Carpathian Journal of Earth and Environmental Sciences, August 2012, Vol. 7, No. 3, p. 231 - 246

ECOLOGICAL SIGNIFICANCE OF LAND-COVER BASED ON INTERPRETATION OF HUMAN-TOURISM IMPACT. A CASE FROM TWO DIFFERENT PROTECTED AREAS (SLOVAKIA AND SERBIA)

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Abstract: This study analyses landscape components and human activities, in two different protected landscapes. The main purpose of this work is to measure landscape elements, mainly land cover patches within tourism zones. Outputs of the landscape quantification are numerical values, which is possible to interpret toward to the quality of an on-going ecologic process in landscape. The interpretation of the quantified data will be used to determine ecologic signification of landscape in selected study areas. This research examines land cover patches in the protected areas by a set of landscape metrics for area, size, density, shape and diversity (Number of patches - NP, Patch's density - PD, Mean patch size - MPS, Patch's size standard deviation – PSSD, Mean shape index – MSI, and Shannon's Diversity Index - SHDI). First landscape is represented by Protected Landscape Area of Štiavnica Mountains, located in Slovakia, and second landscape is represented by Special purpose area of "Fruška Gora" National Park in Serbia. The classification of land cover patches was based on Corine Land Cover 2000 (CLC2000) seamless vector data. The result of the tourism impact on the landscape in protected area (Slovakia and Serbia) is the fragmentation of land cover patches. Recreational activities are the main reason of disruptions the integrity of the landscape in researched tourism zones. The increase of the landscape fragmentation may lead to the decreasing of biodiversity in future.

Keywords: landscape metrics, tourism-human impact, ecological signification, Štiavnica Mts., Fruška Gora Mt.

1. INTRODUCTION

The terrestrial surface, or land covers of the Earth and changes therein, is central to a large number of the biophysical processes of global environmental change, qualifying "land change as a forcing function in global environmental change" (Turner 2002, 2006). Land cover has been defined by the attributes of the Earth's land surface and immediate subsurface, including biota, soil, topography, surface and groundwater, and human (mainly built-up) structure (Lambin, et al., 2006). Land cover conversions constitute the replacement of one cover type by another and are measured by a shift from one land cover category to another, as is the case of agricultural expansion, deforestation, or change in urban extent. Land-cover modifications, in contrast, are more subtle changes that affect the character of the land cover without changing its overall classification (Turner et al., 1995; Lambin et al., 2003). Land-cover modification is possible to measure with mathematical metrics (Turner & Gardner, 1991; Forman & Godron, 1981; Forman, 1995; McGarigal & Marks, 1995) that quantify different aspects of landscape pattern (O'Neill et al., 1988).

A landscape can be characterized by both its composition and configuration, sometimes referred to as landscape physiognomy or landscape pattern (Dunning et al., 1992, Turner 1989). Current landscape is a result of various factors, including variability in abiotic conditions such as climate, topography, and soils, biotic interaction that generate spatial pattering even under homogeneous environmental conditions, past and present patterns of human settlement and land use, and the dynamics of natural disturbance and succession (Turner, et al., 2001).

The types of changes in land cover, respectively in landscape pattern encompass changes in biotic diversity, actual and potential primary productivity, soil quality, runoff and sedimentation rates, and other such attributes of the terrestrial surface of the Earth (Steffen et al., 2004; DeFries et al., 2004). Land covers and changes in them are sources and sinks for most of the material and energy flows that sustain the biosphere and geosphere, including trace gas emissions and the hydrological cycle (Vitousek et al., 1997; Meyer et al., 1998; Haberl et al., 2004; Kabat et al., 2004; Crossland et al., 2005; Canadell et al., 2006). Contemporary land cover change is generated principally by human activity, activity directed at manipulating the Earth's surface for some individual or societal need or want, such as agriculture (Turner et al., 1990; Ojima et al., 1994; Walker et al., 1999; Cassman et al., 2005). The subject of any landscape transformation is significant to all human issues that involve land. Wise forestry, economics, biodiversity, conservation, agriculture, landscape architecture, sociology, wildlife biology, soil science, and so forth explicitly recognize and deal with a dynamic land (Forman, 2006).

Levin (1976) identified three general categories of cause of spatial pattern. The first category is local uniqueness, deals with unique features of a point in space, such as abiotic variability or unique land uses imposed by society. Levi's second category is phase difference; deal with a spatial pattern resulting from disturbances. The ecosystem responds to a local disturbance by going through a succession. Levi's third category, dispersal, prevents the landscape from becoming uniformly covered with a single, dominant population.

Using the term landscape as „land use" has been defined as the purposes for which humans exploit the land cover. It involves both the way in which biophysical attributes of the land are manipulated and the intent underlying the manipulation, i.e., the purpose for which the land is used (Lambin, Geist & Rindfuss, 2006). However, any changes of landscape use makes transformation in landscape pattern and land cover. In a present period the changes are mainly generated by human activities in manipulating the Earth's surface. The changes are also based on the variability of abiotic and biotic conditions.

Landscape pattern consists of a sum of elements which independently or together influence variety ecological processes in the landscape (McGarigal & Marks 1995). Landscape pattern has been described as ecological processes that are linked and can be predicted from some broad-scale pattern (Baskent & Jordan, 1995; Gustafson, 1998).

This paper will analyse landscape components (land cover patches) and human activities (their impact on land cover), in the form of tourism activities, in two different protected landscapes. The main purpose of this study is to measure landscape elements, mainly land cover patches within tourism zones (Figs. 1 and 2). Quantified land cover patches carry most useful information about the state of landscapes influenced by tourism. The interpretation of the quantified data will be used to determine ecological signification of landscape in selected study areas. First landscape is represented by Protected Landscape Area of Štiavnica Mountains, located in Slovakia, and second landscape is represented by Special purpose Area of "Fruška Gora" National Park in Serbia.

2. MATERIAL AND METHODS

Landscape elements are changing over time. Landscape metrics can be use to compare same landscapes within different time periods or spatially different landscapes in the one time period. It is the most common analysis in geographical or landscape ecological researches. Methodology for the compation of landscapes is based on quantifying land cover patches. This study is focused on comparing the two spatially different landscapes that are under a certain level of tourism influence. Most of the landscape metrics are based on mathematical–statistical approach that measures area, perimeter, length and shape. Many researchers have been defined wide scale of landscape metrics (Pielou, 1975; Forman & Godron, 1981; O'Neill et al., 1988; Baker & Cai, 1992; Gustafson & Parker, 1992; McGarigal & Marks 1995).

2.1 Land cover patches classification

The classification of land cover patches in this study was based on Corine Land Cover 2000 (CLC2000). It is the product of European Environment Agency (EEA) and its member countries in the European environment information and observation network (Eionet). It is based on the results of IMAGE2000, a satellite imaging programme undertaken jointly by the Joint Research Centre of the European Commission and the EEA. CLC2000 is based on the photointerpretation of satellite images by the national teams of the participating countries. The resulting national land cover inventories are further integrated into a seamless land cover map of Europe. CLC2000 provides consistent information on land cover and land cover changes across Europe. Today, the Land Cover data is used in more than 30 countries and within hundreds organizations. CLC2000 has been made in scale of 1 : 100000, with minimal mapping area of 25 hectares and minimum width of linear elements of 100 meters. The mapping represents a trade-off between production costs and level of details of land cover information (Heymann et al., 1994).

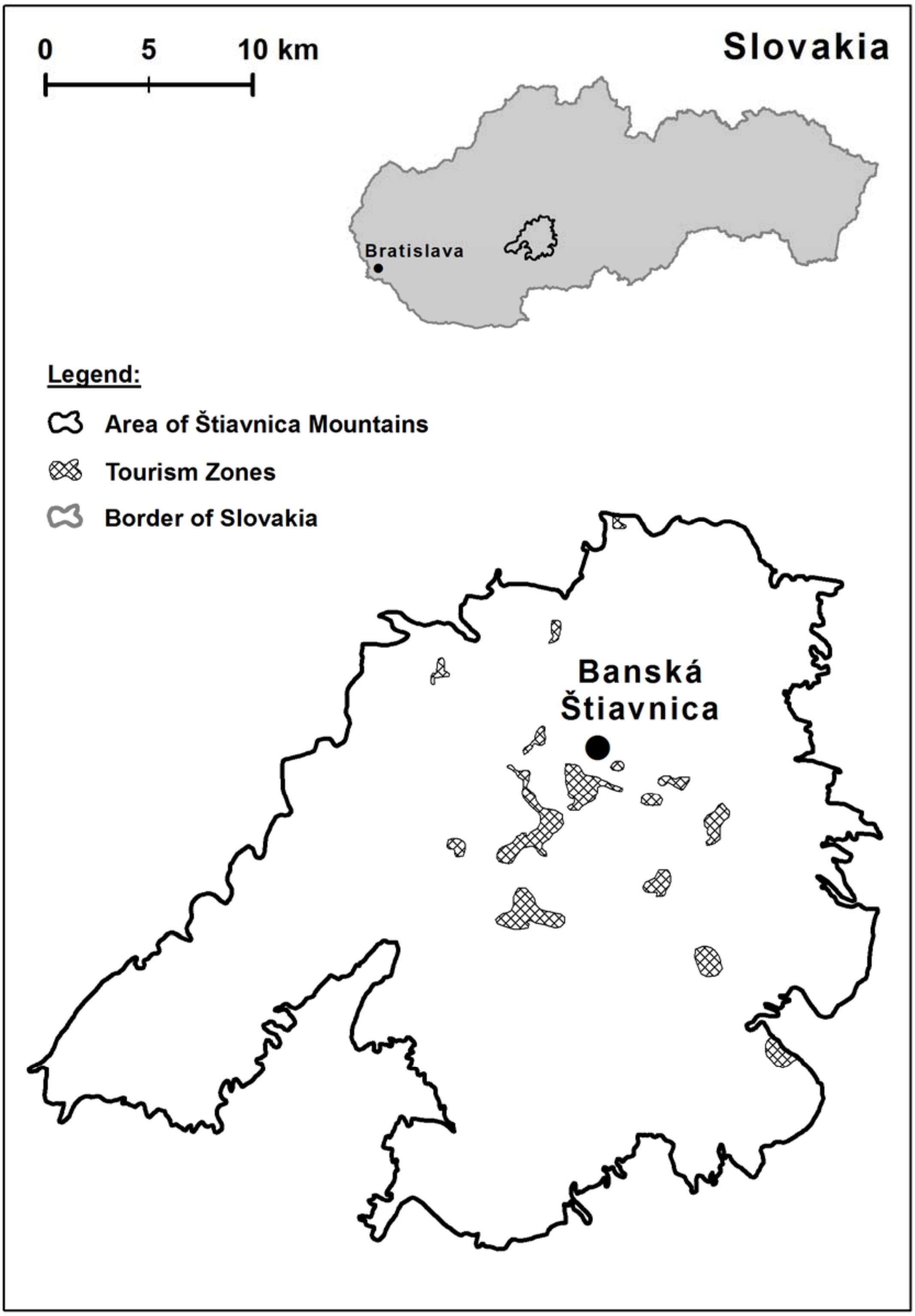

Figure 1. Protected Landscape Area of Štiavnica Mts.

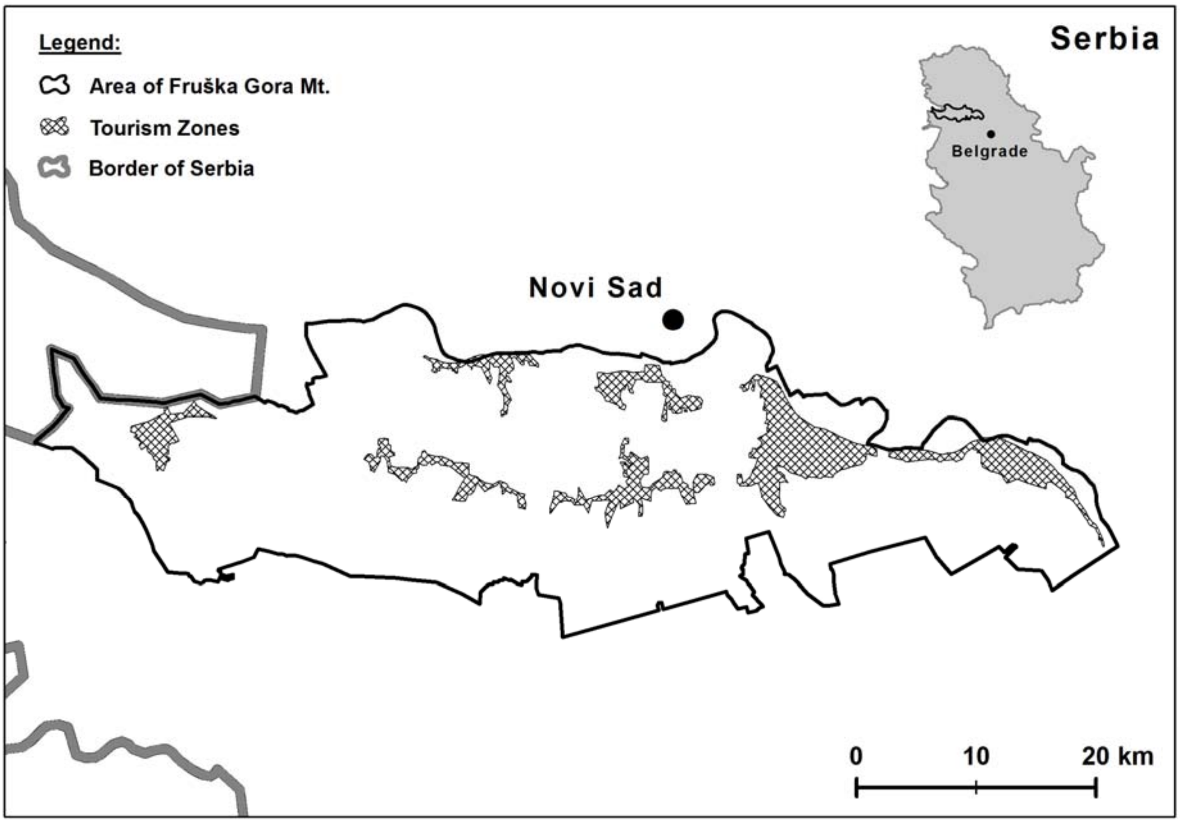

Figure 2. National Park of Fruška Gora Mt.

The standard CLC nomenclature includes 44 land cover classes, grouped in a three-level hierarchy. The five main (level-one) categories are: 1) artificial surfaces, 2) agricultural areas, 3) forests and semi-natural areas, 4) wetlands, and 5) water bodies (Heymann et al., 1994). All national teams adopted this standard nomenclature.

The approach of computer assisted visual interpretation of satellite images is chosen as the main mapping methodology. The raw satellite images have to be pre-processed and enhanced to yield a geometrically correct document in National projection. For CLC2000, ortho-corrected Landsat-7 ETM satellite images were provided by the IMAGE2000 component, with an RMS error below 25 metres. Detailed topographic maps and in some cases orthophotos were used to achieve this accuracy. Usually, in IMAGE90 only a polynomial correction was applied, and GCPs were mostly selected from 1:100000 scale maps. The accuracy of IMAGE90 products was significantly poorer than that of IMAGE2000. During the first CLC inventory, the photointerpretation method was done on hardcopies: a transparent overlay was fixed on top of a satellite image and the photointerpreter drew polygons on it marking them with a CLC code. Later the overlay was digitised, topology was created and the CLC code entered (Büttner et al., 2002).

2.2 Ecological signification

According to Gustafson (1998), McGarigal & Marks (1995), Gergel & Turner (2002), Forman (2006) each land cover is possible to measure by landscape metrics for size, density, shape, edge and diversity. The outputs values from landscape metrics directly influence the quality of on-going ecological processes at different levels. On the base of the variables is possible to interpret each of the land cover patches toward a quality of on-going ecological processes (Fig. 3). Output of the interpretation is determined by the level of ecological signification in following levels (Hrnčiarová et al., 1997):

1 – Very significant land cover patches
2 – Significant land cover patches
3 – Moderately significant land cover patches
4 – Almost insignificant land cover patches
5 – Insignificant land cover patches.

With the increasing of the level of ecological significance, the quality of landscape ecological processes in the landscape also increases. The first step of the interpretative process was to assign the level of ecological signification (S_A) for every land cover patch. The process of assignation is based on the operations of the ecological processes in the landscape.

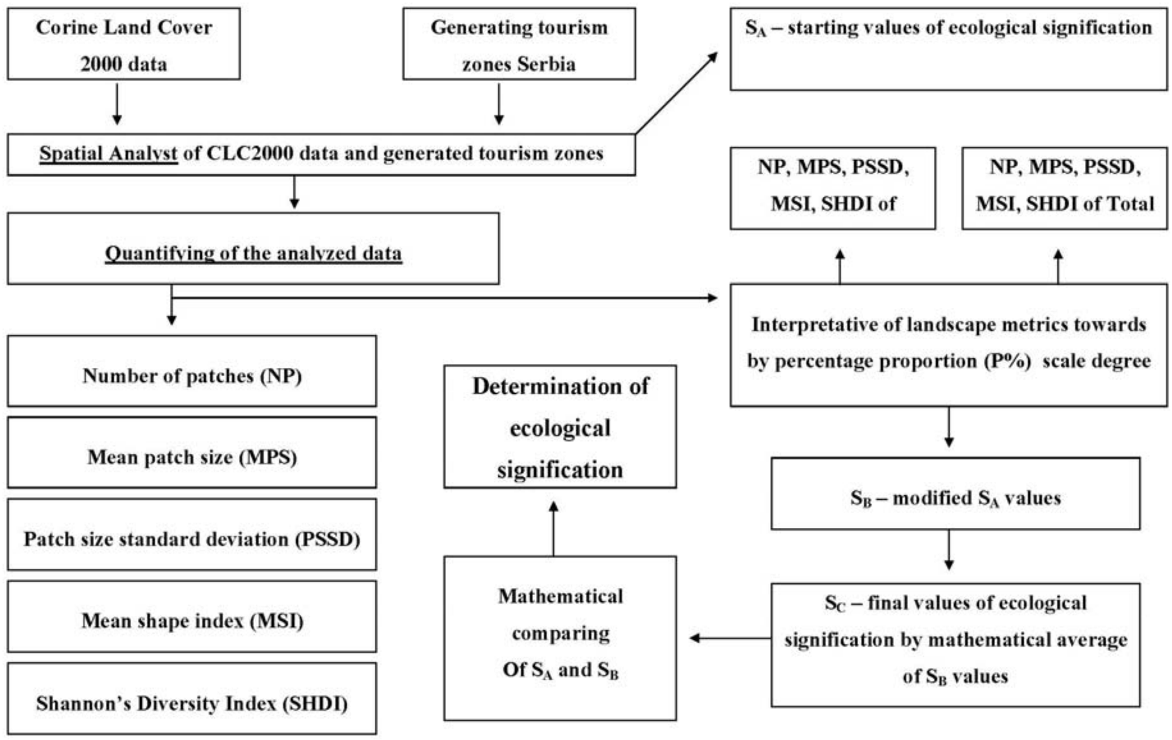

Figure 3 Steps in determination of landscape signification

It is more subjective than objective process. However, next step will modify the assigned values. The next step is interpretation of the landscape metrics (NP, PD, MPS, PSSD and MSI) and is based on detecting the percentage proportion ($P_{\%}$) of the tourism zones values into the values of total landscape area. This step modified assigned level of the ecological signification (S_A) by following scale:

A) 0 – 20 % = S_A same value;
B) 21 – 40 % = $S_{A,}$ one level up;
C) 41 – 60 % = $S_{A,}$ two levels up;
D) 61 – 80 % = $S_{A,}$ three levels up;
E) 81 – 100 % = $S_{A,}$ four levels up.

The main purpose of this modification is to create partial ecological significations (S_B). The value S_C represents match average of values S_B. It is the final ecological signification for land patch class. The general structure of the methodology is represented in figure 3.

3. OVERVIEW OF STUDY AREAS

The landscape of Protected Area of Štiavnica Mountains is sorted to the System of Alpine-Himalayan, Subprovince of Inner Western Carpathians, Geomorphological area of Slovak Central Highlands and Geomorphological total of Štiavnica Mts. (Mazúr & Lukniš, 1986). The area of Štiavnica Mts. (77630ha) is the biggest stratovolcano area in Slovakia from period of the Upper Tertiary Era. Štiavnica Mts are the result of different resistance of volcanic rocks and the strength of rugged relief. The mountains are in the contact zone of the Carpathian arc and Pannonian basin with a specific natural and socioeconomically development (Grega & Vozár, 1964). The area of Štiavnica Mts, as whole Slovakia (respectively central Europe), is situated in the northern temperate zone where oceans and inland zones were influencing landscape.

Štiavnica Mts are part of the west-floriculture pre-carpathian district of Slovak flora in Central Highlands. Extremely varied subsoil, together with a natural geomorphologic structure, enable the development of diverse species plant cover of the landscape. A relatively preserved large forest complexes, as well as exposed south enclaves forest-steppes and steppes, are the basic character of the original habitats (Futák, 1972). The fauna is committed to specific habitats, which include oak and beech forests, coniferous forests, mixed forests, grasslands and arable, riparian vegetation, streams and reservoirs and also human settlements (Kelemen et al., 1986).

Centuries-old mining activity has strongly influenced the current landscape appearance (Grega & Vozár, 1964). According to Lichner (2005) the special elements of the landscape are artificial lakes called “tajchy”, which were created for mining and today are used for recreation purposes. The main reason for the landscape conservation (second level in Slovakian law of nature and landscape protection) is harmonized relation between land covers and land use. During the last three decades, a massive “tourism attack” on landscape are reported (Králik, 2001).

The study area in Serbia encompassed Fruška Gora Mt. and surrounding area (138.92 ha) included in The Spatial Plan for the “Fruška Gora” National Park Special - Purpose Area adopted by the Republic Agency for Spatial Planning of the Republic of Serbia.

Fruška Gora Mt. is an inselberg in the Southern Pannonian Basin. It is situated south of Novi Sad, on the right bank of the Danube River (Lesić, et al., 2007). The massif extends in an east-west direction and it is about 80 km long, while the widest part of the chain has the width of 15 km. The highest pick of the Fruška Gora Mt. is Crveni čot (549 m) (Milić, 1973), located in the central part of the mountain. Western and eastern parts are considerably lower, ranging from 200 to 300 m (Miljković, 1975).

The area of Fruška Gora Mt. is part of Pannonian Europe's biogeographical region. Rocks of various age and type can be Found in Fruška Gora Mt – from palaeozoic metamorphic rocks to young post-tertiary sand and loess, and from limestones to siliceous rocks and serpentines (Cvetić & Sabovljević, 2005). Fruška Gora Mt belongs to the mild-continental central European climatic region, but cover of forests changes this type of climate into a climate with sub continental characteristics (Tomić et al., 2000). Almost all soils found in Fruška Gora Mt. belong to the automorphic (terrestrial) order. An exception is found in alluvial-deluvil soil that belongs to hydromorphic (semi-terrestrial) order (Miljković, 1975).

Fruška Gora Mt. has a rich hydrological underground and surface network, which is relatively evenly distributed. Some springs are even thermal and healing. Beside streams, there is also standing water, but all lakes are artificial (Petrović et al., 1973).

Fruška Gora Mt. was originally a woody region. However, only areas above 300 m altitude are still covered by native woods, mainly Aculeato-Querco-Carpinetum and Tilio-Fagetum submontanum (Obradović, 1966). The slopes are mostly covered by pastures, vineyards, orchards and cultivated land. On the basis of natural conditions (primarily climatic and ecological) several producing regions may be distinguished such as: region of natural highland forests, region of fruits and vine-culture production or region of field corps production (Miljković, 1975).

Because of its position close to two biggest cities in Serbia, Belgrade and Novi Sad, Fruška Gora Mt. can be categorized as a tourist mountain for excursions and recreational activities. The mountain has many picnic areas and areas for hiking, biking, hunting and fishing. There are 16 Serb’s Orthodox monasteries on the mountain. Most of them represent pilgrimage destinations for Orthodox and other Christian and religious believers (Stamenković, et al., 2009).

Fruška Gora Mt is proclaimed a National Park in 1960 in order to provide its permanent protection and to improve its natural resources and beauty. The area of active protection is 25.525 ha. “Fruška Gora” National Park is enlisted into V Category of IUCN Protected Area Management.

3. THE THEORY OF LANDSCAPE METRICS AND ECOLOGICAL SIGNIFICATION

Quantified lands cover patches and their outputs metrics can be used for different ecological and geographical purposes. They express:

A) result of the used mapping scale (MacArthur & Wilson, 1987).

B) appearance of habitats which are bound to a specific type of land cover patches category – class (Gilpin & Hanski, 1991).

C) diversity that influence species interaction within land cover’s patches. Landscape with more land cover patches exhibits greater diversity (heterogeneity). Increasing diversity raises up the diversity of on-going ecological processes in landscape (Kareiva, 1990).

D) anthropic pressures, such as a wide range of human activities in the landscape. The result of anthropogenic activities is the increased number of landscape elements, as according to Franklin & Forman (1987) anthropic pressure disrupts the integrity of the landscape area. Thus, disturbed area responds differently to external disturbances, e.g., fires, or wind flow.

According to Forman (2006) small land cover patches are holistic habitat types. By contrast, large land cover patches include several types of habitats or ecosystems. Several smaller land cover patches, which are distributed in area, increase the overall heterogeneity and fragmentation of the landscape. The differences in patch size variability suggest that the human-altered landscapes contain more uniformity in patch size than the unaltered landscape (McGarigal & Marks, 1995). The shape of the land cover patches is another important phenomenon that affects the quality of on-going ecological processes. The shape of landscape elements influences wind flow in the area of forest vegetation, which may be reflected in changes in microclimate (Gratkowski, 1956; Ranney et al., 1981; Chen, et al., 1990) and subsequently in change of vegetation structure (Ranney et al., 1981). Each organism reflects to the shape and boundaries of the environment in another way (McGarigal & Marks, 1995).

The land cover is possible to define by attributes of the Earth's land surface as well as by ecological signification of each one land surface elements. According to Hrnčiarová et al., (1997) the ecological significance is resulting from the operation of the ecological processes in landscape. The ecological signification is purpose-built landscape property, establishing a degree of naturalness and natural functioning (self-regulatory) processes in the ecosystem to maintain and sustain the conditions for regeneration and genetic resources, natural resources, ecological stability, biodiversity and the implementation of various utility functions in the country (Hrnčiarová, 1999).

4. RESULTS

The main result of this work is quantified land cover patches in tourism zones within chosen Slovakian and Serbian protected areas. Outputs of the landscape quantification are numerical values, which is possible to interpret toward to the quality of on-going ecological process in landscape.

4.1 Land cover of the tourism zones in Štiavnica Mountains (Slovakia)

The areas of tourism zones in Štiavnica Mts., (Slovakia) as shown in table 1 occupy 2,36 % of the total area. The Number of patches (NP) in tourism zones is 120, and that is 21 % of all patches (Table 2). Patches density (PD) is focusing on extensive concentration land cover patches in tourism zones and the value is 64.59 patches per 1,000 ha. The occurrence of a lot of small patches is the main reason for this concentration. On the base of values (Table 2): A) Number of patches, B) Area of tourism zones and C) Total area of Štiavnica Mts. is possible to state that tourism zones are extensively fragmented, but markedly heterogeneous – diversified.

From the Number of patches and their area is possible to determinate Mean patch size (MPS). Outputs values of MPS (Table 2) focuses on fact that following land cover patches has similar size: 231 Pastures, 242 Complex cultivation patterns, 243 Land principally occupied by agriculture, 311 Broad-leaved forest, 312 Coniferous forest, 313 Mixed forest. The situation in total area of mountains is completely different. Tourism zones show very small value of MPS, expect patch types: 142 Sport and leisure facilities and 112 Discontinuous urban fabrics.

Patch size standard deviation (PSSD) is focused on the significance of size difference among patches in tourism area (Table 2). The value of PSSD that is closer to zero means same size of all patches, that is, the existence of human impact on the land cover. The concentrations of biggest size differences are present in following patches: 112 Discontinuous urban fabrics, 243 Land principally occupied by agriculture, 313 Mixed forest. Knowing the number of patches it would bevery interesting to interpret patches from the class 324 Transitional woodland shrub (324). The values of this class are very small.

Mean size index (MSI) indices shape of patches (Table 2). Value index increases with irregularity of patch shape. Patches with low values have circular shape and imply small range of human impact. This metrics should be interpreted with the Number of patches or area. On the base of patch number, very high values have following patches: 112 Discontinuous urban fabrics and 311 Broad-leaved forests. Oppositely, very low values are present in the patches: 243 principally occupied by agriculture and 313 mixed forest. According to landscape metrics is possible to state land cover patches in tourism zones are significant fragmented by human impact.

The changes of ecological signification (from starting value S_A to C_c value) caused by activities are committed mainly to the following land cover patch types: 131 Mineral extraction sites, 231 Pastures, 242 Complex cultivation patterns, 243 Land principally occupied by agriculture, 311 Broad-leaved forest, 312 Coniferous forest, 313 Mixed forest and 324 Transitional woodland shrub. Overall ecological signification has changes from level two to level four (insignificant land cover patche).

4.2. Land cover of the tourism zones in Fruška Gora Mountain (Serbia)

The tourism zones in Fruška Gora Mt. occupy 14 186.49 ha, i.e., 10.21% of total area. Number of patches (NP) in tourism zones is 436, i.e., 65.96 % from all patches (Table 3). Patches density (PD) of 30.73 patches per 1 000 ha is the consequence of the great number of small patches within a reference area.

Table 1 Representation of the Land Cover patches and Tourism Zones in the Štiavnica Mountains and Fruška Gora Mt.

Code	Name of Land Cover patches – class type	Land Cover[1]		Tourism Zones[1]		Land Cover[2]		Tourism Zones[2]	
		ha[1]	%	ha	%	ha	%	ha	%
112	Discontinuous urban fabric	1470.81	1.87	314.40	16.92	5547.11	3.99	1077.65	7.6
121	Industrial or commercial units	51.31	0.07	x	x	302.49	0.22	12.74	0.09
122	Road and rail networks and associated land	x	x	x	x	84.34	0.06	x	x
131	Mineral extraction sites	54.77	0.07	2.39	0.13	407.95	0.29	92.77	0.65
132	Dump sites	40.17	0.05	x	x	x	x	x	x
141	Green urban areas	x	x	x	x	230.92	0.17	x	x
142	Sport and leisure facilities	167.24	0.21	156.99	8.45	x	x	x	x
211	Non-irrigated arable land	3401.33	4.32	47.45	2.55	66701.64	48.01	1259.28	8.88
221	Vineyards	18.69	0.02	x	x	1218.57	0.88	17.18	0.12
222	Fruit trees and berry plantations	74.37	0.09	x	x	1126.28	0.81	0.79	0.01
231	Pastures	6133.30	7.78	190.59	10.26	661.81	0.48	13.49	0.1
242	Complex cultivation patterns	125.59	0.16	18.01	0.97	11427.52	8.23	4086.62	28.81
243	Land principally occupied by agriculture	8074.66	10.25	434.40	23.38	13171.23	9.48	4883.02	34.42
311	Broad-leaved forest	49802.70	63.20	288.86	15.55	29430.06	21.18	2179.68	15.36
312	Coniferous forest	497.00	0.63	39.74	2.14	42.82	0.03	41.44	0.29
313	Mixed forest	6129.11	7.78	257.90	13.88	397.74	0.29	55.03	0.39
321	Natural grassland	18.55	0.02	x	x	x	x	x	x
324	Transitional woodland shrub	2736.82	3.47	107.15	5.77	3270.11	2.35	243	1.71
331	Beaches, dunes, sands	x	x	x	x	25.54	0.02	x	x
411	Inland marshes	x	x	x	x	548.89	0.40	x	x
511	Water courses	x	x	x	x	3907.95	2.81	215.64	1.52
512	Water bodies	x	x	x	x	419.82	0.30	8.17	0.06
Total		**78796.41**	**100**	**1857.89**	**100.00**	**138922.76**	**100.00**	**14186.49**	**100.00**

Index[1] Representation of the Land Cover and Tourism Zones patches in Štiavnica Mountain
Index[2] Representation of the Land Cover and Tourism Zones patches in Fruška Mountain
ha Area representation of the patch type in hectares
% Percentage representation of the total area
x Land Cover patches without representation

Table 2 Landscape Metrics of the Land Cover patches and Tourism Zones in the Štiavnica Mountains

Code	Name of Land Cover patches	NP		PD		MPS		PSSD		MSI	
		LC[1]	TZ[2]	LC[1]	TZ[2]	LC[1]	LC[1]	TZ[2]	TZ[2]	LC[1]	TZ[2]
112	Discontinuous urban fabric	30	7	0.38	3.77	49.03	44.91	97.50	50.58	2.18	1.82
121	Industrial or commercial units	2	x	0.03	x	25.66	x	24.50	x	1.96	x
131	Mineral extraction sites	2	1	0.03	0.54	27.39	2.39	7.76	0.00	1.55	1.32
132	Dump sites	1	x	0.01	x	40.17	x	0.00	x	1.39	x
142	Sport and leisure facilities	3	3	0.04	1.61	55.75	52.33	5.37	7.55	1.50	1.42
211	Non-irrigated arable land	94	9	1.19	4.84	36.18	5.27	67.92	6.67	1.95	1.63
221	Vineyards	4	x	0.05	x	4.67	x	2.98	x	1.50	x
222	Fruit trees and berry plantations	5	x	0.06	x	14.87	x	16.46	x	1.52	x
231	Pastures	132	14	1.68	7.54	46.46	13.61	55.70	14.21	1.97	1.69
242	Complex cultivation patterns	14	1	0.18	0.54	8.97	18.01	11.91	0.00	1.92	1.24
243	Land principally occupied by agriculture	168	29	2.13	15.61	48.06	14.98	77.19	20.07	2.01	**1.46**
311	Broad-leaved forest	31	22	0.39	11.84	1606.54	13.13	4287.37	18.37	2.48	1.79
312	Coniferous forest	9	3	0.11	1.61	55.22	13.25	18.16	12.41	1.77	1.50
313	Mixed forest	39	17	0.49	9.15	157.16	15.17	223.76	26.20	2.05	**1.64**
321	Natural grassland	1	x	0.01	x	18.55	x	0.00	x	2.00	x
324	Transitional woodland shrub	51	14	0.65	7.54	53.66	7.65	45.28	6.50	1.89	1.67
Total		**568**	**120**	**7.21**	**64.59**	**140.52**	**18.25**	**308.87**	**14.78**	**2.28**	**1.56**

Legend:ndex[1] Landscape Metrics of the Land Cover patches in Štiavnica Mountain
Index[2] Landscape Metrics of the Tourism Zones patches in Štiavnica Mountain
x Land Cover patches without representation
NP Number of patches
PD Patch density
MPS Mean patch size
PSSD Patch size standard deviation
MSI Mean shape index

Table 3 Landscape Metrics of the Land Cover patches and Tourism Zones in Fruška Gora Mt.

	Name of Land Cover patches	**NP**		**PD**		**MPS**		**PSSD**		**MSI**	
		LC[1]	**TZ[2]**	**LC[1]**	**TZ[2]**	**LC[1]**	**TZ[1]**	**LC[2]**	**TZ[2]**	**LC[1]**	**TZ[2]**
112	Discontinuous urban fabric	46	14	0.33	0.99	120.59	76.97	100.72	60.79	1.981	1.878
121	Industrial or commercial units	7	1	0.05	0.07	43.21	12.74	26.48	0.00	1.381	1.427
122	Road and rail networks and associated land	2	x	0.01	x	42.17	x	15.22	x	2.145	x
131	Mineral extraction sites	7	2	0.05	0.14	58.28	46.39	31.11	19.06	1.670	1.736
141	Green urban areas	4	x	0.03	x	57.73	x	18.35	x	1.922	x
211	Non-irrigated arable land	73	85	0.53	5.99	913.72	14.81	4600.09	26.53	2.052	1.706
221	Vineyards	17	4	0.12	0.28	71.68	4.29	59.15	6.45	1.502	1.625
222	Fruit trees and berry plantations	17	3	0.12	0.21	66.25	0.26	38.34	0.15	1.497	1.637
231	Pastures	16	4	0.12	0.28	41.36	3.37	14.37	3.10	1.893	1.489
242	Complex cultivation patterns	149	96	1.07	6.77	76.69	42.57	90.16	64.60	1.989	1.743
243	Land principally occupied by agriculture	158	93	1.14	6.56	83.36	52.51	130.63	155.79	2.233	1.880
311	Broad-leaved forest	75	92	0.54	6.49	392.40	23.69	2627.60	54,13	2.197	1.843
312	Coniferous forest	1	1	0.01	0.07	42.82	41.44	0.00	x	1.586	1.522
313	Mixed forest	9	5	0.06	0.35	44.19	11.01	25.52	7.67	1,662	1.769
324	Transitional woodland-shrub	55	13	0.40	0.92	59.46	18.69	71.28	28.54	1.984	1.692
331	Beaches, dunes, sands	1	x	0.01	x	25.54	x	0.00	x	1.834	x
411	Inland marshes	8	x	0.06	x	68.61	x	59.86	x	2.059	x
511	Water courses	8	20	0.06	1.41	488.49	10.78	833.42	28.36	4.297	3.676
512	Water bodies	8	3	0.06	0.21	52.48	2.72	41.35	3.73	1.651	1.520
Total		**661**	**436**	**4.76**	**30.73**	**144.69**	**24.15**	**462.30**	**30.59**	**2.059**	**1.81**

Legend:

Index[1]	Landscape Metrics of the Land Cover patches in Fruška Gora Mountain
Index[2]	Landscape Metrics of the Tourism Zones patches in Fruška Gora Mountain
x	Land Cover patches without representation
PD	Patch density
NP	Number of patches
MPS	Mean patch size
PSSD	Patch size standard deviation
MSI	Mean shape index

On the base of values (Table 3): A) Number of patches, B) Area of tourism zones and C) Total area of Fruška Gora Mt. is possible to state that tourism zones are extensively fragmented but markedly heterogeneous – diversified.

Table 3 shows that 211 Non-irrigated arable land, 311 Broad-leaved forest and 511 Water courses have the significantly largest sizes within total referenced area. MPS of all Tourism zones is exactly 6 times smaller than MPS of all referenced area, while the dominantly largest value of MPS have patch type 112 Discontinuous urban fabrics.

The most size differences in Tourism zones in Fruška Gora Mountain are in following patches: 243 Land principally occupied by agriculture, 242 Complex cultivation patterns and 112 Discontinuous urban fabrics.

The largest value of MSI is present in 511 Water courses patch. However, this is the consequence of the natural flow of the Danube River, which is represented by this patch. Very high values of MSI that imply increased human impact have following patches: 243 Land principally occupied by agriculture 112 Discontinuous urban fabric and 311 Broad-leaved forests.

According to table 5 the changes of ecological signification caused by human activities, including tourism, is committed mainly to following land cover patch types: 131 Mineral extraction sites, 242 Complex cultivation patterns, 211Non-irrigated arable land, 312 Coniferous forests. This is mostly the consequence of the type of tourism activities that are in close relation to agriculture production (vine, fruit, and cereals) which is still dominant human activity in Fruška Gora Mt. Ecological signification of the tourism zones was moved to level four from level two.

5. DISCUSSION

The landscape of the selected areas and their tourism zones should be characterized by spatial configuration and landscape composition, which directly influences ecological processes. The tourism zones are part of the total landscape that is influenced by of recreational activities. Those activities are completely changing number, size, density, shape and diversity of land cover patches. According to output values of landscape quantifying is possible to express a quality of on-going ecological processes in landscape.

Table 4 Ecological signification of the land Cover patches, the tourism zones in the Štiavnica Mountains

Code	Name of Land Cover patches in Tourism zones	S_A	NP		PD		MPS		PSSD		MSI		S_C
			$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	
112	Discontinuous urban fabric	**5**	23	5	992	5	92	5	52	5	83	5	**5**
131	Mineral extraction sites	**2**	50	4	1800	5	9	2	0	2	85	5	**4**
142	Sport and leisure facilities	**4**	100	5	4025	5	94	5	141	5	95	5	**5**
211	Non-irrigated arable land	**2**	10	2	406	5	15	2	10	2	84	5	**3**
231	Pastures	**2**	11	2	449	5	29	3	26	3	86	5	**4**
242	Complex cultivation patterns	**2**	7	2	300	5	201	5	0	2	65	5	**4**
243	Land principally occupied by agriculture	**2**	17	2	733	5	31	3	26	3	73	5	**4**
311	Broad-leaved forest	**1**	81	4	3034	5	1	1	0	1	72	4	**3**
312	Coniferous forest	**2**	33	2	1464	5	24	2	68	4	85	5	**4**
313	Mixed forest	**1**	44	3	1867	5	10	1	12	1	80	5	**3**
324	Transitional woodland shrub	**1**	28	2	1160	5	14	1	14	1	88	5	**3**
Total ecological signification of the tourism zones		2	3		5		3		3		5		4

Symbols legend: S_A - Starting values of ecological signification for each one land covers patch class. The levels are assigned according to Hrnčiarová et al., 1997.

S_B - Assigned values of ecological signification for each one land cover patch class by proportion scale degree.

S_C – Determined values of ecological signification for each one land cover patch class by average NP, PD, MPS, PSSD and MSI.

$P_{\%}$ - Percentage proportion values (NP, PD, MPS, PSSD and MSI) of Tourism zones to values (NP, PD, MPS, PSSD and MSI) of Total landscape area.

NP Number of patches
PD Patch density
MPS Mean patch size
PSSD Patch size standard deviation
MSI Mean shape index

Qualifying of on-going ecological processes is based on interpretative of landscape metrics toward to ecological signification of the landscape. Tables 4 and 5 represent determined value of ecological signification for each land cover patch classes. Input ecological signification (S_A) of landscape in tourism zones is determined by scale degree of Hrnčiarová et al., (1997). Methodology of Ecological carrying capacity is based on scientific work of Landscape Ecological Planning (LANDEP) by Ružička and Miklós (1982, 1990). Survey research studies to present have not yet made any follow-up, respectively expanding the research base for LANDEP landscape planning methodology. The last official revision or improving of LANDEP methodology is dated to work of Hrnčiarová et al., 1997.

This study presents simply model (methodology) application of landscape metrics for interpretation of human impact on the landscape. Chosen methodology is combination of ecological and geographical approaches in landscape research. The geographical approach is based on quantifying (landscape metrics) of state land cover patches in landscape. The ecological approach is based on interpretative relationships between the state of land cover patches and on-going ecological processes in landscape. The approach is mainly focused on landscape fragmentation aspect and its interpretation. Landscape fragmentation commonly disrupts the integrity of a stream network system, water quality of an aquifer, the natural disturbance regime in which species evolved and persist, ant other ecosystem processes (Binford & Buchenau, 1993; Forman & Godron, 1986; Hobbs, 1993; Pickett & White, 1985; Turner, 1987). Many species, including most large mammals and birds, cannot maintain viable populations in small habitat patches, which lead to extinction and loss of biodiversity (Forman, et al., 1976; Harms et al., 1987; Saunders et al., 1987; Soulé, 1987; Wilson, 1992).

Table 5 Ecological signification of the land cover patches, the tourism zones in the Fruška Gora Mt.

Code	Name of Land Cover patches in Tourism zones	S_A	NP		PD		MPS		PSSD		MSI		S_C
			$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	
112	Discontinuous urban fabric	5	30	5	300	5	64	5	60	5	95	5	5
121	Industrial or commercial units	5	14	5	140	5	29	5	0	5	103	5	5
131	Mineral extraction sites	2	29	3	280	5	80	5	61	5	104	5	5
211	Non-irrigated arable land	2	116	5	1130	5	2	2	1	2	83	5	4
221	Vineyards	3	24	4	233	5	6	3	11	3	108	5	4
222	Fruit trees and berry plantations	3	18	3	175	5	0	3	0	3	109	5	4
231	Pastures	2	25	3	233	5	8	2	22	3	79	5	4
242	Complex cultivation patterns	2	64	5	633	5	56	4	72	5	88	5	5
243	Land principally occupied by agriculture	2	59	4	575	5	63	5	119	5	84	5	5
311	Broad-leaved forest	1	123	5	1202	5	6	1	2	1	84	5	3
312	Coniferous forest	2	100	5	700	5	97	5	x	x	96	5	5
313	Mixed forest	1	56	3	583	5	25	2	30	2	106	5	3
324	Transitional woodland-shrub	1	24	2	230	5	31	2	40	2	85	5	3
511	Water courses	2	250	5	2350	5	2	2	3	2	86	5	4
512	Water bodies	2	38	3	350	5	5	2	9	2	92	5	3
Total ecological signification of the tourism zones		**2**	**4**		**5**		**3**		**3**		**5**		**4**

Legend:SA - Baseline values of ecological signification for each one land covers patch class. The levels are assigned according to Hrnčiarová et al., 1997.

SB - Assigned values of ecological signification for each one land cover patch class by proportion scale degree.

SC - Determined values of ecological signification for each one land cover patch class by average NP, PD, MPS, PSSD and MSI.

$P_{\%}$ - Percentage proportion values (NP, PD, MPS, PSSD and MSI) of Tourism zones to values (NP, PD, MPS, PSSD and MSI) of Total landscape area.

NP Number of patches

PD Patch density

MPS Mean patch size

PSSD Patch size standard deviation

MSI Mean shape index

The result of the tourism impact on the landscape in protected area (Slovakia and Serbia) is the fragmentation of land cover patches. Recreational activities are the main reason of disruptions the integrity of the landscape in researched tourism zones. The increase of the landscape fragmentation may lead to the decreasing of biodiversity in future (Saunders et al., 1991; Harris 1984).

The interpretation process is partial based on the existing methodology for Ecological carrying capacity (Hrnčiarová et al., 1997). This methodology does not bring clarification for assignation levels of ecological signification (S_A). The level of ecological signification was directly given by this methodology that represents the results from the operations of the ecological processes in landscape. In addition, starting values were than modified by outputs values of landscape metrics. Modification of this level was based on percentage proportion ($P_{\%}$) of landscape metrics of tourism zones in total area of the protected areas. The authors defined the scale degree for the proportions to modify starting values (S_A). Chosen methodology is a particular experiment used to objectively determine the levels of ecological signification for all patch cover classes. Used methodology is focused on the fact that influence of the recreational activities (tourism zones) completely change ecological signification in selected landscapes. The methodology was verified on two model areas, which are protected by national laws.

On the other hand, quantification is often used only for comparing one area in different time period. This study brings approach that can compare different areas in the same time by landscape metrics. Numbers of papers were focused on time aspects of the landscape changes. It would be interesting to compare both landscapes at different time periods to determine ecological signification of land cover patches.

6. CONCLUSION

The main result of this work is determined ecological significant that focuses on tourism impact on land cover patches. The methodology used for interpretative process is based on intersection of ecological and geographical approach to landscape research. The landscape changes are the result of the influences of tourism zones to the land cover patches. The interpretative process examines land cover patches by the set of landscape metrics for area, size, density, shape and diversity (NP, PD, MPS, PSSD and MSI). The output values could express a spatial process in landscape, such as perforation, dissection, fragmentation, shrinkage or attrition.

Land cover patches represent spatial information of landscape, which was processed and interpreted by geoinformation technology. Spatial and data attributes of the land cover patches allows:

- First, to locate each land cover patch and make spatial analyst of total area and tourism zones.
- Second, to measure area, size, density, shape and diversity of land cover patches in tourism zones and in total area.
- Third, to make database operation for evaluation process.

Protected landscape lrea of Fruška Mt, and especially the area of Štiavnica Mts. indicate strong tourism impact on landscape. In case of both study areas ecological signification of land cover patches was moved from level two to level four.

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Received at: 30. 01. 2012
Revised at: 12. 06. 2012
Accepted for publication at: 25. 06. 2012
Published online at: 29. 06. 2012