LANDSCAPE DIVERSITY EVALUATION ACCORDING TO LAND COVER CLASSES IN THE NORTHERN HINTERLAND OF THE ZEMPLÍNSKA ŠÍRAVA WATER RESERVOIR

Eva MICHAELI[1], Jaroslav HOFIERKA[2], Monika IVANOVÁ[3]

Abstract: *The observed territory delimited by the cadastral territories of the villages of Vinne, Kaluža, Klokočov, Kusín and Jovsa. It is located at the northern bank of Zemplínska šírava water reservoir. Until 1960s when the construction of water reservoir was finished the geographic situation of the territory was different. The southern part of region was spread in the partial Šírava rift valley. Till the end of Riss there was a relative tectonic inactivity in this structure. The process of subsidence in Würm and in the post-glacial period evoked the origin of marshy environment in depression. Considering the aspect of the landscape structure it was not appropriate to use it in agrarian system and even it was unhealthy. Based on the evaluation of the potential of the studied locality in melioration of the East-Slovakian lowland it was decided to integrate it into the system of retention water reservoir. It means, that the factor of the physicogeographic position of the studied territory that is located at the border of two contrast morphostructures with a different tectonic activity (the Vihorlat mountains and East Slovakian lowland) caused (in relation to agricultural activity of man) in the studied region a significant change in the landscape structure, land cover and thus also in its biodiversity.*

Key words: *paradynamic region, landscape diversity, land cover, nature landscape, Shannon index*

INTRODUCTION

The aim of the contribution is to study the changes of landscape diversity in northern hinterland of the Zempínska šírava dam in 1956 – 2005. The selection of area was influenced by its geographic location on the edge of two contrast units. The location in the largest scale has affected the transformation of land structure and the diversity of land cover. Factors that have conditioned the above changes might be divided into several groups. Since 1956 to 1960 the agrarian-economic factors occured, later on there were institutional-organisation and social factors. After 1960 the factor of agrarian national politics became relevant, which was related to self-sufficiency corn production, and also the factor of dvelopment of water area recreation. In the last decade the region has

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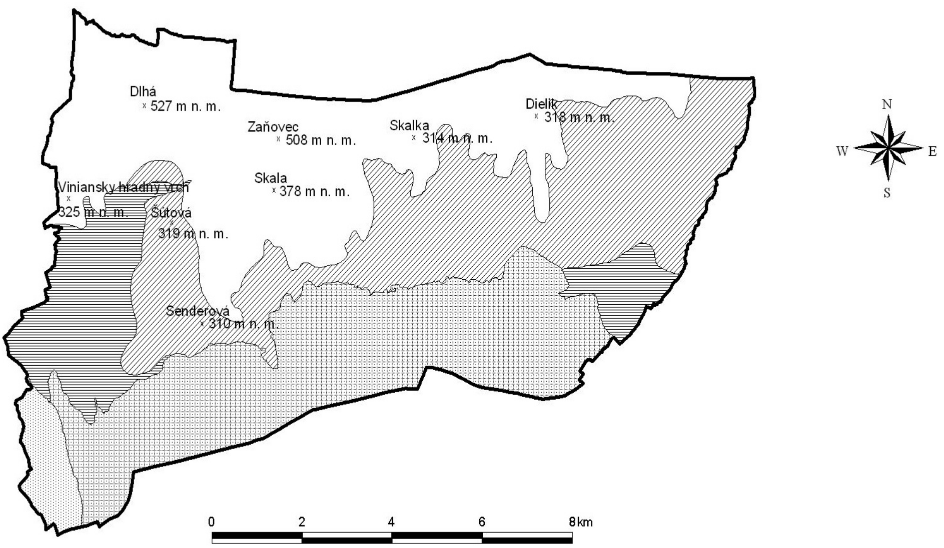
been affected by environmental factors which evoke new serious changes in landscape biodiversity.

GEOGRAPHIC POSITION OF THE REGION

The observed territory is located on the northern bank of Zemplínska šírava water reservoir, on the border of two genetically different contrasting units: the neovolcanic Vihorlat mountains that are built mainly by Neogene effusive formation and the East Slovakian lowland built by the loose clastic sediments of Miocene with cover of eolic and polygenetic sediments. It is located in the most tectonically active zone, that dropped approx. 500m during the period between the Early Badenian and Early Pliocene. The tectonic activity in this region was decreasing until the end of Sarmatian period, but the slowly processes of the subsidence were continuing to Pliocene and Quaternary period. The Quaternary neotectonic drifts present mainly new phase, independent by its extent and character; its beginning is dated beginning to the period of old Pleistocene. They caused the origin of the marked tectonic depression the Sub-Vihorlat rift valley. The part of this rift valley is the Šírava rift valley. Till the end of the Riss there was a relative tectonic inactivity in this structure. The intensive drifts reactivated the depression at the beginning of the Würm and in the postglacial. Its subsidential character was manifested by the swampy environment where moors were created. The clay fluvial and slope sediments were accumulated there. The total decrease of the Šírava rift valley was 10 – 15 m in that period (Baňacký 1987). The current tectonic subsidence of the territory is 1 – 0,5 mm per year. The geographic position of the observed territory considering the aspect of the above mentioned morphostructures is very important. It greatly influenced future development of its landscape structure that is a subject of the research described in this paper.

Fig. 1: *Geoecological landscape types*



1 INTERMOUTAINOUS REGION

1.1 Plain accumulation region with porous groundwater

1.1.1 Fluvial plains with hydromorphic soils and humid vegetation

1.1.1.1 Aluvial cones and fluvial plains with the cover of Gleyic Stagnosols and Gleyic Fluvisols with primary vegetation of Carici elongotae - Alnetum typicum and Carici pilosae - Carpinetum

1.1.1.2 Flat marshy depressions with Haplic Gleysols with primary vegetation of Carici elongotae - Alnetum typicum

1.2 Hilly accumulation - erosive region with capillary groundwater

1.2.1 Accumulation - erosive to denudated hills with primary vegetation of the termophilic forests

1.2.1.1 Polygenetic uplands with Gleyic Stagnosols with primary vegetation of thermophilic Quercetum

1.2.2 Loess - accumulation hills with primary vegetation of thermophilic forests

1.2.2.1 Loess uplands with cover of Gleyic Stagnosols and Andic Cambisols with primary vegetation of Carici pilosae - Carpinetum

2 MOUNTAINOUS REGION

2.1 Mountainous erosive -denudation region with rift groundwater

2.1.1 Temperately warm uplands mountains with forests vegetation Carici pilosae Carpinetum and Fagetum

2.1.1.1 Highlands on the silicate substrate with Distric Cambisols and Andic Cambisols with Carici pilosae - Carpinetum and acidophilic Fagetum

Source: (Mazúr et al. 1980 and own terrain research)

Considering other factors in this territory, the key role have climatic and hydrologic conditions. Speaking about climate the main southern part of the territory belongs to a warm climate region, area T7, that is warm, moderately humid with cold winter with the average temperature in January –3 ºC and lower temperature. The northern part of the territory belongs to the moderately climate region, area M3, that is moderately warm, moderately humid. The average July temperature is ≥16 ºC (Lapin, et. al. 2002, map No. 27 Climatic regions). Hydrologically it belongs to the Laborec basin. The soil cover is presented by cambisoils and luvisoils with the epiphenomenon types of intrazonal soils. The primary plant communities were mostly removed and a landscape was transformed to the cultural steppe. Later in the sixties, after Zemplínska šírava construction, the dominant agricultural function, typical for the central and southern part of the region, is declining in favour to the recreational function.

METHODOLOGY

In the frame of current geographic research we consider studying the relations between nature and society as well as the quantification of those relations to be a cardinal trend. The observed territory, as it is evident from the above mentioned aspect of the geographical position, has a character of the paradynamic system with two contrasting units, the Vihorlat mountains and East Slovakian lowland bounded together by the flow of mass and energy.

The primary paradynamic system of the Vihorlat mountains and adjacent part of the East Slovakian lowland evoked by its geoecological structure in a connection with a dominant agricultural function of the whole East Slovakian lowland, whose quality was lowered by the vast inundations that appeared on approximately 60 000 ha of agricultural land. The decreasing swampy Šírava rift valley between Vinné and Jovsa had good presumptions for construction a retention water reservoir that was a significant and very important element in the melioration system of the East Slovakian lowland. Landscape in the northern hinterland of Zemplínska šírava water reservoir is a result of a mutual long - lasting activity of natural factors, conditions and processes, as well as the economy exploitation by a man. Evident changes in its structure have been recorded in last 45 years. The aim of this paper is to analyze and evaluate those changes during the period of 1956 - 2005.

The analysis and evaluation of the changes of the studied territory was based on the particular methodological procedures. In the preparation pre-research phase we accepted the hypothesis about the original status of the landscape that functions without the involvement of a man – ergo reconstructed landscape before human activities. According to Ložek (1973) at our territory the existence of such landscape can be limited by the period of Epiatlantic (from -3000 to -3500 years), when a more continuous farmer settlement appeared (primeval ecumena). A reconstruction of the natural landscape lies in an analysis of its physicogeographic elements and components, relations and characteristics that are conditioned by a dynamic homeostasis of the landscape. The relevant method for the knowing of the spatial natural landscape is the complex taxonomical physicogeographic synthesis on the level of the topic units that were mapping in the terrain. This method is very laborious, but correct. The spatial taxonomical synthesis can be achieved by the overlaying the map layers of the physicogeographic analytical maps with the same measure.

In this article the natural landscape was studied according to regional typology of the Slovak territory proposed by Mazúr et. al. in the Atlas of SSR (1980) by the map of Geoecological Natural Landscape Types, that were used as a basis for evaluation of the studied territory in relation to its usage. This map was modified at the base of a detailed analytic terrain research, other literature sources and cartographic materials. The terrain research stem from geological maps in scale 1: 50 000 (Baňacký 1988) and from the geomorphologic mapping. The identified soil types were based on the current morphogenetic classification system (Šály et. al. 2000) and soil maps produced by VUPOP (Soil Science and Conservation Research Institute, Bratislava). These maps were verified by field mapping. A potential natural vegetation of the territory was elaborated based on a Geobotanic map of Slovakia (Michalko 1986a,b) and according to the author maps of Botany Institute SAV (Slovak Academy of Science, Bratislava). To evaluate a current structure of the landscape, modified Slovakian Corine Land Cover database in our paper was also used (Oťaheľ et al. 2004), that is a component part of the European Corine Land Cover database (CLC) created at the beginning of 1980s.

The identification of land cover changes is an appropriate means for assessing the dynamism of natural processes and social influences, as well as the possibilities of landscape development. We understand the changes in land cover as a succession of various statuses of the landscape at particular time periods (Feranec et al. 1997) and it is represented by the data layers of land cover.

The term diversity is mostly used in biological and ecological sciences and is associated with evaluation of the quality of environment and stability of plant and animal associations. In a broader sense the diversity is evaluated also in ecological stability of landscape (ÚSES – territorial system of ecological stability) and permanent sustainability. The terms biodiversity and landscape diversity in geographical sense associated especially with the need of landscape and territorial planning of the ecologically balanced function-spatial landscape structure are very often used in the works of these authors: Mimra (1995), Oťaheľ, et. al. (2004), Bugár, Petrovič, Boltižiar, Vereš, Hreško (2006), Boltižiar (2007). The landscape diversity as the important characteristics is significant especially from the aspect of its use, organization and managing the landscape, but also from the aspect of landscape planning and environment protection. The current landscape status is a result of human influence on the natural landscape. The landscape diversity was analyzed in the context of known relations of both structures at various time periods. To evaluate the landscape diversity the land covers from the various time periods were used. The diversity was expressed as a number of areas of land covers in different classes of a natural landscape. As this method did not consider the area of the natural landscape types we also introduced the calculation per 1 ha of the area of a particular type of natural landscape. The more apposite values were received using the environment GRASS, where using the command r.le.pixel (Baker, Cai, 1992) we calculated the values of landscape diversity for moving windows with the real size 450*450 m with 15 m raster definition. The above mentioned command was also applied in calculating landscape diversity for the types of natural landscape that is understood as regions.

LANDSCAPE DIVERSITY ASSESSMENT

One of the basic indices used in a landscape diversity research (level of fragmentation) is a **number of land-covers classes in different types of natural landscape**. But, as the classes of the land-cover reflect different level of social usage and its potential development, we divided them (in accordance with the modified CORINE Land Cover legend, Oťaheľ et al. 2004) into three groups: 1xx (urban areas and industrial areas), 2xx (agricultural areas) and 3xx - 5xx (forest and semi-natural areas, marshes and water bodies).

Tab. 1: *Landscape diversity according to the number of polygons of the selected classes of the land cover (CLC) in the individual types of natural landscape*

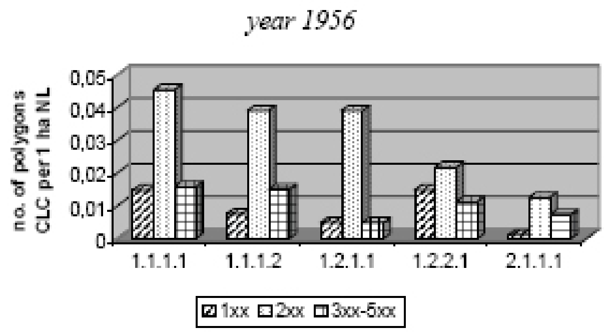
Classes of natural landscape	CLC 1956				CLC 2005				Change CLC 1956 –2005			
	1xx	2xx	3xx -5xx	**Total**	1xx	2xx	3xx -5xx	**Total**	1xx	2xx	3xx -5xx	**Total**
1.1.1.1	12	44	18	**74**	14	38	22	**74**	2	-6	4	**0**
1.1.1.2	15	78	30	**123**	6	2	7	**15**	-9	-76	-23	**-108**
1.2.1.1	1	8	1	**10**	2	11	6	**19**	1	3	5	**9**
1.2.2.1	34	50	26	**110**	67	50	56	**173**	33	0	30	**63**
2.1.1.1	3	33	19	**55**	10	22	64	**96**	7	-11	45	**41**
Total	**65**	**213**	**94**	**372**	**99**	**123**	**155**	**377**	**34**	**-90**	**61**	**5**

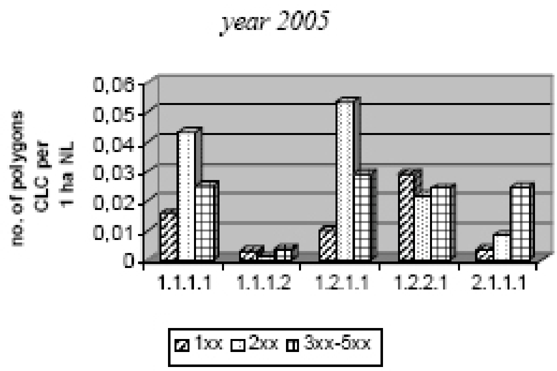
1.1.1.1 Alluvial cones and fluvial plains with the cover of Gleyic Stagnosols and Gleyic Fluvisols with primary vegetation of Carici elongotae – Alnetum typicum and Carici pilosae-Carpinetum

1.1.1.2 Flat marshy depressions with Haplic Gleysols with primary vegetation of Carici elongotae – Alnetum typicum
1.1.1.1 Polygenetic uplands with Gleyic Stagnosols with primary vegetation of thermophilic Quercetum
1.1.1.1 Loess uplands with cover of Gleyic Stagnosols and Andic Cambisols with pri mary vegetation of Carici pilosae-Carpinetum
1.1.1.1 Highlands on the silicate substrate with Distric Cambisols and Andic Cambisols with Carici pilosae-Carpinetum and acidophilic Fagetum

More detailed data about diversity can be found in graph 1 calculated as the share of number of polygons of the selected land cover classes per 1ha of area of particular types of natural landscape. The range in 1956 varies from 0,0011 (urban and industrial areas within the type of natural landscape 2.1.1.1) do 0,0455 (agricultural areas within a type of nature landscape 1.1.1.1). In 2005 the values range varies from 0,001 (agricultural areas within a type of nature landscape 1.1.1.2) till 0,0536 (agricultural areas within a type of natural landscape 1.2.1.1).

Graph 1: *Landscape diversity according to the number of polygons of the selected classes of the land cover per 1 ha of area of particular types of nature landscape*





Source: (authors)

The spatial distribution of landscape diversity can be seen in the fig. 2 - 5. Their values were calculated by ***d_2* – Shannon's Diversity Index H':**

$$H' = \sum_{i=1}^{m} p_i * ln(p_i),$$

where p_i is the share of the area of *i*-th polygon of the total area of analysed spatial unit represented by *m* polygons.

The first method (used in fig. 2 and 3, Shannon's Diversity Index H' calculated per types of nature landscape) was based on the analysis of two maps: natural landscape types and land cover. The resulting values of diversity were calculated in GRASS GIS using the r.le.pixel command that is part of the r. le set of programs developed by Baker and Cai (1992). The outcomes were the maps of the natural landscape types with a particular value of diversity. The highest diversity was calculated for year 1956 and identified in the type of natural landscape of the loess uplands (1.280); a bit smaller diversity was found in the type of polygenetic uplands (1,125). Middle high diversity (1,042) appeared on the flat marsh depressions, the lowest (0.603) on the alluvial cones and fluvial plains.

In 2005 almost doubled increase of the land cover classes appeared compared to 1956 and the highest values of diversity was identified in the type of natural landscape of the polygenetic uplands (1,555).

The increase of the land cover classes in case of the type of natural landscape of loess uplands was adequately reflected also in the index of their diversity (1,256). Conversely, a marked decrease in a number of areas of land cover classes was manifested in the natural landscape type of the flat dam depression and in a landscape type of the alluvial cones and fluvial plains.

The more precise calculation of diversity provides the method of moving windows (fig. 4 and 5 calculated using Shannon's Diversity Index). The landscape diversity was calculated by r.le.pixel command (Baker, Cai, 1992) for moving windows of real size 450*450 m and 15 m raster resolution. The final value was added to the central pixel of moving window.

Contrary the previous method it is not limited to the space of particular nature landscape type but it enables also to quantify (depending on a number of moving windows) relatively high number of values in a space of whole studied region. The analysis of the spatial distribution of diversity shows that the highest values were reached in the year 2005 in the area of recreational center Biela hora (the White mountain), along the state communication No. 582 in Vinné – Jovsa direction, easterly from the built-up area with family houses and gardens of Klokočov village, westerly from the built-up area with family houses and gardens of Jovsa village and along the eastern bank of Zemplínska šírava water reservoir in cadastral territory of Jovsa village.

In 1956 the highest concentrations of diversity were associated with the areas of grasslands, vineyards and shrubs localized among the Viniansky castle and the northern part of the built-up area with family houses and gardens of Vinné village, as well as in the space of corridor area of a state road in direction Michalovce - Jovsa and Michalovce - Trnava nad Laborcom. The heterogenity was also found in the space of grasslands and vineyard northerly from the built-up area with family houses and gardens of Kaluža village. A high landscape diversity that was identificated in the year 2005 in several parts of the studied area is a result of occurrence of higher number of smaller areas of land cover classes within a moving window. A good example is a space localized at the northeast – east from the built-up area with family houses and gardens of Klokočov village that was originally covered just with the areas of grasslands and arable land.

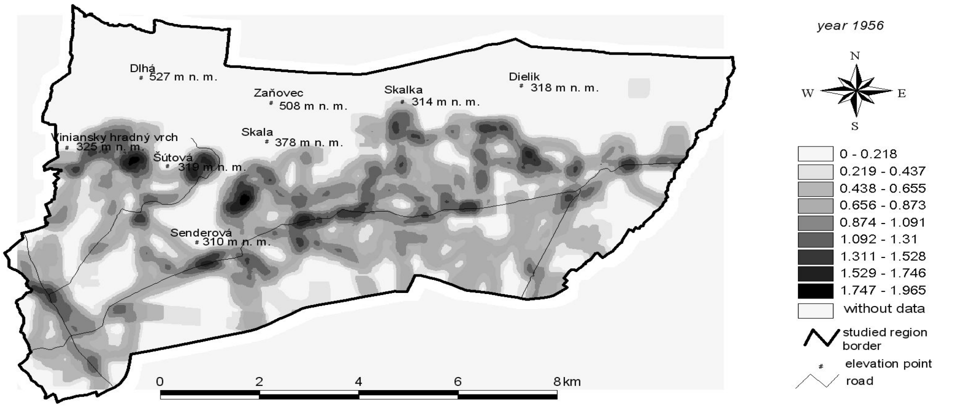
Fig. 2: *Landscape diversity in the types of nature landscape (year 1956)*

Source: (authors)

Fig. 3: *Landscape diversity in the types of nature landscape (year 2005)*

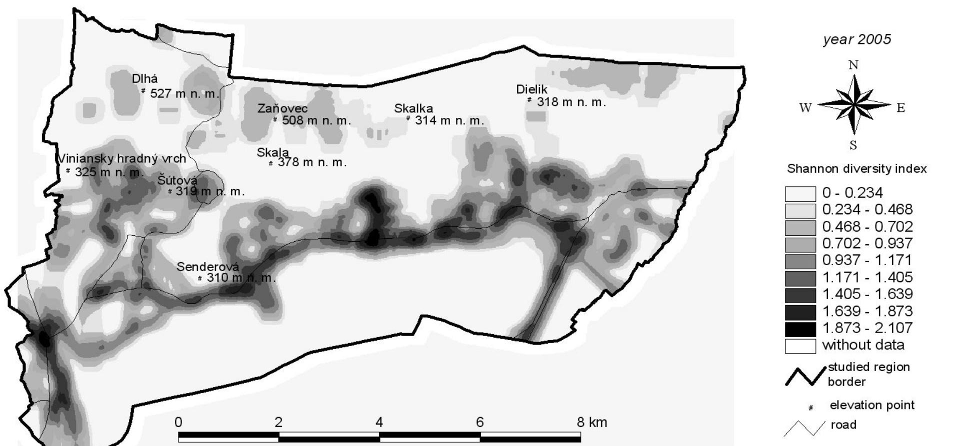
Source: (authors)

Fig. 4: *Landscape diversity (real size of moving window 450*450 m, raster resolution 15 m, year 1956)*



Source: (authors)

Fig. 5: *Landscape diversity (real size of moving window 450*450 m, raster resolution 15 m, year 2005)*



Source: (authors)

CONCLUSION

The most significant change in a landscape structure were influenced by the construction of Zemplínska šírava water reservoir that supported a major change (increase) in the diversity development mainly in its coastal zone. On the other side there was a significant decrease of diversity in the area of flat marshy depressions with primary vegetation of Carici elongotae - Alnetum typicum and swamp vegetation that was annexed by a water reservoir. The landscape diversity belongs to the basic characteristics of landscape. In the paper was calculated at the base of the land cover classes. It reflects the level of exploitation of the landscape by a society. The knowledge about the landscape diversity is a source for determining the quality of environment, ecological stability of landscape and a basis for other environmental planning.

A structure of land cover, studied using various methods in GIS enabled us to compare the changes in landscape diversity in the hinterland of Zemplínska šírava water reservoir at various time horizons. In this context it shows at the causes of its increase, or decrease of the land cover classes in the various types of natural landscape. The research results are closely connected with a functional structure of the landscape and enable us to make a prognosis about future development of the studied territory.

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HODNOTENIE DIVERZITY KRAJINY PODĽA TRIED KRAJINNEJ POKRÝVKY V SEVERNOM ZÁZEMÍ VODNEJ NÁDRŽE ZEMPLÍNSKA ŠÍRAVA

Zhrnutie

Najzávažnejšiu zmenu v diverzite krajiny- krajinnej pokrývky, podmienila výstavba vodnej nádrže - Zemplínska šírava, ktorá na jednej strane síce podporila zmenu a zvýšenie - rozvoj diverzity vo svojom pobrežnom pásme, ale na druhej strane došlo k jej výraznému

zníženiu v priestore plytkých zamokrených depresií s pôvodnou vegetáciou lužných lesov a močiarovou vegetáciou, ktorý bol zabratý vodnou nádržou. Diverzita krajinnej pokrývky patrí k základným vlastnostiam krajiny. Odráža mieru exploatácie krajiny spoločnosťou. Poznanie diverzity krajinnnej pokrývky je zdrojom pre určenie kvality životného prostredia, ekologickej stability krajiny a podkladom pre ďalšie environmentálne a plánovacie činnosti.

Štruktúra krajinnej pokrývky – diverzita, skúmaná prostredníctvom rôznych metód v prostredí GIS, nám umožnila porovnať zmeny v diverzite krajiny v zázemí Zemplínskej šíravy v rôznych časových horizontoch a v tejto súvislosti odhaliť príčiny nárastu, resp. poklesu tried krajinnej pokrývky v jednotlivých triedach prírodnej krajiny. Výsledky výskumu veľmi úzko súvisia s funkčnou štruktúrou krajiny a umožňujú prognózovať jej vývoj v predmetnom území.

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