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A web-map of the landscapes of Vitosha Mountain and the development of landscape science in Bulgaria

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Abstract

On the first hand, the purpose of this article is to present the map and classification of the landscapes of Vitosha Mountain. On the other hand, it aims to present this map as an example and illustration in the context of traditionally applied approaches in Bulgaria in defining the landscape, as well as in researching and classifying the landscapes. There is also a brief overview of the development of landscape science in Bulgaria.
The choice of the territory in study relates to the fact that Vitosha Mountain is a protected area, i.e. a Nature park declared in 1934, now part of the NATURA 2000 network.
The Vitosha Landscape Map is developed by using GIS tools and it is implemented as a web-map, which makes it much easier to access, examine and work with it, as compared to static maps.

Keywords: *Vitosha Mountain, landscapes, GIS, web-mapping*

Rezumat. O hartă web a peisajelor Muntelui Vitosha și dezvoltarea științei peisajului în Bulgaria

În primul rând, scopul articolului este acela de a prezenta clasificarea peisajelor și harta acestora la nivelul Muntelui Vitosha. Pe de altă parte, lucrarea furnizează harta ca exemplu și ilustrare în contextul abordărilor tradiționale utilizate în Bulgaria cu privire la definirea peisajului, precum și în cercetarea și clasificarea peisajelor. În articol se realizează și o succintă prezentare a dezvoltării științei peisajului în Bulgaria.
Alegerea arealului de studiu este legată de faptul că Muntele Vitosha reprezintă o arie protejată, fiind declarat Parc natural în 1934, iar în prezent este parte a rețelei Natura 2000.
Harta peisajelor Muntelui Vitosha este realizată prin utilizarea instrumentelor GIS și este implementată ca o hartă web, ceea ce ușurează mult accesul, examinarea și lucrul cu aceasta, în comparație cu hărțile statice.

Cuvinte-cheie: *Muntele Vitosha, peisaje, SIG, web-mapping*

Introduction

In the context of the European Landscape Convention – ELC (ratified in 2004 by the Bulgarian Parliament) it is crucial to increase cooperation in landscape science between all European countries, because ELC emphasizes that landscape "identification and assessment procedures shall be guided by the exchanges of experience and methodology, organised between the Parties at European level". Landscape science in Bulgaria has a long tradition. It covers numerous branches like landscape mapping, landscape evaluation, landscape geochemistry etc. Unfortunately, as most of the publications in this field are issued in Bulgarian language, they are not well known to the international scientific community in the area of landscape science and landscape ecology. In an attempt to fill this gap, in the present article we will present a short introduction to the development of landscape science in Bulgaria. Then, we will introduce a web-map of the landscapes in Vitosha Mountain (South-West Bulgaria), as an example of this tradition. This web-map application is made by using free GIS tools in QGIS Cloud service. It contains two separate layers, the first one being that of the potential landscapes (or primary landscape structure) and second one being that of the anthropogenic landscape changes (or secondary landscape structure). All attributes of the layers are bilingually expressed (in Bulgarian and English), which, in combination with the easy access to the web-map, makes it suitable to present some of the landscape concepts used in Bulgaria to a broader scientific audience.

A short history of the landscape science in Bulgaria

The development of the landscape science in Bulgaria started in the first half of the 20th century in the Sofia University, with the names of Prof. Jeko Radev and Prof. Dimitar Yaranov, who first used the term "landscape" in their scientific works. In 1934, Prof. Ivan Batakliev published "Landscape differentiation of Bulgaria", the first scientific paper dedicated especially to landscape science issues. In 1943, Ignat Penkov published a broad study with the title "Cultural landscapes". Most of them follow the German tradition in landscape science. After the WWII, D. Yaranov and I. Batakliev were dismissed from the Sofia University and the development of landscape science was discontinued for nearly 25 years. In 1970, I. Ivanov, D. Dimitrov and P. Penchev argued the necessity of Bulgarian physical geography to turn again to the study of landscape problems. In 1972, the Department of Landscape Science (now Landscape Science and Environmental Protection) was established in the Faculty of Geology and Geography of the Sofia University. Until the end of the

eighties, many young geographers were trained in the field of landscape science in the former Soviet Union, where they acquired Ph.D. For several decades, hundreds of scientific publications were issued, covering almost all branches in the field of landscape science, such as landscape classification and landscape mapping, landscape geophysics, landscape geochemistry, and landscape evaluation (Velchev et al., 2011).

To the end of the eighties, landscape science in Bulgaria (Petrov, 1990) was strongly influenced by the scientific traditions and concepts established in the former Soviet Union and in other Eastern and Central Europe countries. Afterwards, broader scientific concepts, theories and methods from the field of landscape ecology started to penetrate the Bulgarian landscape science. The contemporary challenge of Bulgarian landscape science is to apply these concepts developed in different scientific schools, preserving the best of the old tradition and accepting all the best from the landscape ecology.

Table 1 Comparison of the two basic landscape classifications in Bulgaria

Landscape level	Petrov, 1979		Velchev et al., 1992	
	Taxonomic unit	Criteria	Taxonomic unit	Criteria
Level 1	Class	Physical conditions of the surface – territory or water surface. Macro-geomorphologic features, determining the character of zonation (plains or mountains).	Class	Relief and its geologic content (plains or mountains).
Level 2	Type	Typical features of zonation; vegetation and soil type.	Type	Hydroclimatic conditions; vegetation types and their relation with climate conditions.
Level 3	Subtype	Features of zonation inside the type; vegetation and soil subtype.	Subtype	Secondary features of zonation and bioclimatic conditions.
Level 4	Group	Geologic and geomorphologic features – mesorelief; base rock formation (parent material); phytocoenosis and soil.	Genus	Relief type and geological structures; vegetation and soil.
Level 5	Species	The most relative homogeneity of the environmental features.	Species	Geologic and geomorphologic homogeneity; soil-vegetation cover; microclimate conditions.

The view of landscape and the landscape classifications in Bulgaria

The view of landscape in Bulgarian science is mainly based on the works of the Russian scientists and geographers like V. V. Dokuchaev, L. S. Berg, A. A. Grigoriev, S. V. Kalesnik, N. A. Solntsev, A. G. Isachenko, N. A. Gvozdetskii, F. N. Milkov, D. L. Armand, V. A. Nikolaev, and V. B. Sochava. In this context, a common definition of landscape accepts that it is "a natural formation in exact stage and operating in time and space within the environmental system; it holds some natural resources and it is affected more or less by the human activity" (Velchev et al., 2011). In contrast with one of the broad accepted views in landscape ecology, where "a landscape is an area that is spatially heterogeneous in at least one factor of interest" (Turner et al., 2001), this perspective postulates a more holistic approach, i.e. landscape is only a spatial whole consisting of all environmental components: rocks and geologic structures, geomorphologic features, air masses and its climate, water masses, soils, vegetation cover, animals, human activity reshaping the natural environment (Petrov, 1990; Velchev et al., 2011).

On the national level, there are two basic landscape classifications accompanied by landscape maps for Bulgaria. The first one is based on N. A. Gvozdetskii's landscape classification and it was accompanied by a landscape map at scale 1:400,000 (Petrov, 1979). The second one is based on N. L. Berouchashvili's landscape classification and it was accompanied by a landscape map at scale 1:500,000 (Velchev et al., 1992). Table 1 displays the taxonomic units and the differentiation criteria.

Besides these two basic classifications, several dozens of variants and modified versions of them, as well as a few generally different landscape classifications were used for landscape mapping only for a part of the country and they were not applied at national level.

Short description of the study area

Vitosha Mountain is located in South-West Bulgaria, near the capital Sofia. Its total area is 27,485 ha and the highest peak is Cherni Vrah (Black Peak), with 2,290 m a.s.l. The mean altitude of the moun-

tain is nearly 1,400 m a.s.l. The mountain is the first Bulgarian National Park and the first in the Balkan Peninsula, being declared in 1934. Since 1998, Vitosha is a Nature Park, with a total area of 27,079 ha. It includes two reserves. "Bistrishko Branishte" (1061 ha) is a forest reserve with mainly spruce forests. "Torfeno Branishte" (784 ha) is a peat-bog reserve located in the sub-alpine mountain belt. Vitosha Mountain preserves a valuable natural heritage with great biological diversity and it has important ecological functions to the adjacent country capital Sofia.

Vitosha Mountain landscape classification

For Vitosha Mountain landscape, we used a modified classification generally based on the second one presented above (Velchev at al., 1992), but combining elements from both. This landscape classification is describing the potential landscapes (primary landscape structure) without taking into account the human impact on the landscapes. Therefore, this map has some hypothetical content especially concerning the attempt to reconstruct the potential vegetation cover, which is mostly affected by human impact.

This classification of the potential landscapes has six levels. Each level is described below, together with the corresponding criteria and with a list of the correlative landscape units existing in Vitosha Mountain.

Level one (Class) with differentiation criteria: presence or absence of altitudinal zones (plains or mountains).

- Mountain landscapes (with altitudinal zonation)

Level two (Type) with differentiation criteria: climate type.

- Warm-temperate semi-humid
- Temperate humid
- Cold-temperate humid
- Cold humid

Level three (Subtype) with differentiation criteria: vegetation type.

- Low mountain forests in oak-hornbeam belt
- Mid mountain forests in beech belt
- Mid mountain forests in coniferous belt (mainly spruce)
- High mountain subalpine meadows and shrubs
- High mountain subalpine meadows and shrubs and intrazonal sphagnum vegetation
- Intrazonal riparian vegetation
- Bare rocks with sparse mainly rock vegetation

Level four (Group) with differentiation criteria: topological features of the relief.

- Ridges with denudation and slopes under 4 degrees
- Slopes with erosion and denudation
- Slopes with erosion, denudation and karst
- Hydromorphic and sub-hydromorphic with erosion and accumulation (river-bed/river banks)
- Hydromorphic and sub-hydromorphic with upland accumulation (peat-bogs)

Level five (Genus) with differentiation criteria: rock formation and type.

- Alluvial unconsolidated sediments
- Unconsolidated and semi-consolidated sedimentary rocks
- Non-calcareous concrete sedimentary rocks
- Calcareous concrete sedimentary rocks
- Intrusive rocks
- Volcanic rocks (andesite)
- Metamorphic rocks

Level six (Species) with differentiation criteria: soil type.

- Brown-forest soils
- Brown-forest soils and rendzinas
- Dark-coloured and brown-forest soils
- Mountain-meadow soils
- Peat soils and peat-bogs
- Alluvial soils
- Bare rocks and lithosols

To reveal the contemporary state of the landscapes and the anthropogenic changes (secondary landscape structure), we used a classification based on several works of A. Velchev, N. Todorov and R. Penin (Todorov, 1997). The main advantage of this classification is that it describes five ranks (stages) of anthropogenic modifications and their criteria:

1. Unaffected landscapes (conditionally unaffected) – with climax vegetation and without visible traces of human disturbance; only slight changes of the geochemical background is possible due to contamination transport by air flows from remote places.
2. Landscapes with slight anthropogenic impact – with secondary vegetation, but identical in species composition with the climax vegetation, with possible appearance of grass vegetation within forested areas due to less dense tree cover; slow soil erosion is also possible.
3. Landscapes with moderate anthropogenic impact – with significant lower phytomass due to changes, i.e. to the replacement of climax vegetation with vegetation with less biomass (e.g. forests with scrubs); other features are the lower litter horizon and the possible erosion of the humus soil horizon.
4. Landscapes with strong anthropogenic impact – with strong change of the vertical structure, complete destruction of the natural vegetation and replacing with vegetation with very low biomass (e.g. forests with meadows); tree plantation with trees without ecological correspondence with the natural (e.g. coniferous in the vegetation belt of deciduous); agriculture and arable land with active soil erosion and melioration.
5. Anthropogenic landscapes – without vegetation cover and often without soil cover, changes

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could affect also topographic surface and base rocks (e.g. settlements, roads and mining areas).

For the purpose of Vitosha Mountain landscape mapping, these five ranks were reduced to three by combining the first with the second and the third with the fourth, in the attempt to make the mapping units more objective and easily to outline by the available input spatial data. This classification of landscape changes by human-induced factors, with 3 ranks and 13 types is presented below.

Unaffected landscapes and landscapes with slight anthropogenic impact:

- bare rocks
- broad-leaved forest
- coniferous forest.

Landscapes with moderate and strong anthropogenic impact:

- meadow and shrub lands
- planted coniferous forest
- agriculture and arable lands.

Anthropogenic landscapes:

- ancient dump site (ore deposit)
- stone-pit
- lift
- road
- buildings and single yards
- settlement
- artificial lake or dam.

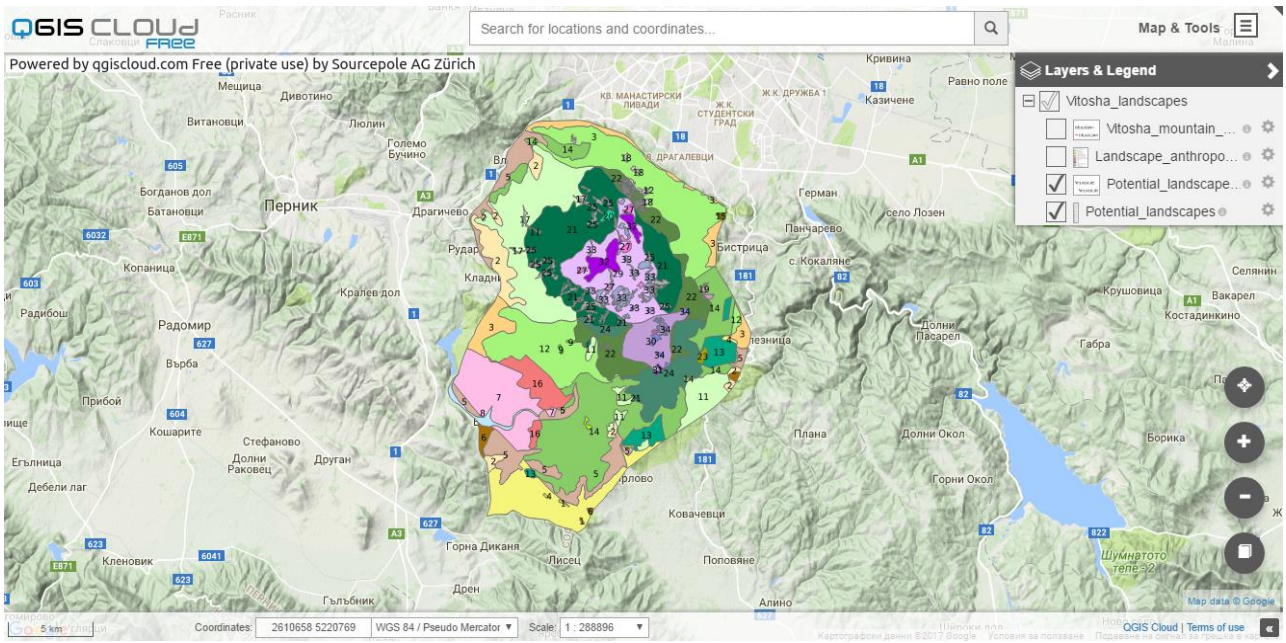

Fig. 1: Screenshot of the web-map application of the landscapes in the Vitosha Mountain with base view of the potential landscapes

Method

Various input data in digital format were used to perform landscape mapping for the Vitosha Mountain: Vitosha DEM, generated from EU-DEM with 25 m raster resolution (European Environmental Agency), the geologic map (vector layer, scale 1:100,000), forest inventory maps (vector layers, scale 1:5,000, from the Administration of "Vitosha" Nature Park), aerial photography (orthophoto) - images for 2006 year (raster data from the Bulgarian Ministry of Regional Development), and field investigations from transects (descriptions of selected sites or so called "landscape points").

The data was processed with GIS software and the two layers are the final outputs. The first data layer corresponds to the potential landscapes of Vitosha Mountain, its reference scale being 1:50,000 and its minimum mapping unit 4 ha. The second layer corresponds to the landscape anthropogenic modifications, its reference scale being 1:5,000 and its minimum mapping unit 0.02 ha. Finally, by using the open-source QGIS, a web-map application was created in QGIS Cloud service, with the following URL: http://qgiscloud.com/jdgis/Vitosha_landscapes.

Discussion

The first layer, i.e. that of the potential landscapes, contains 35 potential landscape units (on level 6 – "landscape species") and 158 polygons (fig. 1). The second layer, i.e. that of the landscape anthropogenic modifications, contains 13 landscape units and 3,698 polygons (fig. 2).

The landscape structure characteristic of Vitosha Mountain shows certain variety. It is represented both by landscapes with zonal character, as well as with azonal one – karst, hydromorphic (e.g. peatbogs) and rocky landscapes (bare rocks).

The altitude landscape belts are represented by a full height landscape spectrum, including subtypes of low mountain landscapes with oak-hornbeam forests, middle mountain landscapes with beech forests, mid-mountain landscapes with coniferous forests and sub-alpine landscapes.

Human activity has taken place for centuries in Vitosha Mountain and it has led to several types of impacts on landscapes. The human-induced impact during the Ottoman period was the greatest. Within this period, agricultural (grazing) and industrial (iron and gold mining) activities contributed most to the formation of the modern landscapes of Vitosha Mountain (Deliradev, 1926; Georgiev, 1978; Avdev, 2005). After 1934, there has been a radical change in the functional purposes on the territory of Vitosha, the economic functions moving towards conservation and recreation.

The potential landscape structure has been significantly modified because of the intense anthropogenic impact in the past. As a result, it is best preserved mostly in the northern part of the mountain (fig 2). In the southern part of the mountain, landscapes with natural coniferous forests are totally replaced by meadows and shrubs. The total area of unaffected landscapes and of landscapes with slight anthropogenic impact covered with forest amounted to 11,456 ha or 41% of the total area of Vitosha Mountain (of which about 9,983 ha - 36% are deciduous forests and about 1,473 ha - 5% are coniferous forests). The total area of landscapes with moderate and strong anthropogenic impact, with secondary meadows and shrubs that occupied the place of forest landscapes amounts to 6,688 ha (24%). The total area of planted coniferous forests in Vitosha Mountain amounts to 4,318 ha (15.7%).

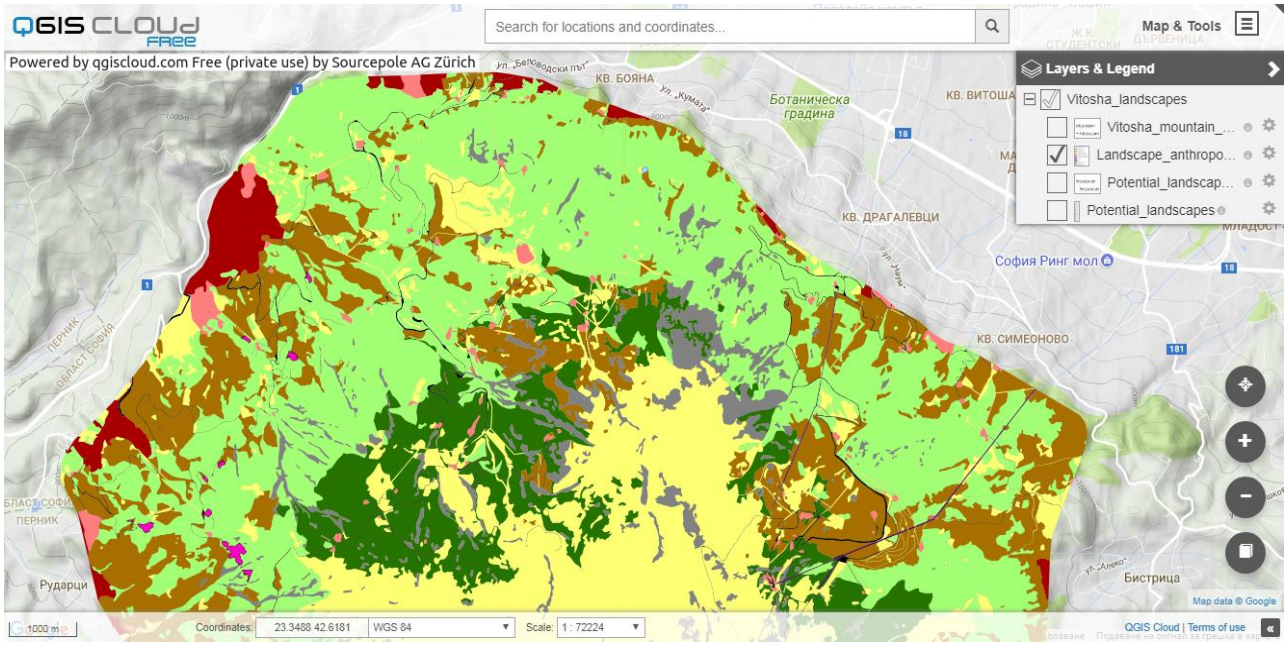

Fig. 2: Screenshot of the web-map application of the landscapes in the Vitosha Mountain, with a view of the landscape anthropogenisation map (fragment for the Northern part of the mountain)

Conclusion

There are several benefits of the built-in web-map. On the one hand, it provides an opportunity to explore interactively and in more detail the structure of the Vitosha landscapes, both of the potential landscapes (primary structure) and of the anthropogenic modifications (secondary structure). On the other hand, it provides an opportunity to get to know the concepts related to landscape classification and mapping that are employed in Bulgaria, although different approaches to exploring the landscapes are used in our country.

Finally, it can be noted that there is some proximity in approaches and convergence in landscape exploration through a typological approach in different landscape schools (Wascher, 2005). This facilitates the exchange of such ideas and approaches and it is the basis for future closer cooperation in carrying out international studies in the field of landscape science and landscape ecology.

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