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EVOLVING GIS TECHNOLOGIES IN NATURE CONSERVATION AND THE SPATIAL PLANNING STRATEGY OF TARA NP (SERBIA) AS A POTENTIAL UNESCO MAB RESERVE

Abstract: Mt. Tara NP was nominated in 2004 within the UNESCO – ROSTE programme, for Man and the Biosphere (MAB) Reserve status in Serbia as transboundary "Peace Park" status between Serbia and Bosnia & Herzegovina. Mt. Tara is one of the most important centres of Balkans and European ecosystems and species diversity. They represent a unique example of well preserved forests in south eastern Europe with numerous endemic and relict species of flora and fauna. In this floristic diversity of Mt Tara of the greatest interest is the Serbian (Pančić's) spruce *Picea omorika*. Mt. Tara NP is characterized by specific geomorphologic, hydrologic, geologic, soil and climatic features. The geographical information system (GIS) that we have created has proved an excellent tool for the spatial planning stratey in assessment and conservation of all natural characteristics of Mt. Tara NP, and is helpful to Park management for sustainable use of landscape resources. GIS of Mt. Tara NP includes data on natural, artificial and management themes.

Key words: GIS, Tara NP (Serbia), Nature conservation, Geodiversity, Biodiversity, Spatial planning strategy, Management for sustainable use of natural resources

Извод: Део планине Тара је статус Националног парка добио 1981. године. Половином 2004. године НП Тара је реноминован у оквиру UNESCO-ROSTE програма човек и биосфера (MAB) за будући Резерват биосфере и трансгранични Парк мира између Србије и Босне и Херцеговине. Планински комплекс Тара представља један од најзначајнијих центара специјског и екосистемског диверзитета Балкана и Европе. Тара представља јединствен пример добро очуваних шума на простору Југоисточне Европе са бројним ендемичним и реликтним врстама флоре и фауне. Свакако да посебан печат флористичком диверзитету Таре даје ендемо-реликтна врста панчићеве оморике *Picea omorika*. Осим биотичке компоненте специфичне геоморфолошке, хидролошке, геолошке, педолошке и климатолошке карактеристике, простору Таре такође дају свеукупне високе природне вредности. Географски информациони сустем (ГИС) који смо креирали представља изванредан алат за израду савремене стратегије просторног плана овог подручја, као и алат за валоризацију и заштиту свих природних вредности НП Тара. ГИС НП Тара истовремено представља савремен и незаобилазан алат за управљање Парком и одрживо коришћење његових природних ресурса. Садржаји ГИС НП Тара укључују природне, антропогене и управљачке атрибуте.

Кључне речи: ГИС, НП Тара, UNESCO MAB Резервати биосфере, геодиверзитет, биодиверзитет, Одрживо управљање природним ресурсима

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Introduction

Conservation International has identified 25 regions worldwide with high species richness and with high concentration of threatened species ("biodiversity hotspots") for conservation priorities (Myers *et al*. 2000). One of them is Mediterranean Basin with Balkan peninsula. Biogeographically, almost all basic biomes of Europe are present in the territory of Serbia: temperate grasslands, temperate woodland, temperate deciduous forest, mountain boreal coniferous forest and alpine grasslands and shrublands. (Stevanović, Vasić, 1995).The territory of Serbia inhabit 70% of European mammals, 75% of European birds, 52% of European freshwater fishes, and 39% of European vascular plants, including over 1,000 internationally significant species.

In Serbia there are 1,032 protected natural areas, covering 534,232 ha, which is equivalent to 6.5% of the national territory. Five of protected natural areas are National Parks: Mts. Fruška gora, Tara, Kopaonik and Šara and the Djerdap gorge, covering 158,853 ha (http:// www.natureprotection.org.yu).

Mt. Tara is a unique example of well preserved forests in south eastern Europe with exceptional biodiversity including numerous endemic and relict species of flora and fauna. It is also characterized by specific geomorphologic, hydrological, geological, soil and climatic features. Mt. Tara is on the list of Important Bird Areas of Europe (IBA) (Puzović, Grubač, In: Heath, Evans, 2000) and Prime Butterfly Areas in Europe (PBA) (Jakšić, In: Swaay, Warren, 2003). There is an initiative to include Mt. Tara on the list of Important Plant Areas (IPA) in the Central and Eastern Europe (Stevanović, 2002). Mt. Tara, recognized and identified as Important Species Area (biodiversity hotspots) may play a key role in the development of the Pan-European Ecological Network.

During the Joint International Workshop on MAB Biosphere Reserves and Transboundary Cooperation in south eastern Europe Region" (held in Belgrade in June, 2004, under the auspices of the UNESCO / ROSTE – IUCN) Mt. Tara NP was nominated for the MAB Reserve in Serbia as transboundary "Peace Park" between Serbia and Bosnia & Herzegovina (Radović, 2004b). The MAB status of NP is still under consideration. The first attempt to declare Mt. Tara for a national park was made in 1951, but Mt. Tara NP was not established until 1981 year. The current Spatial Plan on Mt. Tara NP was accepted in 1989. In order to manage it effectively, it is divided into five managing units containing 751 parcels and sub-parcels in all (Spatial Plan of Tara NP, 1989).

There is the question whether it is possible to optimally manage such a complex natural system using "traditional" data sources like paper maps and statistical books. The decision making processes in management and protection of complex natural systems require numerous data, cartographic as well as statistical, needed to produce necessary information in an efficient way. The respond to the demands is searched in the functionalities of a geographic information system (GIS) as a computerized system that facilitates the phases of data entry, data analysis and interpretation and data presentation.

As nature conservation poses a complex problem, a key goal of this kind of study is to bring specialists from different disciplines together who will jointly help in applying GIS to this crucial field (Ashdown and Schaller, 1990; Ahn, Lee, 1999; Wadsworth and Treweek, 1999; Convis, 2001; Dragut, Thompson, 2005; Longley *et al*, 2005; Milevski *et al*, 2007; Telbisz *et al*, 2007).This type of research is fully in line with global Nature-GIS programme i.e. European Thematic Network for Protected Areas/Preservation and Geographical Information, set up in 2002 by the EU Commission, aimed at the creation and application of new Guidelines to implement GIS in protected areas (www.gisig.it/nature-gis).

Therefore, the purpose of this study is to design the GIS consisted of reliable data for assessment of the natural resources and to provide the reasonable ground for sustainable

managing landscape resources and to protect the area with high biological diversity. This is the first time in Serbia that GIS was implemented on Nature protected area.

Research Methods

Study Site

Mt. Tara NP is located in the southwestern part of the Republic of Serbia, within the territory of the municipality of Bajina Basta, 180 km from Belgrade between 43°52'30'' and 44°01' North and 19°14'30'' and 19°41'30''East. The Park covers an area of 19,175 ha, while the protected buffer zone surrounding it covers an area of 37,584 ha. The highest point of Mt. Tara is Kozji rid 1,591 m, while the lowest point is at 300 m. There are two characteristic spatially-functional areas within Mt. Tara NP: High Tara (11,562 ha) and Flat Tara (7,613 ha). The average altitude ranges from 1,000 – 1,200 m. Based on these characteristics Mt. Tara is classified as medium-high mountain in Serbia.

Study Procedure

In order to create functional GIS for Mt. Tara NP, the accent was put to selection and creation of thematic data layers for analyzing natural values through consultations with experts from various fields. The relevant studies on the Park were reviewed and field surveys conducted to collect and check all necessary data on the landscape resources. The data, mostly in analog form had to be transformed into digital form and then organized in the meaningful system of thematic data layers. The procedures also included database creation, adopting GIS guidelines in terms of resource data analysis and conclusion drawing (Fig. 1).

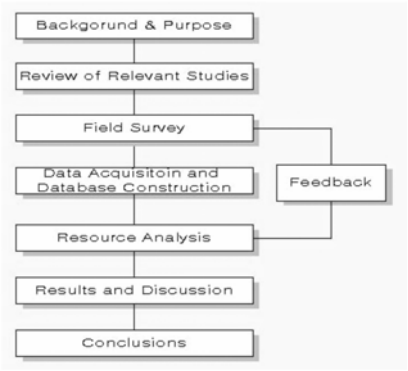

Fig. 1. Study procedure

Input Data

All data were georeferenced in the National projection system. This is a geodetic system based on datum – Hermanskogel with prime meridian in Greenwich and ellipsoid Bessel (major axis – 6 377 397.155 m, semi major axis – 6 356 078.963 m). Projection is defined as Transverse Mercator (Gauss-Kruger) with the following parameters:

- latitude of origin 0°00′00.00″
- longitude of origin 21°00′00.00″
- scale factor at central meridian 0.9999
- false easting 7 500 000.00 m
- false northing 0 000 000.00 m

To create thematic data layers, relevant input data from a large number of various types of data sources were used:

- Topographic map: 1:50,000,
- Topographic map: 1:50,000 (in a digital raster form),
- Relief and hydrology map: 1:50,000,
- Geological map: 1:100,000,
- Soil map: 1:50,000,
- Aerial photographs,
- Satellite image: Landsat 7 ETM+ multispectral; Spot 5 multispectral, pan sharpened.
- Vegetation map of Tara NP: 1: 50,000,
- Map of five managing units of Tara NP: 1: 50,000,
- Map of five managing units of Tara NP: (with 751 parcels): 1:10,000,
- Managing units data, consisting of nine properties for each parcel (unit name, parcel and sub-parcel ID number, woodland type, vegetation communities, vegetation ecological affiliation according to the type of soil, percentage of vegetation communities, type and purpose of land use, level of protection - zoning),
- Data on the fauna and flora diversity, and
- Tourist map of Tara NP 1: 25,000.
- Corine Land Cover 2000 (CLC 2000) 1: 100,000
- Corine Land Cover Changes (1990 - 2000) 1: 100,000

Thematic data layers creation

We applied the procedures used in most GIS projects: scanning, georeferencing, digitizing (manual and semiautomatic), database creation and data integration (Radovic, 2004a).

The Mt. Tara NP GIS is divided (by type and format) into various data forms: raster data, vector data, digital elevation model and database. Raster data include all maps, aerial photographs and satellite images (cited in data sources) after having been georeferenced. The following entities are represented in vector form:

Geology (polygon),
Soil (polygon),
Hydrology (line / polygon),
Vegetation communities (polygon),
CLC 2000 (polygon)
CLC Changes (1990 - 2000) (polygon)
Locations of important species of flora and fauna (point),
Border of Tara NP (polygon),
Management units (polygon),
Management units parcels (polygon),
Settlements (polygon),
Roads (line),
Mountain paths (line) and
Other structures: hotels, belvederes, waterfalls, caves, (point).

The GIS software used to organize these data are: Geographic Transformer (georeferencing raster data), MicroStation (manual digitizing), Raster to Vector (semiautomatic digitizing), ArcView 3.3 and ArcGIS 9 (digitizing, raster data integration, vector data and data base; analyses).

Results and Discussion

We used GIS to analyze natural values and resources that significantly contribute to the proclamation of Mt. Tara for a future UNESCO MAB Reserve. In order to understand the current status of the study site thematic data layers in our GIS were logically organized in the three sets of data on the National Park: Physical data, i.e. topography (elevation, slope, aspect), geology, soil, hydrology, watersheds and climate; Biological diversity data, (vegetation community, flora and fauna) and distribution of endemic and relict species; Managing mechanisms data and identification of current human pressure that may lead to violation of natural habitats.

Topography/ Geomorphologic characteristics

To achieve the maximum effect of visualization, 3D analyses were used throughout this GIS study. Analyses demand that certain phenomena be correlated with relief characteristics (elevation, aspect, and slope). To meet the set requirements, a digital elevation model (DEM) (resolution 20 m pixels) was created. The DEM covered an area of about 1200 km^2 providing for each pixel: coordinates (in meters), elevation (in meters), aspect (in degrees), and slope (in degrees and percentages) (Fig. 2). The elevation value in all Figures and 3D models is authentic (Z factor is 1.00 and H=100 %), so relief images are absolutely realistic and appear as in nature. The 3D model lies on a rectangle, which represents sea level (altitude is zero meters) (Fig. 3).

Relief and hydrology maps were included as input data for DEM development. The Managing procedure included scanning maps and georeferencing, as well as semiautomatic digitizing of isolines. After that, each isoline was given a unique identification (ID) and then converted to points (retaining ID), which were finally interpolated to grid (DEM) by spline method. Topography is a dominant factor affecting processes occurring on the Earth's surface. It interferes with spatial climate distribution, and consequently with the distribution and productivity of biological systems (Manojlović, Dragićević, 2002).

The GIS analyses of the National Park's topographic characteristics included: elevation zones, relief aspect and slope. Thus, it was established that most of the Park area is situated at altitudes ranging from 800 - 1,200m (12,571ha or 65.56%) (Fig. 3), north (2,853ha; 14.9%), northeast (3,604ha; 18.8%) and northwest (2,199ha; 11.5%) aspects cover most of the Park. The slope between 0- 9.1% covers 4,964.2ha (25.9%), between 9.2- 18.3% covers 5,363.4ha (28%), between 18.4- 27.4% covers 3,895.4ha (20.32%) and slope between 27.5- 36.5% covers 2,768.2ha (14.44%) of the Park area. It is possible to correlate and analyze the distribution of biotic elements to topography data as well as all other themes.

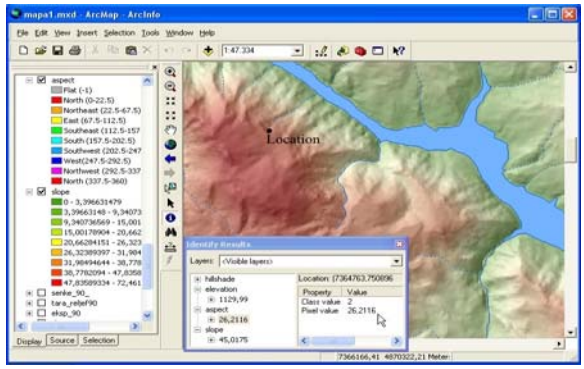

Fig. 2. Coordinates, elevation, aspect and slope for chosen location (2D)

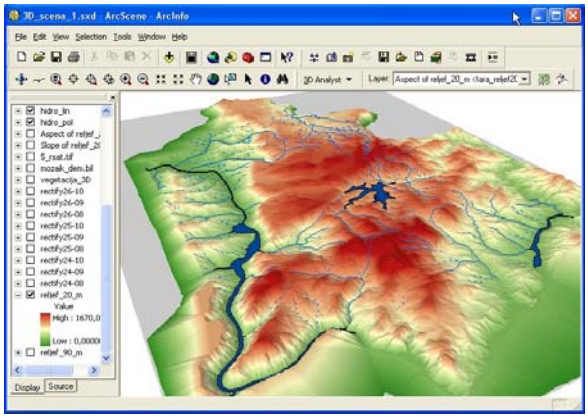

Fig. 3. Digital elevation model (3D)

Aerial photograph. The material used to process aerial photographs included a series of 19 photos of Tara NP (scale, 1: 30,000; Wild RC-5 camera, year of production 1959). By using photographs that are almost 50 years old, we were able to observe changes in vegetation, some of which were caused by human impact. Processing of these photographs included scanning (resolution 750 dpi grayscale), georeferencing, and their combining with other data (vector and DEM) (Fig.4).

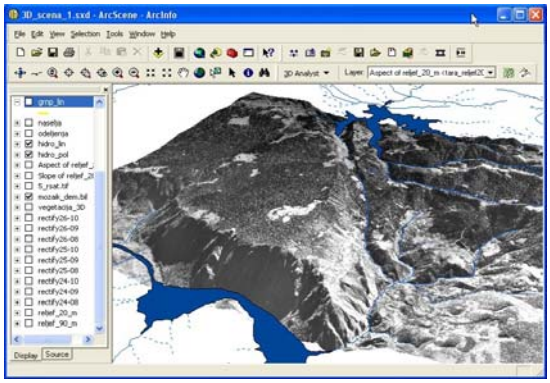

Fig. 4. Aerial photo (1959) georeferenced, combined with DEM and hydrology (actual) (3D)

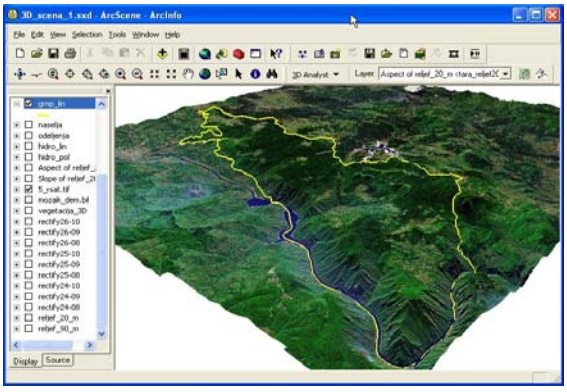

Fig. 5. Satellite image combined with DEM and Park border (3D)

Satellite images. For this study several types of satellite images were used: Landsat 7 ETM+ Multispectral, SPOT 5 multispectral, pan sharpened.

After satellite images were combined with other data (raster, vector, data base and DEM), the authentic visualization of the area (satellite images and aerial photos were joined to the DEM in 3D analyst) was obtained (Fig.5). Simultaneously vector data were integrated with the database to represent qualitatively and quantitatively abiotic, biotic and human content.

Geologic characteristics

The complex of Mt. Tara is characterized by high geological diversity with respect to age, origin and composition. There are rocks from the Carboniferous, Triassic, Jurassic, Cretaceous, Tertiary and Quaternary.

The GIS analyses of geology covered a total area of 34,351 ha. Authentic content was classified into 35 types of geologic cover. In order to make adequate correlations, primarily with the vegetation, a generalization into six basic and six combined types was performed (Tab. 1). Inside the Park, limestone constitutes 77% of the rock.

Table 1. Distribution of geology (absolute and proportional)

Geology	Area (ha)	Area (%)
Limestone	14778.13	77.07
Mostly clastites	1381.11	7.20
Clastites	328.66	1.71
Mostly clastites with carbonates	95.53	0.50
Serpentinites- ofiolites (peridotites)	736.50	3.84
Ofiolites	700.82	3.65
Metamorphite	941.49	4.91
Free fluvial	130.58	0.68
Serpentinites- ofiolites	6.24	0.03
Mostly clastites (meta sediments)	24.90	0.13
Decomposed substrate	43.77	0.23
Mostly metamorphite	6.83	0.04
total	19174.56	100.00

Soil characteristics

The soil cover, of the area of 55,024 ha was digitized. The following ten types of cover are present: skeletal-rocky ground, chernozem on serpentines (humus silicate soil), alluvial deposit, deluvium, brown reddish soil on limestone, calcareous-skeletal soil on firm limestone, brown skeletoid soil on schist, parapodsol-gleized soil, eroded smonitza (shallow), and skeleton soil on serpentines. There are five types of soil cover inside the park.

Hydrologic characteristics

The most conspicuous hydrological characteristic of the park is the Drina River (total length 346 km; 22.7 km running around the park) and its canyon. The Drina forms a canyon over 1,000 m high on the park's boundary line.

There are three reservoirs in the region of Tara NP: Perucac, Zaovinsko Lake (altitude is 600 m above Perućac) and Kruščica. The Perućac Reservoir (50 km long, area 12.4 km^2, max. depth 85 m) was created when a dam (93 m high and 461 m long) was built in 1962 to provide hydroelectric power for Bajina Basta. The Zaovinsko Lake belongs to the artificial reversible type used to preserve water for the hydroelectric power during dry season. Kruscica is used only for the supply of drinking water for the whole region.

The GIS theme Hydrology includes all hydro elements present in Mt. Tara: streams, rivers, and lakes. It is possible to get information about the length of every watercourse or its stretches. The data provides information about the ichtyofauna present.

Analyses of vegetation and floristic diversity

Complexity of the topography, geology, soil, hydrology and climate of Mt. Tara is readily evident from the distribution of vegetation. Within its spacious area at the altitude from 900 – 1,200 m, almost all species of European boreal dendroflora and their communities occur. All communities of mixed deciduous-coniferous forests and coniferous forests are spread like a mosaic, dependent on the aspect and slope of the relief.

The vegetation map (Mišić, 1988) for the area of 28,244.5 ha was digitized, being differentiated into 35 vegetation communities consisting of 354 polygons. Attribute data are Serbian and Latin names. Inquiries, arising from the database, allow obtaining data on the size of every polygon and all other statistical indices regarding the distribution of vegetation communities (Tab.2; Fig.6). Vegetation parameters can be readily correlated to all other themes, e.g. how the vegetation distribution corresponds to the type of geology, soil, elevation zones as well as to relief slope and aspect.

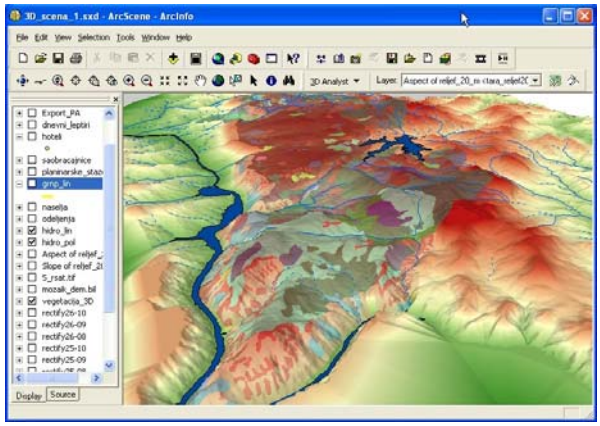

Fig. 6. Vegetation combined with DEM and hydrology (3D)

Until now, 1,013 plant species have been recorded in Mt. Tara which accounts for almost 1/3 of the entire flora of Serbia (Stevanović, 2002). With large number of relict and endemic species Mt. Tara is one of the centers of floristic and vegetation diversity not only in Serbia but also in this part of the Balkan Peninsula.

In this floristic diversity of Mt. Tara of greatest interest is certainly the Serbian (Pančić's) spruce, *Picea omorika*, a unique paleo–endemic species and a living fossil of the European dendroflora with a range confined to the middle course of the Drina River in Western Serbia and Eastern Bosnia and Herzegovina (Gajić *et al.* 1994).

Locations of important endemic and relict plant species was mapped with GPS (*Picea omorika, Micromeria croatica, Centaurea derventana, Euphorbia glabriflora, Acer heldreichii, Spirea cana, Daphne malyana, Leontopodium alpinum, and Aquilegia grata nikolicii*).

Owing to this high floristic diversity, the initiative taken for including Mt. Tara in the International Plant Areas (IPA) list is absolutely justifiable (Stevanović, 2002).

Analyses of fauna diversity In addition to floristic and vegetation diversity, one of the most important characteristics of the natural resources of Mt. Tara is the high diversity of its fauna (Radović, 2004a) (Tab. 3).

The special value to the fauna of Mt. Tara is lent by the presence of the grasshopper *Pyrgomorphulla serbica*, an endemorelict from the Pliocene. Among other insect species, the occurrence of three butterfly species (*Euphydryas maturna, Maculinea arion, and Parnassius apollo*) is very important. They qualify Mt. Tara as one of the Prime

Butterfly Areas (PBA) in Europe. Thus, since 2003, Mt. Tara is on European PBA list (YU-14) and a priority site for conservation (Jakšić, 2003).

Table 2. Distribution of vegetation (absolute and proportional)

Latin name	Area (ha)	Area (%)
Carpino orientalis-Quercetum confertae cerris	61.18	0.22
Quercetum cerris carpinetosum orientalis	33.16	0.12
Quercetum cerris juglandetosum	24.85	0.09
Parietario-Juglandetum cerretosum calcicolum	16.73	0.06
Orno ostryetum carpinifoliae	2291.34	8.11
Orno ostryetum juglandetosum	85.79	0.30
Ostryo pinetum nigrae	867.94	3.07
Quercetum montanum	5.75	0.02
Alnetum glutinosae	9.85	0.03
Aceri-Ostryo-Fagetum	585.50	2.07
Fagetum submontanum	130.44	0.46
Fagetum submontanum juglandetosum	57.51	0.20
Erico-Pinetum	131.47	0.47
Fagetum montanum	352.53	1.25
Abieti-Fagetum	327.76	1.16
Piceeto-Abieto-Fagetum	2656.65	9.41
Piceeto-Abieto-Fagetum oxalidetosum	8922.71	31.59
Piceeto-Abieto-Fagetum myrtilletosum	108.74	0.38
Piceeto-Abieto-Fagetum pinetosum	1210.80	4.29
Piceeto-Abieto-Fagetum ostryetosum	21.30	0.08
Piceeto-Abieto-Fagetum ilicetosum	7192.42	25.46
Piceeto-Abieto-Fagetum taxacetosum	25.54	0.09
Piceeto-Abieto-Fagetum – Pinetum nigrae ostryetosum	53.03	0.19
Omoriko-Piceeto-Abieto-Fagetum	56.64	0.20
Omoriko-Piceeto-Abieto-Fagetum-Alnetum mixtum	574.47	2.03
Brometum erecti	47.17	0.17
Alectorolopho-Cynosuretum cristati	1831.14	6.48
Danthonietum calicinae	9.15	0.03
Nardetun strictae s.l.	148.65	0.53
Magnocaricion	43.04	0.15
Danthonietum calicinae	133.54	0.47
Poo molineri-Plantaginetum carinatae	99.37	0.35
Fagetum submontanum mixtum	24.48	0.09
Future reserve in beech forest	82.61	0.29
Reserve of Picea omorika	21.16	0.07
Total	28244.42	100.00

In addition to floristic and vegetation diversity, one of the most important characteristics of the natural resources of Mt. Tara is the high diversity of its fauna (Radović, 2004a) (Tab. 3).

The special value to the fauna of Mt. Tara is lent by the presence of the grasshopper *Pyrgomorphulla serbica*, an endemorelict from the Pliocene. Among other insect species, the occurrence of three butterfly species (*Euphydryas maturna, Maculinea arion, and Parnassius apollo*) is very important. They qualify Mt. Tara as one of the Prime Butterfly Areas (PBA) in Europe. Thus, since 2003, Mt. Tara is on European PBA list (YU-14) and a priority site for conservation (Jakšić, 2003).

There are three important fish species in Mt. Tara: Danubian salmon *(Hucho hucho*), brown trout *(Salmo trutta*), and grayling *(Thymallus thymallus*) (Simonović, 2001). Some of the important amphibians and reptiles species are: *Salamandra salamandra, Rana graeca, Zootoca (Lacerta) vivipara, Vipera ammodytes*.

Table 3. Numerical synopsis of fauna diversity in the region of Mt. Tara and Serbia

Taxa	Region		
	Mt. Tara	Serbia	Mt. Tara/ Serbia (%)
Butterflies	115	192	59.9
Freshwater fishes	27	91	29.7
Amphibians	12	23	52.2
Reptiles	12	26	46.1
Birds	170	350	48.6
Mammals	51	107	47.7

At the proposal of Serbian ornithologists (Puzović and Grubač, 2000) this area was nominated as one of the Important Bird Areas (IBA) of Europe. The nomination was accepted (as IBA 019) for the following: six bird species: *Aquila chrysaetos, Falco peregrinus, Otus scops, Picus canus, Picus viridis, and Phoenicurus phoenicurus*, the population of which in Mt. Tara is larger than 1% of the total world populations. Among other important bird species of Tara NP are *Picoides tridactylus and Tetrao urogallus*.

The mammal fauna of Mt. Tara is characterized by the presence of the following large species: *Ursus arctos, Canis lupus, Rupicapra rupicapra, Sus scrofa, Felis sylvestris, Capreolus capreolus, Martes martes, Martes foina, Meles meles,* and (recently) *Lynx lynx*. The bear, *Ursus arctos*, is the symbol of Mt. Tara and is a characteristic resident of the western part of the mountain. Based on intensive monitoring of the bear population, the estimated number today is about 30 individuals. The chamois, *Rupicapra rupicapra*, is the second protected species of large mammals. It is present on steep limestone peaks, cliffs, and hillsides. Today it numbers about 100 individuals (Savić *et al.* 1995). The presence of the great vole (*Microtus multiplex*) is very important. Its habitat in Mt. Tara is the only one in Serbia, and at the same time the easternmost point of its range in Europe.

The distribution of all the mentioned fauna species in Tara NP is mapped with GIS. As a PBA, an IBA and an IPA, Mt. Tara has all the characteristics required for joining the Pan-European Ecological Network (PEEN), which is tool of the Pan European Biological and Landscape Diversity Strategy (PEBLDS), and can be seen as one of the priority issues for nature conservation in Europe (Council of Europe, UNEP & ECNC 1996).

GIS and Management

In order to manage Mt. Tara NP effectively, it is divided into five managing units with composed of 751 parcels and sub-parcels. By now the managing of almost all natural potentials of Tara NP was mainly based on principles of forestry technology.

In this GIS study all 751 parcels of five managing units were digitized. For each parcel, following eight characteristics were put together in the relational database: unit name, parcel and sub-parcel ID number, woodland type, vegetation communities, vegetation ecological affiliation according to the type of soil, percentage of vegetation communities, type and purpose of land use, and level of protection - zoning. Database consists of eight tables with 2978 rows. Queries about combination of forest species distribution for every parcel in percentages are enabled. When we identify the present distribution of endangered endemic species we can easily calculate other areas in NP that fulfill similar combination of forest species and other biotic (vegetation, CLC) and abiotic (relief, hydrology, geology and soil) conditions present in those parcels and then try to spread that species (Fig.7; Fig.8).

The GIS of Tara NP also includes information about nature reserves, settlements, roads and transportation, tourist facilities and line of visibility.

Nature reserves. There are ten nature reserves within Tara NP. The data model enables obtaining information about area, zoning, and the presence of specific plant and animal species.

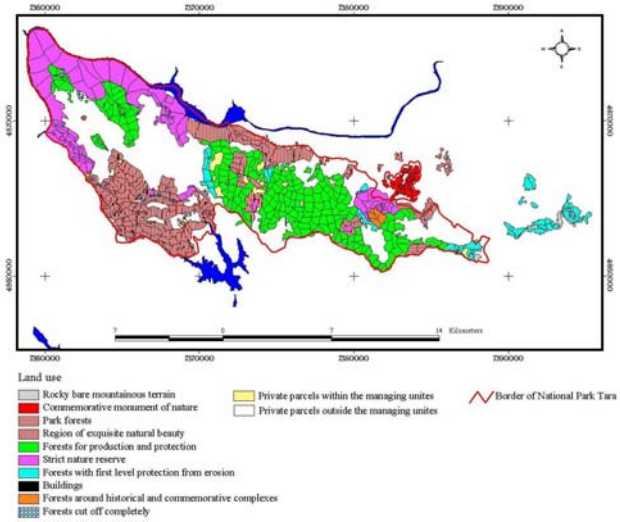

Fig. 7. Type of land use (2D)

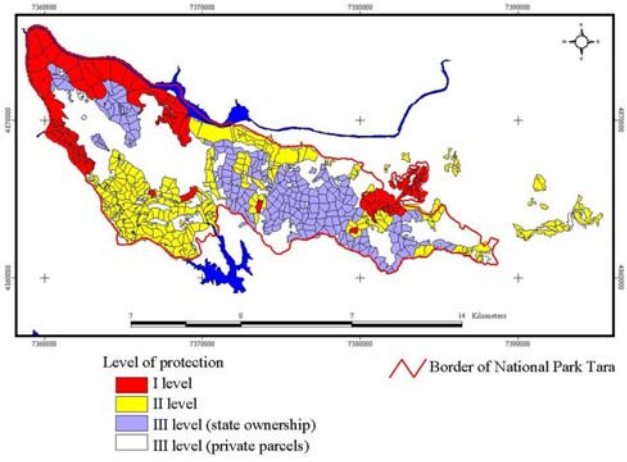

Fig. 8. Level of protection - zoning (2D)

Settlements. The settlements theme was digitized on the basis of topographic map (in digital raster form). All urban and rural settlements within the National Park are included. The biggest settlement is Bajina Basta, the administrative center of the municipality.

Roads and transportation. The roads theme was digitized from a topographic map on a scale of 1:50 000 (in a digital raster form) representing all types of roads. Roads were divided into three categories: asphalt, macadam, and dirt roads. All digitalization rules have been followed, so that queries enabled getting of precise information about the length of every section and the shortest road distance between any of two points or crossroads in Mt. Tara.

Tourist contents. A tourist map of Tara NP was the basis for digitizing hotels, mountain paths, scenic sights, administrative buildings and monuments of culture.

Line of visibility. This GIS allows presenting the line of visibility from any point on the DEM, giving information about visibility, relief profile, starting and end points of the

elevation, and the distance between these two points. This is of particular interest from the stand point of tourism, mountaineering, telecommunications, and defense.

GIS and CLC 2000 Serbia

For the interpretation of habitats diversity in NP Tara we are used a seamless vector database (CLC 2000 Serbia & Montenegro, 2006) which follows standard methodology of CLC 2000 (**C**orine **L**and **C**over) as part of the European Comission programme to **CORINE CO**o**R**dinate **IN**formation on the **E**nvironment Habitats Codes by EEA (European Environmental Agency, 2006) aiming to provide information about land cover resources, environmental monitoring and national/regional spatial planning strategies. The I&CLC 2000 project in Serbia and Montenegro aims to provide a satellite "snap shot" of Serbia and Montenegro (IMAGE 2000)) (Nestorov, Protić, 2006).

Table 4. CORINE Land Cover Classes for the year 2000 (Acording: CLC 2000 Serbia)

	Code	CLC Class	Polygons	Area (ha)	Area (%)
1	231	Pastures	8	352.14	1.84
2	242	Complex cultivation patterns	6	54.34	0.28
3	243	Land principally occupied by agriculture, with significant areas of natural vegetation	32	1041.34	5.44
4	311	Broad-leaved forest	21	5190.05	27.1
5	312	Coniferous forest	14	990.73	5.17
6	313	Mixed forest	6	8639.93	45.13
7	321	Natural grassland	6	194.17	1.01
8	324	Transitional woodland/shrub	23	2490.46	13.00
9	331	Beaches, dunes, sands	1	5.53	0.03
10	511	Water courses	3	86.82	0.45
11	512	Water bodies	2	104.95	0.55
Total	122	19150	100		

The CLC nomenclature described in CORINE Land Cover Technical Guide is a physical and physiognomic land cover nomenclature relevant for environment, nature and landscape protection. It distinguishes land cover classes grouped in a 3 level hierarchy. The classes of the first level are: (1) artificial surface, (2) agricultural areas, (3) forests and semi-natural areas, (4) wetlands and (5) water bodies. In a second level there are 15 land cover classes and in third one 44.

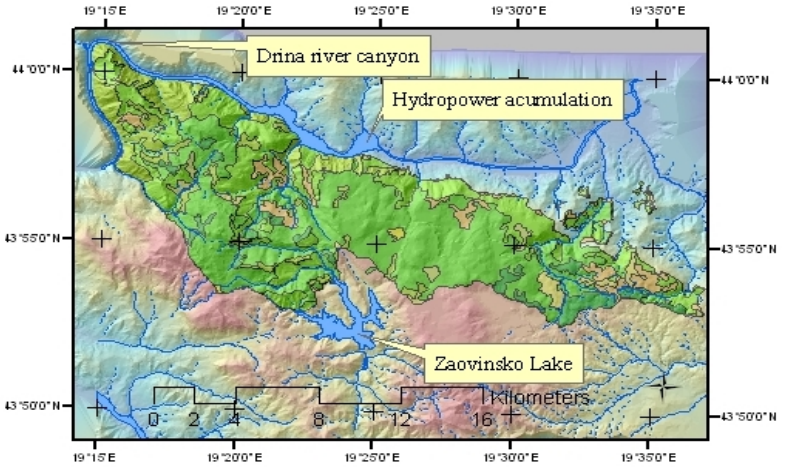

Fig. 9. CLC 2000 classes in Mt. Tara NP

Land Cover in Serbia is characterized by 29 out of 44 classes of the third level of CORINE Land Cover Nomenclature.

On the territory of the NP Tara (19150 ha) we have distinguished even 11 CLC third level classes (Tab. 4; Fig. 9), a convincing fact about high habitat diversity.

Conclusions

Mt. Tara NP represents an area incorporating natural values of global importance, most of which have retained the character of autochthonous environment.

The present work is a contribution to the GIS application in the areas of conservation geography, biogeography, environmental ecology, biodiversity protection, physical geography and spatial planning. This will be helpful to a wide circle of users in the areas of natural, biotechnical, technical, economic, and social sciences, as well as in tourism, sports, and recreation.

The advantages of the Mt. Tara NP GIS are: highly sophisticated computer solutions (hardware and software); production process standardization (data input and storage); data standardization (they may be used with any other GIS software currently and in the future); system openness (the system is open to input of new themes and modification of existing ones); clear visualization; analyses thoroughness (interactive, with more systematic, thematic, and topographic parameters); and system decision support.

All of these elements allow the efficient managing and provide the basis for good decision making for the protection and conservation of natural resources.

It also provides a basis for adequate preparation of documentation supporting the nomination of Mt. Tara for MAB "Biosphere Reserve"status within the global network of the UNESCO MAB Biosphere Reserve Program.

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ДРАГУТИН ПРОТИЋ

Р е з и м е

ПРИМЕНА ГИС ТЕХНОЛОГИЈА У ЗАШТИТИ ПРИРОДНИХ ПОТЕНЦИЈАЛА И СТРАТЕГИЈИ ПРОСТОРНОГ ПЛАНИРАЊА НП ТАРА (СРБИЈА) КАО ПОТЕНЦИЈАЛНОГ UNESCO MAB РЕЗЕРВАТА

Прве студије и иницијативе за проглашење планине Тара за Национални парк покренуте су још 1951. године, али је статус добијен тек 1981. године. Просторни план Националног парка Тара усвојен је 1989. год. У функцији ефикасног управљања Парком исти је данас подељен на пет газдинских јединица , које обухватају укупно 751 оделење.Половином 2004. године НП Тара је реноминовaн у оквиру UNESCO-ROSTE програма Човек и биосфера (MAB) за будући Резерват биосфере и трансгранични Парк мира између Србије и Босне и Херцеговине.. Територија Националног парка Тара обухвата највећи део планине Тара и налази се на просечној надморској висини између 1000 - 1200 m. Површина Националног парка је 19.175 ha, док 37.584 ha представља заштитну тампон зону око Парка.

Планински комплекс Тара представља један од најзначајнијих центара специјског и екосистемског диверзитета Балкана и Европе. Тару карактерише присуство 39 различитих и веома добро очуваних листопадних, мешовитих и четинарских шумских заједница (буква, јела, смрча). Тара представља јединствен пример добро очуваних шума на простору Југоисточне Европе са бројним ендемичним и реликтним врстама флоре и фауне. Свакако да посебан печат флористичком диверзитету Таре даје ендемо-реликтна врста панчићеве оморике *Picea omorika*. Због тога се иницијатива за укључивање простора планине Тара у Међународно значајна биљна подручја (IPA) може сматрати веома оправданом. Ово тим више, што се Тара већ налази на листи Подручја од значаја за фауну лептира Европе (PBA) и Међународно значајних подручја за птице Европе (IBA).

На основу ових карактеристика планински комплекс Тара испуњава све неопходне услове да буде укључен у Пан-европску еколошку мрежу.

Осим биотичке компоненте специфичне геоморфолошке, хидролошке, геолошке, педолошке и климатолошке карактеристике, такође дају простору Таре свеукупне високе природне вредности.

Географски информациони сустем (ГИС) који смо ми креирали представља изванредан алат за израду савремене стратегије просторног плана овог подручја, као и алат за валоризацију и заштиту свих природних вредности НП Тара. ГИС НП Тара представља истовремено савремен и незаобилазан алат за управљање Парком и одрживо коришћење његових природних ресурса. Садржаји ГИС НП Тара укључују природне, антропогене и управљачке атрибуте.