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Evolving GIS at Tara National Park (Serbia)

Abstract

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The Tara Mountain is among the most important centers of Balkan and European ecosystem and species biodiversity. It is characterized by diversified and well-maintained communities of old deciduous and mixed coniferous forests (beech/fir/spruce). They represent a unique example of well-preserved forests in SE Europe with numerous endemic and relict species of indigenous flora and fauna. Specific geomorphologic, hydrologic, geologic, soil and climatic features are also present on Tara Mountain. Tara National Park is located in the West part of the Republic of Serbia (180 km southwestward from Belgrade), and encompasses the largest part of Tara Mt. (average altitude 1000-1200 m asl). NP Tara has an area of 19175 ha, and a protected buffer zone around it of 37584 ha. The first study to declare Tara Mt. a National Park was carried out in 1951, but NP Tara was not established until 1981. During 2004 NP Tara was nominated within the UNESCO-ROSTE program as one of the next MAB Biosphere Reserves. We have developed a Geographical Information System (GIS) that has proved to be an excellent tool for evaluating and protecting the natural resources of NP Tara.

Introduction

NP Tara is one of the most researched National Parks in Serbia. During the last 60 years many scientists and managers of the Park have collected a huge amount of data dealing with the natural values of the area.

Until now the managing and directing of practically all the natural potentials of NP Tara was primarily based on the principles of forestry technology and management.

The GIS that we have created for NP Tara includes data on natural themes (ecosystems, vegetation, flora, fauna, landscapes, geology, soil, and hydrology), artificial (human) themes (roads, bridges, dam, hotels, rest camps and other visitor facilities) and management operational themes. At the same time it has proved an excellent tool in evaluating and protecting the natural resources of NP Tara, especially in preparing the indispensable documentation for nominating Tara Mt. as a Reserve of the Biosphere within the UNESCO program: Man and the Biosphere (Ashdown & Schaller 1990; Radović 2004a).

This type of research has its full scientific base in the worldwide actions of research, preservation, and protection of mountain ecosystems, because they are centers (hot spots)

of high species and ecosystems diversity (Wadsworth & Treweek 1999; Convis 2001; Longley & al. 2001).

Research Methods

Study Site

NP Tara is located in the Southwest part of Serbia within 43º 52' 30'' and 44º 01' North and 19º 14' 30'' and 19º 41' 30'' East . The highest point of NP Tara is Kozji Rid 1591 m asl, and the lowest point is at 300 m (exactly where the Perućac hydro electric power station is). Based on these characteristics, Tara Mt. is classified as a medium high mountain in Serbia.

NP Tara has an area of 19175 ha, and a protected buffer zone around it of 37584 ha. Within NP Tara we can differentiate two spatially-functional characteristic areas: High Tara (11562 ha) and Flat Tara (7613 ha).

In order to manage the NP Tara effectively it is divided into five managing totalities with a total of 751 parcels and sub parcels. The National Park is completely within the territory of the Bajina Bašta community (Fig. 1).

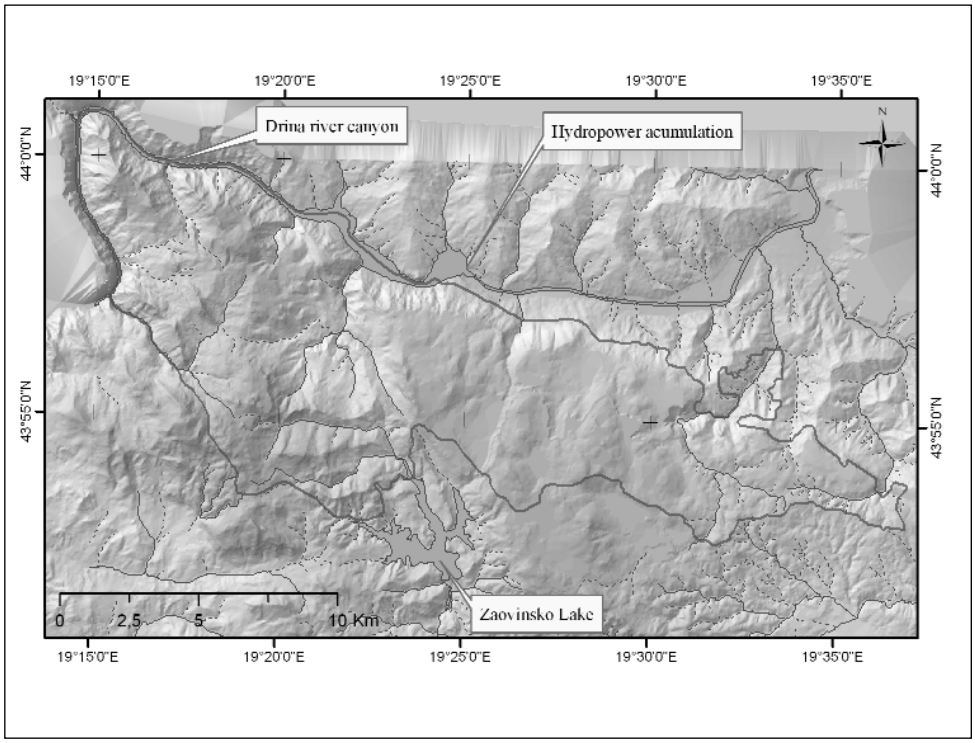

Fig. 1. Border of NP Tara on DEM.

Data sources

One of the major factors for developing a successful GIS project is the reliability of data. In this case we used a large number of data sources, but only from authorized governmental institutions:

topographic maps, maps of relief and hydrology, geological and soil maps, vegetation maps, aerial photographs, maps of five managing totalities (with 751 parcels) of NP Tara (Zvezda, Crni Vrh, Rača, Tara, Kaludjerske Bare) and tourist maps,

data consisted of 9 types of information for each parcel in each totality (name of totality, number of parcels and sub parcels, type of woodland, vegetation communities that occur, ecological belonging of vegetation to the type of soil, percentage of every vegetation species that occurs, parcel purpose, and parcel level of protection - zoning),

data on representatives of flora and fauna.

Methodology of work

Like in most GIS projects the usual procedures were applied: scanning, georeferencing, digitalizing (manual and semiautomatic), creating a database and integration of data (Radović 2004).

Content of NP Tara GIS

NP Tara 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 and aerial photographs cited in data sources after georeferentiation.

Next entities were represented in vector shape: geology (polygon), soil (polygon), hydrology (line/polygon), vegetation communities (polygon), locations of important floristic and faunistic species (point), border of NP Tara (polygon), management totalities (polygon), departments - parcels (polygon), settlements (polygon), roads (line), mountaineer trails (line) and other objects: hotels, tourist sights, waterfalls, caves, groceries (point).

To achieve the maximum effect through project 3D analyses were anticipated. These analyses require making correlations between certain phenomenon and relief characteristics (elevation, aspect and slope). To accomplish our objectives a digital elevation model (resolution 20 m pixel) was created. DEM covered an area of about 800 km^2. DEM provided for each pixel: coordinates (in meters), elevation (in meters), aspect (in degrees) and slope (in percentages).

Material to process the aerial photographs included a series of 19 photographs of NP Tara (scale R= 1: 30000; camera Wild RC-5, 1959). By using photographs that were almost 50 years old, we were able to notice some changes in vegetation and the human influences that led to them.

Results

Geomorphologic characteristics of Tara Mt.

To interpret the geomorphology of the Park this GIS project included elevation zones, aspect and slope of relief. Analyses of elevation zones showed that most of the area in the

Park represents altitudes from 800-1200 m (12571 ha; 65,56%) (Fig. 2). Analyses of aspect showed that North (2853 ha; 14.9%), Northeast (3604 ha; 18.8%) and Northwest (2199 ha; 11.5%) take most of the Park. Analyses of slope of relief showed that: 0-9.1% encompass 4964.2 ha, 25.9%; 9.2-18.3% encompass 5363.4 ha, 28%; 18.4-27.4% encompass 3895.4 ha, 20.32%; 27.5-36.5% encompass 2768.2 ha, 14.44%.

Geological characteristics of Tara Mt.

Tara Mt. is characterized by high geological diversity including age, origin and composition. There are rocks from the Carbon, Triassic, Jurassic, Cretaceous and Quaternary periods.

The total area of 34351 ha has been managed. Authentic content was classified into 35 types of geologic cover. To be able to make adequate correlations with vegetation primarily, a generalization into six basic and seven combined types was performed. Limestone and ophiolitic bedrocks covers about 77% and 7.5% of the territory of the Park, respectively.

Soil characteristics of Tara Mt.

The soil cover was digitizaled for an area of 55024 ha, with ten types of cover. There are five types of soil cover inside the Park: chernozem on serpentines (humus silicate soil) (2413 ha, 13%); brown reddish soil on limestone (6530 ha, 34%); calcareous-skeletal soil on firm limestone (9119 ha, 47.6%); diluvium (44.55 ha, 0.23%); brown skeletoid soil on schist (1068 ha, 5.6%).

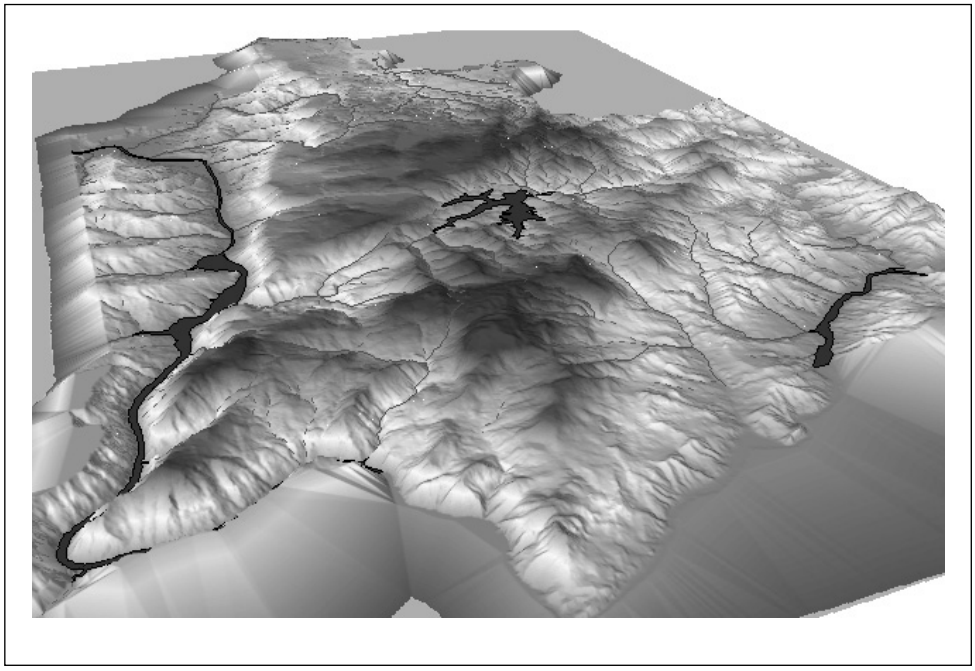

Fig. 2. Elevation zones on 3D model (NW view).

Hydrologic characteristics of Tara Mt.

The most expressed hydrologic characteristic of the Park is the Drina river (total length 346 km; 22.7 km around the Park) and the canyon. The canyon is over 1000 m high from Drina in the line of the Park. Most of the water flowing on Tara Mt. belongs to the Drina river basin. Drina represents the biggest tributary (by length, river basin area and flow of water) of the Sava river.

There are three artificial lakes in the area of the Park: Perućac hydro accumulation, Zaovinsko Jezero lake and Kruščica.

GIS theme hydrology includes all hydro elements on Tara: streams, rivers and lakes. It is possible to get information about the length of every flow or segment. The data model allows us to input information about the presence of ichtyofauna.

Climate of Tara Mt.

The climate of Tara Mt. is characterized by fresh to cool summers and quite cold winters (annual temperature variation is small). Nice weather is prolonged to the first part of autumn and October is warmer than April. Compared to other mountains in Serbia, Tara has a more expressed mountain climate. The average yearly temperature is 7.9ºC. Average yearly precipitation is 977 mm. A characteristic particular to the climate of Tara Mt. is its very high average yearly humidity (83.4%). The snow starts at the beginning of November and is present until the first part of May. Average thickness of snow cover is about 100 cm (Fig. 3).

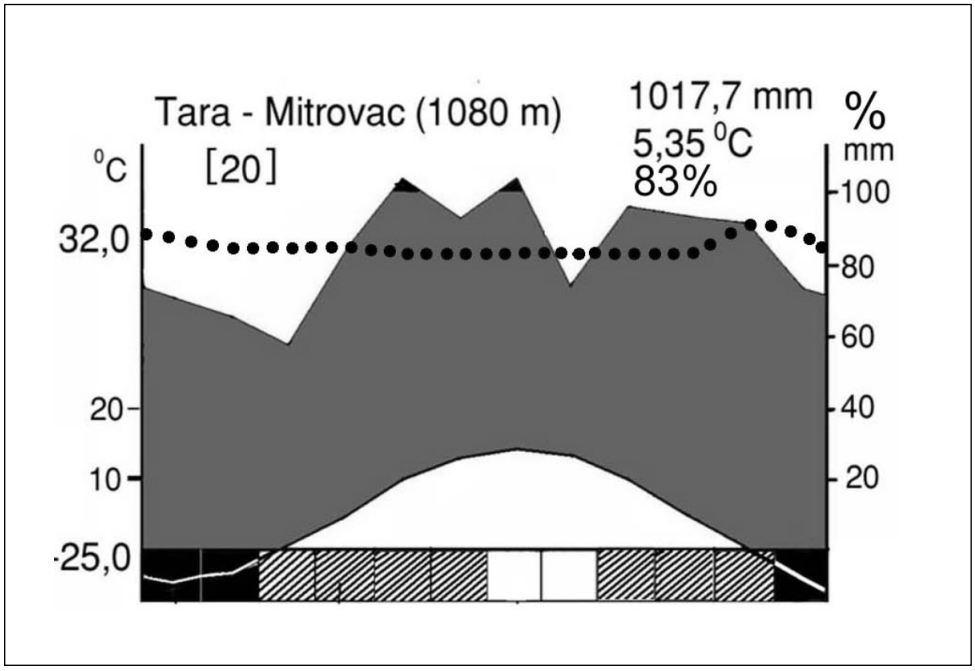

Fig. 3. Climatic diagram of Tara Mt.

Analyses of vegetation and floristic diversity of NP Tara

During more than century of floristic investigation, 1013 plant species have been recorded in Tara Mt., and that represents almost 1/3 of all flora of Serbia (Gajić 1988; Jovanović & Ostojić 2001).

The large number of relict and endemic species confirms the opinion of botanists that Tara Mt. is one of the centers of floristic and vegetation diversity in Serbia and this part of the Balkan Peninsula. Some of the most important endemic and relict species are: *Picea omorika*, *Centaurea derventana*, *Potentilla visianii*, *Aquilegia grata*, *Edraianthus graminifolius* aggr., *Gypsophila spergulifolia*, *Onosma stellulata*, *Halacsya sendtneri*, *Cephalaria pastricensis*, *Haplophyllum boissieranum*, *Daphne blagayana*, *Hieracium waldsteinii*, *Acer heldreichii* (Stevanović 2002).

In the center of floristic diversity of Tara Mt. is the Serbian (Pancic's) spurce a *Picea omorika* (Pančić) Purkyně, a unique paleoendemic species and one of the 'living fossils' of European dendroflora with a range confined to the middle course of the Drina river in western Serbia and eastern Bosnia and Hercegovina (Pančić 1887; Gajić & al. 1994; Dinić & Tatić 2006).

Within GIS analyses the theme 'vegetation' was digitizaled from vegetation map scale R=1:50000; (Mišić 1988). The vegetation map covers a total area of 28244.5 ha. The vegetation is differentiated into 35 vegetation communities in a total of 354 polygons. Attribute data are given using the Serbian and Latin name. Inquiries in the database allow us to get answers about the size of every polygon, and all other statistical indexes regarding the spread of vegetation communities. Parameters of vegetation can be easily correlated to all other themes. For instance, it can show us how the distribution of some vegetation corresponds with the type of geology, soil, elevation zones, slope and aspect of relief (Mišić 1988; Gajić & al. 1992) (Tab. 1).

Analyses of fauna diversity in NP Tara

Besides floristic and vegetation diversity, one of the most important natural potentials of Tara Mt. is the high diversity of fauna.

Until now there are records in Tara of 115 species of daily butterflies (60% of Serbian fauna), 27 species of fish (25%), 12 species of amphibians (46%), 12 species of reptiles (27%), about 170 species of birds (45%) and 51 species of mammals (48%) (Radović 2004).

Of special value to the fauna of Tara is the presence of the grasshopper *Pyrgomorphella serbica*, an endemorelict from Pliocene (Matvejev 1978). Beside this, the presence of three species of daily butterflies (*Euphydryas maturna*, *Maculinea arion*, *Parnassius apollo*) is important. They qualify Tara Mt. for one of the Prime Butterfly Areas in Europe (Jakšić 2003).

Within the ichtyofauna of NP Tara three species have a high value: *Hucho hucho* (Danubian salmon), *Salmo trutta* (brown trout) and *Thymallus thymallus* (grayling) (Simonović 2001).

Some important species of amphibians and reptiles in the area of park are: *Salamandra salamandra*, *Rana graeca*, *Zootoca* (*Lacerta*) *vivipara*, *Vipera ammodytes* (Džukić 1995).

Among important species of birds and mammals are: *Tetrao urogallus*, *Picoides tridactylus*, *Microtus multiplex*, *Ursus arctos*, *Rupicapra rupicapra* (Vasić 1977; Puzović & Grubač 2000; Savić & al. 1995).

Distribution of below listed species was mapped.

Table 1. Distribution of vegetation (absolute and proportional).

Communities	Area	
	ha	%
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
Nardetum 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

Analyses of NP Tara managing contents

GIS analyses of NP Tara contents include the area of the 5 managing units (Zvezda, Crni Vrh, Tara, Rača and Kaludjerske Bare) which include 751 parcels.

For each parcel 8 characteristics have been joined in the relational database: name of the totality, number of parcel and sub parcel, type of woodland, vegetation communities that occur, ecological belonging of vegetation to the type of soil, percentage of every vegetation species that occurs, purpose that department is used for, and level of protection.

GIS of the Park also includes Nature Reserves, settlements, roads and transportation, tourist facilities, line of visibility and aerial photos.

Conclusions

NP Tara represents an area with great natural value of worldwide importance which, to a great extent, has retained its character of an autochthon natural environment.

This work is a contribution to the crucial application of GIS technologies in the areas of: environmental ecology, biodiversity protection, biogeography, conservation geography, physical geography and spatial planning and their implementation in the protection and management of natural resources in NP Tara. This information will be accessible to a wide circle of users in the areas of natural, biotechnical, economic and social sciences, as well as in tourism, sports and recreation.

GIS of NP Tara has outstanding possibilities for adequately preparing the indispensable documentation for the nomination of Tara Mountain as a Biosphere Reserve within the UNESCO program Man and the Biosphere.

GIS of NP Tara can easily be used as a multilateral model, applicable to all other National parks, nature reserves and protected natural areas in Serbia and Montenegro.

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References

Ashdown, M. & Schaller, J. 1990: Geographic information systems and their application in MAB-projects, ecosystem research and environmental monitoring. – MAB Mitteilungen **34:** 1-250.

Convis, Ch. (Jr.) 2001: Conservation Geography; Case Studies in GIS, Computer Mapping and Activism. – Redlands (California).

Dinić, A. & Tatić, B. 2006: Šume pančićeve omorike. – Pp. 213-244 in: Škorić, D. M. & Vasić, O. (eds), Vegetacija Srbije **2(2).** – Beograd.

Džukić, G. 1995: Diverzitet vodozemaca (*Amphibia*) i gmizavaca (*Reptilia*) Jugoslavije, sa pregledom vrsta od medjunarodnog značaja. – Pp. 447-469 in: Stevanović & V., Vasić, V. (eds), Biodiverzitet Jugoslavije sa pregledom vrsta od medjunarodnog značaja. – Beograd.

Gajić, M. [1988]: Flora Nacionalnog parka Tara. – Beograd & Bajina Bašta.

—, Kojić, M., Karadžić, D., Vasiljević, M. & Stanić, M. 1992: Vegetacija Nacionalnog Parka Tara. – Beograd & Bajina Bašta.

—, Vilotić, D., Karadžić, D., Mihajlović, Lj. & Isajev, V. 1994: Omorika - *Picea omorika* (Pančić) Purkyne na području Nacionalnog Parka Tara. – Bajina Bašta & Beograd.

Jakšić, P. 2003: Yugoslavia. – Pp. 655-684 in: van Swaay, C. A. M. & Warren, M. S. (eds.), Prime Butterfly Areas in Europe, Priority sites for conservation. – The Netherlands.

Jovanović, S. & Ostojić, D. 2001: Zašto je Tara Nacionalni Park. – Pp. 21-34 in: Orlović, V. & Ostojić, D. (eds), Otkrivanje Tare. – Beograd.

Longley, P., Goodchild, M., Maguire, D. & Rhind, D. 2001: Geographic Information Systems and Science. – New York.

Matvejev, S. 1978: Geografske i biogeografske osobenosti reliktnih stanista Pančićevog skakavca (*Pyrgomorphella serbica*, Orthoptera). – Zbornik radova o entomofauni SR Srbije **2:** 1-28. – Beograd.

Mišić, V. 1988: Vegetacijska karta NP Tara. [In: Prostorni plan područja Nacionalnog Parka Tara]. – Službeni glasnik SRS **29/88.** – Beograd.

Pančić, J. 1887: Omorika, nova fela četinara u Srbiji. – Težak **18(1):** 1-8 + I-II.

Prostorni plan Nacionalnog Parka Tara 1989: – Službeni glasnik SRS **3/89.**

Puzović, S. & Grubač, B. 2000: Federal Republic of Yugoslavia. – Pp. 725-745 in: Heath, M. F. & Evans, M. I. (eds.), Important Bird Areas in Europe: Priority sites for conservation. 2: Southern Europe. – Cambridge.

Radović, D. 2004: Implementation of GIS (Geographic Information Systems) on the valorization and conservation of natural values of National Park Tara (Serbia). Master Thesis. – Beograd.

— 2004a: Presentation of the working methodology and the Tara National Park case. UNESCO/ROSTE – IUCN, Joint International Workshop on "MAB Biosphere Reserves and Transboundary Cooperation in the SEE Region. Belgrade and Tara National Park 13-17. June, 2004.

Savić, I., Paunović, M., Milenković, M. & Stamenković, S. 1995: Diverzitet faune sisara (*Mammalia*) Jugoslavije, sa pregledom vrsta od medjunarodnog značaja. – Pp. 517-554 in: Stevanović, V. & Vasić, V. (eds), Biodiverzitet Jugoslavije sa pregledom vrsta od medjunarodnog značaja. – Beograd.

Simonović, P. 2001: Ribe Srbije. – Beograd.

Stevanović, V. 2002: Fitogeografski položaj i opšti prikaz flore i vegetacije planine Tare. – Pp. 4-7. in: Zbornik radova XXV Savetovanje o lekovitim i aromaticnim biljkama. – Bajina Bašta.

Vasić, V. 1977: Pregled faune ptica planinskog kompleksa Tara (zapadna Srbija). – Arh. Biol. Nauka Beograd **29(1-2):** 69- 81.

Wadsworth, R. & Treweek, J. 1999: Geographical Information Systems for Ecology: An Introduction. – London.

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