(RESEARCH ARTICLE)

Plant biodiversity hotspots mapping and prioritization in the Bulgarian floristic region Eastern Balkan Mountains

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Abstract

The main goal of the present study was to create a dynamic map of plant biodiversity hotspots of the Bulgarian floristic region Eastern Balkan Mountains. A GIS model, as well as a weighted value scheme for scoring each area, were created in order to identify and to prioritize the hotspots. A total number of defined hot spots of phytodiversity was 34. They were categorized into five classes, based on the cumulative weighted value scheme, and were indicated on the map using color scale. The territories into category I predominated, contrary to preceding investigations of the Black Sea coast and northeastern Bulgaria where category V predominated. In addition, an attempt to refine the borders of the floristic region was made.

Keywords: Biodiversity hotspots; Floristic region; Eastern Balkan Mountains; Geographic information system (GIS)

1. Introduction

Holistic approach of biodiversity management is based on loss reduction under limited financial and human resources [1]. Therefore, fundamental task of conservation biology is species and their habitats identification and prioritization [2] in order to focus limited public financial resources to the most endangered species and areas [1, 3].

In recent years, the newly developed evaluation systems for identification and prioritization of conservation territories, unlike the classical models for conservation significance are based on cumulative criterion schemes for identification and assessment of dynamic areas [2, 4, 5].

The hotspot approach is based on biodiversity indicators [3, 6], which identify geographical areas characterized by high species diversity, high concentration of endemic species, and high risk of habitat loss [7]. Although, the concept of plant biodiversity hotspots was created for global use [8, 9, 10], it can be applied in local and regional scale after improvement [11]. Local hot spots conception is useful tool for assessing the vulnerability of habitats, annual monitoring, distribution and protection of plants, as well as for the creation of long-term strategies for development and protection of phytoresources and habitats [12].

Clearly and precisely formulated evaluation criteria of the assessments are reliable base for developing GIS-based models, which comprise dynamic geographical maps of habitats with assessment scale and associated numerous data sets [13]. Based on this concept, a regional assessment scale can be created in order to identify hot spots of local phytodiversity. This model as well as local assessment scheme were applied for the floristic subregions of the Black Sea coast [2, 4, 6].

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The aims of the present study were 1) to prepare a map of hot spots of plant biodiversity for the floristic region Eastern Balkan Mountains and 2) to develop a regional scheme for assessment, classification, and prioritization of natural areas based on the concept of hot spots of plant biodiversity.

2. Material and methods

The studies of the spatial distribution of the plant communities were based on literature data of the distribution of plant species in the study area [14, 15, 16, 17, 18, 19, 20] and were detailed and refined with data from field observations and remote sensing during the vegetation period of 2021.

Conservation status, as well as endemics and relics were determined after [15, 16, 21, 22, 24, 25].

A regional plant species assessment scheme based on the concept of plant biodiversity hotspots was used. The summarized scheme, based on 3 groups of criteria that comprise the distribution and conservation status of plant taxa is presented in Table 1 [6].

Table 1 Summary scheme of criteria for the assessment of plant taxa [6]

C1	Criterion "Presence and distribution of the species in floristic regions and subregions of Bulgaria"					
Category	Only in the study region		From 2 to 15 regions		From 16 to 29 regions	
Evaluation	5		3		0	
C2	**Criteria of population fragmentation**					
Category	Highly fragmented		Low fragmented		Unfragmented	
Evaluation	5		3		0	
C3	**Criterion "National conservation status"** **(Included in the Bulgarian Biological Diversity Act)**					
Category	Included in Annex 2		Included in Annex 3	Included in Annex 4	Not included	
Evaluation	3		3	2	0	
C4	**Red Data Book Criterion**					
Category	CR	EN	VU	NT	LC/DD/NE	N/A
Evaluation	4	3	2	1	0	0
C5	**Endemics and Relics**					
Category	Endemic		Relics		N/A	
Evaluation	3		2		0	
C6	**International conservation status criterion**					
Category	IUCN		Directive 92/43/EEC	Berne Convention	CITES	N/A
Evaluation	2		2	2	2	0

CR - Critically Endangered, EN - Endangered, VU - Vulnerable, NT - Nearly Endangered, LC - Low Affected, DD - Insufficient Data, NE - Not Rated; Annexes II and V to Council Directive 92/43 / EEC on the conservation of natural habitats and of wild fauna and flora, Annex I to the Convention on the Conservation of European Wildlife and Natural Habitats (Berne Convention), Annex II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Annexes 2, 3, and 4 of the Biodiversity Act - BDA (2002).

The evaluation of each individual taxon was obtained as the sum of the points of each of the criteria, after applying the relevant coefficients of significance of the criterion according to the formula:

$$A_i = 0{,}5 \times C1_i + 0{,}5 \times C2_i + 1{,}25 \times C3_i + 1 \times C4_i + 1{,}25 \times C5_i + 1{,}5 \times C6_i$$

where,

A_i - general assessment of the taxon i

$C1_i$ - $C6_i$ - estimates by criteria C1 to C6 for taxon i.

In order to map hotspots, a dynamic GIS-based model was built and was applied using the Model Builder module of ArcView Spatial Analyst (ArcGIS v.10.0 ESRI Inc.). The model was designed to identify and to estimate the areas with a concentration of species and the places of overlap of the polygons of their distribution. The general assessment of each polygon was calculated according to the formula:

$$E = \frac{\sum_{k=1}^{n} An}{n}$$

where,

E - general assessment of the territory

A - assessment of each individual taxon

n - total number of assessed taxa in the territory.

When drawing the maps, the following were used: UTM Zone 35 North map projection, WGS84 terrestrial coordinate system and the Baltic altitude system. The collected field and remote sensing data were organized in attribute tables and assigned to the layers in vector format using relational classes in a GIS environment using base maps and Digital Terrain Model (DTM).

3. Results and discussion

The identification of hot spots is based on an adequate inventory of the flora the study area [26]. For this purpose, a list of flora was prepared based on literature data, as well as unpublished own studies. The established total number of plant species found in the region was 1723. 785 of them had a score of 0 points. Only the species that can be defined as indicators of biodiversity for the territory of Bulgaria were included in the study (they had a score higher than 0 points). For the floristic region of Eastern Balkan Mountains their number is 938 or 54.43% of the total established taxa. Comparing to previous studies, these values are higher than floristic region North-Eastern Bulgaria [26], and consistent with data from the subregions of Bulgarian Floristic region Black Sea Coast [2, 4, 6].

The borders of the floristic region of Eastern Balkan Mountains were defined after the Flora of Bulgaria [15, 18, 19]. Based on some geographical characteristics, an attempt to refine the border of the floristic subregion was made.
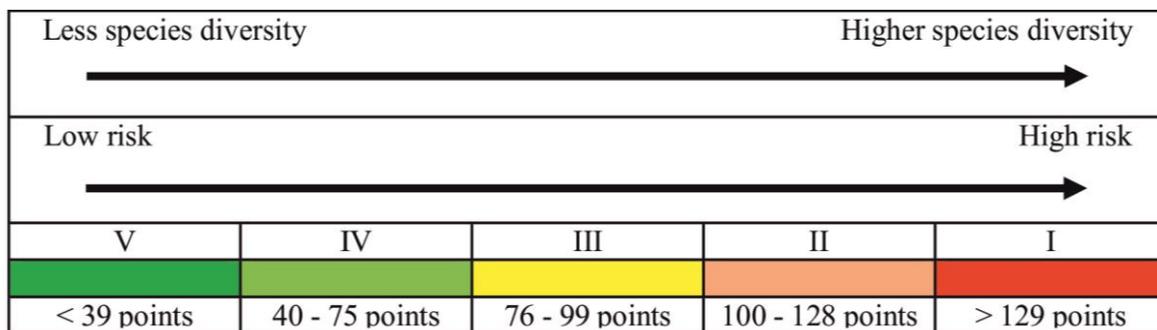
Less species diversity				Higher species diversity
Low risk				High risk
V	IV	III	II	I
< 39 points	40 - 75 points	76 - 99 points	100 - 128 points	> 129 points

Figure 1 Generalized weight scheme in 5 classes and their color representation

The used model is designed to integrate a regional scheme for prioritization. Preceding investigations and analyzes of the Black Sea coast [6, 27] and northeastern Bulgaria [26] showed that the classes of hot spots have similar values in different regions. Taking into account that the flora and vegetation of the floristic regions in Bulgaria differ, the assessment of each class was as a percentage of the maximum assessment for each territory. Based on this, all five categories of hotspots were identified (Figure 1).

Applying the constructed model and as a result of the "overlay" analysis, all values within the areas of overlap of the polygons were summarized and the hot spots of the biodiversity were determined (Table 2).

Table 2 Number of defined hotspots

Category					Total number
I	II	III	IV	V	
17	2	4	5	6	34

Detailed maps of the biodiversity hotspots for the floristic region Eastern Balkan Mountains in GIS environment were drawn (Figure 2). As a result of the prepared map, the border of the floristic area was refined.
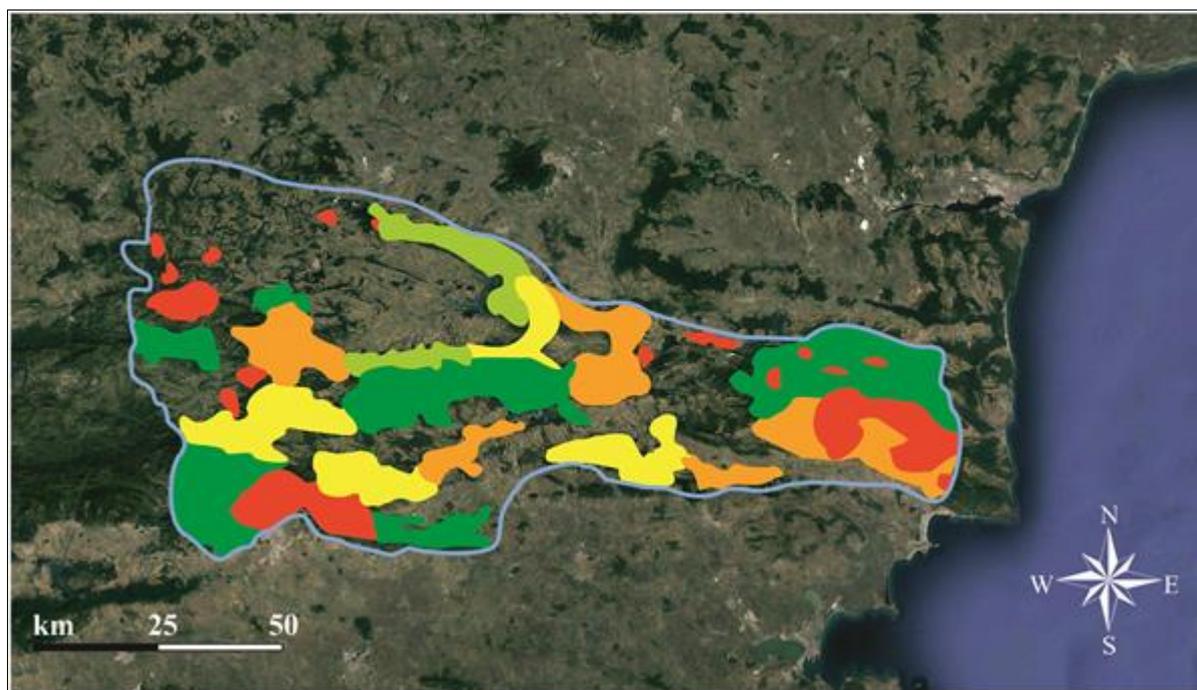

Figure 2 Map of the hot spots of biodiversity in the floristic region of Eastern Balkan Mountains (Base map: Google Earth 2017, TerraMetrics; CNES / Airbus)

The total number of defined hot spots of phytodiversity in the floristic region Eastern Balkan Mountains was 34. The territories into category I predominated, contrary to preceding investigations of the Black Sea coast [6, 27] and northeastern Bulgaria [26] where category V predominated.

4. Conclusion

The total number of defined hot spots of phytodiversity in the floristic region Eastern Balkan Mountains was 34. The territories into category I predominated.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare the absence of a conflict of interest.

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