*Marko Zebec*[1], *Vladimir Zebec*[2]

[1]Šumarski fakultet, Sveučilište u Zagrebu, zebec@sumfak.hr

[2]Hrvatski prirodoslovni muzej, Zagreb, 014851700

# Establishing and Analysing a Gis Model of the Žumberak - Samoborsko Gorje Nature Park

## 1. Introduction

The Žumberak – Samoborsko Gorje Nature Park is the second largest nature park in Croatia after Velebit. As it is situated in the vicinity of Zagreb, it is becoming an increasingly popular destination for numerous hikers and picnickers. In spite of the fact that this area is still relatively insufficiently investigated, it represents a sample area for the establishment of a GIS model.

Unlike the nearby Medvednica Nature Park, the Žumberak - Samoborsko Gorje Nature Park is still in the initial stage of organisation. There are no comprehensive natural scientific research activities in the Park area, while past research is partial, random, and for the most part unsystematised. This paper is an attempt to systematise and unify past research of the geological substrate and soil in the form of thematic GIS layers.

## 2. Field of research

An area covering 33,300 ha of Žumberak – Samoborsko Gorje was proclaimed a park of nature on 2 June 1999 (Narodne Novine 58/1999).

The seat of the Park is in Slani Dol, not far from Samobor. Despite the vicinity of large centres (Zagreb, Karlovac), the Park is yet to become a strong tourist area. Presently, it is visited mainly by hikers and nature lovers.

In terms of orography, Žumberačka Gora and Samoborsko Gorje make up a geographic unity. The area is some forty kilometres long and twenty kilometres wide and is situated south-east of Zagreb in the north-western part of Croatia.

Its northern boundary follows the valley of the river Krka, the southern goes along the valley of the river Kupa, the eastern and the north-eastern boundary are determined by the valley of the river Sava, while the south-eastern boundary is defined by the slopes of Plešivica. In the west, Žumberak leans on Kočevske Gore. With Gorjanci in Slovenia it is fused into a unified mountain massif.

This area is characterised by a highly indented relief resulting from the erosive action of flowing waters in combination with tectonics. This is reflected in deep valleys, distinct ridges and steep slopes.

It should be pointed out that the ridges follow the direction of the Alps (south-west – north-east), causing the slopes to have predominantly southern or northern expositions. As this is a transitional area between the Alps and the Dinaric mountain chain, the steep forms and sharp contours of the peaks bear an alpine character, while karst landforms (caves, sinkholes, gorges) are of Dinaric origin.

The relief of Samoborsko Gorje is profoundly affected by the streams Lipovečka and Rudarska Gradna, whose channels divide three distinct groups: Plešivica (779 m), Oštrc (752 m) and Japetić (879 m). The highest mountain peaks Sveta Gera (1,178 m), Sljeme (978 m), Pliješ (977 m), Ječmište (976 m) and Zečak (795 m) are located in the watershed between the rivers Sava and Kupa.

## 3. Goal of research

The goal of this work was to analyse the obtained data within the established GIS-model of the Žumberak – Samoborsko Gorje Nature Park. The analysis was preceded by the establishment of a database for this area and data integration into a uniform geographical information system (GIS).

The previously geocoded data were thematically organised and mutually aligned. The obtained thematic layers and the related data within the established GIS-model were analysed and the problem of obtaining the best possible GIS layers from a relatively heterogeneous database was presented. Heterogeneity is due to the use of maps with different scales, cartographic projections, and relatively long periods of time passing between the collection of field data, their processing and printing.

## 4. Methods of work

### 4.1. Map digitalisation (vectorisation)

All the maps used as a basis for the construction of thematic layers and their integration for further analyses were first converted from the analogous into the digital form.

Before the vectorisation process, the maps were georeferenced so that distinct points were first determined that were recognizable both in the topographic map (TM) (1:25,000) and the currently processed thematic map.

The very poor graphic quality of the maps required manual vectorisation. Since two sheets of the Basic Pedological Map of SFRY (SAMOBOR 1, NOVO MESTO 2 were done manually in black-

and-white, the boundaries of some mapped units were indistinct, causing collision between this and other elements in the map (toponyms, contours, hydrological units, roads).

### 4.2. Construction of thematic map layers

- geological thematic layer

To construct a geological thematic layer, three sheets of the Basic Pedological Map of SFRY – scale 1: 100,000 were used: ZAGREB (ŠIKIĆ et al., 1979); NOVO MESTO (PLENIČAR et al., 1977); ČRNOMELJ (BUKOVAC et al., 1984).

As three maps of varying delineation accuracy within individual mapped stratigraphic units were used for the construction of the geological thematic layer, several similar members had to be homogenized into a "general member". However, this has affected the quality of further analysis. This resulted in a lower number of mapped units, whose basis was the sheet ZAGREB, where the majority of the members were retained, while the units of NOVO MESTO and ČRNOMELJ were homogenised in order to correspond to some members of the sheet ZAGREB.

The starting point for the construction of thematic geological layers was the geological stratigraphic map. Individual tectonic and engineer-geological layers, required to balance the geological substrate and the related soil types, were based on this map.

In terms of tectonics, only more important structural units were considered (faults and other phenomena).

The engineer geological map of Croatia (1: 600,000) by K. Braun, Geological Institute in Zagreb (2002) was used to construct the engineer geological layer. The new engineer-geological layer was based on the geological map, where engineer-geological characteristics, taken from Braun's map, were added to individual stratigraphic members.

After the completion of the geological thematic layer, the Žumberak – Samoborsko Gorje Nature Park management supplied the geological stratigraphic-tectonic map (Geological Institute in Zagreb, 2003) for comparison, from which only the layer of the area's hydrological activity was used.

- pedological thematic layer

The pedological thematic layer was based on the Basic Pedological Map of SFRY (1: 50,000), whose five sheets encompassed the area of the Nature Park: SAMOBOR 1 (BOGUNOVIĆ et al., unpublished); SAMOBOR 2 (KALINIĆ et al., 1969); SAMOBOR 3 (MAYER et al., 1978); SAMOBOR 4 (KOVAČEVIĆ et al., 1969); NOVO MESTO 2 (BOGUNOVIĆ et al., unpublished).

As the terminology of the soil types in all five sheets of the Basic Pedological Map of SFRY was based on the classification by Kovačević et al., (1972), the names had to be redefined according to

the new soil classification (ŠKORIĆ et al., 1985). However, the idea was given up because the correlation of pedological terminology was only published for the sheets of the Upper Posavina area (BOGUNOVIĆ & RAPAIĆ, 1993), or in this case only for the sheets of SAMOBOR 2 and SAMOBOR 4.

The new pedological classification would also be questionable because the geological map is outdated in terms of classification and terminology of the presented attributes. Therefore, classification update of the pedological map (here by its generalisation) would cause disproportion between the correspondence of the parent substrate and the overlying soil types, which would pose serious problems in further geological-pedological analysis.

For these reasons, a new, more adequate classification was made that was modified according to Kovačić. The features of rockiness and relative relationships between the volume participation of individual soil types, making up a classification unit, were eliminated from the descriptions of individual cartographic members.

Erosion processes were treated theoretically due to the lack of an adequate DTM and an applicable formula for the calculation of erosion in a specific area of the Nature Park. The constructed engineer geological layer served as a specific indicator of the rock weathering rate and connections between the rock mass and the soil supporting it.

In the final stage, the geological and pedological substrate was aligned with characteristic phytocoenoses occurring on a given soil type, altitude and exposition and the patterns of alignment were established. Since the phytocoenological map was being made, the company Hrvatske Šume provided attribute maps with vectorised data on any individual management unit in the Park area; the data were taken from the area management plan and represent forest management parameters.

Of the mentioned parameters, we were interested in altitude, exposition and phytocoenoses for the management units of Blaževo Brdo and Sušica. The geological substrate – soil – phytocoenosis relationship in given compartments and subcompartments was analysed for these areas. The relative regularity of the relationship was established and the applicability of GIS confirmed despite the cartographically heterogeneous input data.

## 5. Results and discussion

A GIS model of the Žumberak – Samoborsko Gorje Nature Park was constructed containing a number of usable thematic layers that can be mutually complemented and integrated. New thematic layers may be based on these. The GIS model consists of the following maps:

- geological-stratigraphic map (1: 100,000) – Figure 1
- geological-tectonic map (1: 100,000)
- engineer –geological map for the management unit Blaževa Gora (1: 600,000)
- pedological map (1: 50,000)

The geological-pedological-phytocoenological analysis was made for the area of the management units of Blaževo Brdo and Sušica (Figure 2).

The management unit Blaževo Brdo is a plateau abounding in karst phenomena ranging in altitude from 800 to 1,000 m. It covers an area of 1,864.59 ha.

This management unit was selected for analysis for reasons of homogeneity and uniformity of the phytocoenological composition. According to Pernar and Bakšić (2003), the dominant association – the montane beech forest with deadnettle (Lamio orvalae-Fagetum sylvaticae /Ht. 1938/ Bohridi 1963) occurs on brown soil on limestone and dolomite, illimerised soil on limestone and brown limestone-dolomite humus. Since it is a plateau with very slight altitudinal oscillations and exposition, our research focused on the relationship between primary rock masses and the overlying soils. The best examples of this are compartments 5a, 16a, 16b, 16c, 16d, 17a and 17b. These compartments are located on Middle Triassic and Upper Triassic layers in the carbonate development of early diagenetic dolomites.

Compartment 9a, apart from the dominant dolomite component, sporadically features dolomite limestones and shales, indicting a higher proportion of the accumulate silicate component in the weathering product and the soil; the prevailing soil type is rendzina; depending on the petrographic substrate, it is developed in several subtypes.

The management unit Sušica, located in the westernmost part of the Nature Park, is characterised by the diversity of forest communities. It covers an area of 1989.13 ha. The analysis was made in a segment of 625 ha in the following compartments: 31f, 32d, 33a, 33b, 33c, 33d, 33e, 34a, 34b, 34c, 34d, 34e.

All these compartments occur on the same, clastic, petrographic substrate (breccias, conglomerates, shales, marls, silty marls, marly limestones, red thin bedded limestones and cherts). Stratigraphically, they belong to Upper Cretaceous (Cenoman, Turon, Senon). The pedological composition (eutric brown – brown on limestone and dolomite – lessivated – rendzina, on chalky flysch) corresponds to the geological substrate. This small area supports almost all principal forest communities of Žumberak and Samoborsko Gorje (montane forest of beech with deadnettle, montane beech forest with woodrush, Illyrian forest of sessile oak and common hornbeam, forest of sessile oak and sweet chestnut); in terms of altitude, they occur within the boundaries established in research by Vukelić and Rauš (1998), with the only exception of montane beech forest, which climbs down below 400 m, taking up southern and eastern expositions, as this area is a deeply cut stream valley (300 – 500 m above the sea; compartments 33a, 34c, 34d, 34e).

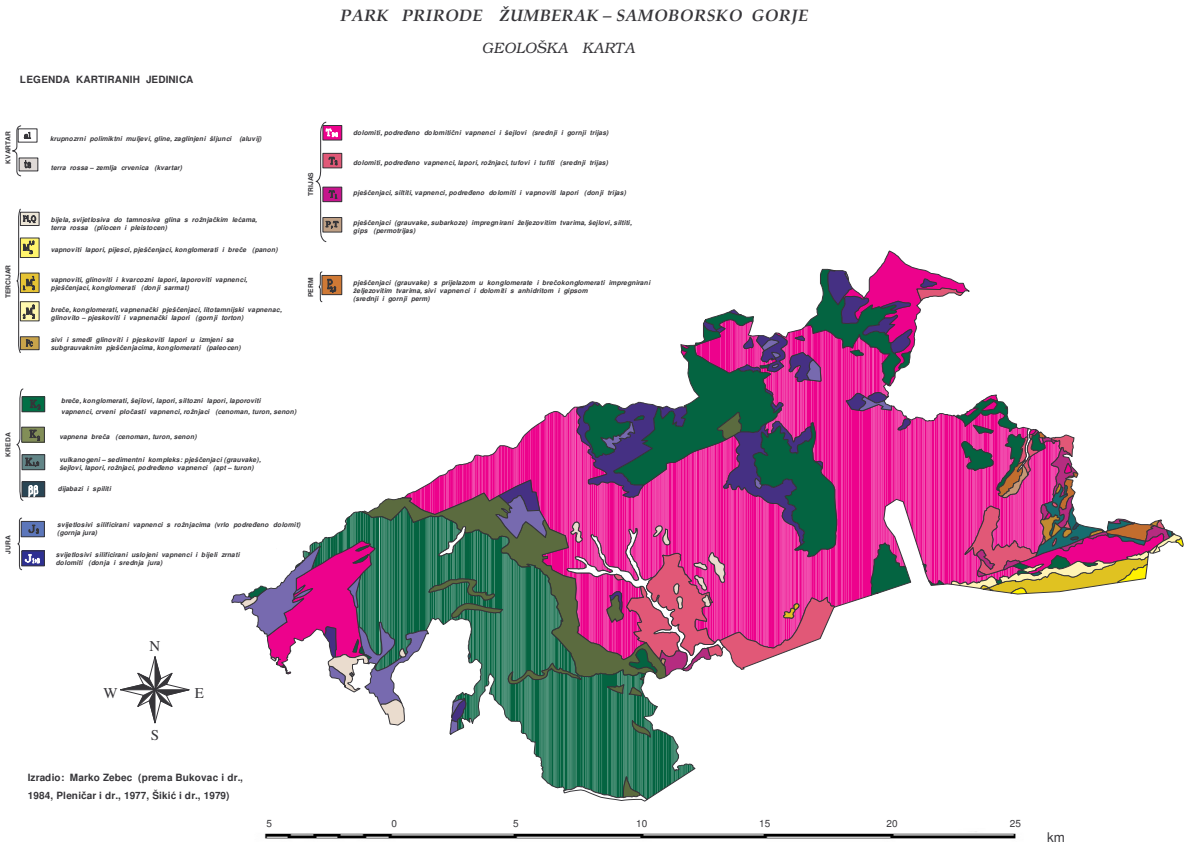


Figure 1. Geological-stratigraphic map of the Žumberak-Samoborsko Gorje Nature Park (1: 100,000)

The division into mapped stratigraphic units within the geological map also depends on the degree of terrain exploration; consequently, new research produce changes. The changes may relate to divisions of a single mapped member into several stratigraphic levels, making the map more precise.

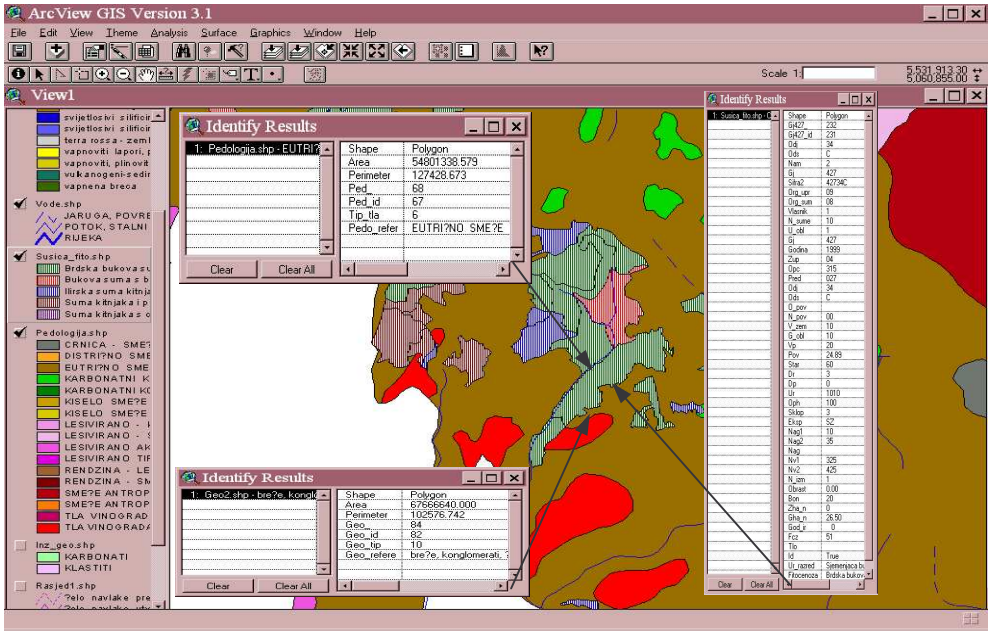


Figure 2. GIS interface in the geological-pedological-phytocoenological analysis of compartment 34c

## 6. Conclusion

The obtained thematic layers may be used as a starting point for further research into this area, but may primarily serve as a basis for inventorying the Park's natural resources. In fact, this is the priority of the Public Enterprise Žumberak – Samoborsko Gorje Nature Park, an organisation managing the analysed area.

There were multiple problems in the course of work. They relate in the first place to the lack of suitable, sufficient and uniform input data. Such data are a prerequisite for any reliable construction of a good quality GIS.

Despite the relatively good correlation, in several places it was hard to establish any relationship between the parent rock and the soil features. The problem is due to the fact that the geological substrate was formed in the units primarily linked to geological age. Thus, one mapped stratigraphic member may contain several rocks differing substantially in petrography and mineralogy; however, they were not delineated in the map as such. By overlapping these two thematic layers, such critical points were located, but should be tested in the field. A very similar problem occurred in aligning the mineralogical-petrographic composition, the dominant soil type and the phytocoenosis. In several of the sites (admittedly, to a limited degree), the soil above the same petrographic substrate has the same pedological features, but supports practically all forest communities present in the Park in a very narrow area. In such cases, only a field visit can explain this phenomenon.

The areas of Žumberak and Samoborsko Gorje are tectonically highly disturbed. Tectonics is occasionally responsible for the prevalence of characteristic soil formation and weathering, relief development and terrain permeability. Its morphology indicates general tectonic directions: the older Dinaric direction on the one hand and the younger direction of the Balaton series placed vertically to the Dinaric direction on the other.

The GIS technology has made it possible to integrate several maps into a unit composed of layers. Its geographically positioned points, available to different disciplines, are open to chronological overviews and permanent additions to the databases in line with new research.

**Bibliography**


1. Bogunović, M. i Rapaić, M., 1993: Digitalizacija pedološke karte Republike Hrvatske, Bilt. dalj. istr. fotoint., Vol 12, Zagreb, 65-76
2. Bukovac, J., Poljak, M., Šušnjar, M. i Čakalo, M., 1984: Tumač za list ČRNOMELJ, Osnovna geološka karta SFRJ, 1: 100 000, Savezni geološki zavod, Beograd
3. Kalinić, M., Kovačević, P., Pavlić, V., Stepančić, D., Stritar, A., Radman, B., Mayer, B., 1969: Tumač za list SAMOBOR 2, Osnovna pedološka karta SFRJ, 1: 50 000, Institut za pedologiju i tehnologiju tla Poljoprivrednog fakulteta Sveučilišta Zagreb, Zagreb
4. Kovačević, P., Kalinić, M., Pavlić, D., Bogunović, M. i Tomaš, I., 1969: Tumač za list SAMOBOR 4, Osnovna pedološka karta SFRJ, 1: 50 000, Institut za pedologiju i tehnologiju tla Poljoprivrednog fakulteta Sveučilišta Zagreb, Zagreb
5. Mayer, B. i Rastovski, P., 1978: Tumač za list SAMOBOR 3, Osnovna pedološka karta SFRJ, 1: 50 000, Projektni savjet za izradu pedološke karte SRH, Zagreb
6. Pernar, N. i Bakšić, D., 2003: Tla bukovih šuma. U: Slavko Matić (edt.): Obična bukva Fagus sylvatica L. u Hrvatskoj, Šumarska akademija, Zagreb, 58-65
7. Pleničar, M. i Premru, U., 1977: Tolmač za list NOVO MESTO, Osnovna geološka karta SFRJ, 1: 100 000, Zvezni geološki zavod, Beograd
8. Šikić K., Basch V., Šimunić A., 1979: Tumač za list ZAGREB, Osnovna geološka karta SFRJ, 1: 100 000, Savezni geološki zavod, Beograd
9. Vukelić, J. i Rauš, Đ., 1998: Šumarska fitocenologija i šumske zajednice u Hrvatskoj, Šumarski fakultet, Zagreb, str. 256-258

**Establishing and Analysing a Gis Model of the Žumberak - Samoborsko Gorje Nature Park**


## Abstract

"Žumberak - Samoborsko gorje" was proclaimed park of nature in 1999. It is the second park of nature in Croatia, considering its surface area. Researches conducted on the area of the Park so far are partial and uneven and therefore this paper tries to systematize and unify all previous researches, primarily the ones that relate to geologic basis and soil, into topic-related GIS layers.

All maps, which later served as the basis for creation of individual topic-related layers and their integration for the purpose of further analysis, are at first transferred from analogue into digital form using R2V program package. Since particular maps were of poor graphical quality, we utilized manual vectoring and exported the vectorized data from R2V into program package ArcView 3.1. for further processing.

Numerous efficient topic-related layers (geological-stratigraphic map, geological-tectonic map, engineering-geological map, pedological map) were used to create the GIS model of the nature park "Žumberak - Samoborsko gorje". Geological-pedological-phytocenological analysis was conducted for the two management units on the area of the Park.

Problems emerging during the work proved to be manifold. There is primarily the insufficient number of adequate, enough dense and properly balanced input data. As early as upon the first connecting of parent rocks with soil character, alongside with relatively good correlation, an issue occurred to decide on any kind of relation on many spots. Similar problem occurs upon connection of mineral-petrographic compounds, dominant soil type and phytocenosis. Such critical spots are located by overlapping of these three layers and they need a field check-up.

By the analysis of obtained topic-related layers and belonging data within the established GIS model, we tried to explain the issues of getting high-quality GIS layers from relatively heterogeneous data base, since for creating particular topic-related layers we used maps of various scale, cartographic projections, and large time intervals among collecting data on the field, creating and printing maps.

GIS technology enabled us to connect many various layers (maps), with all the points geopositioned and available to users of various professions, and opened by time sections and constant updating of the base, parallel to new researches.

Keywords: GIS-model, Park of nature “Žumberak – Samoborsko gorje”, spatial analysis