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Complex geoecological assessment of habitat 91M0 as a natural capital for SCI "Zapadna Stara Planina i Predbalkan", Bulgaria

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Abstract. The xerothermic oak forests are one of the most exposed of the anthropogenic impact forests in Bulgaria as they are most deeply connected with traditional economic practices in the country. The aim of present study is to assess the potential of habitat 91M0 as a natural capital for the one of the biggest Natura 2000 sites in Bulgaria. This assessment can be the basis for a comprehensive study of the ecosystem services provided by this type of forest habitat. The study includes complex approach for assessment – cartographic analysis of the habitat polygons; ecological diversity and dominance coefficients of the habitat 91M0; geophysical assessment of the structure of the habitat and mathematical models for the resilience and anthropogenic pressure, all done comparatively for the site, forest and non-forest habitats and other oak habitats. Habitat 91M0 is highly fragmented scattered over the area of the SCI without connection between individual polygons. At the same time, the vertical structure and the assessment of the resilience define these forests like a very plastic and adaptive to the various environmental factors and increase their ecological and economical importance. The historical economic impact of the xerothermic oak forests is preserved until nowadays and they are a natural capital with great importance for the Natura 2000 sites.

Key words: habitat 91M0, geoecological assessment, anthropogenic impact, resilience.

Introduction

Nowadays, more and more emphasis is placed on the need to assess the nature intangible benefits and their valuation for the concept of sustainable development realization of human society and environmental protection (Costanza et al., 1998; Millennium Ecosystem Assessment, 2005; Assenov, 2010; Burkhard et al., 2012, Assenov et al., 2014, Mori et al., 2017; Maes et al., 2018; Lyubenova, 2019).

The implementation of this purely constructive strategy, softening the clash between the development of the economy and environmental quality preservation, is hindered by political, socio-economic and other factors (Lyubenova et al., 2019).

The present study makes an attempt to use a system of different type of assessment to evaluate the importance of any type of habitat for the total natural capital of the Natura 2000 sites so that we can make a scientifically base account of the ecosystem services that they offer to us like a human society.

The complex geoecological assessments includes not only the ecological aspects of the habitat capital but also assessments of spatial disturbance and resilience of the habitats. This helps us to more fully understand the

environmental value of habitats. At this stage, the understanding that ecological principles embedded in applied sciences are the most successful and effective approach to achieving sustainability is increasingly widely recognized (Avetisian et al., 2016).

The assessment of the natural capital of habitat 91M0 is decided because oak forests are deeply connected to traditional economic practices in the country (Assenov, 2016; Grigorov et al., 2023) and the chosen Natura 2000 site also. SCI BG0001040 "Zapadna Stara planina i Predbalkan" is one of the largest protected sites in Bulgaria with 40 habitat types (Natura 2000, Standard Data Form, 2021), located on the territory of the most economically backward region in Bulgaria.

Materials and Methods

Study area

Protected Site BG0001040 was declared under Directive 92/43/EEC, approved by the decision of the Council of Ministers No.661 on October 16, 2007. The total number of habitats in the SCI is 40 - 16 forest, 4 scrublands, 10 grasslands, 5 rocky and 5 aquatic habitats (Natura 2000, Standard Data Form, 2021). The forests habitats are: beech (9110, 9130, 9150, 91W0), oak (91G0, 91H0, 91M0), coniferous (9410, 9530, 91BA, 91CA) and others (9170, 9180, 91Z0, 9260, 91E0).

SCI BG0001040 covers the Western parts of the Stara planina mountain chain and part of the ForeBalkans (the mountains Vrashka Chuka, Babin Nos, Belogradchishki Venets, Shiroka Planina, etc.) - Fig. 1. According to the climatic zoning of Bulgaria (Velev, 2002), the area is in the temperate continental climate with an average annual amount of rainfall 750-1000 mm. The zone is part of the Carpatho-Danube soil region and its two provinces: Western Fore-Balkan and Stara planina - medium high (Ninov, 2002). The vegetation of the studied territory makes it a part of the European broad-leaved forest area and the Illyrian (Balkan) province with species of European and Euro-Asian distribution (Bondev, 2002). According to the biogeographical regionalization of Bulgaria, the zone is a part of the ForeBalkan and the region of Stara planina of the Balkan biogeographical province (Asenov, 2006).

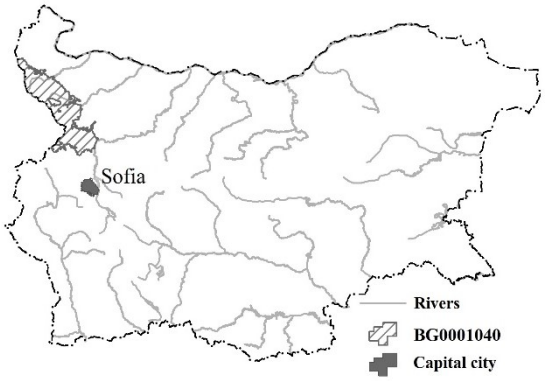

Fig. 1. Schematic map of the location of SCI BG0001040

Methods

This study is focused on the oak habitats, especially 91M0 in the site. In order to establish and analyze comparatively this habitat in SCI "Zapadna Stara Planina i Predbalkan", data from the standard form of the Natura 2000, as well as data from the Forest Management Plans of the Chuprene and Govezhda State Forestry (2007, 2018) were used. The vectorized and georeferenced (WGS84, UTM:35N) data from these two sources were merged into a common database. In 2011 - 2013 and 2019-2020, verification field studies were carried out, which supplemented and refined the available information in our data-base. This georeferenced data was a basis of habitat map that was made in the protected area (Fig. 2).

When differentiating habitat 91M0, in addition to the indicated sources, the study was based on field descriptions and GPS data.

The comparative analysis of the habitats diversity was carried out by cartographic mathematics-statistical methods, using the following coefficients.

- Gerenchuk coefficients for degree of complexity (by Velchev et al., 2011):

$$Kc = n/S_0 \quad (1)$$

where n is the number of polygons and S_0 – the average polygon area;

- Annenskaya mosaic (by Velchev et al., 2011):

$$Km = n/S \quad (2)$$

where n is the number of polygons and S – the total polygon area;

- Fragmentation of the mapped polygons (by Velchev et al., 2011):

$$K=1- (S_0/S) \quad (3)$$

where S_0 is the average polygon area and S – the total polygon area;

- Coefficients of the total diversity of Shanon (Lyubenova, 2004, 2009):

$$H=\Sigma((ni/n)\ln(ni/n) \quad (4)$$

where ni is the number of polygons from a given habitat type and n – the total number of polygons of habitats in the protected site;

- Dominance coefficient - Simpson diversity index (Lyubenova, 2004, 2009):

$$1- D = 1 - \Sigma(ni/n)^2 \quad (5)$$

where ni is the number of polygons from a given habitat type and n – the total number of polygons of habitats in the protected site.

Habitat 91M0 was investigated comparatively on the basis of geophysical methods - assessment of the vertical structure of the habitat (according to Todorov, 2004) and application of ball and mathematical assessments for the degree of sustainability and anthropogenic load (according to Borisova, 2013).

- Degree of sustainability:

$$R=\int\sum(a+b+c+d+e+f+g)xN/\sum(A+B+C+D+E+F+G) \quad (6)$$

where a,b,c… are ball assessments of natural resources like soil, erosion, rocks, plant canopy, climate; A,B,C… are assessments of the same resources in referent ideal conditions and N is ball assessment of the anthropogenic load.

- Anthropogenic load:

$$A=\sqrt{D}+\sqrt{r/P}+S^2+T^2+n^2+m^2+y^2+c^2+z^2+o^2+sol^2+ar^2+\sum x_i \quad (7)$$

where the alphabetic sight are the ball assessment of anthropogenic factors like population of the area, transport, tourism, economic structures, pollution, soil degradation, etc.

The ball assessments are made of the information from the Regional Development Plan 2014-2020 of the Western Region of Bulgaria and the balls are consistent with the quoted values according to Borisova (2013).

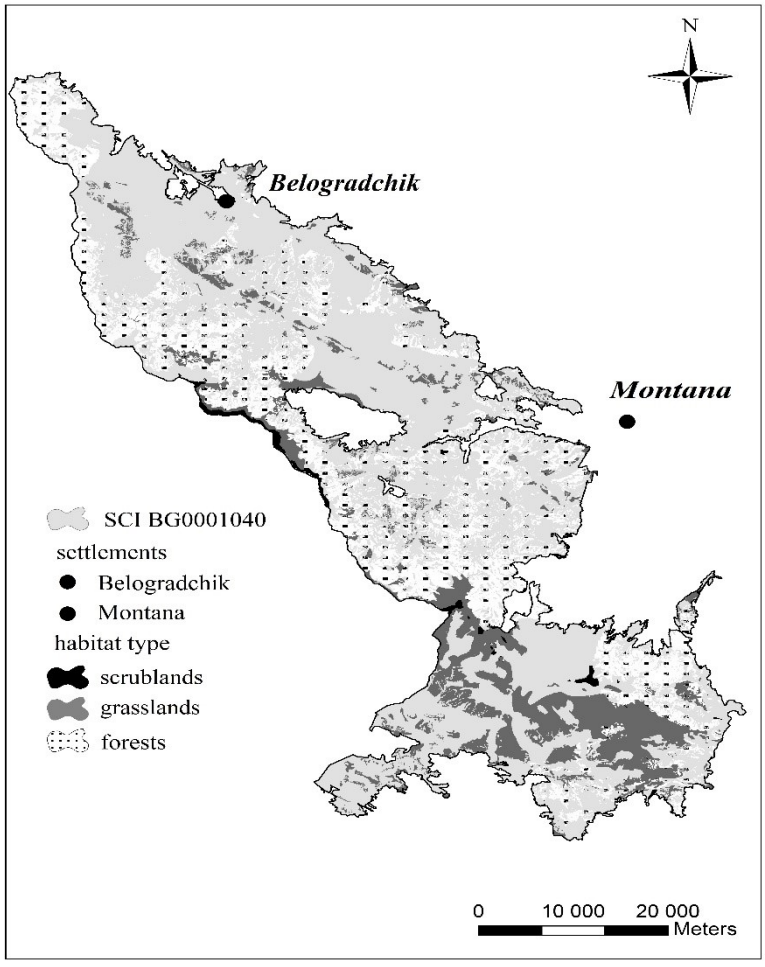

Fig. 2. Map of the habitats in SCI "Zapadna Stara planina i Predbalkan".

Results

The prepared and terrain verified database (and its visual interpretation map of habitats) was a major source of spatial data for the mathematical calculations.

Shannon's coefficient was calculated for the total diversity of habitats in the protected site BG0001040 - H = 1.3 for all habitat types (4). The dominance index for the habitats over the entire territory of the site was 0.52, and for the shrubland, grassland and forest habitats it was respectively: 0.01, 0.21 and 0.75 (5). The obtained results for the horizontal structure of habitats in the area are presented in Table 1.

The area of forest habitats was distributed as follows: 9466.74 ha (74.4%) of the forest communities were those of beech; 2877.29 ha (22.6%) were oak forests, and of the remaining 3% were about 0.5% coniferrous forests (9410, 9530, 91BA, 91CA) and 2.5% other deciduous forests and riparian communities (9170, 9180, 91Z0, 9260, 91E0). The horizontal structure of the forest communities was presented in Table 2. The Simpson dominance index for forest habitats was: 0.59, 0.67 and 0.31, respectively, for beech, oak and other forest habitats (5). The quantitative indicators of the horizontal structure of all oak habitats were discussed in Table 3.

Table 1. Quantitative assessment of the horizontal structure of habitat types in SCI.

Indicators	SCI BG0001040	Grassland habitats	Shrubland habitats	Forest habitats
Area S (ha)	219753.26	35160.52	3524.41	12723.83
Number of polygons (n)	29140	11880	70	17190
Mosaicity coefficient (Km = n/S) (2)	0.13	0.38	0.02	1.35
Average area of polygons (S_0 = S/n)	7.54	2.96	50.35	0.74
Complexity coefficient (Kc = n/S_0) (1)	3864.72	4013.53	1.39	23229.73
Fragmentation coefficient, K = 1 - (S_0/S) (3)	0.99	0.99	0.99	0.99

Table 2. Quantitative assessment of the horizontal structure of forest habitats.

Indicators	SCI BG0001040	Beech habitats	Oak habitats	Other forest habitats
Area S (ha)	219753.26	9466.74	2877.29	379.8
Number of polygons (n)	29140	9031	7226	933
Mosaicity coefficient, Km (2)	0.13	0.95	2.51	2.46
Average area of polygons, S_0	7.54	1.05	0.40	0.41
Complexity coefficient, Kc (1)	3864.72	8600	18065	2275
Fragmentation coefficient, K (3)	0.99	0.99	0.99	0.99

Table 3. Quantitative assessment of the horizontal structure of oak habitats.

Indicators	Oak habitats	9170	91G0	91H0	91M0
Area S (ha)	2877.29	963.56	1015.06	4.36	894.35
Number of contours (n)	7226	2500	2467	14	2245
Mosaicity coefficient, Km (2)	2.51	2.59	2.43	3.21	2.51
Average area of contour, S_0	0.40	0.39	0.41	0.31	0.40
Complexity coefficient, Kc (1)	18147.31	6486.36	5995.79	44.95	5635.41
Fragmentation coefficient, K (3)	0.99	0.99	0.99	0.93	0.99

The assessment of morphological structure of the habitats in SCI "Zapadna Stara planina i Predbalkan" showed that all habitat types in study area have very high Gerenchuk complexity coefficients, which corresponds to a large dissection of the relief, differences in environmental conditions: microclimate, soil types, exposure, slopes and others or for anthropogenic inter-

vention leading to differentiation and fragmentation of habitats. Only the shrub habitats and oak habitats - 91H0 were characterized by a lower complexity coefficient. Their communities were secondary and have a smaller territorial scope. At all levels, the degree of fragmentation of habitats was maximal; there-fore, habitats occupied all ecological niches provided by the environment with their specific conditions. Habitat 91H0 had a slightly lower degree of fragmentation (0.93) compared to the others, which was due to the highly xerophytic nature of the *Quercus pubescens* Willd communities.

The results of terrain work were shown in the vertical assessment of habitat 91M0. There was found that the geohorizons of the vertical structure of the habitat in different parts of the area varied between 7 and 11, with an average high of the forests of 25-30 m.

The degree of sustainability of the Balkan-Pannonian *Quercus cerris – Q. dalechampii* (habitat 91M0) forests has an estimated value of 5.5 (6), and the degree of anthropogenization – 16 (7).

Disscussion

About 55% of the established habitats in the country are found in SCI "Zapadna Stara Planina i Predbalkan", which is due to the relatively large territory – 219 753.262 ha. The Shannon index was usually used to characterize the species diversity of a given territory, and its reference values were 1.5-3.5 (Viktorovna et al., 2002). The obtained values of the index (1.3) for the SCI indicated relatively great diversity, which represents unexploited natural capital for the region. From the values of Simpson's dominance index, it could be seen that the forest communities had the greatest diversity (0.75) and, accordingly, the greatest ecological importance for the study area. Among them, the oak forests had a high index (0.67). The great habitat diversity also the forests diversity indicated the level of adaptability of the territory to the changing conditions of the environment; the genetic and biological diversity; the value of the habitat as a generator of ecosystem services.

The values of the fragmentation coefficient for the territory corresponded to the values indicated for the landscapes of the Danube Plain (from 0.75 to over 0.95) (Velchev et al., 2011). The mosaicity coefficient of the protected site had low values (< 2), which was due to the fact that parts of the habitats were represented by the large polygons occupying the large areas of the site territory. Such were the alpine and subalpine grassland habitats, shrubland habitats and from the forest ones - beech habitats.

Habitat 91M0 occupied about 0.4% (894.35 ha) of the site territory and had an average number of geohorizons 7-11. The geohorizons were characterized by a great variety and complexity of vertical structure, which was up to 30 m high. The base rock of the habitat was mainly represented by jointed sedimentary rocks, which were of weak to medium resistance and not particularly deep gray forest soils, which were not suitable for agricultural exploitation. The habitat had a high mosaicist coefficient and fragmentation of polygons, which was not so much due to the specific requirements of these communities to the environment, but because most of the habitat polygons were close to populated areas and were highly fragmented.

According to the calculated value for anthropogenic load of habitat (16) in the protected area, it was of medium load. This was mainly due to the current state of the region, which was characterized by a smaller population, more limited production capacities and low degree of pollution of natural components compared to other planning regions in Bulgaria (Regional Development Plan 2014-2020). The assessment of habitat resilience (5.5) indicated medium to low resilience to anthropogenic load (Borisova, 2013).

Oak forests, with the deep and highly developed intensive root system of trees that form them, such as those from habitat 91M0 in SCI BG0001040, were important for soil protection from erosion, for soil surface runoff infiltration, feeding and maintaining the level of groundwater. They are light forests with a well-developed grassland layer, providing a large range of non-forest resources, easily passable and accessible, offering good conditions for various types of tourism. Their wood is an important raw material for industry and households. The complex of diverse ecosystem services offered by the communities of 91M0 habitat combined with their not so sustainable character according to Borisova's scale (2013) exposed them to the real danger of xerophytization and complete destruction. This would be an unacceptable loss for the habitat diversity of the protected area and for the country.

Conclusions

The predominance of forest habitats in SCI "Zapadna Stara Planina i Predbalkan" is related to its mountainous and hilly relief. The oak habitats are highly fragmented, scattered over the area of the site but that determine their great variability, plasticity and adaptability to various combinations of environmental factors and anthropogenic influences. The main part of this diversity are the xerothermic oak forests of habitat 91M0, a characteristic autochthonous vegetation for Bulgaria, deeply connected with the cultural and historical processes that took place on its territory. The applied geoecological characteristic allows for a comparative assessment of habitats in a given area or in different areas, as well as for the assessment of a particular habitat as natural capital.

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