

The Typology of the Biocultural Landscape in Slovakia

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Abstract

Context. The European Landscape Convention is international strategy that aims to promote landscape protection, management and planning. This must be done on the basis of identification and knowledge of basic landscape types, which were created by the interaction of man and nature during historical development.

Objectives. This paper presents a methodological approach for creation and evaluation of representative biocultural landscape classification types in order to elaborate an effective strategy of landscape protection, and proposes a management strategy of sustainable use of representative biocultural landscape types of Slovakia that will ensure the regular maintenance of the landscape in view current global trends and factors affecting the landscape.

Method. Our interdisciplinary approach is based on previous classifications of cultural landscape and interaction of natural elements and valuation of the biotic and biocultural value of the landscape. The classification of the biocultural landscape is a result of multi-criteria analysis in GIS and synthesis of maps of potential vegetation, real ecosystem and current land use, abiotic conditions of representative geoecosystems of Slovakia, and other specific statistical data. We assessed the perception and significance of individual landscape types by way of questionnaire survey.

Results. In Slovakia, 7 basic types of landscape were singled out, from natural to semi-natural to anthropogenic, within which other subtypes were specified. The individual types were assessed from the point of view of protection of threats to and degradation of the landscape.

Conclusions. The most valuable types of biocultural landscape are given insufficient protection at present and new tools and methods of support and protection have to be implemented.

Introduction

The landscape is a very dynamic system, composed of two mutually interconnected subsystems (natural and social), which are constantly in a state change. The natural and human forces influence each other and change the landscape into a cultural form, giving it a unique character (Žigrai 2003). A cultural landscape is a snapshot of the state and development of society, because all social changes manifest themselves sooner or later in changes to the structure and utilisation of the landscape.

Land use is determined by the natural attributes, capabilities and overall possibilities of a landscape which offers potential for land utilization by humans. Land use is also determined by the requirements and demands of society, which change over the course of time (change of human conditions, change of priorities, change of ownership, change in technologies etc.). A value which was a non-essential luxury good in the past could later become an essential good. The change in the demands and requirements of human society is cyclically reflected in the changes of forms and intensity of land use. Current land use displays a combination of natural, semi-natural (human-changed) and artificial (human-created) elements of landscape structure. Cultural landscapes often show a high diversity of habitats which together form a versatile mosaic, produced by the application of different management strategies and by the introduction of a variety species over the years, which came to play various specific economic, social, or environmental roles.

By acting on the natural landscape and transforming it, man creates new types and forms of landscape which provide various ecosystem services (Maes et al. 2015). This interaction of man and nature creates various bio-cultural types of landscape, often very rare. Biocultural landscapes embed high ecological and cultural values, and reveal the link between nature and culture. This link is essential for understanding the character of these landscapes, providing tools for their conservation and development, and advancing studies in landscape ecology. Different cultures and nations perceive and appreciate biodiversity in different ways due to their distinct heritage and experience (Posey 1999). Approaches to perception, to definition, and especially to the assessment of biocultural biodiversity are very diverse. This latter concept includes biological diversity at all its levels, from genes to populations of species to ecosystems; cultural diversity in all its manifestations (including linguistic diversity), ranging from individual ideas to entire cultures; and, importantly, the interactions between all of these (Agnoletti 2006; Agnoletti, Rotherham 2015; Bridgewater 2017; Bridgewater, Walton 1996; Rotherham 2015). In our paper we focus on the assessment of the biocultural diversity on the landscape level and we shall adopt the aforementioned papers' definition of 'biocultural diversity' as comprising biological diversity, cultural diversity and the links between them.

Biocultural assets and heritage result from interactions between people and nature at a given time in a given place. Separation of nature from human culture has been identified as a serious issue in the conservation of both nature and heritage (Rotherham 2008, 2014). The biocultural diversity concept presents an opportunity to revise some of the current approaches to biodiversity, recognizing the broader meaning of this term and the need for a revision of the current conservation strategies. Most discussions on the complex relationship between the conservation of biodiversity and conservation of cultural diversity focus on the argument that cultural diversity can preserve a wide range of practices and the conservation of natural resources. At the landscape level we can identify an eco-cultural resource made up of components of biocultural heritage embedded in a cultural landscape. Recognition and appropriate management of biocultural elements is the key to successful future conservation of nature and cultural heritage.

The idea of biocultural systems arose primarily from the work of landscape geographers and ecologists who perceived the landscape more as a socio-ecological complex and as human-centric cultural landscapes. However, these concepts also developed in a political way. At the world level, besides CBD and IUCN, another possibility is to introduce the concept of biocultural diversity into important conservation programmes such as the UNESCO World Heritage List and FAO's Globally Important Agricultural Heritage Systems programme (UNESCO 2019, Koohafkan, Altieri 2011).

In the context of global changes, with the biosphere being intensively and rapidly modified by man, one of the tasks of Landscape Ecology is to define methods to analyse the interaction of humans and the modified ecosystems, considering the consequences for both people (tradition, well-being) and the ecosystems (resilience, integrity), and to provide indicators for these interactions and consequences (IALE 2017). The need to protect the landscape's biocultural values is also highlighted in the European Landscape Convention (ELC 2000). Contracting states ought to analyse the landscape types in the whole

area of their countries, as follows: 1) by defining their own landscape types throughout their territory, and analysing their features; 2) by recording changes in them; 3) by identifying basic drivers and formational pressures; 4) by assessing selected types with respect to special values attributed by engaged participants and inhabitants; and 5) by ensuring the necessary protection of all defined landscape types.

Knowledge and identification of individual landscape types enable the intensification of maintenance of diversity of individual landscape types and landscape biodiversity. This is an indispensable part of the strategic planning process and effective protection of regionally special landscape.

Slovakia signed the ELC in 2005 and became an active participant in its implementation. In accordance with the ELC, the basic aim of the Slovak Republic (SR) was to identify and define the landscape types with regard to their special values. The aim of this paper is to present an interdisciplinary approach to typology of biocultural landscape, the development of biocultural landscape as a result of interaction of humanity and nature, evaluation of changes in landscapes of various types, preservation of natural landscape types and perception of landscape types by population. The results represent an objective basis for the conservation, protection and effective use of individual landscape types.

Method

Study area

Slovakia is a small but very diverse landscape. The total area is 49,036 km². The total population was 5.464 million inhabitants in 2020 (SYSR 2020). Slovakia has a relatively dense network of settlements. There are about 7,000 settlements, including 141 cities but predominantly (95%) rural settlements, with less than half of the population living in the latter.

Three basic types of natural landscape have been singled out according to the abiotic conditions in Slovakia: lowland, basin and mountainous landscapes, each with various subcategories (Miklós et al. 2006). The mountain landscape is the most widespread type of landscape in Slovakia. In the north, the Carpathians form a massive arch, and the Pannonian Basin extends to the south. The mountains and highlands occupy about 52.99% of the Slovak territory. The vast mountain range of the Carpathians consists of many mountains and basins. The individual groups of mountains differ according to their origin and the geological rocks of which they are composed. The highest peak in Slovakia is Gerlachovský štít (2,655 m above sea level). The basin landscape does not form a continuous area but is divided into several areas, which results from the configuration of the mountains. This type covers 18.27% of the Slovak territory, and it is the type of landscape with the highest density of settlements. The lowlands occupy 28.74% and they stretch to the southwest, south and east. They belong to the vast depression of the Pannonian Basin. The largest and most fertile is the Danubian Lowland. The lowest point is the level of the Bodrog river at Streda nad Bodrogom (94 m above sea level). The geographical conditions of Slovakia give rise to significant diversity of fauna and flora. More than 11,000 plant species, and almost 29,000 animal species, have been described throughout its territory (Lieskovská, Lényiová eds. 2019).

From a socio-economic point of view, the SR is an industrial-agricultural country with a market economy. The automotive industry is dominant in industrial production, and crop production in agriculture. Most of the arable land is used to grow cereals.

Typology of biocultural landscape

The methodological approach of processing the typology of the biocultural landscape was based on multi-criteria analysis and spatial synthesis of natural and cultural factors using the Quantum GIS 3.10 software. We used following maps to specify the basic biocultural types of the Slovak landscape:

- *Map of natural landscape types* – represents the basic natural units, which were distinguished on the basis of the properties of the abiotic complex of the territory, primarily by relief and geological conditions, secondarily by soil properties and hydrological conditions. In Slovakia, 3 basic types of natural landscape were singled out: lowland landscape, basin landscape and mountainous landscape (Miklós et al. 2006). This map was important for understanding the spatial distribution of individual types of biocultural landscapes, which we have defined in the following steps as the effect of human interaction on natural landscapes.
- *Map of land cover* – represents the basic form of land use by man. Land use and management are the basic factors that transform a natural landscape into a cultural landscape and imprint its specific cultural and historical features. We used the digital database of Corine Land Cover (CLC 2012) to define the main landscape types. The territory of Slovakia was processed in accordance with this methodology by visual interpretation of Landsat satellite images; with mapped areas having a minimum size of 25 ha (Feranec et al. 2018). On the basis of CLC data, we classified the biocultural landscape into the main categories and (after analysing in more detail) into subtypes.
- artificial surfaces including industrial or commercial units; road, rail networks; port areas; airports; mineral extraction sites; dump sites; construction sites used for typology of industrial landscapes
- artificial surfaces including continuous and discontinuous urban fabric; green urban areas; sport and leisure facilities, used for typology of settlement landscapes, further analysed in more detail with statistical settlement data
- agricultural areas, used for typology of agricultural landscape and extensively-used forest-agricultural land
- forest areas for typology of forest landscapes
- semi natural areas including natural grassland; moors and heathland; traditional woodland-shrub; inland marshes; peat bogs for typology of extensively-used forest-agricultural land and sub-natural non-forest land
- *Statistical data about settlements* – for the classification of settlements we used publicly available data from the list of municipalities, cities and self-governing regions (eGovernment 2021), plus additional information about dispersed settlement (Petrovič 2006), tourist regions and spa resorts (Slovak Region 2021). Additionally, we analysed data about historical green infrastructure that includes (1) natural protected sites (ŠOP SR 2020) containing historical parks and arboreta, and (2) protected cultural monuments with accompanying green infrastructure like alleys of trees, gardens and historical

parks (PÚ SR 2020). We distinguished six subtypes of landscapes relating to settlements: Urban, Urban with historical green infrastructure, Rural, Rural with historical green infrastructure, Dispersed settlement and Recreation areas.

- The distribution of agricultural landscape was derived from CLC data; additional information was used for distinguishing between subtypes, especially the viticultural division of the territory of the Slovak Republic vineyard regions (ÚKSÚP 2020), results of inventory of traditional agricultural landscapes (Špulerová et al. 2011) and statistical data about agricultural production (SYSR 1995, 2020).

The typology of natural and semi natural types of landscape (extensively-used forest-agricultural land, sub-natural non-forest land, forest land) was derived from the changes of potential vegetation and current status of real vegetation.

- *Map of potential vegetation* – Potential natural vegetation represents the potential distribution of individual similar vegetation units where the abiotic natural habitat conditions (relief, geological substratum, climate, water regime, soils) remain practically unchanged (Michalko et al. 1986; Moravec 1998). In Slovakia, 9 basic zones of potential vegetation were allocated. This map represents the basis for assessing the conservation and naturalness of ecosystems.
- *Map of Slovakia's ecosystems* – this was used as a baseline of spatial distribution of real vegetation, its status and selected properties (Černecký et al. 2020). The ecosystem types were classified in accordance with the EUNIS classification system on level 3 precision (EEA 2018), using GIS analytical tools to combine datasets on nature protection, forestry, and agriculture and other environmental data. The impact of human activities was expressed by assessment of naturalness of habitats, divided into five degrees of naturalness, taking into account the habitat conservation status: 1) Artificial system and intensively-used cultural landscape; 2) Semi-natural habitats; 3) Quasi-natural habitats; 4) Sub-natural and 5) Natural habitats. We determined the conservation status from the monitoring data of permanent monitoring sites (more than 10,000 sites) and assigned one of three categories: favourable (FV), unfavourable (U1) and bad (U2) (Janák et al. 2015; ŠefferoVá Stanová et al. 2015). Vegetation maps showing naturalness, derived in a raster GIS (grid-precision of 800 m) was one of the inputs for typology of the biocultural landscape. Based on these vegetation data, we have identified natural and sub-natural landscape subtypes, covered by forest or non-forest habitats.

Sociological survey on landscape perception

To evaluate the perception and appreciation of individual landscape types by the public, we used a sociological survey – an online questionnaire. We used the national thematic networks of the Slovak Ecological Society (SEKOS) and the national network of landscape ecologists (SK IALE) to request participation in the sociological survey and promote the questionnaire to the wider general public. In addition to basic demographic questions, the questionnaire contained 5 questions aimed at identifying the representative landscape types of Slovakia, the perception of the state of degradation and the need to protect individual landscape types, as well as preferences for housing and recreation. Individual types of landscape were presented in the questionnaire in the form of photographs. A total of 185 respondents participated in the survey, representing different economic sectors (31.5% academic and school, 18.5% services, 10.9% industry; 9.2% public administration and 29.9 others). The highest interest in participating in the survey was expressed by the university-educated population (80.5%) and the economically active population in the age categories of 40-60 years (51.9%), and 25-40 years (24.9%).

Results

We identified a total of seven biocultural landscape types and 26 subtypes in Slovakia (Fig. 2):

- *Industrial landscape* – a strongly anthropized landscape with scarce vegetation, which has hygienic-protective and landscape-aesthetic function rather than biological value. While in the past industrial objects were situated directly within settlements, after the post-socialist transformation to a market economy (hereafter referred to just as “the transformation”) new industrial parks, areas and logistics centres were built at the edges of settlements, often not suitably integrated into landscape. Most of them were built on “green fields”. The problem is that a lot of companies from the previous period were closed and currently they are undesirable landscape elements – “brownfields”. Industrial landscape covers 0.93% of Slovakia and is mostly situated in the lowlands and basins.

Landscapes of Slovakia

- *Urban landscape* – landscape dominated by urban or rural settlements. Beside residential area, their structure also includes administrative, service-commercial, and cultural-historical objects, and areas supplemented by biotic landscape elements – urban vegetation or preserved remnants of forests. There is a diverse proportion of biotic elements. For the purpose of biotic value assessment we established a separate category of urban and rural settlements with presence of historical vegetation, which is protected as part of natural or cultural heritage (historical parks, arboreta, green infrastructure surrounding cultural monuments). The urban infrastructure of Slovakia is dominated by rural settlements, covering 4.15% of Slovakia. The proportion of the urban landscape is 1.37%. Approximately 4% of urban settlements and 8.8% of rural settlements fit the category of presence of historical green infrastructure. In the post-transformation period, we can see an increase of built-up areas in rural settlements, connected to increased interest in living in the countryside. This is a characteristic mainly of suburban areas near the cities, like satellite villages. New villa districts often disturb the original rural character of the rural settlements. A characteristic form of settlement in Slovakia is the landscape with dispersed settlements. This is the original form of settlement, characterised by settlements formed with gradual, dispersed structure. Residential areas do not form continuous units, but individual houses are situated directly in open natural landscape. In their vicinity we can see mosaics of narrow fields, grasslands and orchards. These landscapes are remnants of historical forms of settlement and their area is constantly shrinking. Currently, they cover around 0.49% of Slovakia. Due to harsh living conditions, many objects have been abandoned and transformed into recreational cottages. Agriculture is likewise declining here. Because of changes in agricultural use (reduction or even elimination of livestock and sheep farming) some grassland are left abandoned (Petrovič, Bielikova 2016).

- *Recreational landscape* is a special type of urban landscape, as it consists of infrastructure needed for realisation of sports and recreational activities (ski-lifts, aqua parks, stadiums, spas, cottage settlements etc.) and also infrastructure providing service for recreation and tourism (accommodation and catering facilities). The total area of this type of landscape is 0.47% of the country. This category is dominated by recreational landscape with winter sports situated in mountainous areas of Slovakia. This subcategory takes up 53% of the area of the recreational landscape type. The second most represented subcategory is landscape with water sport areas (aqua parks, swimming pools), with 23% representation. This type of landscape provides cultural ecosystem services.
- *Agricultural landscape* represents the dominant type of landscape in lowlands and basins, covering 30% of Slovakia. This is a semi-natural type of landscape, where the dominant element of landscape structure is land with cultivation of agricultural crops. This type of landscape structure provides mainly production functions. In most areas of Slovakia it is characterised by typical large-scale ploughed fields. Arable land represents 93% of the agricultural land. The structure of crops is diverse, with priority being given to crops with a high market value in recent times. Beside cereals, it is mainly energy crops like sunflower, corn, rapeseed that are currently being grown. The area of energy crops has increased by almost 300% since 1990. The area of cereals has decreased slightly, by 12% (SYSR 1995, 2020). Uncoordinated cultivation of energy crops can not only be a threat for natural ecosystems and cause loss of species (including pollinators and birds), but also threaten various landscape resources (water and soil degradation). Other subtypes are areas of permanent crops and vineyards. Their areas are small. Vineyards cover 1.49% and permanent crops cover 0.69% of Slovakia. Productive vineyards have decreased by 65% since 1990. Significant decrease also occurred in all types of fruits. The numbers of walnut, plum and cherry trees has decreased by 90%, apple trees by 60% (SYSR 1995, 2020). Cultivation of vines and fruit is threatened not only by unsuitable socio-economic conditions, but also by the change of climatic conditions, which brings increased temperature, decrease of precipitation, the spread of different diseases, and increased incidence of pests.
- *Forest landscape* – the dominant landscape structure element is forest with varying species composition. This type of landscape covers 34.4% of Slovakia. Forest landscape dominates the foothills and mountain areas of Slovakia. Based on the structure of woods within the forest landscape, we selected three categories: forest landscape with predominance of deciduous forests (72.9%), forest landscape with predominance of coniferous forests (17.2%) and forest landscape with predominance of mixed forests (9.9%). If the conservation status of an area was assessed as unfavourable or bad, we identified one of the subcategories of deteriorated forests. In addition to biomass production aspects forests are also very important in terms of provision of various ecological and environmental functions. They are significant not only from the point of view of biodiversity protection and support of landscape stability, but also because of their contribution to the protection of other landscape components (natural resources) – in particular, the protection of water and soil resources. Most of them also provide a number of cultural services, such a place for relax and recreation, scientific-educational function and so on. Despite the irreplaceable functions of forests, Slovakian forests are constantly threatened by various pressures, including several abiotic, biotic and anthropogenic factors. Of the abiotic factors, the foremost are the harmful action of wind, snow, rime, and drought. Among the damaging biotic agents in forest growths, the spruce bark and wood-boring insects predominate followed by the leaf-eating and sucking insects, putrefaction, tracheomycoses, and game. The most important of the anthropogenic factors is mainly the production of emission. The most endangered and affected by these factors are coniferous forests, of which 88% have been changed from the potential vegetation (Lieskovská, Lényiová eds. 2019).
- *Extensively-used forest-agricultural landscape* – the dominant subcategories within this group are landscapes of permanent grasslands and mosaic landscape structures. In the case of mosaic landscape structures, the landscape is created by combination of various landscape elements. Usually it is a combination of small-scale arable land, permanent grasslands and woody vegetation. Landscape structures of semi-natural grass-herbal biotopes cover 13.71%, and mosaic landscape structures cover 10.47%, of Slovakia. Permanent grasslands in Slovakia are represented by grasslands and pastures. After transformation, there occurred a significant decrease in the use of pastures, and a smaller decrease of use of grasslands. Many of them are overgrown by weeds, non-native grasses and shrubs, which significantly endangers biodiversity and the landscape aesthetics. In addition to production ecosystem services, these landscapes also provide important regulation ecosystem services. The perceived attractiveness of mosaic landscape structures means, they also provide some cultural ecosystem services. These elements are present mainly in the mountain and foothill areas of Slovakia. They are one of the most important types of historical structure of the agricultural landscape in Slovakia. As a result of their location, usually in less-favoured areas, which are difficult to access and manage, they are the most endangered type of landscape.
- *Sub-natural non-forest land* – Alpine, subalpine or rocky land, steppic habitats and wetland areas are included in this category. The alpine landscape is made up of typical alpine herbaceous grassland, snow patch dwarf willow scrub, hydrophilous tall herb fringe communities, or alpine tall grass communities. It occupies the highest parts of the Slovak mountainous regions. The subalpine landscape is an area with a predominance of dwarf mountain pine scrub, often in combination with alpine meadows, occurring in the higher mountains. Alpine and subalpine land cover 1.58% of Slovakia. Wetland occupies 1.44% of Slovakia. Wetland ecosystems are among the most endangered not only in Slovakia, but from an international perspective. The main pressures leading to the degradation of inland wetland include land use changes, drainage, flow regulation, and urbanization in floodplains. Steppic grassland occurs mainly in warm lowland and basin areas and they cover 0.22% of Slovakia. All of these habitats are valuable from a biodiversity point of view, and all have been affected by human activity. They provide regulation and cultural ecosystem services, and are attractive from a landscape-aesthetic point of view.
- *Water areas* – landscape formed by water features, watercourses, reservoirs, and lakes. Water landscapes occupy 0.74% of Slovakia. Water elements in Slovak countryside, in addition to their important biotic and regulatory function (significant waterfowl habitats, eco-stabilization effects, water regulation in the countryside, etc.) also provide several production and recreational ecosystem services – water supply, providing utility water for industry and agriculture, and providing areas for fishing, water sports, swimming, etc.

The list of the defined biocultural types of landscapes and their proportion of the territory of the SR is given in the Table 1.

Table 1
Distribution of biocultural landscape across the main landscape types

Landscape types/ Biocultural landscape types	Lowland landscape					Basin landscape			Mountainous landscape		
	Plain depression	Wide floodplains	Udulated plain of flood terraces and loess tables	Duned plains	Lowland polygenetics hill lands and plateau foothills	Cores of basins and valleys with floodplain	Highlands of basins and valleys	Uplands of basins and valleys margins	Strongly dissected highlands to uplands of intermountain furrows	Core areas of uplands (slopes and ridges)	Upland plateaus
Industrial landscape											
Industrial	0.01	0.21	0.09	0.03	0.06	0.27	0.14	0.01	0.02	0.06	
SUM (%)	0.01	0.21	0.09	0.03	0.06	0.27	0.14	0.01	0.02	0.06	0
Settlement landscape											
Urban	0.01	0.16	0.08	0.01	0.04	0.17	0.18	0.02	0.04	0.05	
Urban with historical green infrastructure		0.14	0.05	0.01	0.04	0.19	0.08	0.01	0.01	0.05	
Rural	0.07	0.47	0.30	0.12	0.40	0.41	0.59	0.05	0.36	0.54	0.01
Rural with historical green infrastructure	0.02	0.14	0.10	0.02	0.09	0.08	0.10	0.02	0.05	0.06	
Rural dispersed settlement						0.04	0.05		0.08	0.20	
Recreation areas		0.03	0.01	0.01	0.03	0.01	0.07	0.03	0.04	0.10	
SUM (%)	0.1	0.94	0.54	0.17	0.6	0.9	1.07	0.13	0.58	1	0.01
Agricultural landscape											
Intensively-used agricultural landscape	1.67	6.01	3.91	1.50	5.17	2.27	4.10	0.16	0.88	1.73	0.01
Vineyard landscape	0.03	0.22	0.12	0.07	0.47	0.10	0.20	0.01	0.04	0.22	
Permanent agricultural crops and gardens	0.01	0.09	0.07	0.03	0.13	0.06	0.12	0.01	0.03	0.11	
SUM (%)	1.71	6.32	4.1	1.6	5.77	2.43	4.42	0.18	0.95	2.06	0.01
Extensively-used forest-agricultural land											
Mosaic of forest-agricultural landscape	0.11	0.43	0.09	0.25	0.43	0.18	1.16	0.29	0.48	4.11	0.03
Semi-natural grassland	0.35	0.66	0.33	0.28	0.45	0.64	2.35	0.38	1.25	3.99	0.02
Semi-natural grassland, deteriorated	0.01	0.04	0.03	0.02	0.03	0.08	0.15	0.01	0.09	0.32	
SUM (%)	0.47	1.13	0.45	0.55	0.91	0.9	3.66	0.68	1.82	8.42	0.05
Sub-natural non-forest land											
Alpine, subalpine or rocky land		0.02			0.01	0.02	0.05		0.05	0.20	
Alpine, subalpine or rocky land, deteriorated						0.01	0.02	0.01	0.01	0.06	

Landscape types/ Biocultural landscape types	Lowland landscape					Basin landscape			Mountainous landscape		
	Plain depression	Wide floodplains	Udulated plain of flood terraces and loess tables	Duned plains	Lowland polygenetics hill lands and plateau foothills	Cores of basins and valleys with floodplain	Highlands of basins and valleys	Uplands of basins and valleys margins	Strongly dissected highlands to uplands of intermountain furrows	Core areas of uplands (slopes and ridges)	Upland plateaus
Wetland	0.07	0.09	0.02	0.09	0.03	0.10	0.18	0.03	0.08	0.20	
Deteriorated wetland	0.05	0.05	0.01	0.02		0.05	0.03	0.01	0.01	0.04	
Steppic habitats		0.02	0.02		0.01	0.02	0.06		0.01	0.03	
Deteriorated steppic habitats										0.01	
SUM (%)	0.12	0.18	0.05	0.11	0.05	0.2	0.34	0.05	0.16	0.54	0
Forest land											
Coniferous forest				0.03	0.01	0.01	0.07	0.01	0.01	0.13	
Coniferous forest, deteriorated	0.01	0.01		0.18	0.02	0.06	0.30	0.14	0.10	1.68	
Deciduous forest	0.02	0.10	0.02	0.03	0.17	0.05	0.43	0.13	0.18	4.36	0.03
Deciduous forest, deteriorated	0.03	0.20	0.07	0.08	0.75	0.09	0.87	0.25	0.35	8.03	0.09
Mixed forest				0.01	0.01		0.02			0.15	
Mixed forest, deteriorated	0.01	0.02	0.01	0.13	0.06	0.02	0.14	0.07	0.07	0.98	0.01
SUM (%)	0.07	0.33	0.1	0.46	1.02	0.23	1.83	0.6	0.71	15.33	0.13
Water areas											
Water areas and reservoirs, water structures	0.02	0.32	0.06	0.01	0.02	0.11	0.08		0.06	0.03	
SUM (%)	0.02	0.32	0.06	0.01	0.02	0.11	0.08	0	0.06	0.03	0
Total SUM	2.52	9.45	5.37	2.94	8.43	5.04	11.54	1.69	4.29	27.40	0.20

We have created a classification system of four basic categories of biocultural landscape types according to nature and the transformation of the natural landscape by man, from natural to artificially created anthropogenic landscape types (Table 2). We have identified the forms of protection applying individual biocultural landscape types, which is important information for preserving their existence. The best form of protection is that provided for natural landscapes under Act no. 543/2002 Coll. on nature and landscape protection, in the form of protected areas and NATURA 2000 sites. Protection of forest landscapes is provided by Act no. 326/2005 Coll. on forests, in the form of protected forests and forests of special purpose. The protection of water landscapes is provided by Act no 364/2004 Coll. on water, in the form of protection of water elements and protection areas of water resources. The best protection of anthropogenic landscapes is that provided for rural and urban settlements by Act no. 49/2002 Coll. on the Protection of Monuments and Historic Sites, in the form of Monument zones and Monument reserves. The least protection is provided for semi-natural landscapes types and biocultural landscapes associated with agriculture, although these landscapes often represent very rare traditional agricultural landscapes.

Table 2
Categories of biocultural landscapes and the forms of protection applying to them

Anthropogenic landscape	Form of protection
Industrial	No protection
Urban	No protection
Rural	No protection
Recreation area	No protection (partly situated in Protected Landscape Areas or Buffer zone of National park)
Semi-natural landscape	
Intensively used agricultural landscape	No protection
Vineyard landscape	No protection
Permanent agricultural crops and gardens	No protection
Natural landscape	
Sub-natural non-forest land (Alpine, subalpine or rocky land; Wetland; Steppic habitats; and deteriorated subtypes)	Natural protected areas, NATURA 2000 sites
Forest land (Coniferous forest;; Deciduous forest;; Mixed forest and deteriorated subtypes;)	Natural protected areas, NATURA 2000 sites
Water areas and reservoirs	Water protection areas
Biocultural landscape	
Semi-natural grassland/ deteriorated	Natural protected areas, NATURA 2000 sites
Rural dispersed settlement	No protection
Mosaic forest-agricultural landscape	No protection
Rural with historical green infrastructure	Monument reserves, Urban monument zones, Protected sites
Urban with historical green infrastructure	Rural monument zones, Monument reserves of folk architecture, Protected sites

Perception On Slovak Landscape

We conducted a questionnaire survey to find out how the Slovak public perceives individual types of biocultural landscapes, their protection, and threats to them. Public involvement recommended by the ELC and it is important in terms of the protection and preservation of the representative types of Slovakia. 47.2% of respondents consider a rural agricultural landscape to be a characteristic Slovakian type, 30.3% consider semi-natural forest-agricultural landscape and rural landscape to be the best landscapes to live in (Fig. 3). A relatively high proportion of respondents (13.5%) consider industrial country to be a characteristic type of Slovak landscape, which may be related to the creation of new industrial parks and logistics centres in the transformation period. Natural and semi-natural mountain landscapes are preferred for recreation. The result of the sociological survey shows that the respondents perceive more positively the natural landscapes, or biocultural landscapes which combine important cultural monuments with vegetation elements.

Traditional agricultural landscape (mosaics of arable land, grasslands, orchards, small woodland and balks), traditional meadow-pasture landscape, and extensively-used forest-agricultural landscapes; are considered by respondents to be highly threatened (Fig. 4). They also consider the natural mountain landscape to be a highly threatened landscape. According to the respondents, the highest level of protection should be provided to the traditional agricultural landscapes, valuable not only because of biodiversity but also from the cultural-historical point of view (Fig. 5).

CM – Cultural monuments in settlements; ISL – Industrial and settlement landscape; EFA – Extensively used forest-agricultural landscape; HLW – Historical landscape with watermills; HLM – Historical landscape of mixed type (technical monuments, monuments and museums of folk architecture); NML – Natural mountain landscape RAL – Rural agricultural landscape; SM – Sacred monuments, pilgrimage sites; TAL – Traditional agricultural landscape (mosaics of arable land, grasslands, orchards, small woodland and balks); TML – Traditional mining landscape; TMPL – Traditional meadow-pasture landscape; TWL – Traditional wine-growing landscape

Discussion

The landscape represents a living space not only for humans but also for all living organisms, where they live in mutual interaction. Man can be considered the principal shaper of the landscape in which he resides. Human activities in the landscape take various forms (Izakovičová et al. 2017):

- placing artificial elements into the natural landscape – construction of anthropogenic buildings, areas, lines, etc. The result of this process is the creation of cultural objects (cultural landscape).
- large-scale exploitation of the natural landscape – zones of agriculture, forestry, etc. The result of this process is the creation of semi-natural landscape.

- selecting different functional zones in order to protect elements of the natural landscape (protected natural landscapes, protected zones of water resources, etc.). The result of this process is protection and preservation of natural landscape elements (natural landscape).

Man also leaves his footprint on the landscape in less obvious ways: human activities cause stress factors which lead to landscape deterioration – introduction of harmful artificial substances, soil degradation processes, etc. The result of this process is a change in the ecological conditions of natural ecosystems and their subsequent degradation. The result of this interaction of people and nature at a given time and in a given place is the creation of a landscape structure with different landscape types consisting of natural, artificial, or mixed elements. Current landscapes are a mixture of human activity with expressions of biodiversity – that is, they are biocultural landscapes (Bridgewater, Walton 1996). Biocultural diversity denotes the link between biodiversity and human diversity (Diaz et al. 2015, Hill et al. 2011). Each historical period brings certain changes and imprints elements of the landscape, shaping its character. These changes can be not only positive, but also negative, when rare and valuable landscape structures are degraded and disappeared. In Slovakia, we have so far identified a total of 26 landscape types, of which 13 were natural, 4 anthropogenic and 9 mixed biocultural landscape types.

Over the course of historical development, man has significantly influenced the structure of the natural ecosystems, which has been manifested mostly by expansion of man into space originally occupied by forest ecosystems, causing deforestation and subsequent transformation into agricultural land, especially arable soil (Izakovičová 2000). This activity created new types of landscape structures. Remains of old landscape structures have been preserved, the so-called archetypes (Hreško et al. 2010). A massive intensification of agriculture took place during collectivisation under socialism, with frequent deforestation, drying-up and ploughing-up of the land. The traditional forms of farming were destroyed along with the traditional rural lifestyle (Slavkovský 2002, Izakovičová et al. 2010). Hedges and terraced fields were ploughed up, grassland and meadows were destroyed. Progressive use of heavy machinery resulted in elimination of green infrastructure, which created unstable monotonous, intensively-used agricultural landscapes. This was particularly evident in the geographical regions with favourable nature conditions for agriculture with prevalence of lowland and flatland relief and with the most fertile soils and favourable warm climate (Feranec et al. 2010).

Urbanization together with industrialization has also had major effects on the natural ecosystems. Artificial objects were created, whether industrial or residential. New city districts and uniform apartment blocks were built. Historic centres with accompanying vegetation of considerable biocultural value were destroyed (Skanes, Bunce 1997, Medvedkov, Medvedkov 2007). A significant change in landscape types was also recorded in the transformation period, as in other post-socialist countries. Extensive construction of industrial parks and logistics centres began. On the other hand, many industrial and agricultural buildings were closing, gradually falling into disrepair and remaining abandoned, becoming “brownfields” that are aesthetically inappropriate elements in the landscape (Haase et. al. 2013). Significant changes have occurred in the rural landscape, especially in satellite villages with extensive migration of urban populations to the better conditions of the rural countryside.

The new market economy has also significantly affected the agricultural landscape since the accession of the SR to European Union. There has been a change in the types of crops being cultivated. Socio-economic conditions have encouraged the cultivation of energy crops that are not environmentally friendly (Jepsen 2015). The abandonment of farmland has affected high nature value farmland, which is the most valuable agricultural landscape type from biodiversity and biocultural point of view, although they form a low proportion of the SR by area. These areas have often been shaped by specific mountainous natural conditions and ecologically-friendly management (Dobrovodská et al. 2019). In many countries, these agricultural landscapes have been created, shaped and maintained by generations of farmers and herders using locally adapted, distinctive and often ingenious combination of management practices and techniques, and creating significant biodiversity in the area (Hong et al. 2014). Maintaining valuable habitats and landscape types requires appropriate management. Certain sites reflect specific techniques of land use that guarantee and sustain biological diversity (Bridgewater, Rotherham 2019). Many of these rare landscape structures are disappearing in Slovakia due to less favoured conditions for farming or low economic profit. They are covered in weeds, slowly being overgrown with the invasion of woody plants, and thus creating new elements of landscape structures which are inappropriate from the landscape-aesthetic point of view (Halada 2017). They are also threatened by pressure from investors to seeking to build new residential and recreational areas.

The mountain regions are the regions with the highest ecological quality, characterised by a high rate of natural ecosystems. Non-forest habitats were mainly influenced by shepherds’ activity in the past. Mountain regions with a high proportion of natural ecosystems are at risk due to the intensive development of recreation. Many forest ecosystems are affected by the construction of technical recreational infrastructure – ski slopes, hotel complexes, accommodation and catering facilities (Kuemmerle et al. 2007). Changes in forest structure also occur as a result of the impact of climate change, which causes significant damage to forest ecosystems due to wind disasters, drought, fires, pest multiplication, etc. Similarly, wetlands and water-dominated types are also negatively affected by changes in climatic conditions.

If we want to preserve this biocultural wealth and heritage, we must pay attention not only to the protection of individual types of landscape but also to their management (ELC 2011, Grunewald, Bastian 2015). In Slovakia, landscape protection is insufficient. Protection is focused only on the protection of the individual components of water, of soil, and – predominantly of biota. Protection is also predominantly biased towards the more attractive forms of biota – endemic, rare, endangered, and habitats. The most notable omission is the lack of protection for lowland and basin areas, which do not qualify for any forms of nature protection despite being very important geographical units of Slovakia (Miklós et. al. 2006). Traditionally significant protection tends to be received by mountain and high-mountain landscape types, which have been declared national parks. Separation of nature from human culture has been identified as a serious problem in the conservation of both nature and heritage (e.g. Rotherham 2008, 2014). Therefore, it would be desirable to develop and apply a new approach to protection of valuable biocultural landscape types, which is not limited to natural habitat types and wildlife, but also takes into account human activities. Many valuable types of landscapes and habitats are the result of e.g. agricultural activity and are considered part of the natural heritage (Halada et al. 2011). Many artificial, man-made landscape elements are also accompanied by the presence of valuable ecosystems, creating important biocultural types of landscape, e. g. species-rich-habitats on terraced landscapes (Kladnik et al. 2017; Slamova et al. 2015).

The protection of the biocultural landscape must respect the fact that culture and nature mutually interact. These links have developed over time through mutual adaptation and possibly co-evolution (Poe et al. 2014, Hill et al. 2011, Loh, Harmon 2005).

In order to reverse this unfavourable trend of the disappearance of valuable landscape structures, it is necessary to provide support for appropriate management. This is also possible through the rural development program. It is also necessary to ensure awareness and effective education in this area. Recognising and then appropriately managing these biocultural elements is the key to successful future conservation of nature and cultural expression. Furthermore, to achieve this objective effectively, a more integrated and joined up approach is required that leads from research, to policy, and to implementation (Bridgewater, Rotherham 2019).

Conclusion

The current landscape structure in Slovakia is the result of long historical development as evidenced by the creation of several types of biocultural landscapes, from natural through semi-natural/ biocultural to anthropogenic. They vary in value from a biotic or cultural-historical point of view. In addition to constituting the most valuable natural landscape types in Slovakia, biocultural types can be considered valuable and endangered, as they represent a certain symbiosis of natural and cultural heritage. Traditional mosaic forest-agricultural landscape, rural dispersed settlement, and historical landscape of mixed type are the most valuable types of biocultural landscapes. Despite their high biocultural value, many are threatened either directly by construction and activities, often inappropriately located in the local environment, or by inappropriate management. In addition, abandonment of traditional agriculture results from low interest in the continuation of traditional farming, especially by the young and middle generation, as the relationship to the land was broken during socialism.

The weakness of biocultural landscape protection in Slovakia is almost complete lack of protection of certain types of biocultural landscapes. The landscape is protected under the Act on Nature and Landscape Protection, which is oriented on protection of biodiversity, species and habitats. Cultural monuments are protected separately by the Act on the Protection of Monuments and Historic Sites, but the objects of protection are cultural and historical objects, which is not sufficient for the effective protection and preservation of these biocultural landscapes. If we want to maintain these valuable biocultural landscape types, as required by the ELC, it would be necessary to establish categories for the protection of valuable landscape structures in the form of protected landscape elements or zones. Slovakia has an opportunity to do so at present, as the Act on nature and landscape protection is being amended, and an Act on landscape is also being prepared. If we really want to preserve these valuable landscape structures, financial support for extensive farming in these areas would also be needed. There are ways the requirements for support of traditional farming could be met by the Strategic Plan of the Common Agricultural Policy for the years 2021–2027 (which is currently being drawn up), in the form of new measures that support organic farming and green architecture, increase support for the management of mosaic land, support restoration of abandoned and overgrown meadows and pastures, and improve conditions for local production and consumption.

Declarations

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Conflicts of interest: The authors declare no conflict of interest or state

Ethics approval: The manuscript is original unpublished work, and it is not under consideration for publication anywhere else. The final manuscript has been approved by all co-authors. No data, text, or theories by others are presented, all relevant literature is cited.

Consent to participate The final manuscript has been approved by all co-authors.

Consent for publication

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Figures

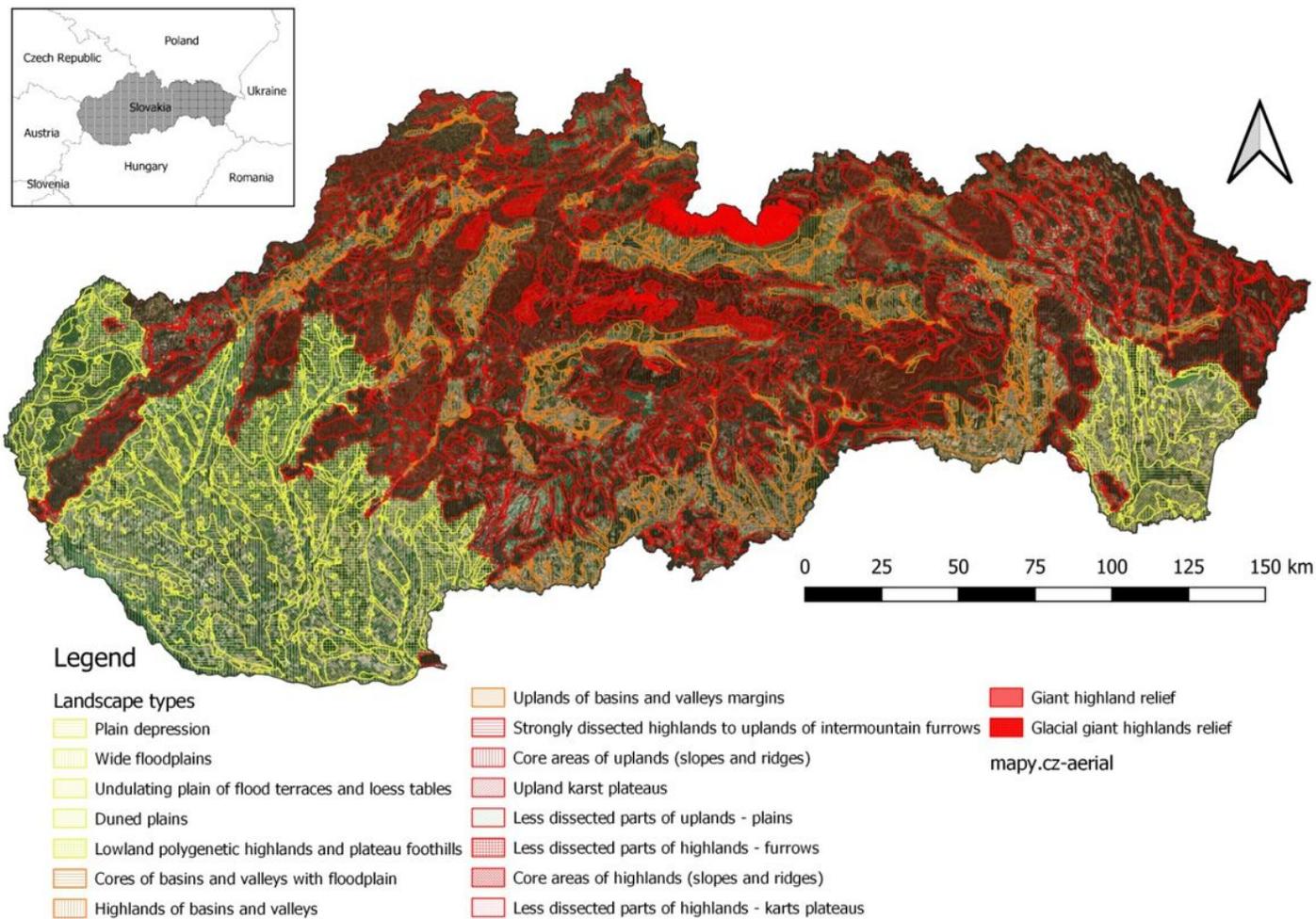


Figure 1

Study area of Slovakia Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

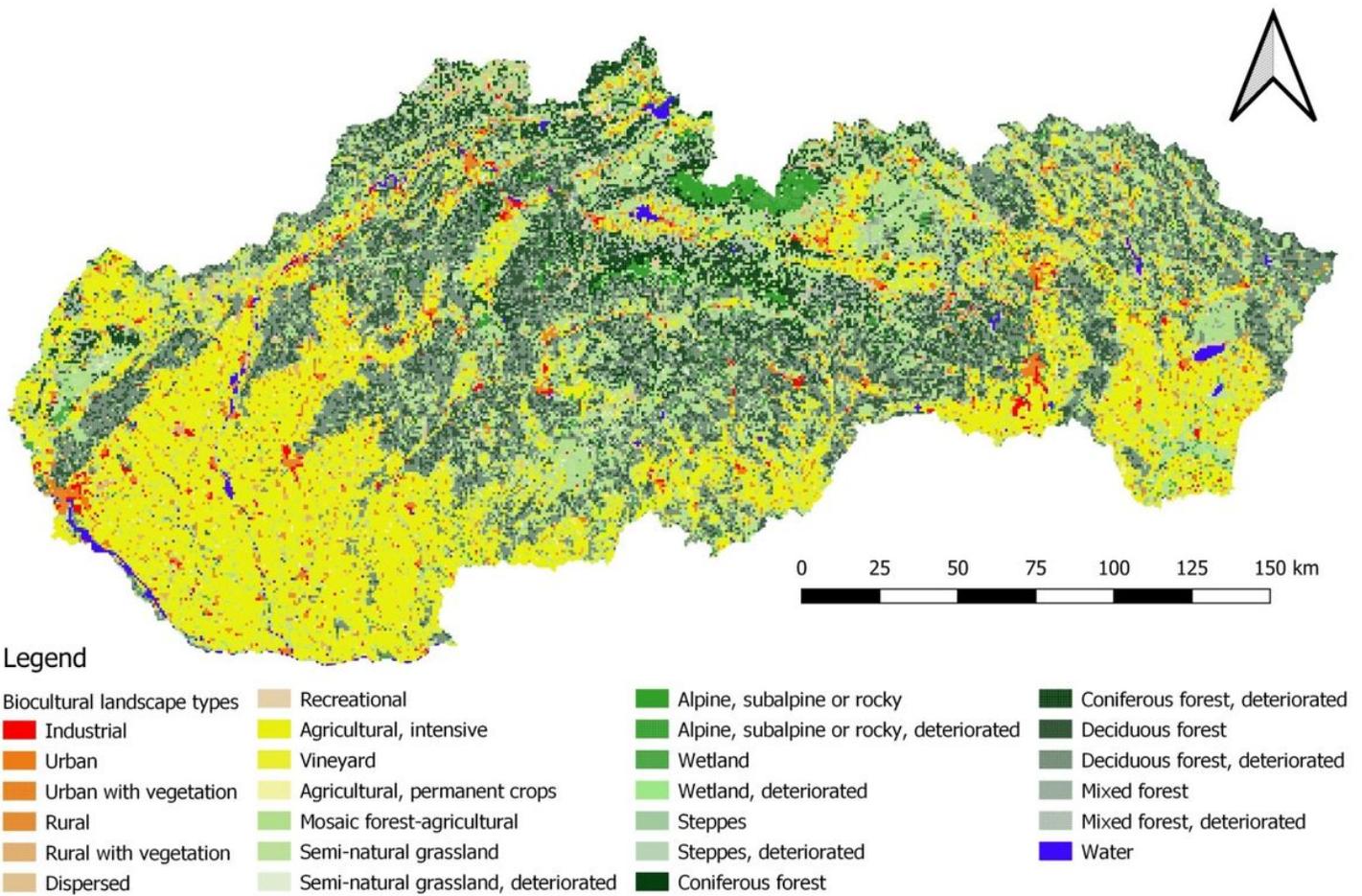


Figure 2
 The map of biocultural landscape types in Slovakia Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

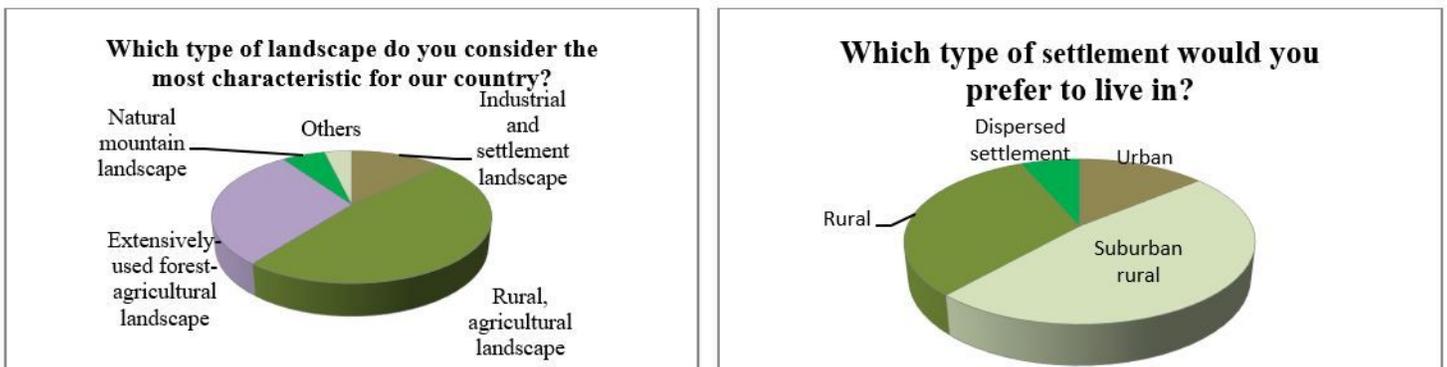


Figure 3
 Public perception of the landscapes most characteristic of Slovakia, and preference of respondents for landscape type of residence



Figure 4

Traditional agricultural landscape (mosaics of arable land, grasslands, orchards, small woodland and balks), traditional meadow-pasture landscape, and extensively-used forest-agricultural landscapes; are considered by respondents to be highly threatened (Fig. 4).

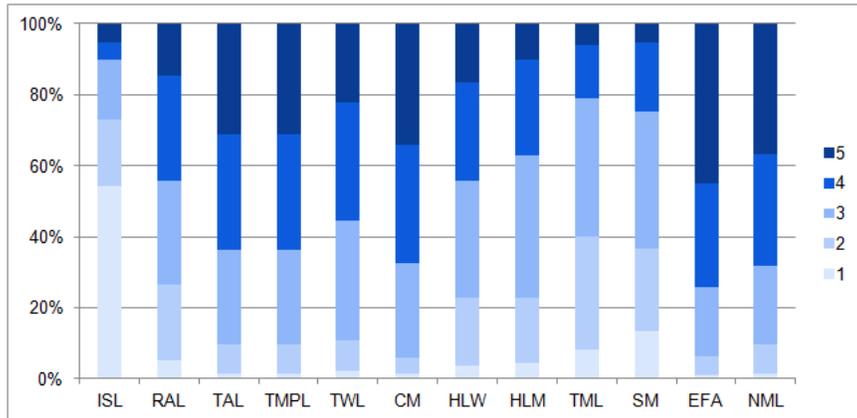


Figure 5

Which types of biocultural landscape do you find the most endangered / degraded? (5 – under greatest threat, 1 – under least threat)

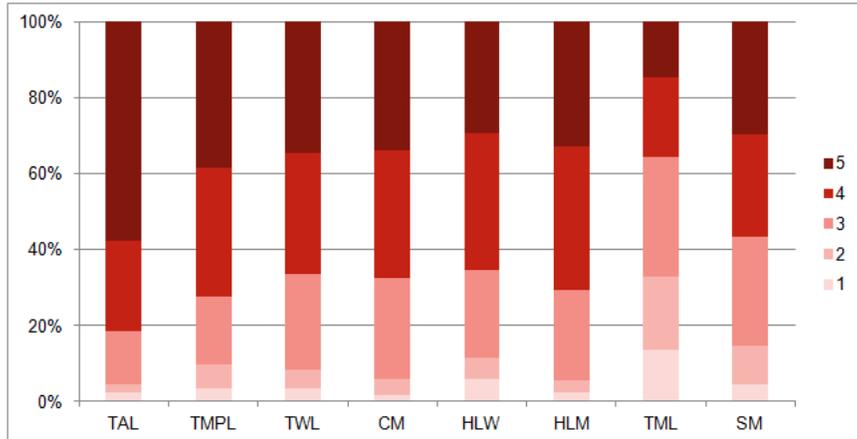


Figure 6

Which type of biocultural landscape should have the most protection? (5 – the most protection, 1 – least protection)