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SPATIAL ANALYSES OF LANDCOVER AND RELIEF DIVERSITY OF THE MEDVEDNICA NATURE PARK – POSSIBLE IMPLICATIONS FOR OPTIMISING VISITOR PRESSURE

PROSTORNA ANALIZA ZEMLJIŠNOG POKROVA I RELJEFA PARKA PRIRODE MEDVEDNICA – DOPRINOS OPTIMIZACIJI PRITISKA POSJETITELJA

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Summary

The Nature Park Medvednica, which is V protection category, according to the IUCN categorization implies recreation beside landscape preservation management in terms of natural protection, tourism and recreation, as well as scientific research, biodiversity preservation, education and sustainable exploitation of natural resources. The forests represent basic value of this area and condition its purpose and management. It has been determined that habitat diversity indices vary dependently on data spatial resolution. The habitat map M 1:25,000 showed to be the most appropriate (compared to 1:50,000 and 1:100,000 scales) for the analyses of the Park's management and for certain areas the data of higher spatial resolution would be desirable. Data on plant diversity, and previously calculated landforms diversity per MTB 1/64 grid units were used as well. When identifying the tourist and visiting areas of the Park it is necessary to include biodiversity value of the area in order to sustainably manage among nature and cultural protection and tourist exploitation. The GIS usage in nature protection management is justifiable and very efficient, enabling the generation and collection of multidisciplinary data as well as spatial model projection obtained using these data, helping in prompt decision making, saving time and resources.

KEY WORDS: landforms, GIS, habitat map, vegetation map, diversity index

INTRODUCTION
UVOD

In assessing protected areas there are several difficulties to be encountered in regard to biodiversity, ecosystem, clean air and water safety, as well as overall nature protection since these are economically difficult measurable parameters. The value of non-commercial goods and services is necessary to express in monetary terms, wherever possible (WCPA, 1998). Excessive exploitation might occur in case when protected area is not correctly evaluated which decreases ecological goods and services value (Hat, 2003; Jenkins et al., 2004.). World trend indicates decreased finan-

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cing of protected areas (White & Lovett, 1999, Githiru et al., 2015), as well as shift from financing exclusively from public sources to various other sources nowadays (Gurung 2010). Efficient management that covers the most important and threatened areas to be protected on national and global level, is of crucial importance for biodiversity protection as well as for market and non-market goods and services that these areas provide for the local community (Brunner et al., 2004). There are app. 100,000 protected areas worldwide on 18.58 million km^2 of which 11.5% are forest habitats (Jenkins et al., 2004). The establishment of protected area systems demands long term political and financial commitment which is beyond easy proclamation of new parks (Brunner et al., 2004). Insufficient financing indicates the lack of human resources, technical equipment and other management needs which restrict management efficiency in the protected areas.

The Nature Park Medvednica, V protection category, according to the IUCN categorization of protected areas extends on 17,938 ha. The V category implies recreation as well as landscape preservation management (Dudley, 2008). Primary goals imply natural and cultural heritage protection, tourism and recreation, whereas secondary goals imply scientific research, biodiversity preservation, education and sustainable exploitation of natural resources.

The Law on Nature Protection defines a nature park as a vast area of landscape of educative, cultural, historical, tourist and recreational importance. All activities carried out by public agencies are allowed if they are focused on area protection and preservation as a primary goal and education and tourist promotion as a secondary goal (OG 70/2005).

For proper management of any area, and particularly protected ones, it is essential to include as much relevant data as possible from different sectors (e.g. natural science, demography, administration, forestry, agriculture, etc.). Very often those data have different formats, precision, resolution, origin, etc. A geographic information system (GIS) enables successful integration of such diverse data into harmonized database containing all data in compatible format. Such database enables e.g. the creation of zones in some protected areas as a foundation for management planning and decision making. Furthermore, it is possible to develop various scenarios for the estimation of possible impacts on managed areas. It is also very useful in the complex analyses of diversity, such as in Jelaska et al. (2010).

Aim of this study was to identify characteristics of areas with highest visitor pressure in terms of their biodiversity and relief complexity in order to find areas with similar characteristics. Latter can be used for future optimisation of visitor pressure with aim of improving nature conservation success in the Nature Park.

STUDY AREA
PODRUČJE ISTRAŽIVANJA

Medvednica is situated as a separated massif immediately north of the City of Zagreb and represents isolated mountain between Sava, Krapina and Lonja river valleys. There are two landscape complexes, forest areas and settlement areas. Forest complex predominates with few meadow areas. Large number of streams with ravines and karstic ecosystems contribute to landscape diversity of the forest area. Medvednica is of exceptional importance for the City of Zagreb from ecological, esthetical, recreational and touristic aspect.

In 1981 the western part of Medvednica was proclaimed the Nature Park (OG 24/1981). The forests represent basic values of this area and condition its purpose and management. Within the vast forest complex of 14,550 ha the most valuable parts are extracted as forest reserves (996.71 ha) whereas remaining part of forests represent the recreational area. Geological structure of Medvednica is very diverse as well. The rock age ranges from palaeozoic to quaternary beds. All three main rock groups, such as igneous, metamorphic and sediment rocks, are represented. The most represented soils on Medvednica are forest cambisol soils that together with forests make inseparable forest habitats which represent basic natural phenomenon of Medvednica (Pernar, 2008). The problem of illegal urbanization as well as population increase within the Park's confines had occurred in the spatial plan. This led to proposing the change of the Nature Park's borders. In February 2009 the Parliament promoted the Law on amendment of the Law on the Proclamation of Medvednica as the Nature Park (OG 25/2009).

Forests, covering as much as 78% of the total Nature Park's area, are the most significant phenomena. The most widespread forest types are: *Luzulo-Fagetum* beech forests; Illyrian oak-hornbeam forests (*Erythronio-Carpinion*) and Illyrian Fagus sylvatica forests (*Aremonio-Fagion*). Other habitats include streams and springs, thermal springs, bushes and ruderal habitats which are particularly outspread in the area of private properties and forests (Kušan, 2007). Subterranean habitats are a special category. The Veternica cave is famous for being a habitat for fourteen bat species and a series of invertebrates (Ozimec, 2005). In the Nature Park's area the recent data show that there are 1,205 plant species (Nikolić & Kovačić, 2008). Such high plant diversity was analysed by numerous authors (Hršak et al., 1999; Sočo et al., 2002, Cigić et al., 2003; Dobrović et al., 2006a, 2006b, Mareković et al. 2009; Vuković et al. 2010). Due to forest and meadow habitats variety there is large number of fungus findings. Large number of so far identified fungi species is protected and classified in one of the IUCN category of endangered species. According to the Regulations on the Proclamation of Protected and Strictly

Protected Wild Species (OG 07/2006), 56 species of fungi are strictly protected. In the „Red Register of fungi in Croatia" there are 71 species and thereof 21 species are found only in the nature park Medvednica (Tkalčec, 2007). Regarding mammals, the common forest species of special importance are bats represented with 24 species. Some of them inhabit the Veternica cave, whereas others inhabit the forests (Hamidović, 2005). Very high faunal biodiversity of Nature Park can be further seen in numerous papers in which Ćiković (2004) and Tutiš (2007) reports on ornithofauna, Janev Hutinec (2007) on amphibians and reptiles, Šašić (2005) on butterflies, Temunović (2007), Šerić Jelaska & Durbešić (2009), Šerić Jelaska et al. (2010) on other insects, etc.

MATERIAL AND METHODS
MATERIJALI I METODE

Spatial data manipulation and analyses were done in frame of GIS. Digital elevation model with 50-meters spatial resolution was obtained from the Faculty of Science, University of Zagreb, as well as the spatial distribution of vascular plants mapped based on MTB 1/64 grid (Nikolić et al. 1998), and vegetation map at 1:50000 scale. Map of habitats at 1:25000 scale was obtained from the Nature Park, while one at 1:100000 from the State Institute for Nature Protection. All map layers were spatially harmonized using the same basic spatial unit. Used grid is based on the Central European MTB (abbreviation of German term „Meßtischblätter" that stands for a sheet of topographic map) grid that was proposed for mapping of Croatian flora (Nikolić et al., 1998). Basic MTB grid unit of 10' longitude × 6' latitude was further divided into 1/64 subunits, which were then used as a basic spatial units in subsequent analyses.

Digital elevation model was used for the calculation of landforms as proxy for very diverse relief of the Nature Park in subsequent analyses. Landforms are classified in six categories (namely: valley; lower slope; flat slope; middle slope; upper slope; ridge) as shown in Fig.1. Topographic Position Index (TPI), necessary for calculating landforms categories was calculated using the neighbourhood of 1,000 meters. All above calculations were made using the Topographic Position Index extension for ArcView 3.1 from Je-

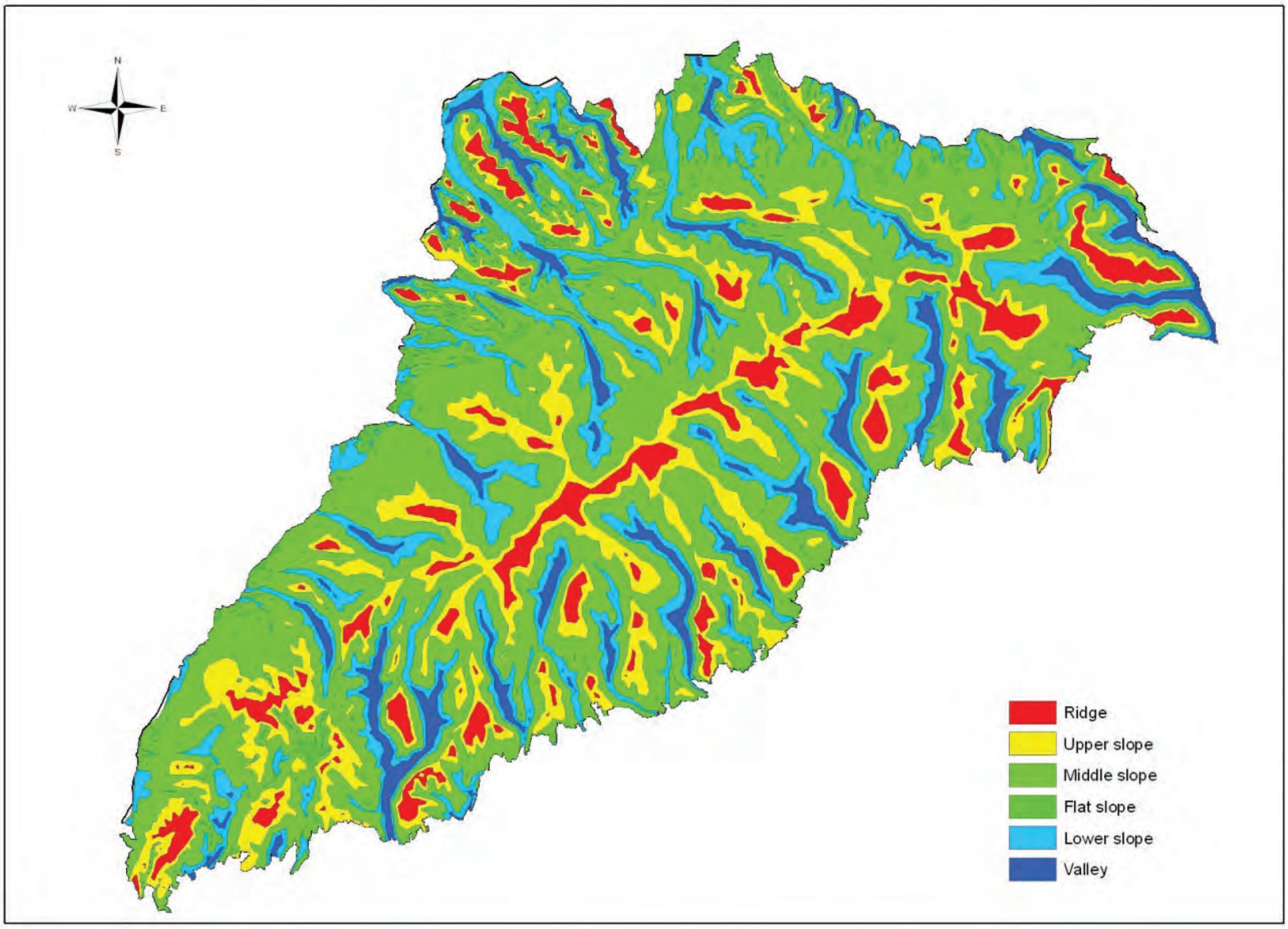

Figure 1. Landform map calculated with 50 meters resolution digital elevation model
Slika 1. Karta reljefnih morfoloških cjelina izračunata na temelju 50-metarskog digitalnog modela terena

Table 1. Shannon-Wiener Index diversity of habitats and landforms, and number of plant species in the selected 7 MTB-quadrants
Tablica 1. Vrijednosti indeksa raznolikosti staništa i reljefa, te broj biljnih vrsta u odabranih 7 MTB kvadranta

Name *Ime*	MTB/64	**Shannon habitats 25000** *Shannon staništa*	**Plant species** *Biljne vrste*	**Relief** *Reljef*
Puntijarka	0061.443	0.41	126	1.38
Tomislavac	0161.212	0.74	135	1.36
Grafičar	0161.211	1.05	101	1.29
Skiing track / *Skijalište*	0061.434	0.70	144	1.19
Hunjka (Horvat)	0061.441	0.28	220	0.95
Kraljičin well / *zdenac*	0161.214	0.68	158	1.47
Medvedgrad	0161.232	1.17	135	1.06

nness (2006). Layer of calculated landform was overlapped with other thematic maps of interest for the analyses of preferred areas for the Nature Park's visitors, i.e. meadows; recreational sites; hiker guest houses; old mine etc. Furthermore, landform data were combined, using GIS spatial operations with: map of habitats; Shannon-Wiener index of habitats per MTB 1/64 unit; plant diversity per MTB 1/64 unit. Obtained results were further analysed with descriptive statistics, while interactions were tested using linear regression.

For each MTB quadrant the *Shannon-Wiener* indexes of relief and habitats diversity were calculated using the formula:

$$H = -\sum_{1}^{s} p_i \ln(p_i)$$

where p represents percentage of area occupied by distinct landform of habitat class in particular MTB quadrant.

MTB quadrants in which are seven most visited areas (Puntijarka, Tomislav lodge – Vidikovac, ski track, Grafičar, Hunjka, Medvedgrad and the spring Kraljičin zdenac) were identified according to the analysed survey conducted among the visitors on their habits in the Park (Malić-Limari, 2009) as well as according to the employee's experience. In Table 1 values of habitat and relief diversity, as well as number of plant species in those MTB quadrants are shown. Range of those values we used for selection of other MTB quadrants in additive manner i.e. to be selected MTB quadrant has to have all three values within range of values found in seven identified MTB quadrants. This way we found MTB quadrants that has similar properties as most frequently visited ones, in terms of its diversity, hence with potential to attract visitors to these „new" areas.

Secondly, we calculated descriptive statistics for number of plant species, habitat and relief Shannon-Wiener diversity across all MTB quadrants (Table 2). These values we used for reclassification scheme as follows:

a) If the value is between the minimum and the lower quartile, the value is 0
b) If the value is between the lower quartile and the arithmetical mean, the value is 0.25
c) If the value is between the arithmetical mean and the upper quartile, the value is 0.5
d) If the value is between the upper quartile and the maximum, the value is 1,

for number of plant species and habitat diversity. We presumed that greater reclassified value indicates the greater quadrant values in terms of its diversity and attractiveness potential for visitors. The exception was made for relief values where greater value can at the same time show the well-indented relief which makes it hardly passable hence less attractive for visitors. Therefore, the relief index values between lower and upper quartiles were chosen as the most favourable ones with highest value. Finally, reclassified values were summed per each MTB quadrant, and values compared amongst most frequently visited quadrants, and rest of it.

RESULTS
REZULTATI

Calculated values of Shannon-Wiener index of habitat diversity per landform classes for different spatial resolutions of habitat/vegetation are shown in Table 3. Calculated values of Shannon-Wiener index of habitat diversity per spatial unit is correlated with the spatial map resolution where lower spatial resolution has lower value of diversity index. All correla-

Table 2. Descriptive statistics for all MTB 1/64 units used
Tablica 2. Vrijednosti deskriptivne statistike korištene u reklasifikaciji

	N	Mean *Aritmetička sredine*	Minimum	Maximum	Lower Quartil *Donji kvartil*	Upper quartil *Gornji kvartil*
Landform div. *Raznolikost morfoloških cjelina*	91	1.219	0.518	1.735	1.063	1.395
Habitats div. *Raznolikost staništa*	91	1.205	0.282	2.014	0.973	1.444
No. Plant sp. *Broj biljnih vrsta*	91	154.242	75	270	118	187

Table 3. Shannon-Wiener indices of diversity of habitats of different resolution of spatial data by landform class (1-ridge, 2-upper slope, 3-middle slope, 4-flat slope, 5-lower slope, 6- valley)
Tablica 3. Shannon-Wiener indeksi raznolikosti staništa različitih rezolucija prostornih podataka po klasama reljefnih morfoloških cjelina (1-greben, 2-gornja padina, 3-srednja padina, 4-ravna padina, 5-donja padina, 6-dolina)

	M1:25 000	M1:50 000	M1:100 000
Landform classes *Klase reljefa*	**Shannon-Wiener indices of diversity** *Shannon-Wiener indeks raznolikosti*		
1	1.85	1.80	1.50
2	1.91	1.71	1.50
3	1.97	1.70	1.59
4	1.86	1.65	1.96
5	2.06	1.60	1.71
6	1.87	1.55	1.53

Table 4. Correlation between the plant species number, Shannon-Wiener indices of diversity of habitats 25 000 and Shannon-Wiener indices of diversity of reliefs
Tablica 4. Međusobne korelacije broja biljnih vrsta, Shannon-Wiener indeksa raznolikosti staništa 25 000 i Shannon-Wiener indeksa raznolikosti reljefa

	r^2	p	N
Relief vs. habitats 25 000 / *Reljef vs.staništa 25 000*	0.1448	0.171	91
Relief vs. number of plant species / *Reljef vs. broj biljnih vrsta*	0.1124	0.289	91
Habitats 25 vs. number of plant species / *Staništa 25 vs. broj biljnih vrsta*	0.2042	0.052	91

tions were positive as shown in Table 4. However, besides the correlation of habitat diversity with plant diversity, the remaining ones were with rather low statistical significance.

Habitat diversity indices (Table 3) based on the habitat map M 1:25,000 showed highest values in comparison to two other habitat maps. Only exception was index in landform class 4 – „flat slope".

Figures 2 and 3 represent Shannon-Wiener index of diversity of habitat and relief, respectively, per MTB quadrants. The habitat diversity map (Figure 2) showed highest diversity index in peripheral region which is a result of presency of all 6 relief classes as well as long lasting human activity on habitats, resulting in the so called „*Landschaftmosaik*" with significant biodiversity.

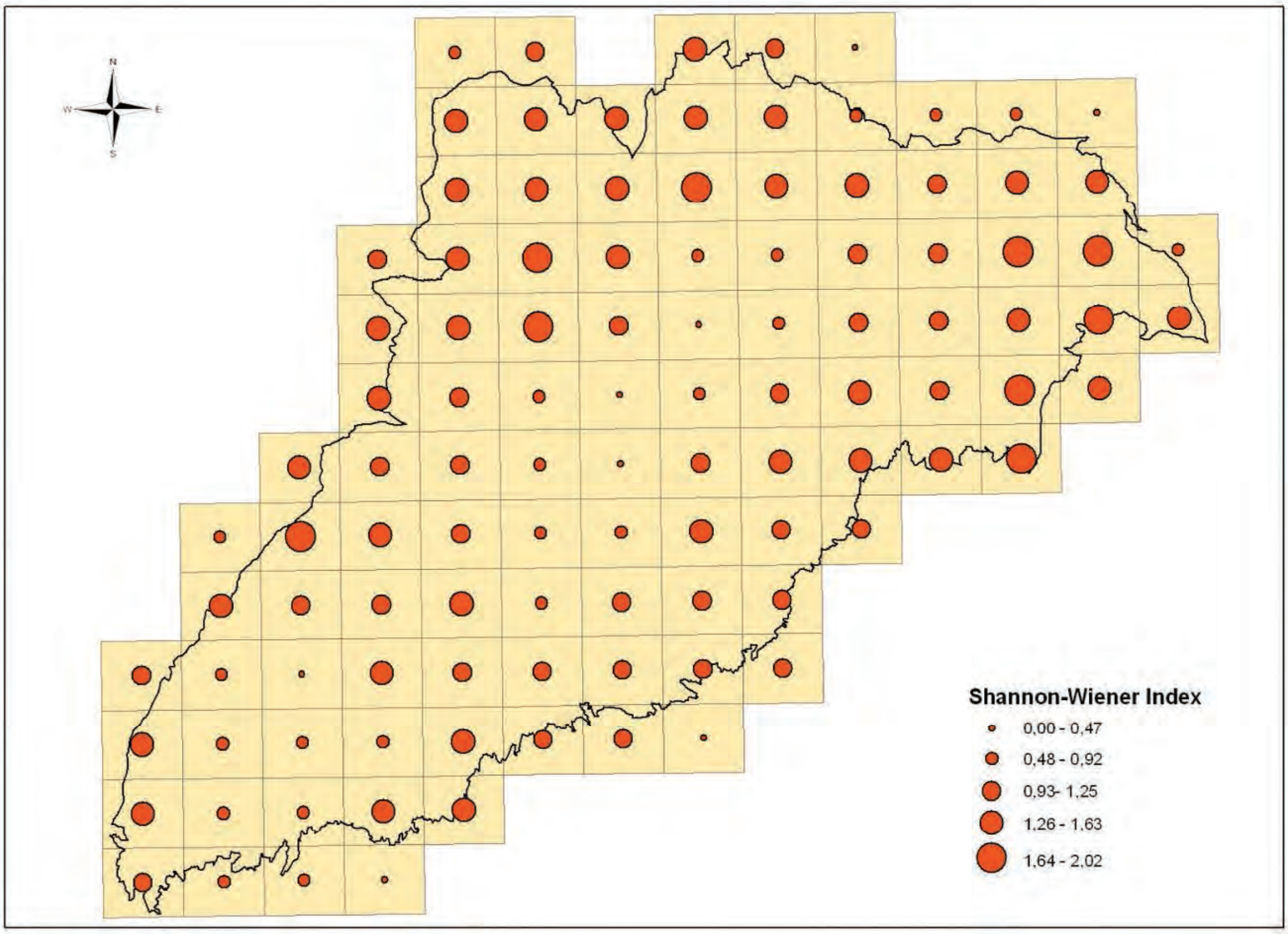

Figure 2. Shannon-Wiener habitat diversity index (M 1:25,000) per MTB/64 quadrants
Slika 2. Shannon-Wiener indeks raznolikosti staništa (M 1:25 000) po MTB/64 kvadrantima

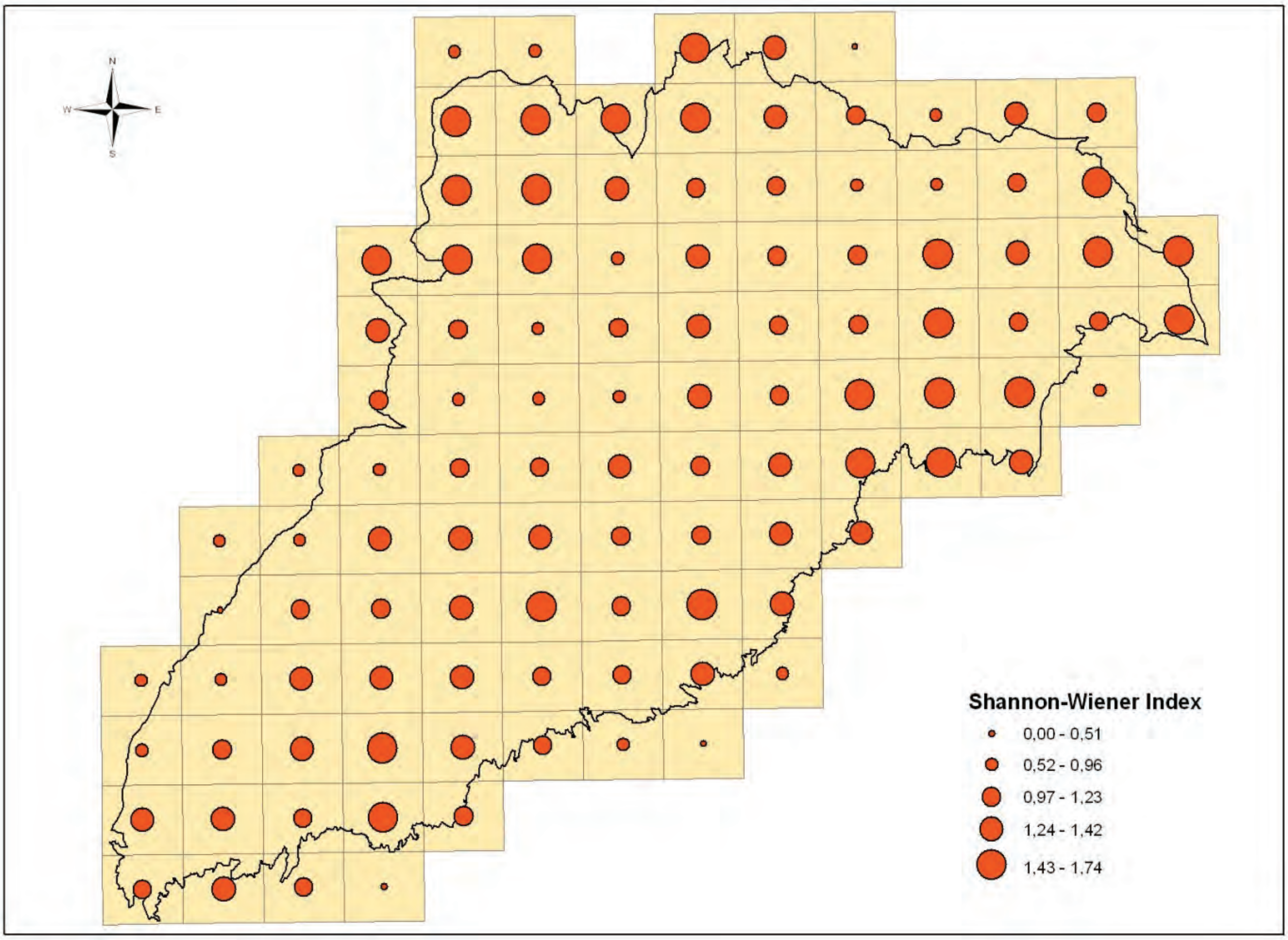

Figure 3. Shannon-Wiener landform diversity index per MTB/64 quadrants
Slika 3. Shannon-Wiener indeks raznolikosti klasa reljefnih morfoloških cjelina po MTB/64 kvadrantima

The additional potential MTB quadrants suitable for visiting were identified in the Park (Fig. 4). Number of identified quadrants does not contain any catering or accommodation. Likewise, some areas that possess such facilities were not identified by this method as visiting potential areas. The overlap with reclassified diversity values (Fig. 4) shows that the majority of MTB quadrants which are at the moment the most visited and the potential visiting areas have lower values of Shannon-Wiener diversity index for relief, habitat 25 and a number of plant species. The exception is the area in the southwest and peripheral along the border in the south and northeast side of the Park. This combined map of MTB quadrants for potentially visiting purpose, especially using the reclassification method could serve as a help in the Park's zoning.

DISCUSSION
RASPRAVA

Out of three habitat/vegetation map used, one with highest spatial resolution i.e. 1:25,000 scale has proved as most suitable in this analyses. Nevertheless, for such purposes even better resolution will be needed (e.g. 1:10,000 or even 1:5,000 scale). Changing the spatial, and thematic, resolution may affect different landscape attributes and mapping accuracy (e.g. Jelaska et al., 2005; Buyantuyev & Wu, 2007), and consequently outcomes of such analyses. Therefore, spatial data on habitats with highest resolution should be used whenever possible. Latter can be applied for specifically designed questionaries' for visitors as well. That way, results of testing whether there are differences among different groups with respect to their socio-economic status, age, education, gender, frequency of visiting etc. could be used in optimisation of visitor pressure. If appropriate, other aspects of social behaviour (e.g. de Bello et al. 2013) can be included as well.

Use of landforms as proxy for relief diversity is useful, and more appropriate for this type of analyses then e.g. aspect or elevation. They are easy to include in multicriteria analyses that are very often used method in various analyses in protected areas worldwide (e.g. Zhang et al. 2013; Riccioli et al. 2016). Furthermore, landforms are mostly well correlated with landscape categories,

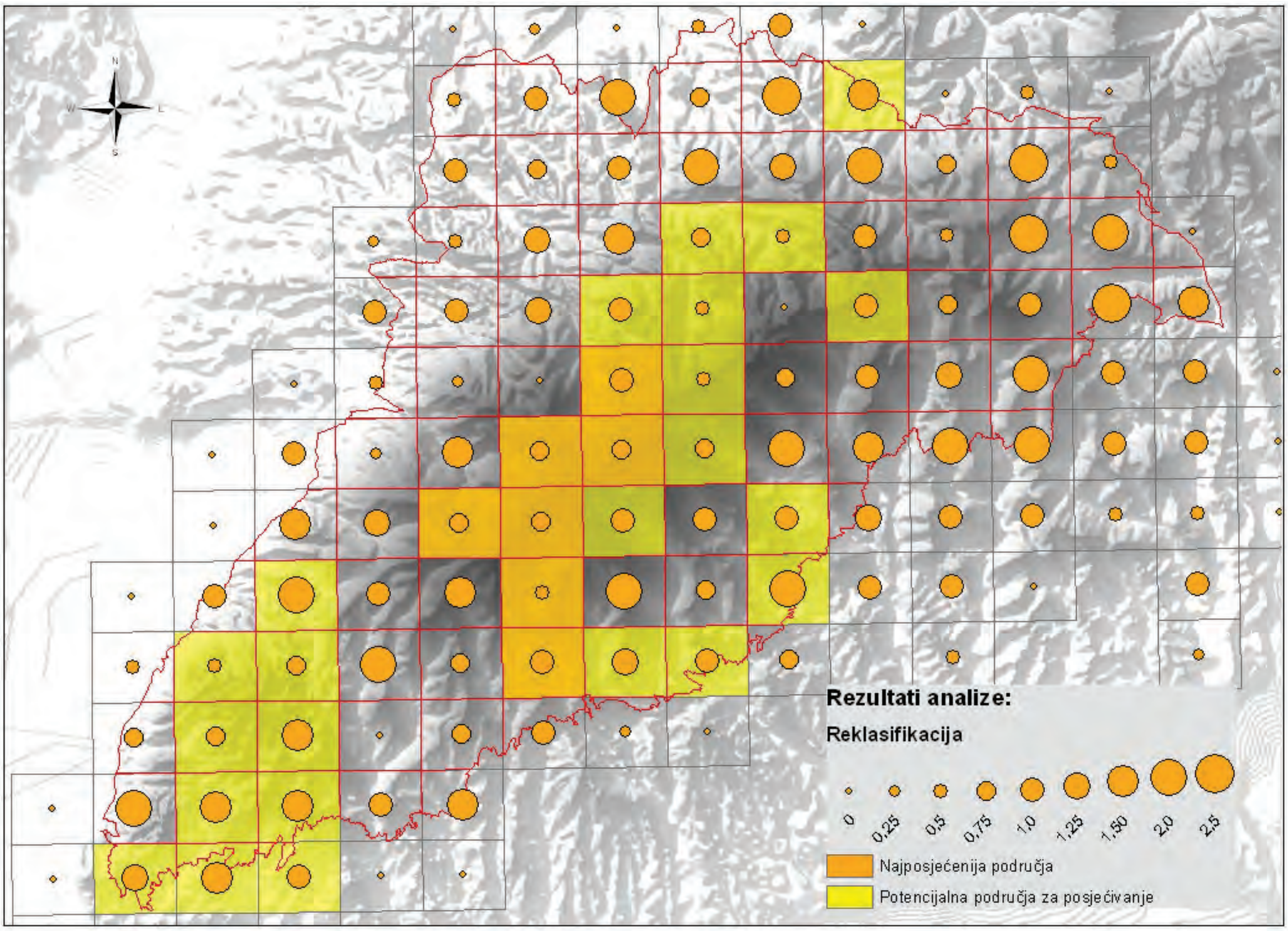

Figure 4. Overlap of most visited quadrants (orange) and potential visiting attractions (yellow) with the reclassified values for diversity of relief, habitat and the number of plant species

Slika 4. Preklapanje najposjećenijih područja (narandžasto) i potencijalnih područja za posjećivanje (žuto) s reklasificiranim vrijednostima raznolikosti reljefa, staništa i broja biljnih vrsta.

which are very important in analysing visitor preferences and plans, as shown in Getzner & Švajda (2015).

The areas that are currently mostly visited only partially overlapped with those with highest diversity of plants, habitats and landform types (Figure 4). This is partly influenced by available infrastructure and offerings to visitors. However, this fact should be useful in planning new areas where to attract visitors ensuring the decrease of pressure on currently most visited areas by offering alternative locations with similar characteristics, and setting aside areas with highest diversity for protection purposes, without risk of having smaller number of visitors. Latter is important given the changes in way protected areas get finance for their activities nowadays (Gurung, 2010). Examples of analyses and optimization of visitor's pressure in protected areas in Croatia are rare (e.g. Kušen 2007; Zmijanović 2014) hence, every contribution and attempt on this subject is very valuable and will help in developing efficient multisector scheme in dealing with this complex issue. We believe that approach presented here is useful and can be applied elsewhere as well.

REFERENCES
LITERATURA

- Brunner, G.A., E.R., Gullison, A., Balmford, 2004: Financial Costs and Shortfalls of Managing and Expanding Protected-Area Systems in Developing Countries, Bioscience, Vol. (54)
- Buyantuyev. A., L., Wu, 2007. Effects of thematic resolution on landscape pattern analysis. Landsc. Ecol. 22 (1), 7-13.
- Cigić, P., T., Nikolić, M., Plazibat, V., Hršak, S.D., Jelaska, 2003: The distribution of the genus Impatiens L. (*Balsaminaceae)* in Medvednica nature park, Croatia. Nat Croat 12:19-29.
- Ćiković, D., 2004: Vodenkos i pastirice Parka prirode Medvednica-studija distribucije i brojnosti. Stručna studija, Ornitološki zavod HAZU, Zagreb.
- de Bello, F., J., Klimešová, T., Herben, K., Prach, P., Šmilauer, 2013: Serious Research with Great Fun: The Strange Case of Jan Šuspa Lepš (and Other Plant Ecologists). Folia Geobotanica 48(3): 297-306.
- Dobrović, I., T., Nikolić, S.D., Jelaska, M., Plazibat, M., V., Hršak, R., Šoštarić, 2006a: An evaluation of floristic diversity in Medvednica Nature Park (northwestern Croatia), Plant Biosystems, VoI.(140):3.
- Dobrović, I., T., Safner, S.D., Jelaska, T, Nikolić, 2006b: Ecological and phytosociological characteristics of association *Abieti-*

Fagetum „pannonicum“ Rauš 1969 on Mt. Medvednica (northwestern Croatia), Acta Botanica Croatica. 65 (1): 41-55.
- Dudley, N., 2008: Guidelines for Applying Protected Area Management Categories. Gland, Switzerland: IUCN. 86pp.
- Getzner, M., J. Švajda, 2015: Preferences of tourists with regard to changes of the landscape of the Tatra National Park in Slovakia. Land Use Policy, 48: 107-119.
- Githiru, M., M.W., King, P., Bauche, C., Simon, J., Boles, C., Rindt, R., Victurine, 2015: Should biodiversity offsets help finance underfunded Protected Areas? Biological Conservation, 191: 819-826.
- Gurung, H.B., 2010: Trends in protected areas. CRC for sustainable tourism Pty Ltd, Gold Coast, Queensland, pp 36.
- Hamidović, D., 2005: Istraživanje ekologije šišmiša u spilji Veternici i prijedlog njihovog trajnog monitoring, Stručna studija, HBSD, Zagreb.
- Hat, M.G., 2003: Application of non-market valuation to the Florida Keys marine reserve management, Journal of Environmental Management, (67): 315-325.
- Hršak, V., T., Nikolić, M., Plazibat, S.D, Jelaska, D., Bukovec, 1999: Orchids of Medvednica Natural Park, Croatia, Acta Biol Slovenica (42):13-37.
- Janev Hutinec, B., 2007: Gmazovi Parka prirode Medvednica, Stručna studija, ArkaArka, Zagreb.
- Jelaska, S.D., V., Kušan, H., Peternel, Z., Grgurić, A., Mihulja, Z., Major, 2005: Vegetation mapping of „Žumberak-Samoborsko gorje“ Nature park, Croatia, using Landsat 7 and field data. Acta Botanica Croatica, 64 (2): 303-311.
- Jelaska, S.D., T., Nikolić, L., Šerić Jelaska, V., Kušan, H., Peternel, G., Gužvica, Z., Major, 2010: Terrestrial biodiversity analyses in Dalmatia (Croatia): A complementary approach using diversity and rarity, Environmental management, 45 (3): 616-625.
- Jenkins, M., J.S., Scherr, M., Inbar, 2004: Markets for Biodiversity Services, Potential Roles and Challenges, Environment, 46 (6).
- Jenness, J., 2006: Topographic Position Index (tpijen.avx) extension for ArcView 3.x, v. 1.3a. Jenness Enterprises, http://www.jennessent.com/arcview/tpi.htm
- Kušen, E., 2007: Utvrđivanje funkcionalnog sustava posjećivanja NP ''Krka" (Establishing functional system for visiting the Krka National Park). Simpozij rijeka Krka i nacionalni park ''Krka". Prirodna i kulturna baština, zaštita i održivi razvitak. Zbornik radova. Šibenik, 707-724.
- Kušan, V., 2007: Kartiranje staništa Parka prirode Medvednica u M 1:25000, Stručna studija. OIKON. Zagreb.
- Malić-Limari, S., 2009: Vrednovanje Parka prirode Medvednica s obzirom na biljni pokrov, reljef i učestalost posjetitelja. Master Thesis, Faculty of Science, University of Zagreb, pp. 118.
- Official Gazette 1981: NN 24/81: www.pp-medvednica.hr
- Official Gazette 2005: NN 70/05: narodne-novine.nn.hr/clanci/…/2005_06_70_1371.html
- Official Gazette 2007: NN 07/06: narodne-novine.nn.hr/clanci/…/2006_01_07_156.html
- Official Gazette 2009: NN 25/09: narodne-novine.nn.hr/clanci/…/2009_02_25_527.html
- Mareković, S., V., Hršak, S.D., Jelaska, T., Nikolić, M., Plazibat, 2009: The grasses (Poaceae) of Medvednica Nature Park, Croatia. Natura Croatica : periodicum Musei historiae naturalis Croatici. 18 (1): 135-154.
- Nikolić, T.; D., Bukovec, J., Šopf, S.D., Jelaska, 1998: Kartiranje flore Hrvatske – mogućnosti i standardi. Natura Croatica : periodicum Musei historiae naturalis Croatici. 7 (Suppl. 1): 1-62.
- Nikolić, T., S., Kovačić, 2008: Flora Medvednice – 250 najčešćih vrsta Zagrebačke gore, Školska knjiga d.d. Zagreb.
- Ozimec, R., 2005: Ekološka analiza i inventarizacija faune prirodnih speleoloških objekata u Parku prirode Medvednica, Stručna studija, HBSD, Zagreb.
- Pernar, N., 2008: Elementi u tragovima u tlu šumskih ekosustava Medvednice, Stručna studija, Šumarski fakultet, Zagreb.
- Riccioli, F., R., Fratini, F., Boncinelli, T. El Asmar, J.P., El Asmar, L., Casini, 2016: Spatial analysis of selected biodiversity features in protected areas: a case study in Tuscany region. Land Use Policy, (57): 540-554.
- Sočo, I., T., Nikolić, V., Hršak, S.D., Jelaska, M., Plazibat, 2002: The distribution of the genus Daphne L. (Thymeleaceae) in Medvednica nature park, Croatia. Natura Croatica. 11 (2): 225-236.
- Šašić, M., 2005: Stanje istraženosti faune danjih leptira PP Medvednice, Stručna studija, Natura, Zagreb.
- Šerić Jelaska, L., P., Durbešić, 2009: Comparison of the body size and wing form of carabid species (*Coleoptera, Carabidae*) between isolated and continuous forest habitats. Annales de la Societe Entomologique de France. 45 (3): 327-338.
- Šerić Jelaska, L., A., Ješovnik, S.D., Jelaska, A., Pirnat, M., Kučinić, P., Durbešić, 2010: Variations of carabid beetle and ant assemblages and their morpho-ecological traits within natural temperate forests in Medvednica Nature Park, Šumarski list, 134 (9-10): 475-486.
- Vuković, N., A. Bernardić, T. Nikolić, V. Hršak, M. Plazibat, S.D. Jelaska, 2010: Analysis and distributional patterns of the invasive flora in a protected mountain area – a case study of Medvednica Nature Park (Croatia). Acta Societatis Botanicorum Poloniae. 79 (4): 285-294.
- Temunović, M., 2007: Istraživanje zajednice kornjaša (*Coleoptera*) i pauka (*Araneae*) livadnih staništa Medvednice, Stručna studija, BIOM, Zagreb.
- Tkalčec, Z., 2007: Studija ugroženosti gljiva u Parku prirode Medvednica, Stručna studija, Hrvatsko mikološko društvo, Zagreb.
- Tutiš, V., 2007: Zajednice ptica, danjih i noćnih grabljivica šumskih ekosustava Parka prirode Medvednica s preporukama za gospodarenje šumama. Stručna studija. Ornitološki zavod HAZU, Zagreb.
- WCPA, 1998: Economic Values of Protected Areas: Guidelines for Protected Area Managers, IUCN, Gland, Switzerland and Cambridge, UK.
- White, P.C., J.C., Lovett, 1999: Public preferences and willingness-to-pay for nature conservation in the North York Moors National Park, UK, Journal of Environmental Management 55: 1-13.
- Zhiming Z., R., Sherman, Z., Yang, R., Wu, W., Wang, M., Yin, G., Yang, X., Ou, 2013: Integrating a participatory process with a GIS-based multi-criteria decision analysis for protected area zoning in China. Journal for Nature Conservation, 21 (4): 225-240.
- Zmijanović, Lj., 2014: Održivi razvoj i upravljanje baštinom zaštićenih područja na primjeru Pokrčja (Study of the sustainable development and management of the heritage of protected areas in the Krka area). Godišnjak Titius : godišnjak za interdisciplinarna istraživanja porječja Krke, (6-7): 71-90.

Sažetak

Park prirode „Medvednica“ prema IUCN kriterijima pripada kategoriji zaštite V, koja podrazumijeva opstojnost interakcija ljudi i prirode, uključujući rekreaciju i turističke aktivnosti, kao i znanstvena istraživanja i očuvanje biološke raznolikosti, uz održivo korištenje prirodnih resursa. Šume predstavljaju jednu od temeljnih vrijednosti Parka te uvjetuju način upravljanja.

Utvrđeno je da zavisno od prostorne razlučivosti (mjerila 1:25000, 1:50000, 1:100000), vrijednosti indeksa raznolikosti staništa variraju. Karta staništa mjerila M 1:25000 pokazala se kao najprikladnija za analize upravljanja Parkom, dok bi za pojedina područja Parka bilo poželjno imati i podatke još veće prostorne razlučivosti. Prilikom prepoznavanja područja od interesa za posjetitelje, neophodno je uključiti i podatke o vrijednosti biološke raznolikosti s ciljem postizanja održivosti i ravnoteže između zaštite prirodnih i kulturnih dobara s jedne, te turističkog iskorištavanja s druge strane. Uz kartu staništa, korišteni su i podaci o broju biljnih vrsta po osnovnoj prostornoj jedinici (kvadrant MTB 1/64 mreže), te indeks raznolikosti prethodno određenih reljefnih morfoloških cjelina na temelju digitalnog elevacijskog modela.

Nizom operacija prostornog preklapanja korištenjem GIS-a identificirali smo područja sličnih reljefnih i vegetacijskih značajki, poput onih na najposjećenijim dijelovima Parka, sa ciljem planiranja potencijalnog razvoja ponude i u tim dijelovima Parka, što bi moglo dovesti do rasterećenja trenutno najposjećenijih područja. Uporaba GIS-a pokazala se opravdanom i učinkovitom u ove svrhe, te je pokazala funkcionalnost u prikupljanju, kao i generiranju multidisciplinarnih podataka, kao i izradi prostornih modela, doprinoseći brzom donošenju odluka, uz uštedu vremena i sredstava.

KLJUČNE RIJEČI: reljefne morfološke cjeline, GIS, karta staništa, vegetacijska karta, indeks raznolikosti.