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Evaluation of Human Impact on the Land Cover Through Landscape Metrics: Nature Park "Šargan – Mokra Gora" (Serbia)

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1. Introduction

The environment provides numerous goods and services to humanity. The integration of ecology into general development, according to the principle of sustainable development, is an obvious necessity [46]. Systematic description of the environment for detection of environmental changes and the human-related causes and responses is essential in land cover and land-use change studies. The terrestrial surface 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" [52, 53, 29, 33]. 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 structure [34]. 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. Land-cover modification is possible to measure with mathematical metrics [57, 15, 12, 41].

A landscape can be characterized by both its composition and configuration, sometimes referred to as landscape physiognomy or landscape pattern [11, 56]. Current landscape is a result of various factors, including variability in biotic 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.

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 [51, 10, 58, 22, 31 ,9, 6]. 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 [54, 44, 5]. 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 [14]. Levis [39] 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. Levis' second category is phase difference; deal with spatial pattern resulting from disturbances. The ecosystem responds to a local disturbance by going through succession. Levi's third category, dispersal, prevents the landscape from becoming uniformly covered with a single, dominant population.

On the other side, using of the landscape as land use has been defined as the purposes for which humans exploit the land cover. It involves both the manner 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 [35]. However, any change of landscape use makes transformation in landscape pattern and land cover. Landscape pattern consists of the sum of elements that independently or together influences variety ecological processes in the landscape [41]. Landscape patterns and ecological processes are linked and can be predicted from broad-scale pattern [2, 20].

This paper analyse landscape components (land cover patches) and human activities (their impact on land cover) at three zones with different levels of protection in nature park. The main purpose of the analyses is to quantify landscape elements, land cover patches within protected zones. Quantified land cover patches are bringing most useful information about state of landscapes that are impacted by human influences. By the interpretation of the quantified data, the authors have determined ecological signification of three zones.

2. Landscape Metrics and Ecological Signification

Quantified lands cover patches and their outputs metrics is possible to apply for many ecological and geographical applications. The number of set land covers patches expressed: result of the used mapping scale [40]; appearance of habitats which are bound to a specific type of land cover patches category – class [19]; diversity influences on species interaction within land cover's patches. Landscape with more classes of patches exhibits greater diversity (heterogeneity). With the increasing diversity, mainly is growing- up the diversity of on-going ecological processes in landscape [32]; anthropogenic pressures, such as a wide range of human activities in the landscape. The result of anthropogenic activities is the increasing number of landscape elements, which according to Franklin, Forman [17] to disrupt the integrity of the landscape area. Thus disturbed area responds differently to external disturbances, e.g. fires, or wind flow.

The area of land cover patches focuses on the argument of Forman [13] that small land cover patches are actually holistic habitat types. However, it is not a general rule, as large land cover patches often include several types of habitats or ecosystems. Several smaller land cover patches which are distributed in the area increase the overall heterogeneity of the landscape, but also its fragmentation. Most often differences in patch size variability suggest that the human-altered landscapes contain more uniformity in patch size than the unaltered landscape. 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 such influences wind flow in the area of forest vegetation, which may be reflected in changes in microclimate [47, 7] and subsequently

changing the vegetation structure. Each organism reflects to the shape and boundaries of the environment in another way.

The land cover can be defined by attributes of the Earth's land surface as well as by ecological signification of each land surface element. According to Hrnčiarová et al. [28] 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 [27].

3. Material and Methods

Landscape elements are changing over time and by landscape metrics is possible to compare same landscapes within different time periods or spatial different landscapes in the one time period. Methodology for the evaluation of landscape is based on quantification of land cover patches. This research is focused on the comparison of three protected landscapes zones that are under human impact. Most of the landscape metrics are based on mathematical – statistical approach that measures an area, perimeter, length and shape. The model will help to identify the impacts that human activities may have on the ecological condition within the nature park; it is necessary to understand these potential impacts in order to select appropriate monitoring variables. Many researchers have been defined wide scale of landscape metrics [1, 21, 43, 30]. Quantification of landscape elements (land cover patches) in this papers was based on following landscape metrics:

Class area – equals the sum of the areas belonging to a given class. Units of equals: hectares (ha).	$CA = \sum_{j=1}^{n} a_{ij}$
Total area – equals the area of the all land cover patches. Units of equals: hectares (ha).	$TA = A$
Number of patches – equals the number of land cover patches in each patch type – class.	$NP = n$

Patch density – equals the number of land cover patches divided by total landscape area. Units of equals: number of patches per 1 000 hectares (ha).	$PD = \frac{n}{A}(1000)$
Mean patch size – equals the sum of the area of all land cover patches divided by the number of patches of the same type. Units of equals: hectares (ha).	$MPS = \frac{\sum_{j=1}^{n} a_{ij}}{n}$
Mean shape index – equals the average shape index of land cover patches of the corresponding patch type.	$MSI = \frac{\sum_{j=1}^{n} \left(\frac{p_{ij}}{2\sqrt{\Pi^{o} a_{ij}}} \right)}{n}$
Shannon's Diversity Index – Equals minus the sum, across all patch types, of the proportional abundance of each patch type multiplied by that proportion.	$SHDI = -\sum_{i=1}^{m} \left(P_i{}^{o} \ln P_i \right)$
Patch size standard deviation – equals size deviation of each land cover patches in own classes. Units of equals: hectares (ha).	$PSSD = \sqrt{\frac{\sum_{j=1}^{n} \left[a_{ij} - \left(\frac{\sum_{j=1}^{n} a_{ij}}{n} \right) \right]^2}{n}}$

Where the subscripts and symbols of algorithms express:

- $j = 1$ → n patches
- $i = 1$ → m patch types (classes)
- n → number of patches in the landscape of patch type i
- m → number of patch types (classes) present in the landscape
- A → total landscape area (hectares)
- a_{ij} → area (hectares) of patch ij
- p_{ij} → perimeter (meters) of patch ij
- P_i → proportion of the landscape occupied by patch type (class) i.

3.1. Study area

By its physical features, the Nature Park "Šargan – Mokra Gora" (43˚46 N; 19˚30 E) belongs to the Inner Dinarides, namely to the Old Vlach – Ras heights that build the western boundary of Serbia.

The international major highway E-761, which crosses Serbia, Bosnia and Herzegovina, and Croatia, passes through Šargan and Mokra Gora, connecting in this way the south-eastern and the Western Europe.

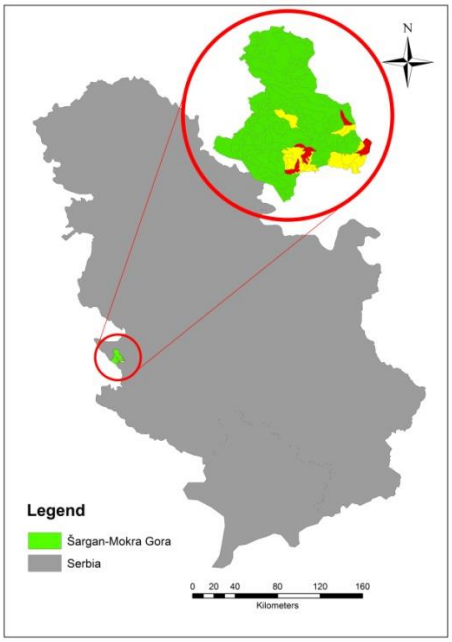

Fig. 1. Location of Nature Park „Šargan – Mokra Gora“ in Serbia
Rys. 1. Położenie Parku Przyrody „Šargan – Mokra Gora” w Serbii

The region of Šargan and Mokra Gora, and the southern slopes of the Tara Mt. have been a part of the protective zone of the National Park "Tara" since 1981, when the National Park was proclaimed, until 2004, when it was put under the previous conservation regime by the Decree of the Institute for Nature Conservation of Serbia No. 02-592/1, in keeping with the Law on Environmental Protection [36, 37], until the Decree on Conservation was issued. The Decree on the previous conservation regime was valid until 2005, when the status of the Landscape of Outstanding Features, as a natural asset of exceptional national importance, was assigned following the Decree on Conservation of the Landscape of Outstanding Features "Šargan – Mokra Gora". The manager of the Nature Park "Šargan – Mokra Gora" is the Limited Liability Company "Nature Park Mokra Gora", founded by the Government of the Republic of Serbia. In keeping with the Law on Nature Conservation [8], the manager of the protected area is obliged to, among other things, preserve, improve, and promote the protected area, implement the prescribed protection regimes, issue the management plan and the act on internal organization

and guardian service, mark the protected area, guarantee the undisturbed course of the natural process and sustainable usage of the protected area, provide supervision over implementation of conditions and measures of nature protection, keep an eye on movements and activities of the visitors, keep evidence on natural assets, on human activities, actions, and processes that represent a threat factor to the protected area, prevent all activities and actions that are opposed to the act on protection and that represent a threat and devastation factor to the protected area, issue the act on reimbursements, and realize other activities consistent with the law and the act on protection.

3.2. Land cover patches classification

The classification of land cover patches was based on Corine Land Cover 2000 (CLC2000) which provides consistent information on land cover and land cover changes across Europe.

The standard CLC nomenclature includes 44 land cover classes. The five main categories are: 1) artificial surfaces, 2) agricultural areas, 3) forests and semi-natural areas, 4) wetlands, and 5) water bodies [25]. All national teams adopted this standard nomenclature.

The approach of computer assisted visual interpretation of satellite images was chosen as the main mapping methodology. During the first CLC inventory the photo interpretation method was done on hard-copies: a transparent overlay was fixed on top of a satellite image and the photo interpreter drew polygons on it marking them with a CLC code. Later the overlay was digitised, topology was created and the CLC code entered [4].

3.3. Methods for determination of ecological signification

According to Gustafson, Gergel and Tuner, and Forman [20, 18, 13] each land cover is possible to measure by landscape metrics for size, density, shape, edge and diversity. The outputs values from landscape metrics directly indicate influence 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.

Output of the interpretation is determined by the level of ecological signification in following levels [28]:
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 increase of the level of ecological significance, the quality of landscape ecological processes in the landscape also increases. The first step of the interpretative process is to assign the level of ecological signification (S_A) for each land cover patch classe. The process of assignation is based on the operations of the ecological processes in the landscape. The next step is the interpretation of the landscape metrics (NP, PD, MPS, PSSD and MSI) which is based on detecting the percentage proportion ($P_{\%}$) of the protected zones values into the values of total landscape area. This step modified assigned level of the ecological signification (S_A) by following scale:

0–20% assign the same value as baseline S_A value,
21–40% move the baseline $S_{A,}$ one level up,
41–60% move the baseline $S_{A,}$ two levels up,
61–80% move the baseline $S_{A,}$ three levels up,
81–100% move the baseline $S_{A,}$ 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 each land patch class.

4. Results

The main results are quantified land cover patches in protected zones within Nature Park "Šargan – Mokra Gora". Outputs of the landscape quantification are number values which can be interpreted toward to the quality of on-going ecological process in landscape.

4.1. Land cover of protected zones in Nature Park "Šargan – Mokra Gora"

The area of 1st level protected zone in "Šargan – Mokra Gora" occupy 355,12 ha, that is 3,31% of the total area. Area of 2nd level protected zone occupy 1167,15 ha, that is 10,88% of the total area and area of 3rd zone occupy 9201,53 ha or 85,80% of the total area of "Šargan – Mokra Gora"

Table 1. Land cover patches and protected zones in the "Šargan – Mokra Gora" Nature Park
Tabela 1. Płaty pokrycia terenu i strefy chronione w Parku Przyrody „Šargan – Mokra Gora"

Code	Šargan – Mokra Gora		Zone I		Zone II		Zone III	
	ha	%	ha	%	ha	%	ha	%
231	76,49	0,71	-	-	-	-	76,49	0,83
242	31,82	0,30	-	-	-	-	31,82	0,35
243	1071,85	10,00	5,31	1,50	14,62	1,25	1051,91	11,43
311	2159,09	20,13	233,43	65,73	555,05	47,56	1370,5	14,89
312	2281,98	21,28	56,97	16,04	223,07	19,11	2001,94	21,76
313	2248,25	20,97	40,72	11,47	310,45	26,60	1897,21	20,62
321	659,36	6,15	-	-	1,84	0,16	657,52	7,15
324	2194,96	20,47	18,69	5,26	62,12	5,32	2114,14	22,98
	10723,8	**100**	**355,12**	**100**	**1167,15**	**100**	**9201,53**	**100**

Where land cover patches – class type are: 231 – Pastures, 242 – Complex cultivation patterns, 243 – Land principally occupied by agriculture,
311 – Broad-leaved forest, 312 – Coniferous forest, 313 – Mixed forest,
321 – Natural grassland and 324 – Transitional woodland shrub.

Number of patches (NP) in 1st level protected zone is 9. That is 11,53% from all patches (78 patches). NP in 2nd level protected zone is 19 – or 24,35%, while number of patches in 3rd zone is 76 what is 97,43% from all patches.

Patches density (PD) value of 1st level protected zone is 25,34 patches per 1.000 hectares. In 2nd level protected zone PD is 16,28 while in 3rd is 8,26 while for whole area of "Šargan – Mokra Gora" is 7,27. The occurrence of a lot of small patches in 1st level protected zone is the

main reason for the highest concentration of patches. PD shows that 1st level protected zone is extensively fragmented, 2nd zone is moderate fragmented, while 3rd zone is the most continuous.

From the number of patches and their area is possible to determinate Mean patch size (MPS). Outputs values from MPS are focused on fact that land cover patches vary greatly in size in three different zones. At 1st level protection zone, there are small value of MPS (41,72 ha). In 2nd zone MPS is 53,62 ha and in 3rd is 103,53 ha. In total area of "Šargan – Mokra Gora" MPS is 115,35 ha. Small increase in MPS between the zones, compared to the huge difference in their surface, confirm that the first zone is extensively fragmented, the second is moderate fragmented, and the third is the most continuous.

Patch size standard deviation (PSSD) is focused on the significance of size differences among patches in "Šargan – Mokra Gora". In this case, the value of PSSD that is closer to zero means same size of all patches indicating more extensive human impact on the land cover. For some patches PSSD value is zero because, there is just one patch from class in whole zone. The most patch size differences in 1st level protected zone are in following patch's types: 311 Broad-leaved forests, 313 Mixed forest. That means this two patch's types still keep its shape, i.e. humans impacts aren't so extensive. In 2nd zone PSSD is highest also for patches 311 Broad-leaved forest and 313 Mixed forest. In other patches in this zone, PSSD is smaller i.e. human impacts are more extensive, which is not suitable for protected area. In 3rd zone, compared to number of patches, PSSD has a higher value for all patches.

Mean shape index (MSI) indices shape of patches. Value index increases with irregularity of patch shape. Patches with low value has circular shape it focused on small range of human impact. This metrics is needed to be interpreted together with number of patches or area. MSI of 1st level protected zone is 1,88 while MSI of total area of "Šargan – Mokra Gora" is 2,01. Very high value (over 2) in 1st level protection zone has following patches: 324 Transitional woodland shrub, 311 Broad-leaved forest and 313 Mixed forest. Oppositely, low values shows patches 243 Principally occupied by agriculture and 313 Mixed forest. MSI of 2nd zone is 2,17 and is bigger compared to whole "Šargan – Mokra Gora" protect area. In 3rd zone MSI is 2,06 and it's bigger than MSI of whole "Šargan – Mokra Gora", but smaller compared to 2nd zone.

Table 2. Landscape metrics of the land cover patches
Tabela 2. Metryki krajobrazowe płatów pokrycia terenu

metric	Class	231	242	243	311	312	313	321	324	total
NP	Š-MG	3	1	10	9	13	16	9	17	**78**
	1st zone	-	-	2	2	1	3	-	1	**9**
	2nd zone	-	-	2	5	2	4	1	5	**19**
	3rd zone	3	1	10	7	13	16	9	17	**76**
PD	Š-MG	0,28	0,09	0,93	0,84	1,21	1,49	0,84	1,59	**7,27**
	1st zone	-	-	5,63	5,63	2,82	8,45	-	2,82	**25,34**
	2nd zone	-	-	1,71	4,28	1,71	3,43	0,86	4,28	**16,28**
	3rd zone	0,33	0,11	1,09	0,76	1,41	1,74	0,98	1,85	**8,26**
MPS	Š-MG	25,49	31,82	107,18	239,89	175,54	140,52	73,26	129,11	**115,35**
	1st zone	-	-	2,65	116,71	56,97	13,57	-	18,69	**41,72**
	2nd zone	-	-	7,31	111,01	111,53	77,61	1,84	12,42	**53,62**
	3rd zone	25,49	31,82	105,19	195,78	153,99	118,57	73,05	124,36	**103,53**

Table 2. cont.
Tabela 2. cd.

metric	Class	231	242	243	311	312	313	321	324	total
PSSD	Š-MG	15,98	0	111,61	327,97	302,67	201,42	96,68	192,6	**156,12**
	1st zone	-	-	0,56	50,89	0	16,93	-	0	**13,68**
	2nd zone	-	-	2,85	101,16	39,76	68,59	0	21,82	**39,03**
	3rd zone	15,98	0	110,78	212,34	273,81	198,13	96,77	194,37	**137,77**
MSI	Š-MG	1,34	1,63	1,87	2,12	2,10	1,97	1,69	2,32	**2,01**
	1st zone	-	-	1,15	2,23	1,56	2,06	-	2,44	**1,88**
	2nd zone	-	-	2,53	2,29	2,08	1,98	1,27	2,27	**2,17**
	3rd zone	1,34	1,62	1,8	2,46	2,27	1,99	1,68	2,3	**2,06**

According to landscape metrics it is possible to state that land cover patches in 1st level protected zone is significant fragmented by human impact and at the same time are very heterogonous. But in some patches as 311 Broad-leaved forest, 313 Mixed forest and 324 Transitional woodland shrub, human impacts aren't extensive, and they have original unchanged natural form. According to some factors (PSSD and MSI) ecological conditions are more suitable in 3rd than in 2nd level zone of protection.

By the Shannon's Diversity Index (SDI), determined diversity is possible to verify the diversification. The land cover patches within 1st level protection zone has SDI 1,036 what is less than in 2nd zone (1,243), or 3rd zone (1,775) or in total area of "Šargan – Mokra Gora" (1,758). That means, except 1st zone is the most fragmented, patches in this zone are unevenly distributed compared to the others protected zones.

According to output values of landscape quantifying is possible to express a quality of on-going ecological processes in landscape. Qualifying of on-going ecological processes is based on interpretation of landscape metrics toward to ecological signification of the landscape, where:

- S_A-Starting values of ecological signification for each one land covers patch class.
- 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 protected zones to values (NP, PD, MPS, PSSD and MSI) of Total landscape area.

Table 3 represents determined value of ecological signification for each one land cover patch classes.

Input ecological signification (S_A) of landscape in protected zones is by scale degree of Hrnčiarová et al. [28]. The landscape of 1st protected zone is expressed by level two, what means significant land cover patches. 1st protected zone is part of the total landscape where is influencing of recreational, tourism and other activities forbidden. Unfavourable relation among patches (PD, MSI and MPS) influences change as well as

ecological signification of 1st protected zone, which is now in level three (moderately significant land cover patches).

Table 3. Ecological signification of the land cover patches, 1st zone
Tabela 3. Znaczenie ekologiczne płatów pokrycia terenu; strefa 1

Code	S_A	NP		PD		MPS		PSSD		MSI		S_C
		$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	
243	2	20	2	605	5	3	2	1	2	61	5	3
311	2	22	3	670	5	49	4	16	2	105	5	4
312	2	8	2	233	5	32	3	0	2	74	5	3
313	1	19	1	567	5	10	1	8	1	105	5	3
324	3	6	3	177	5	14	3	0	3	105	5	4
Total ecological signification of the 1st zone	**2**	2		5		3		2		5		**3**

Where land cover patches – class type are: 243 – Land principally occupied by agriculture, 311 – Broad-leaved forest, 312 – Coniferous forest, 313 – Mixed forest, 324 – Transitional woodland shrub.

In 2nd zone (Table 4) human activities like (recreation, tourism and other activities) are allowed, but limited. Ecological signification of this zone, decreased from level two to level three (from significant land cover patches to moderately significant land cover patches).

In 3rd zone (Table 5), where above mentioned human activities are allowed and unlimited, the activities completely changed number, size, density, shape and diversity of land cover patches that are located under society influencing.

Table 4. Ecological signification of the land cover patches, 2nd zone
Tabela 4. Znaczenie ekologiczne klas pokrycia terenu; strefa 2

Code	S_A	NP		PD		MPS		PSSD		MSI		S_C
		$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	
243	2	20	2	184	5	7	2	3	2	15	2	3
311	2	56	4	510	5	46	4	31	3	12	2	4
312	2	15	2	141	5	64	5	13	2	11	2	3
313	1	25	2	230	5	55	3	34	2	11	1	3
321	1	11	1	102	5	3	1	0	1	8	1	2
324	3	29	4	270	5	10	3	11	3	11	3	4
Total ecological signification of the 2nd zone	**2**	3		5		3		2		2		**3**

Where land cover patches – class type are: 243 – Land principally occupied by agriculture, 311 – Broad-leaved forest, 312 – Coniferous forest, 313 – Mixed forest, 321 – Natural grassland and 324 – Transitional woodland shrub.

Table 5. Ecological signification of the land cover patches, 3rd zone
Tabela 5. Znaczenie ekologiczne klas pokrycia terenu; strefa 3

Code	S_A	NP		PD		MPS		PSSD		MSI		S_C
		$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	$P_{\%}$	S_B	
231	2	100	5	117	5	100	5	100	5	100	5	5
242	2	100	5	117	5	100	5	0	2	100	5	4
243	2	100	5	117	5	98	5	99	5	96	5	5
311	2	78	5	91	5	82	5	65	5	116	5	5
312	2	100	5	117	5	88	5	90	5	108	5	5
313	1	100	5	117	5	84	5	98	5	101	5	5
321	1	100	5	117	5	100	5	100	5	99	5	5
324	3	100	5	117	5	96	5	101	5	99	5	5
Total ecological signification of the 3rd zone	**2**	5		5		5		5		5		**5**

Where land cover patches – class type are: 231 – Pastures, 242 – Complex cultivation patterns, 243 – Land principally occupied by agriculture,
311 – Broad-leaved forest, 312 – Coniferous forest, 313 – Mixed forest,
321 – Natural grassland and 324 – Transitional woodland shrub

The influencing changes as well as ecological significance of landscape, which was in level two, now is in level five (insignificant land cover patches). The most modified land cover patches are in 3rd level protection zone, because human activates are present in the greatest extent.

5. Discussion

The range of the human activities impacting protected areas was determined by ecological signification of land cover patch types. Impact of tourism and other activities on the landscape was observed through fragmentation of the land cover patches [42]. 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 [3, 16, 26, 45, 55]. Many species, including most large mammals and birds, cannot maintain viable populations in small habitat patches, which lead to extinction and loss of biodiversity [15, 24, 48, 59, 50, 38]. The result of the human activities impact on the landscape in protected area is the fragmentation of land cover patches. Recreational activities are the main reason of disrupts the integrity of the landscape in researched zones. Growing up of the landscape fragmentation may contribute to the losing of biodiversity [49, 23].

This study presents simply model application of landscape metrics for interpretative society impact on the landscape. Chosen methodology is intersection of ecological and geographical approach to landscape research. The geographical approach is based on quantifying of state land cover patches in landscape. The ecological approach is based on interpretative relationships between state of land cover patches and on-going ecological processes in landscape. The main task of ecological approach was interpretation of the spatial process in landscape, such as fragmentation. Interpretation process is partially based on the existing methodology for ecological carrying capacity. This methodology is not bringing special clarification for assignation levels of ecological signification (S_A). This approach directly gives the level of ecological signification that represents the results from the operations of the ecological processes in landscape. At the same time, this study represents the starting values which were modified by outputs from landscape metrics. Modification of this level was based on percentage proportion ($P_{\%}$) of landscape metrics of the protected zones to total protected area. By defined scale degree for

the proportion was modified starting values (S_A). Chosen methodology is a particular experiment by which were objectively determined levels of ecological signification for each one patch cover classes. Used methodology is focused on the fact that influencing of the human activities completely changed ecological signification in selected landscapes. The methodology was verified on model area which is protected by national laws.

On the other hand, quantification is often used only for comparing one area in different time period. This work brings approach where is possible to comparing one area with different level of protection in the same time by landscape metrics. Numbers of papers are focused on time aspect of the landscape changes. It would be interesting to compare three landscapes at different time period and then to determine ecological signification of land cover patches.

6. Conclusion

The main result of this research is determined ecological significant that focuses on human 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 as the result of the protected zones influencing on the land cover patches. The interpretative process examines land cover patches by set the 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.

Nature Park "Šargan – Mokra Gora" indicate strong human impact on landscape. In 1st and in 2nd level protected zones ecological signification decrease from level two to level three, and in 3rd level protected zone ecological signification decrease from level two to level five.

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Oceny wpływu człowieka na pokrycie terenu z zastosowaniem metryk krajobrazowych: Park Przyrody "Šargan – Mokra Gora" (Serbia)

Streszczenie

Oddziaływanie człowieka może mieć znaczny wpływ na ekologiczną istotność pokrycia terenów. Określenie modyfikacji pokrywy terenu jest możliwe z zastosowaniem metryk matematycznych, które ilościowo określają różne aspekty krajobrazu. Badania przedstawione w niniejszej publikacji dotyczą płatów pokrycia terenu na trzech różnych poziomach ochrony w Parku Przyrody Šargan – Mokra Gora (Serbia) poprzez zestaw metryk krajobrazowych obszaru, wielkości, gęstości, kształtu i różnorodności (NP, PD, MPS, PSSD, MSI, SHDI). W badaniach klasyfikacja płatów pokrycia terenu była oparta na Corine Land Cover 2000 (CLC2000). Głównym celem badań było określenie ekologicznego znaczenia krajobrazu, które koncentruje się na wpływie człowieka na płaty pokrycia terenu. Metodologia wykorzystywana w procesie interpretacyjnym oparta jest na połączeniu ekologicznego i geograficznego podejścia do badań krajobrazu. Metryki krajobrazowe Parku Przyrody Šargan – Mokra Gora (Serbia) wskazują na silny wpływ człowieka na krajobraz. Wyniki pokazują, że oddziaływanie człowieka na krajobraz zmieniło jego ekologiczne znaczenie głównie w przypadku drugiej i trzeciej strefy ochrony.

Słowa kluczowe: GIS, płaty pokrycia terenu, metryki krajobrazowe, Šargan – Mokra Gora
Key words: GIS, land cover patches, landscape metrics, Šargan – Mokra Gora