived from the EEA reference grid. The recreation potential of the agroecosystem was calculated in SimU that have more than 10% of grasslands (according to typological-productive categorization of agricultural land (Džatko 2002)). The recreation potential of the agroecosystem was calculated as the sum of sub-criteria point values. The recreation potential for SimU was calculated as the weighted average of the potential of all agroecosystems located in each selected grid.

An ecosystem services potential (capacity) has been characterized by Burghard as the hypothetical maximum yield of selected ecosystem services (Burghard *et al*. 2014). The categories of an agroecosystem to provide outdoor recreation activity are as follows: very low relevant capacity (lower than 2 points), low relevant capacity (2.01–3.09 points), medium relevant capacity (3.10–5.09 points), high relevant capacity (5.10–7.09 points), very high relevant capacity (higher than 7.10 points).The recreation potential for all these activities was calculated as the sum of individual recreation activities potential without added points (Natura 2000), which were added only to the final sum in order to prevent multiple evaluations of additional factors. The methodology developed in this paper is replicable and could be applied by planners on condition they are proficient in handling geographical information systems. The software package of the geographic information system ArcGIS® (Version 9.3.1.) was used for processing the input geo-referenced digital data and creating the resulting maps.

Table 1. The assessment factors for hiking, biking and cross-country skiing

Assessment factors		Suitability degree (point value)
Hiking		
Altitude (m a.s.l.)	< 300	1
	300–600	3
	600–1200	2
Proximity to marked trails, nature trails		4
Proximity to protected areas (Natura 2000)		3
Distance to roads (m)	< 100	4
	100–200	3
	200–500	2
	> 500	1
Biking		
Inclination (°)	0–2	1
	2–5	2
	> 5	3
Proximity to marked trails		4
Proximity to protected areas (Natura 2000)		3
Distance to roads (m)	< 100	4
	100–200	3
	200–500	2
	> 500	1
Coss-country skiing		
Inclination (°)	0–2	1
	2–5	2
	> 5	3
Proximity to marked trails		4
Climatic region	02, 01, 00	1
	03, 04, 05	2
	06, 07, 08	3
	09, 10	4

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RESULTS AND DISCUSSION

Cultural ecosystem sevices, mainly recreation, provide many important benefits and contributions to physical and psychological well-being (Chan *et al.* 2012) and thereby represent a major opportunity for managing the interaction between ecosystems and people (Daniel *et al.* 2012). Important services can be delivered by semi-natural as well as agricultural ecosystems (Maes *et al.* 2011).

Mapping the potential of outdoor recreation activity using the SolVES model. The SolVES model belongs to robust models describing the relationship between social value intensity and explanatory environmental variables. These non-monetary values often correspond to cultural ecosystem services. As described in Sherrouse *et al.* (2011), SolVES generates results based on user-selected parameters including a specific public use (e.g. hiking recreation) and an attitude or preference (favour or oppose them). Hiking, biking, and cross-country skiing were chosen from the possible recreation activities provided by the SolVES model. The capacity of grasslands to provide outdoor recreation activity (SolVES model categories) is shown in Table 2. The potential for year-round hiking recreation is shown in Figure 1a, the potential for summer biking recreation is given in Figure 1b. The highest percentage of the study area had a medium relevant capacity to provide outdoor recreation activity – hiking, whereas only 1.9% presented a low and very low capacity. Our results showed that the distance to roads had the highest influence on hiking from our research into the types of recreation. High relevant and very high relevant values were least represented for this type of recreation. The highest percentage of the study area had a medium relevant capacity and high relevant capacity to provide an outdoor recreation activity – biking, whereas only 2.30% presented a low and 0.40% a very low capacity. According to the SolVES, for biking, grasslands with a variable relief are the most suitable. The high potential of this recreation type is associated with the elevated northern part of the region. In comparison with hiking and cross-country skiing, biking has the highest rate of high relevant and very high relevant values. The potential for cross-country skiing winter recreation is shown in Figure 1c. The potential for year-round, summer, and winter recreation is shown in Figure 1d. For cross-country skiing, a sparse occurrence of highly relevant and very highly relevant values is clear. The dispersed nature of these values is probably due to the influence of the distance to roads. Most of the area has medium relevant values. 45% of the study area exhibits a high or very high value for outdoor recreation services, whereas 9.2% present a very low value. The rest of the area has medium relevant capacity for recreation. The map indicates a very high spatial variation of the services across the study area. This is due to the great relief segmentation of the Gemer region. It is just the opposite to the case referred to by Van Riper *et al.* (2012), who found statistically significant spatial clustering across two subgroups of the survey. The highest values are concentrated in mountain areas that often correspond to protected areas of the Natura 2000 database. Mountain areas are defined mainly through the relief inclination. Lower values of the recreation potential are located in areas with lower inclination and elevation, i.e. in basins such as the South Slovak Basin and the Rožňava

Table 2. Capacity of grasslands to provide outdoor recreation activity (in % of all simulation units)

	Very low relevant	Low relevant	Medium relevant	High relevant	Very high relevant
SolVES					
Hiking	0.40	1.50	85.26	12.90	0.00
Biking	0.00	0.80	59.30	36.50	3.40
Cross-country skiing	0.40	2.30	81.50	15.80	0.00
Recreation capacity	0.20	0.90	53.90	43.40	1.60
RegMOD					
Hiking	0.00	8.70	44.90	32.50	13.90
Biking	0.00	2.60	45.20	53.30	0.00
Cross-country skiing	0.00	0.00	42.10	57.90	0.00
Recreation capacity	0.00	0.00	64.90	35.10	0.00

SolVES – Social Values for Ecosystem Services Model; RegMOD – regional model

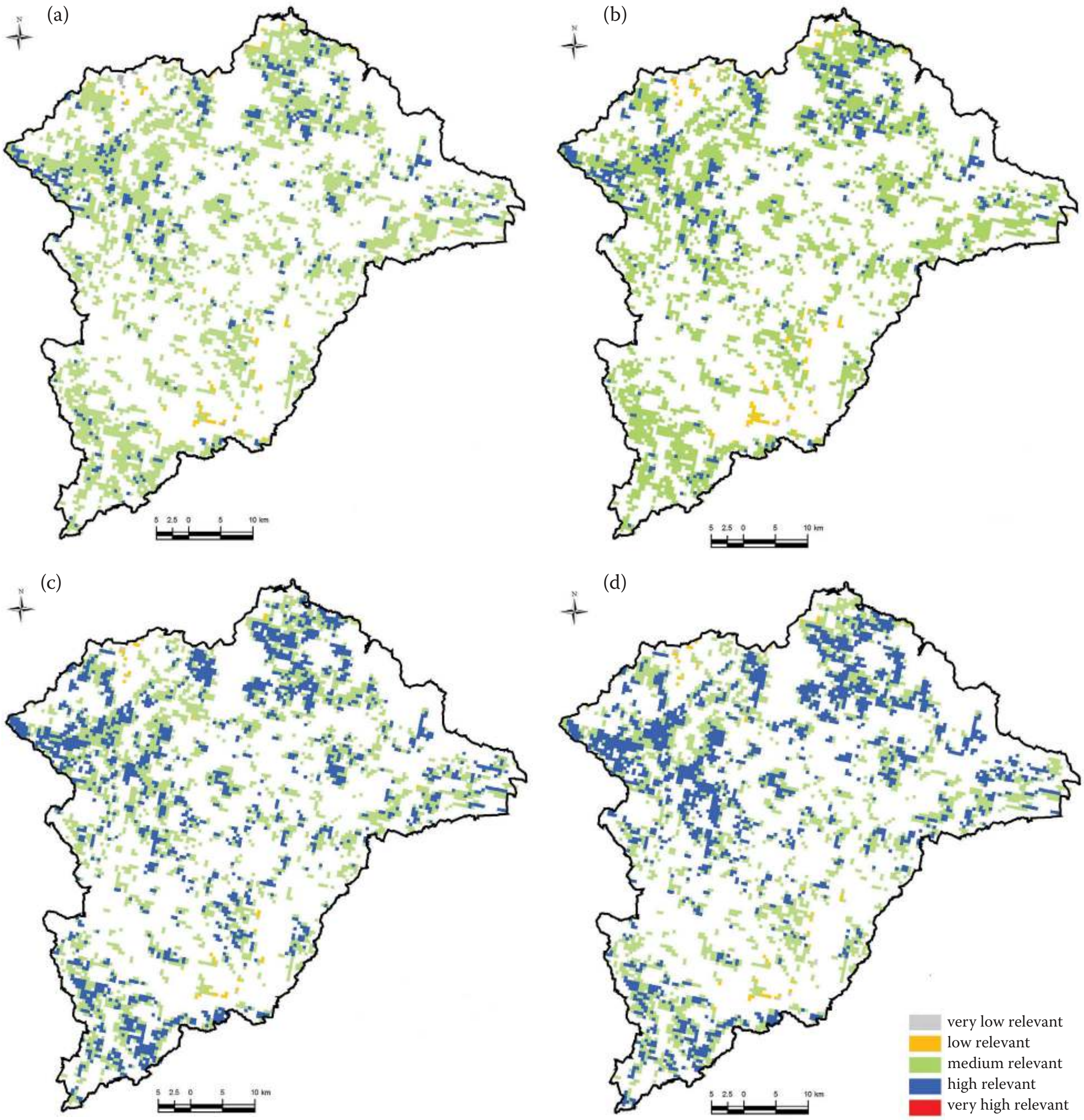

Figure 1. The potential for hiking (a), biking (b), cross-country skiing (c) and recreation capacity of the Gemer region (d) (SolVES model)

Basin. Distance to the roads therefore has low weight for recreation because most streams are currently in the valleys. Another environmental layer with a high impact on recreation is land use. Since the research was focused on agroecosystems, the highest rate falls on the lower-quality agricultural land. High capacity corresponds to pastures, grasslands, and shrub areas. Due to the fact that lower-quality agricultural lands in Slovakia are frequently wasted, part of the region with a high capacity for recreation is listed as deciduous forests within the land use classifications.

Mapping the potential of outdoor recreation activity using the RegMOD model. The degree of naturalness of a landscape is a factor dealth with also in other studies (Maes *et al*. 2011; Schulp *et al*. 2012), the same as the presence of natural protected areas (Willemen *et al*. 2008; Kienast *et al.* 2009). The capacity of grasslands to provide

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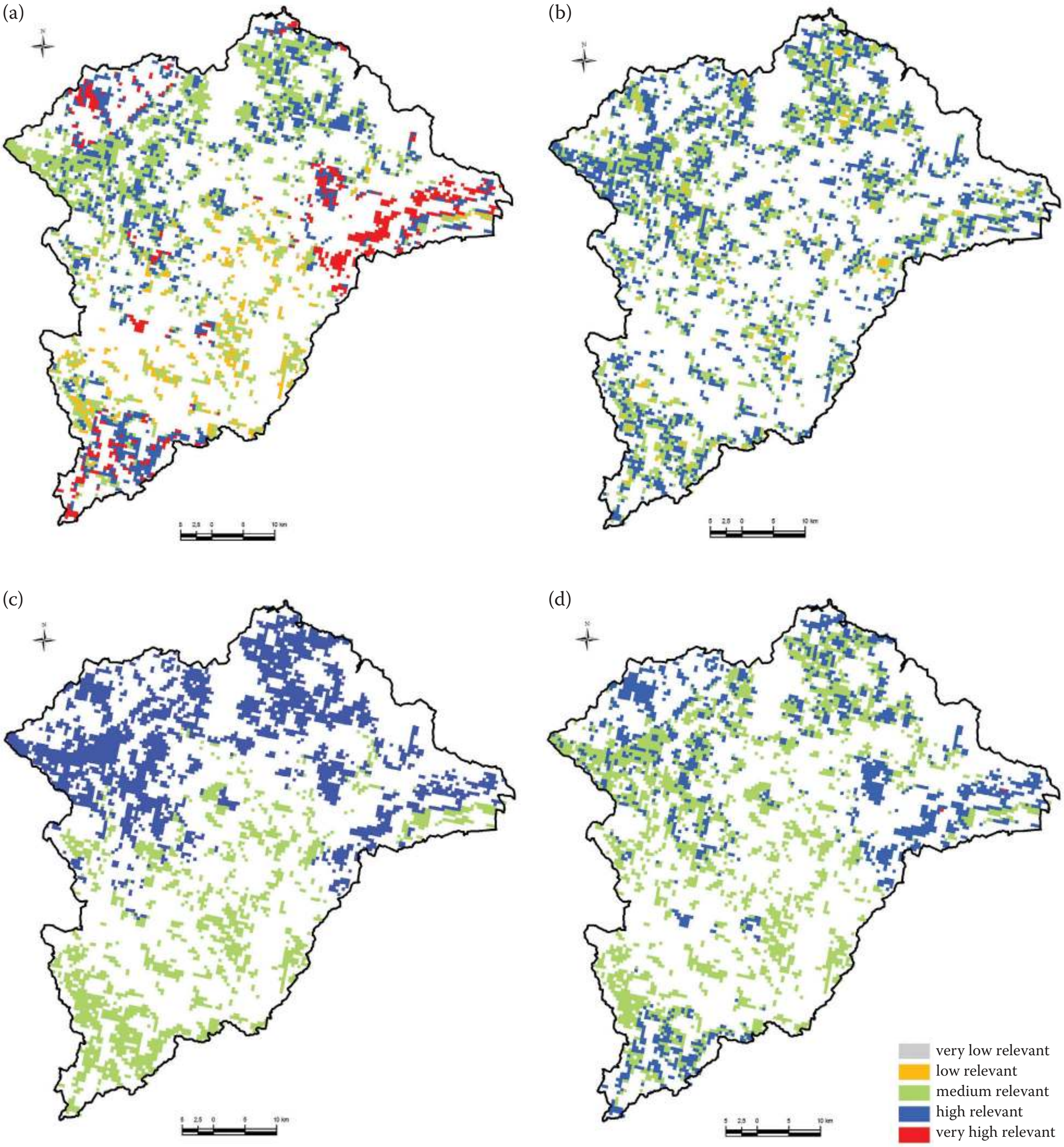

Figure 2. The potential for hiking (a), biking (b), cross-country skiing (c) and recreation capacity of the Gemer region (d) (RegMOD model)

outdoor recreation activity (RegMOD model categories) is shown in Table 2. Similarly as in the case published by (Burkhard *et al*. 2009), grasslands are characterized predominantly by medium relevant capacity to provide outdoor recreation services. The potential for year-round recreation – hiking – is shown in Figure 2a. The potential for summer recreation – biking – is shown in Figure 2b. The highest percentage of the study area has a medium or high relevant capacity for hiking, whereas only 8.7% presented a low capacity. The map indicates a very high spatial variation of the hiking capacity across the study area. The highest values are concentrated in locations of natural protected areas such as the Muráň Plateau National Park and the Slovak Karst National Park, which is in line with Willemen *et al*.

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(2008), Kienast *et al.* (2009) and Willemen 2010. Most of recreation activities depend on the existing infrastructure, accessibility, and other factors, but the ecological conditions are also important (Adamowicz *et al.* 2011). The potential for biking binds to established infrastructure and availability of suitable places. The highest percentage of the study area has a high or medium relevant capacity for cycling, whereas only 2.6% present a low relevant capacity. The potential for winter recreation – cross-country skiing – is shown in Figure 2c. The highest percentage of the study area has a high or medium relevant capacity for cross-country skiing. The map indicates primary links between climate and the capacity for this kind of winter recreation. The highest values are in the northern part of the region and in higher altitudes. The potential for outdoor recreation is shown in Figure 2d.

Based on the above results, the RegMOD model gives a wider range of categories than the SolVES model, particularly for hiking. One reason for this could be that the RegMOD is more influenced by the presence of natural protected areas than the SolVES model. The robust character of the SolVES model, as published by Bagstat *et al.* (2013), gives a reduced range of categories for this recreation activity. The differences in the map view are marked in the case of biking as well as cross-country skiing. By contrast, the percentages in the medium and high relevant capacity categories are in the case of cycling capacity. The medium relevant capacity is higher in the SolVES model (59.30% of the study area) than in the RegMod (45.20%) and, conversely, high relevant capacity is higher in the RegMod (53.30% of the study area) in comparison to the SolVES (36.50%). The cross-country skiing capacity map of the RegMOD indicates primary links between climate and the capacity for this kind of winter recreation in the case of the RegMod. The differences in the biking capacity map view are marked in the case of the SolVES model. In our opinion, the highest values are in the part of the region with higher inclination but less emphasis is placed on the altitude and therefore the model values are incorrect in the southern part of the study area. The comparison of the two models (for recreation capacity) showed differences in the medium relevant category as well as in the high relevant category. Also, the spatial distribution of the categories somewhat differs in the northern and the western part of the study area of Gemer. The SolVES model results indicate a higher representation of high relevant capacity in the northeastern and southern part of the study area in comparison to the results of the RegMod. The primary agroecosystem services are provisioning services. However, for less productive grasslands, as well as for non-productive grasslands, management may be more significant for cultural services and recreation activities. The less productive (53.88% of all non-productive grasslands by the results of the SolVES, 48.00% by the results of the RegMod) and non-productive grasslands show high relevant capacity (41.18% of all non-productive grasslands by the results of the SolVES, 54.40% by the results of the RegMod) to provide outdoor recreation activities, which creates a new view of their management as well as their use. The cultural services (for recreation) potential map can also assist in procedures such as hotspot identification, indicating important areas that might require special attention by managers (Reed & Brown 2003; Brown *et al*. 2005, 2006; Alessa *et al*. 2008). Without information on the factors influencing the quantity and value of the ecosystem services, it is difficult to design policies, incentives or payment schemes that can optimize the delivery of these services (Nelson *et al.* 2009).

CONCLUSIONS

The present study represents the first attempt at a potential assessment of cultural agroecosystem services at the regional level in Slovakia. Although the developing GIS technology and models rank among the tools applicable for mapping this type of services, the research verifying the application at different national and regional levels has still been limited (Frélichová *et al*. 2014). Traditionally, agroecosystems have been considered primarily as sources for providing services, but more recently their contributions to other types of ecosystem services have been recognized (MEA 2005). The analysis of the recreation potential allows optimum land-use and preservation of its services. Agricultural management practices are the key to realizing the benefits of ecosystem services, especially if trying to achieve a synergism effect. In other words, the synergism occurs when ecosystem services interact with one another in a multiplicative or exponential fashion (Felipe-Lucia *et al*. 2014). These can be positive, i.e., multiple services improving in their provision. The grasslands exploitation for cultural agroecosystem services can significantly contribute to the economic stability and prosperity of a particular region. Using soils of low production potential primarily for recreation purposes prevents degradation and

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loss of agricultural soil. The overgrowing of lower-quality agricultural land represents a serious problem in the study area of Gemer, and generally in Slovakia as a whole. Supporting recreation services on these grasslands can prevent their abandonment as well as their final loss as agricultural soils. Even in terms of the recreation potential of these areas, it is necessary to maintain their agricultural management and thus prevent their degradation. In addition, cultural agro-ecosystem services assessment should also account for managers' and stakeholders' preferences, as they are the agents assigning importance to this service.

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Corresponding author:

Prof. Jozef Kobza, Soil Science and Conservation Research Institute Bratislava, National Agricultural and Food Centre, Regional Station Banská Bystrica, Banská Bystrica, Slovak Republic; e-mail: j.kobza@vupop.sk