Klasyfikacja krajobrazu. Teoria i praktyka. Problemy Ekologii Krajobrazu. 2008, t. XX. 341-348.

Time-spatial changes of the landscape diversity in the traditional land utilisation
(Tribeč Mountains, West Carpathians, Slovakia)

František Petrovič[1], Juraj Hreško[1], Mária Vrábelová[2]

[1]Dept. of Ecology and Environmentalistics, Faculty of Natural Sciences
Constantine The Philosopher University in Nitra, Tr. A. Hlinku 1, SK-949 74 Nitra
e-mail: fpetrovic@ukf. sk, jhresko@ukf. sk
[2]Department of Mathematics, Faculty of Natural Sciences
Constantine The Philosopher University in Nitra
e-mail: mvrabelova@ukf.sk

Abstract. The aim of this contribution is an attempt on landscape diversity expression by the quantitative methods in the framework of real spatial units. We came out from the statistical metrics as Shannon diversity index, equitability and dominance. The understanding of the spatial and temporal land use changes is principal objective of the landscape evolution in the human impact conditions.
The spatial structure of individual landscape elements and their attributes corresponds with other landscape categories at different hierarchical levels and scales. Landscape diversity presents significant and synthetic landscape category of landscape elements interactions expressed on the basis of statistical metrics. This contribution is an attempt to better understanding of the evaluating importance on the landscape ecology researches in the mountains catchments. The micro-catchments as elementary spatial and operating units are considered in this case. On the other hand micro-catchments present a relative closed morphodynamical and hydrological landscape units with individual land use development. For the assessment of the diversity we can use the Shannon's index of diversity, index of the evenness and index of the dominance. Finally we focused on changes importance of selected time levels.
We can approve the statistical method in the relative varied mountain landscape between Tribeč Mts. and Pohronský Inovec Mts. with specific form of utilisation. The research area presents an archaic dispersed settlements type of the mountain regions in the West Carpathians developed in different social-economical conditions as known. The land cover arrangement and land use changes concern the 159 years – 1843-1955- 2002.

Key words: landscape changes, landscape diversity, Shannon index diversity, t-test

Introduction

Determination and evaluation of the landscape diversity and biodiversity represents important process of the landscape changes and its elements research. Shannon diversity index (SDI) is generally accepted method to obtain basic information about time and space changes in land use. Petrovič (2005) applied SDI calculation on micro river-catchments while assessing the dynamics of mountainous landscape changes. The originality of this approach is in viewing the micro river-catchments as basic operative spatial entities that has stable borders, create structural, hierarchic system of the area and by its location and morphometric attributes determine atrophic activities directly or indirectly. The diversity index allows relatively large scale of the interpretations and at the other hand remains the problem of objective assessment of changes importance that happened

in the area. The determination of the diversity change has great value for the knowledge of the ecosystems, habitats, because it reflects indirectly the intensity of socio-economical activities on the landscape. Fjellstad et al. (2001) showed the importance of positive interactions between bird species quantity and the landscape diversity and heterogeneity. They also pointed out that the amount of the plant species and the spatial unit correlated with heterogeneity values and not the landscape diversity. So the landscape changes interpretation becomes interesting for nature conservation management.
To solve the approximation of objective assessment landscape diversity changes we emerge from methodic proceeding described by Magurran (1988) and applied by (Cheng, Jan 2000). Authors presented the proceeding of statistical analysis use - t-test for changes importance for forest landscape as the consequence of road building and wood logging.

The study area delimitation and location

The area of the interest consists of cadastres: Jedľové Kostoľany, Malá Lehota and Veľká Lehota. These villages are situated on north-west border of protected landscape area Ponitrie. The overall extent of the area is 6 874,9 ha and the range of vertical levels is from 317 to 815 m above seal level.
The location of these villages within Slovakia is relatively central. Jedľové Kostoľany belongs to Zlaté Moravce district and Malá and Veľká Lehota to Žarnovica district. The location in Nitra and in Banska Bystrica regions integrates this area into the periphery areas form the society development point of view.
Considering geomorphology classification of Slovakia (Mazúr, Lukniš 1978) this area is situated on the contact zone of two different geological-geomorphologic territories: Slovak Central Mountains (Pohronský Inovec) and Fatra-Tatra territory (Tribeč), sub province Inner Western Carpathians.
Mentioned villages belong to the dispersed settlement. There are five areas of dispersed settlements, while area of the interest is situated in Nova Baňa area. The dispersed settlements were formatted as the consequence of the mining, logging, charcoal producing, carrier's trade, glassmaking and pasturing (Petrovič 2002). The term "štále" is defined by Stránska (1966) in the connection with central Slovakian German inhabitants' terminology that came to Slovakia with mining development in 14th century. German immigrants called their seasonal residences "stande" and Slovakian "štále" were also seasonal residences at the beginning.

Methodics

We followed LANDEP methodics (Ružička 2000) for landscape analysis and landscape structure elements, where we divided landscape elements with the regard to spatial specification and aim of the work. Thematic mapping was pursued in ArcGIS method "on screen". The underlayer was composed of historical and topographic maps and ortorectified aviation photographs transformated into standard projection of topographic maps. Outcomes of the mapping were verified by field research and interviews with local experts and users.
The management of the mountain catchments is based not only on the hydrological but on the integrated one too. In the first step the landscape-ecological methods of secondary landscape structure changes enter to synthesis and evaluation processes. The aim of this step is quantitative diversity expression of the intensity changes in the framework of micro-catchments system.
The base of this theoretical concept is the landscape understanding as hydrologic-morphodynamics system with exact micro-catchments arrangement in the high detailed scale. Methodically we followed to Miklòs, Miklosowá (1987a, b, c), Miklòs, Hrnċiarová, Kozová (1989), Nagasaka, Nakamura (1999) and Hreško, Mederly, Halada ey al. (2003). In the sense of hydrology and morphodynamic gradient are individual catchments of study areas consequently classified: initial (source or upper stream) catchments, transiting (middle stream) catchments and ending (down stream, mouth) catchments.
The source of spatial information of the landscape structure elements is aero images interpretation (year 2002), topographical maps analysis (year 1956) and the historic map analysis (year 1843-45) realized in the detailed scale.
We chose the Shannon's index of diversity for the catchments´ landscape elements diversity evaluation. This

index admits to compare different landscape units or compare different times horizons. The Shannon's diversity index quantifies landscape diversity in the number of different patch types and the proportional area distribution in patch types. The Shannon's diversity index grows with the growth of different patch type number or with the growth balanced proportional arrangement area between groups of the elements. The maximum of Shannon's index for exact number of element groups will be in case of all elements groups in similar representation.
The Shannon's index is defined:

$$H' = -\sum_{i=1}^{n} Pi * ln(Pi)$$

where: *n* - number of element types;
Pi - area proportion in element –i

The results of Shannon index of present landscape structure element diversity gave us three catchments categories (H´> 1,0; 1,0 <H´< 0,5; H´< 0,5). The value of Shannon index grew with ascending number of spots and/or with ascending balance of proportional distribution of the area among the group of spots.

Results

Petrovič (2005) in 2003 characterized 8 basic groups of landscapes elements. The largest area is occupied by group of forest and non-forest vegetation elements – 60% of the area. The second largest area is the group of persistent grassland vegetation elements – 26% and important group is also agricultural growth elements. 2% of the area is occupied by group of urban, recreational and traffic elements. The most intense use of the area in 1956 was due to agricultural use, the group of agricultural growth composed 18 % of the area, the group of persistent grassland vegetation elements 28%. On contrary the group of forest and non-forest vegetation elements composed only of 49% of the area.
In years 1843-45 the group of forest and non-forest vegetation elements had the greatest span in history – 76% of the area. The group of persistent grassland vegetation elements expropriated 14% and the group of agricultural growth 9% and urban areas 1% of the area.
In 1843 -45 the highest proportion on the catchments (43%) was classed in category with the highest diversity index (H´>1,0) that is in contrary with the highest proportion of forest in the area. This value was influenced by identification of relatively large number of urban units in historical maps (also in remote places forms), which was connected with farming management in their neighborhood and by higher number of differentiated elements of the landscape structure (fig. 1a). These settlements were bound to water sources and most of them were found in source-spring micro catchments. Almost the same proportion (42%) is occupied by catchments of diversity index (1,0 <H´< 0,5). This balance is conditioned by large proportion of persistent grassland vegetation in forest that were used as pastures and intensively used as agricultural land, which were localized mainly in catchments with flow position. Also catchments with the lowest diversity index H´<0,5 were localized in this position. These represented 12% of study area catchments.
Considering the diversity of the catchments, year 1956 (fig. 1b) was the best. 60% of the catchments reached the value H´>1,0 likewise in 1843-45 these were catchments with source-spring location, but also catchments with flow position. All settlements are situated in these catchments. Great influence on such distribution has the value of agricultural elements that occupied the largest area in history. 30% of catchments have the middle value of landscape diversity, mainly with flow localization. On contrary the lowest diversity value (H´< 0,5) have only 10% of catchments, that are situated in extreme location and are of source-spring location.
In 2002 (fig. 1c) catchments with H´< 0,5 index represent 33% with mainly forest vegetation with couple of areas of extensive meadows. Second category with values 1,0 <H´< 0,5 consists of 40% catchments dominated by forest and non-forest vegetation with areas of grasslands vegetation as well. The highest valued catchments H´>1,0 represent 28% of the area, where elements of urban, recreational areas and mosaics of agricultural

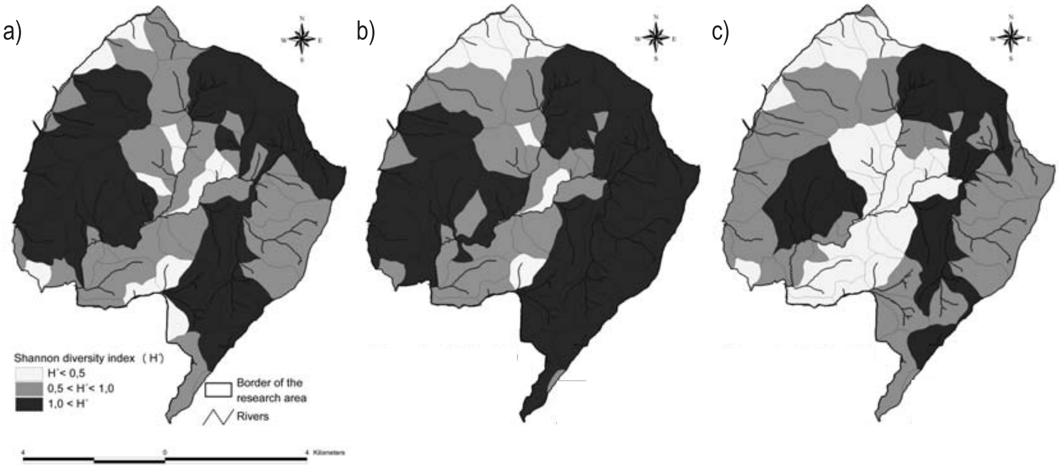

Fig. 1. Shannon's index of diversity for the catchments´ in the year: a) 1843-45, b) 1956, c) 2002

elements with grasslands are situated. In this category it is evident that forest and non-forest wood vegetation is suppressed by human managed elements. The highest diversity index was confirmed in ending – estuary localization, that anthropic land use represented by mosaic of rural settlements with concentrated and dispersed build-up area with texture of agriculturally used land and forest segments.

The index values of evenness and dominance have been calculated also for the year 2002 for which the most accurate data were available. The highest index of equitability was found in micro-catchments with ending (outfall) position where the land utilisation is represented by a mosaic of rural settlements with concentrated and dispersed housing as well, combined with a texture of agriculture land and forest segments.

The Shannon's diversity index and index of the evenness are the biggest on the micro-catchments with the mouth down-stream parts, which present mosaic rural settlements with concentrated and dispersed housing and framed agriculture and forestry land segments.

The index of the dominance Turner, Gardner, O´Neil (2001) has range from 0,22 to 0,96. To the category with value to 0,45 taking 29 % areas of micro-catchments. In the category 0,45–0,75 (41% areas of micro-catchments) present areas with uniform representation landscape elements increase elements of rural settlements. And on the end, micro-catchments with value index of the dominance over 0,75 on the 30% area are using how forest and non-forest tree vegetation.

We have measured the same variable – Shannon index of diversity repeatedly, over three periods of time, in years 1843-45, 1956, 2002. Descriptive statistics of Shannon indexes are presented in table 1. The mean of the Shannon index of diversity in the year 1843-45 equals 0,850165, in the year 1956 is 1,145410 and in 2002 is 0,704578. Standard deviation of Shannon index in the year 1843 equals 0,315078, in the year 1956 is equal to 0,524533 and in 2002 is 0,376814. The mean of Shannon index in 1956 is higher then in 1843 and higher then in 2002. Box plots (fig. 2) of variables SHAN1843-45, SHAN1956, SHAN2002 illustrate those differences.

To analyze this data set, we perform a within–subjects (repeated measures) analysis of variance. The assumptions

Table 1. Descriptive statistics

Variable	**Mean**	Standard Deviation
Shannon index of diversity 1843-45	0,850165	0,315078
Shannon index of diversity 1956	1,145410	0,524533
Shannon index of diversity 2002	0,704578	0,376814

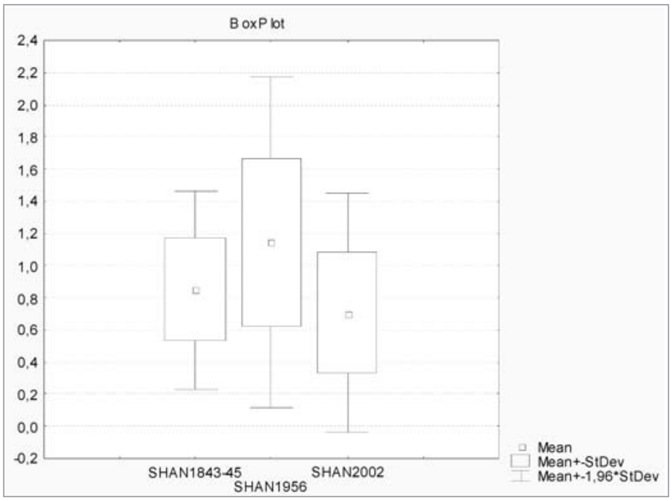

Fig. 2. Box plots for the variables: Shannon index diversity 1843-45, Shannon index diversity 1956 and Shannon index diversity 2002

if this analysis - the normality distribution of dependent variables and the homogeneity of variances, we need not try because the sample size n = 83 is large and the same for all variables.

To analyze this data set, we perform a within–subjects (repeated measures) analysis of variance. The assumptions if this analysis - the normality distribution of dependent variables and the homogeneity of variances, we need not try because the sample size n = 83 is large and the same for all variables.

The null hypothesis for the procedure is that the variables Shan 1843-45, Shan1956, Shan2002 contain samples drawn from the populations with identical means, that is, there is no effect of the factor – time.

Assessing the significance of the effect of time we have used a univariate test.

The repeated measures ANOVA results are obtained in table 2.

Table 2. Results of the ANOVA

	Repeated Measures Analysis of Variance (shannon_micro-ca Sigma-restricted parameterization Efective hypothesis decomposition				
Effect	SČ	Degr. of Freedom	MS	F	p
Intercept	201,7129	1	201,7129	482,2530	0,00
Error	34,2983	82	0,4183		
TIME	8,3746	2	4,1873	85,3455	0,00
Error	8,0464	164	0,0491		

The value if statistics F = 85,3455 and p value = 0,00, hence the null hypothesis is rejected; at least two population means are unequal. By post-hoc tests results (tab. 3) - shows the matrix of p values (significance levels) for the respective pairs of means, displayed in the columns and rows of the spreadsheet.), every two sample means are significantly different from each other because all significance levels are less then 0,05.

The sample means with 95 % confidence intervals are image in the figure 3.

Table 3. Post-hoc comparisons of the means

Cell No.	LSD test; variable ZP_1 (shannon_mikropovodia) Probabilities for Post Hoc Tests Error: Within; MS = ,04906, df = 164,00 TIME	{1} ,85016	{2} 1,1454	{3} ,70458
1	SHAN1843		0,000000	0,000038
2	SHAN1955	0,000000		0,000000
3	SHAN2002	0,000038	0,000000	

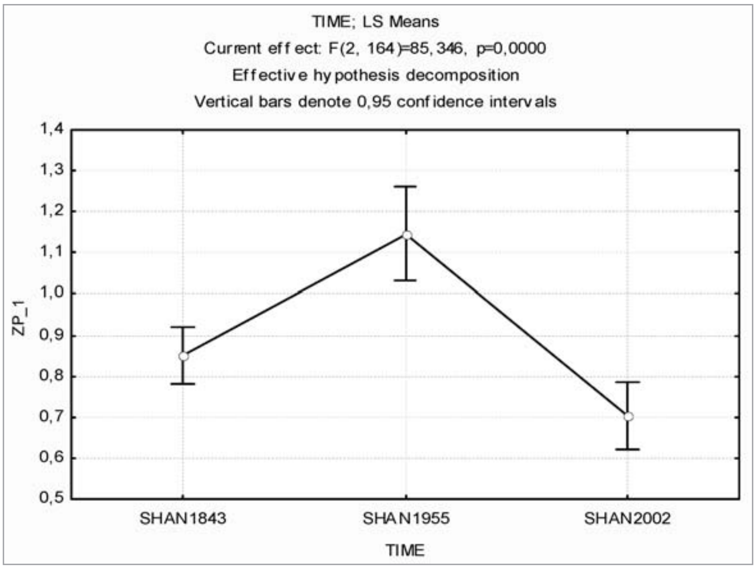

Fig. 5. The means and the confidence intervals

Conclusion

The analysis of the landscape changes is very important for the viewpoint of natural and socioeconomic processes, their dynamics, causes and stability of present state of study area, but mostly for possible trends of further development (Feranec, Oťahel, 1995, 2001; Boltižiar, 2003, 2004; Mojses, 2004; Olah, 2003 a, b; Olschowsky et al. 2006).

Any change in time and space in landscape structure participates through backwards interactions in influencing the course of energy and material flows as well as other characteristics of the landscape (Lipský, 2000).
The aim of the work is to characterize landscape changes with dispersed settlement. Dispersed settlement is specific landscape element in Slovakia. The character of the establishment and development of this specific form of the settlement were conditioned by particular social conditions. The study area consists of Jedľové Kostoľany, Malá Lehota and Veľká Lehota cadastres. These three villages are composed of the village centers and 32 individual parts – štále. In the work we present the dynamics of the landscape changes in three time horizons (years 1843-45, 1956 and 2002).
The presented method of the landscape diversity evaluation in the upper-stream location Žitava River suggested on the legitimate using of mathematically-statistically methods for the research of evolution and present state of the fluvial modeled mountains landscape. The result of the paper is catchments classification of the elementary hydrological-morphodynamical elements on the base of the Shannon's diversity index and index of the evenness. These indexes help to the objective assessment areas and to the processes the formation of the management

catchments strategy with respect to the character present land use and representation of landscape elements. T-test analysis allows evaluating statistical importance of the change of two groups of middle values. The t-test methodic was applied on investigating the difference importance of diversity index counted from catchments that are delimitated by the ridge and talweg system, respectively fall line. Catchments were classified by Shannon index values of landscape elements in years 1843-45, 1956, and 2002. Determined results of diversity indexes were processed by professional statistical software 5.5 and with the use of t-test for dependent samples.
Presented area of dispersed settlement has its peculiar cultural, historical and natural values that are the image of the life and activities of men in difficult mountainous conditions. Considering present development trends these settlements could diminish and thus we should pay attention to them and try to find the conclusions to preserve these historical landscape structures that are dominant in this region.

Acknowledgement. This study was also supported by the scientific grant agency KEGA grants: No. 3/5070/07 The methods and the models of the identification and classification of landscape diversity and landscape changes

References

Boltižiar M., 2003. Štôlska valley in the Vysoké Tatry Mts. – mapping and the analyses land use using results of remote sensing and GIS. (In:) Novák S. (ed.). Geografické aspekty středoevropského prostoru. Geografické studie, Nr. 14. Katedra geografie PF MU v Brne, Brno. 290-296. (in Slovak)

Boltižiar, M. 2004. The analyse of the land use changes in the selected part of the Belianske Tatry Mts. in the years 1949 – 1998 using methods of remote sensing and GIS (in Slovak). (In:) Štúdie o Tatranskom Národnom Parku 7 (40). Poprad. Marmota Press. 483-491.

Falťan V., 2005. The big-scale mapping of the vegetation and land cover (in Slovak). PríFUK, Bratislava. 108.

Feranec J., Oťaheľ J., 1995. Import of the database in the project CORINE Land Cover for the geographie (in Slovak). Geographia Slovaca 10. Geografický ústav SAV, Bratislava. 47-50.

Feranec J., Oťaheľ J., 2001. Krajinná pokrývka Slovenska (Land cover of Slovakia). Geografický ústav SAV, VEDA, Bratislava. 124.

Fjellstad W.J., Dramstatd W.E., Strand G. H., Fry G.L., 2001. Heterogenity as a measure of spatial pattern for monitoring agricultural landscapes. Norsk geogr. Tidsskr.. Vol. 55, Oslo. 71-76.

Hreško J., Mederly P., Halada Ľ. et al., 2003. Landscape-ecological plano f the city Považská Bystrica. FPV UKF Nitra. Nitra. 275. (in Slovak)

Chen Ch., Juan J., 2000. Application of GIS to Measure and Evaluate Landscape Changes, GIS Development ACRS 2000, http://www.gisdevelopment.net/aars/acrs/2000/ts7/gdi002.shtml

Magurran A.E., 1988. Ecological diversity and its measurement. Princeton University Press, Princeton, NJ. 179.

Mazúr E., Lukniš M., 1978. Regional geomorfological classification of the Slovakia. Geografický časopis, 30, 2. Bratislava. 101.

Miklòs L., Hrnčiarová T., Kozová M. 1989. The most important aspects of the spatial structure of hydrologic systems. Sborník prací GGÚ ČSAV, 20. Brno. 43–58. (in Slovak)

Miklòs L., Miklosowá D., 1987a. Shape and size of elementary areas of microbasins –evaluation for landscape ecological planning (LANDEP). Ekológia (ČSSR), 6, 1. 85–100.

Miklòs L., Miklosowá D., 1987b. Shape of hydrographic systems according to structure and connection of microbasins. Ekológia (ČSSR), 6, 2. 187–200.

Miklòs L., Miklosowá D., 1987c. Spatial structure of hydrographic systems as a tool for solving some problems of run-off integration. Ekológia (ČSSR), 6, 3. 265–273.

Mojses, M., 2004. The mapping of the land use changes on the locality Nitra-Žibrica. (In:) Kliment M., Pariláková K., Muchová Z., Igaz, D. (eds.). II. medzinárodná vedecká koferencia Veda mladých 2004. SPU. Nitra. 127-132. (in Slovak)

Nagasaka A., Nakamura F., 1999. The influence of land use changes on hydrology and riparian environment in a northen Japanese landscape. Landscape Ecology, 14, 6. 543–556.

Olah B., 2003a. Potential for the sustainable land use of the cultural landscape based on its historical use (a model study of the transition zone of the Poľana Biosphere Reserve). Ekológia (Bratislava), 22, Supplement 2/2003, ÚKE SAV, Bratislava. 79-91.

Olah B., 2003b. Land use of Banská Štiavnica in 18th and 21st century and the intensity of its change. (In:) Olah B. (ed.). Ekologické Štúdie V. SEKOS. Banská Štiavnica. 232-237. (in Slovak)

Olschofsky K., Köhler R., Gerard F. (eds.), 2006. Land Cover Change in Europe from the 1950'ies to 2000. Institute for Worldforestry, University of Hamburg. Germany. 365.

Petrovič F., 2002. Dispersed settlements of the Novobansky region and his influence on development of the region. (In:) Drgoňa V., Kramáreková H. (eds). 2002. Geographical Informations No. 7, II. part, FPV UKF. Nitra. 152-156. (in Slovak).

Petrovič F., 2005. Land use changes in the area with dispesed settlement in Pohronský Inovec Mts. and Tribeč Mts. ÚKE SAV, Bratislava. 209. (in Slovak)

Ružička M., 2000a. Landscape-ecological planing-LANDEP I.. 1. vyd. Biosféra. Nitra. 120. (in Slovak)

Stránská D., 1966. To the question elevated buildings in the Slovakia. Slovenský národopis, XIV, 1. Bratislava. 65-122. (in Slovak)

Turner G. M., Gardner H. R., O´Neill V. R., 2001. Landscape Ecology in Theory and Practice: Pattern and Process. Springer Verlag. New York. 404.

Klasyfikacja krajobrazu. Teoria i praktyka. Problemy Ekologii Krajobrazu. 2008, t. XX. 349-355.

Multi functional landscape evaluation of Trnava district

Zuzana Miklošovičová

Institute of Landscape Ecology, Slovak Academy of Sciences
Štefánikova 3, 814 99 Bratislava, The Slovak Republic
e-mail: zuzana.miklosovicova@savba.sk

Abstract. The basic goal of the paper is to present a methodology of the multifunctional evaluation of the agricultural landscape. The methodology was applied on the study area Trnava region - this is a typical intensive exploited agricultural landscape. Evaluation of the selected area showed, that this area has many functions that are complement or have influence on other functions of the area. Synthesis of all of the functions of the selected area created mutual combination of the collision of the function's, which can be divided into three main groups: monofunctional, difunctional and polyfunctional areas.
We have created 68 collision areas in total. Within the first group we selected 11 subtypes, within the second group we selected 32 subtypes and within the third group we selected 35 subtypes. Ecological stability of this area was mainly influenced by a human activity and caused many problems which need to be corrected or the negative impact needs to be lowered. Agricultural landscape has many other functions which shouldn't be ignored; otherwise it will cause the destruction or demotion of the landscape. The document presents the results from this study area.

Key words: multifunctional landscape evaluation, collision function, Trnava region

Introduction

An agricultural landscape has undergone through many changes which continue although nowadays. It has been tried to rectify them. The objective of this article is to present multifunctional evaluation of the agricultural landscape on a model area of the Trnava district.
A landscape has many functions that influence each other, substitute or complement other functions. It can be seen on a model area of the Trnava district, where a multifunctionality has been evaluated. Multifunctional use of agricultural landscape is based on human needs. Development of the agricultural landscape gets along with agricultural soils, which is characterized by the production of biomass.

Method

An integral approach was implemented for the evaluation of multifunctional utilization of the agricultural landscape. Landscape has been considered to be a geosystem which consisted of abiotic, biotic and socioeconomical elements of the landscape. Keystone for the methodic process was the LANDEP methodology {Ružička, Miklós 1982) modified for the needs of the evaluation of the multifunctional utilization of the landscape. This process consisted of the following steps:
1. Analysis – objective of the analysis was to evaluate the landscape functions in selected area based on the properties of the particular landscape composing elements. We used analysis of the current landscape structure and positive socioeconomical phenomenon to determine functional exploitation of the landscape.

2. Synthesis – created upon parametric synthesis of the two basic functional types – functional types results from the current landscape utilization and from the functional types resulted from the positive phenomena. Synthetic map of the multifunctional utilization of the agricultural landscape – collision of the mutual functional types was the outcome. Every code on the map represents a selected combination of functions on the area.
3. Evaluation – aim of evaluation was to evaluate mutual combination of the functional exploitation of the area and to create types of the multifunctional utilization of the landscape. Selected functional types were divided into three following groups:
1. **Monofunctional areas,**
2. **Difunctional areas,**
3. **Polyfunctional areas.**

Characteristic of the study area

Study area represents Trnava district which is characterized as an example of agricultural utilized area. Trnava district is located in the western part of Slovakia. It consists from 45 rural villages and 1 urban residence Trnava, which is a centre of the Trnava country.
From a geomorphological point of view this area consists of two basic geomorphological units – Danube lowland (part Trnava upland and Danube flatland) and Carpathian Mountains. Central area, it means central and southern part forms Danuba lowland. Carpathian Mountains form the north western border of the study area. Záruby (768 m a.s.l.) is the highest point of this area, the lowest point of the area (130 m asl.) is the outflow of the river Váh near the village Šúrovce (Izakovičová et al, 2005).

Application on the study area

Basic for the evaluation of the multifunctional land use creates:
- map of the current landscape structure
- map of positive socioeconomical phenomenon

Current landscape structure

Based on the current landscape structure we can see an actual situation of the land use on the study area, it means we can see the actual functional use and functions resulting from the exploitation of the land. In the area of interest we surveyed following elements of land use:
• Forest vegetation – total area of the forest vegetation is 13 190 hectare, it means 17,7% of the total acreage of the district. In the northern part of the study area, there is located important habitat protected landscape area Carpathian Mountains – protected landscape area. Other forests, located near protected landscape area Carpathian Mountains have only protective function, or a special determination.
• Non-forest woody plants – represented by line-woody plants and holding coves. In the residential environment represented by distorted half natural elements – parks, graveyards and other residential vegetation.
• Area of the permanent grassland is 1 524 hectare, it represents only 1,87% of the total study area. Villages located on the foothill of the Carpathian Mountains are characterized by changing grassland and forest areas.
• Dominant position accomplished agricultural soils and permanent crops with an area of 53 107 hectare, it represents 71,6% of the total area. Agricultural soils are characterized by large unified block areas, where mostly sunflowers, swedish turnips and corn is being produced. A part of the area is represented by vineyards, gardens and fruit groves, small unified block areas of arable land that represents mosaic structures.
• Area of the water courses and water surfaces is 1 080 hectares, it means 1,46% of the total study area. To water ecosystems we range water courses and water reservoirs. River network is represented by the river Váh and the upper part of Horný Dudváh and other small rivers and its inflows (Blava, Gidra, Trnávka, Parná, Ronava, Krupský potok, Krupica, Dubovský potok, Smolenický potok, Smutná, Podhájsky potok, Bohatá) and also Manivier canal, which takes away waste water from the nuclear power plant in Jaslovské Bohunice. This

area is also characterized by its extraordinary water reservoirs that are used for retaining of overflowing water in time of moderate and high water flow and its consecutive use depending on the demand. Water reservoirs described: WR Buková, WR Suchá near the village Suchá nad Parnou, WR Boleráz, WR Horné Orešany, WR Dubové between the village Dolné Dubové and Horné Dubové and WR Ronava near the village Voderady. In the local part of the district town Kamenný Mlyn are located Trnava ponds.

• Residential and technical elements occupy 5 417 hectares it means 7,31% of the total area of the district. In the model area rural residential elements have dominant position, with mainly agricultural production preferences. Industrial production is centralized in the district town Trnava. Best – known industrial areas are the nuclear power plant Jaslovské Bohunice and car factory Peugeot.

Based on the analysis of the elements of the landscape use we determined following functions of the agricultural landscape:

- agricultural – productive connected with the production of cereals, fodder crops, in some cases technical crops on arable soils,
- meadow – grassland farming function connected with the farming on permanent grasslands,
- forest management function connected with economic activity in forest ecosystems,
- recreational – productive function connected with winegrowing, gardening, fruit grove, this function is mainly aimed on the own needs of the residents,
- recreational function focused on the recreational area and recreational subjects of the area,
- residential – administrational function represented by residential areas and service areas,
- farming – productive function resulted from the position of farms in specific area,
- industrial – productive function connected with industrial production of the particular industrial manufactures.

Positive socioeconomic phenomena

Slovak law Nr. 543/2002 related to the nature and landscape protection determines spatial protection of the nature. In the model area there occur following categories of the protected areas, which were taken over from the study of integrated landscape management II. (Izakovičová et al. 2005):

• Protected landscape area – Carpathian Mountains

• Protected areas in the 4th and 5th protection level: PA Všivavec, PA Trnavaer ponds, PA Vlčkovský háj, NR Klokoč, NR Buková, NR Skalné okno, NR Čierna skala, NR Lošonský háj, NR Bolehlav, NR Slopy and NR Katarína, NR Záruby and NR Hlboča, PP Ľahký kameň, PP Čertov žľab and PP Vyvieračka pod Bacharkou, NPP Driny

• Northern part of Carpathian Mountains near Pezinok identified as SKUEV 0267 – it's an area proposed to be protected because of the protection of biotopes, which have european value – Carpathian and Pannonian oak – hornbeam forests (91GO) and inaccessible cave formations.

• Buková – identification code SKUEV 0268 – area is significant in term of occurrence of Molinia meadows, lowlands and foothills shafts meadows and animal species which have european value for example Euplagia quadripunctata, Lycaena dispar, Vertigo angustior and river otter.

• Nad vinicami – identification code SKUEV 0277 – the reason for the protection is the appearance of xerophilic herbaceous and scrub vestures on a calcareous soils. The appearance of Orchidaceae and appearance of Himantoglossum caprinum, which has european value.

• Brezovské Karpaty – identification code SKUEV 0278 – the reason for the protection is appearance of species of plants and animals which has european value, for example: *Pulsatilla grandis, Dianthus praecox subsp. lumnitzeri* and also *Myotis myotis*.

Among protected birds areas that appears in the Trnava district we count also this 3 areas: Carpathian Mountains, Pusté Uľany – Zeleneč and Trnava ponds. Special function in the area of interest has game preserves and autonomous peasantries, which are aimed at the intensive animal preservation in closed area. Protected are genetic resources, special locations with special treatment that can subserve different function, for example also for spatial system for ecological stability (Izakovičová et al. 2001). Farming operations are adapted on hunting methods with special focus on protection of some species and leads to minimizing of the negative animal

impact on forest. In the study area of interest there are located two peasantries - cadastral area of the village Brestovany with total area of 126, 18 hectares and in the village Slovenská Nová Ves with area of 803 hectares (Izakovičová et al. 2005).
Among protected areas we can also include elements of territorial system of ecological stability (TSES). In the study area there were set apart following elements of the regional territorial system of ecological stability (Izakovičová et al, 2001):
* 1 supraregional biocentre – forest Biele hory, with its core parts RBc Buková, RBc Záruby, RBc Klokoč, RBc Čierna skala and RBc Hlboča;
* 14 regional biocentres – RBc Slopy – Dobrá Voda, RBc Orešany, RBc water reservoir Boleráz, RBc Suchá nad Parnou, RBc Trnavaer ponds, RBc Boleráz, RBc Šarkan – Dolná Krupá, RBc Horná krupá – Horný Háj, RBc Podháj, RBc Brestovianske háje, RBc Voderady, RBc Križovanský háj, RBc Vlčkovský háj and RBc Šúrovce;
* Supraregional biocorridor, linked to the bottom land of the river Váh, leads through the border of this area in its southern part;
* Biocorridors regional buffer relevance are linked mainly to the water path of the rivers and ecotone zones, sort of forest-forest free area. Following regional biocorridors fall into this group: RBk Carpathian Mountain, RBk Trnávka, RBk Gidra, RBk Parná, RBk Blava, RBk Dudváh, RBk Krupánsky potok, RBk Derňa, RBk Podmalokarpatský and RBk Ronava.
From the perspective of nature resources protection:
• Protection of soil resources – on the selected area there are located soils with the highest quality and the highest soil fertility with very high productive potential – Chernozems, Mollic Fluvisols,Haplic Luvisols and Fluvisols These soils are used for intensive agricultural production.
• Protection of water resources – in the area are located surface water resources and groundwater resources:
- surface water resources – rivers important for water management: Váh 4-21 01 038, Dolná Blava 4-21-16-002, Krupský potok 4-21-16-003, Trnávka 4-21-16-011, Parná 4-21-16-023, Gidra 4-21-16-036, Horná Blava 4-21-10-033, Podhájsky potok 4-21-16-030 a Horný Dudváh 4-21-10-009 (according to the regulation of the Ministry of the Environment Nr. 211/2005),
- groundwater resources – resources important for water management located in Dobrá Voda – source Hlávka and source Pod Mariášom with spring – discharge of 100,0 l.s-1, Dechtice – water well D8-D11 spring – discharge of 230,0 l.s-1, Trnava-Bučianska cesta – st. S–1,2 spring discharge 73,0 l.s-1 a st. S–3, RH–1 spring discharge of 40,0 l.s-1, Trnava–Šelpice–Fľaky – st. NV–2 spring discharge 30,0 l.s-1, Trnava-Biely Kostol –st. HTL–1,
• Protection of forest resources – on the area of Trnava district there are located special determined forests, protective forests, and protected area Carpathian Mountains, these resources are protected by the Slovak law Nr. 326/2005 about forests protection. Total area of the protected forests is 2 006,24 hectares and the total area of special determined forests is 566,82 hectares.
• Protection of mineral resources – this area is used as a mining area for building materials as well as decorative bricks and also natural gas. For example Buková, Dechtice, Lošonec, Trstín (building materials), Boleráz (loess loam), Dobrá Voda (peat – low moor).
Based on the analyze of positive socioeconomical phenomenon following functions in the area has been set apart:
- ecostabilizing represented by the elements of the landscape system of ecological stability
- nature-protective represented by the protected areas
- forest-protective represented by the protective forests which have ecological functions as well as special determined forests which have environmental functions
- water management function represented by the significant water resources
- mining function represented by the mining of mineral resources which appears in the area of the Trnava district.

Results

Synthesis of the listed functions created mutual combinations of collisions of these functions; we divided into three basic types: monofunctional, difunctional and polyfunctional areas. In the area we detailed 68 collision areas in total. In the first group we detailed 11 subtypes, in the second group 32 and in the third group we detailed 25 collision areas (fig. 1, 2).

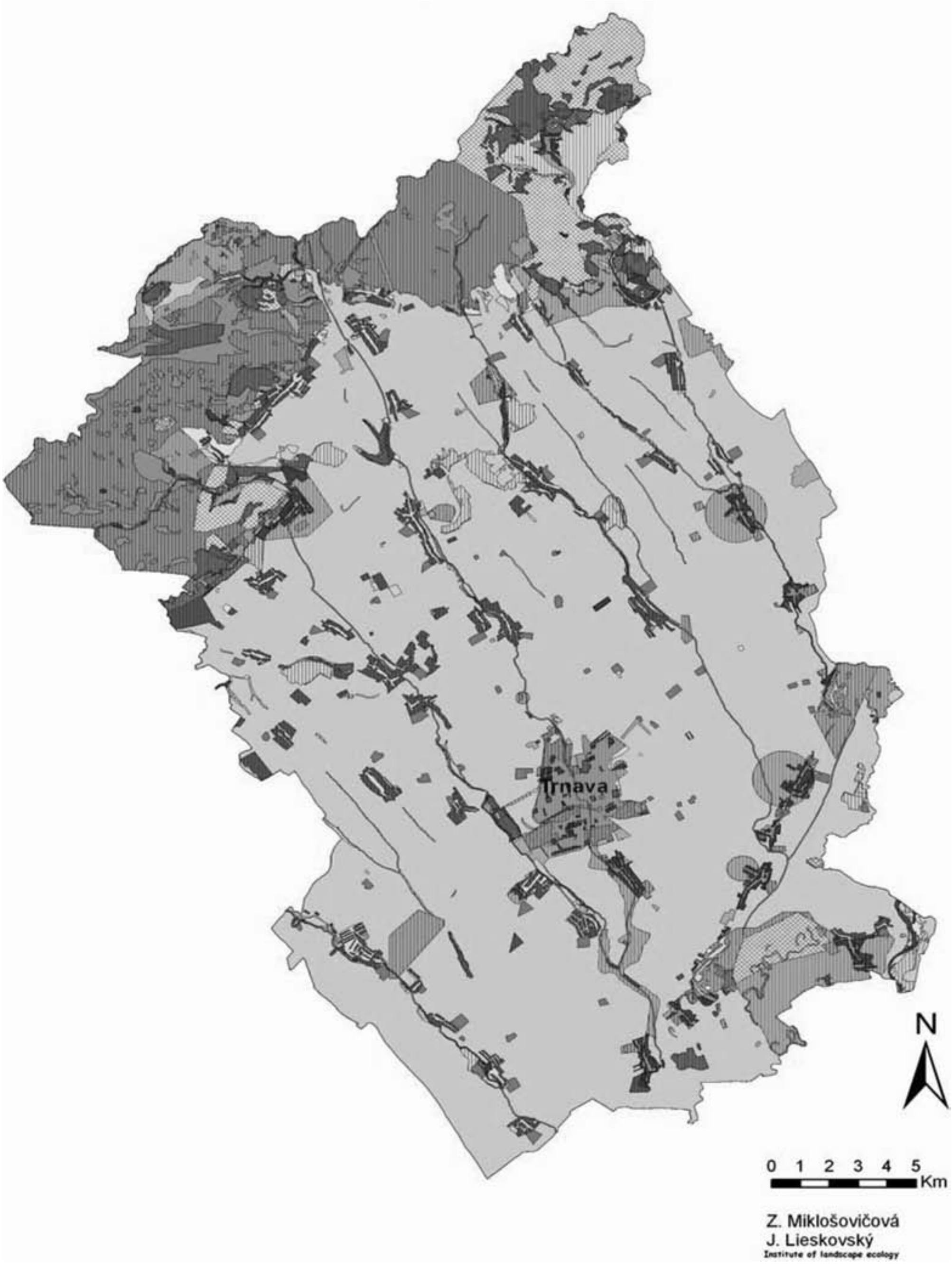

Fig. 1. Map of Multi-functional landscape evaluation of the Trnava district

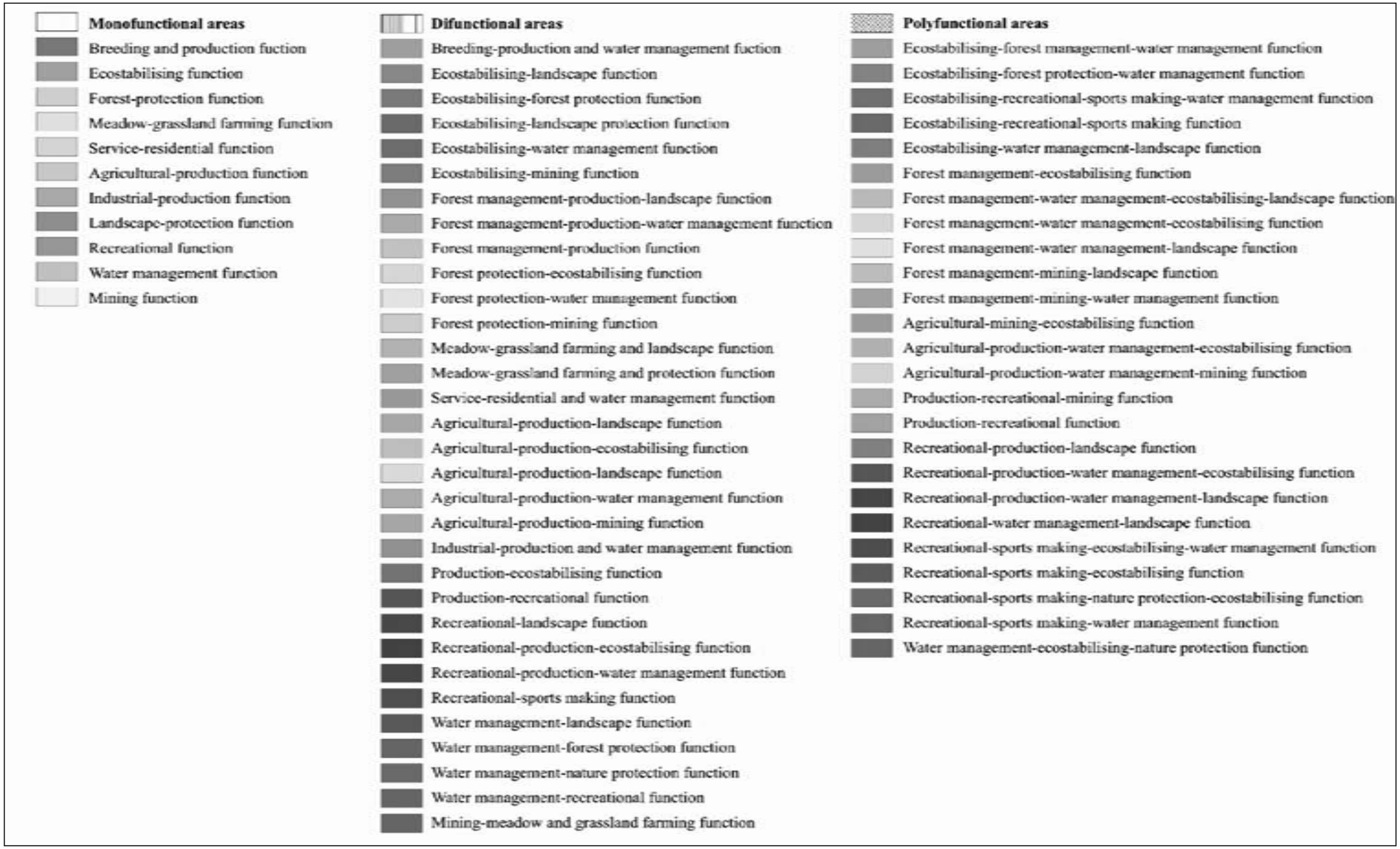

Fig. 2. Legend to the map of multi-functional landscape evaluation of the Trnava district

District Trnava is a typical agricultural intensively utilized landscape with mainly agricultural - vegetable production function.

Created single functions are not the only one result of this document. They are tied together with function that are causing collision in the interests and causing environmental problems. These functions are mostly causing threats of the ecological stability of the existing area as we can see for example on productive-ecological function, agricultural-productive-mining function or agricultural-productive-ecostabilizing function. These functions invade ecological stability and also they are causing change of the agricultural used landscape to a monofunctional landscape which is weakened against pests. When we are talking about mining, it is causing collision in the protected areas and mining of the mineral resources. Dominant in this area is the pollution of soils from percolation of propellants, soil compaction; bad landscape aesthetics for example protected area Carpathian Mountains. We register appearance of water management-recreational function, recreational-productive-water management function, recreational-productive-ecostabilizing function, which are causing disorganization of hydrological regime, increase of pollution. It can endanger and pollute water sources. Recreation is causing increase of noise level, traffic intensification, vegetation treat down, eventually animal intrusion or devastation of fauna and flora.

Further we can mention forest protective-mining function, forest management-productive-landscape function, forest management-productive-water management function. Application of chemical substances is causing devastation of genetic resources, increase of erosion and occupancy of high quality soils, water resources pollution and disorganization of the stability of the selected area.

Conclusion

Evaluation of the model area of the Trnava district showed, that the selected area is intensive agricultural used landscape. It also showed that some function created combinations of functions which cannot exist in real landscape. That is why we create this kind of evaluations to prevent unreasonable collisions of interests and to solve discrepancies more easily. For example some factitious bio-centre and bio-corridors are established to increase ecological stability of the selected area and they also have aesthetic function that is needed for a human to feel better in the surrounding landscape. Evaluation also shoved that landscape has many complementary and influencing functions. For example this is also a way how to point out negative aspects or trouble of the area and if possible to repair, to stop or to soft in the beginning. I think this kind of activities should be extended to other interesting areas.

Acknowledgement. This contribution has been financially supported by GP 2/5071/27- Evaluation of the agricultural landscape in transitive economy

References

Cocklin C., Dibden J., Mautner N., 2006. From market to multifunctionality? Land stewardship in Australia. Geogr. J 172. 197-205.

Hollander G. M., 2004: Agricultural trade liberalization, multifunctionality, and sugar in tme south Florida landscape. Geoforum 35. 299-312.

Izakovičová Z. et al., 2002. Regional territorial system of ecological stability district Trnava. Institute of landscape ecology. SAS. 157.

Izakovičová Z. et al., 2005. Integrated landscape management II. Bratislava: Institute of landscape ecology SAS. 224.

Izakovičová Z. Hrnčiarová T. Moyzeová M. et al., 2001. Ecological management of Parná rivulet catchments. Local Agenda 21. Združenie KRAJINA 21. Institute of landscape ecology SAS, Bratislava. 185.

Otte A., Simmering D., Wolters, V., 2007. Biodiversity at the landscape level: recent concepts and perspectives for multifunctional land use. Landscape Ecol 22. 639-642.

Ružička M., 2000. Landscape ecological planning– LANDEP I. Združenie Biosféra. Bratislava. 119.