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The possibilities for applying vulnerability assessment matrix for biodiversity in protected areas, selected protected area National Park Prokletije in Montenegro

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Abstract

Vulnerability Assessment Matrix for Biodiversity is prepared for further use, as one of basic inputs for more complex analyses of Protected Areas (PA) such as Vulnerability Analyses. Mountain PA National Park (NP) Prokletije in Montenegro is selected as a testing site because of wider application of the Matrix, in different neighbouring mountain PAs (in Kosovo: NP Bjeshket e Nemuna, in Albania: NP Tethi and PA Valbona). Having in mind state of biodiversity data in Montenegro, the matrix is formulated in the way to integrate as wide as possible categories of data on NP biodiversity that also include possibility for graphic modelling for visual interpreting vulnerability assessment. Conditions for creating Vulnerability Assessment Matrix and consequently Vulnerability Analysis for the wider mountain ecoregion of Prokletije are also considered. Typical natural functions of biological but also physical components of Prokletije mountain ecosystem determining its vulnerability.

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Introduction

The concept of vulnerability for biodiversity partly relies on the concept of sensitivity, but it applies to higher "hierarchical" levels, starting from species, over habitats to the level of the ecosystems. Since there is no formal, widely accepted classification of ecosystems and higher hierarchical levels, specific habitat types but also geological formations (geoheritage) or landscape elements could be sometimes used for better characterization of the biodiversity in distinct ecological regions. In Montenegro are present following characteristic ecosystems: mountain, forest, dry grasslands, freshwater and marine, while among specific habitats are present: coastal habitats, caves, canyons, and karst as a specific geologic formation. Limitations of classic biological classifications of vegetation and ecosystems are exceeded by inclusion specific habitat types and geological formations (NBSAP, 2010).

On the other side, Protected Areas (PA) have a strong demand for applying newly biodiversity conservation methods such as Vulnerability Analyses and Assessment, Adaptive Capacity, Ecosystem Diagnostic Analyses etc. Suitability of Prokletije mountain range for applying these methods is recognized during a Study course on Adaptive Conservation Management in the Trounsboudary Bjeshket E Nemuna / Prokletije Mountain area, that was held in Tethi and Skoder, Albania, 28. 08. - 08. 09. 2013. Study course organized by University in Ebersvaled (Germany) along with University of Montenegro and University Donja Gorica (Montenegro), University in Shkodra (Albania) and University of Kosovo.

The mountain range Prokletije is typical mountain ecosystem formed in a bordering ecoregion that share Montenegro, Albania, Serbia and Kosovo. Limestone dominate with various forms of karst phenomena that are developed as a result of the work of glaciers. Due to mediterranean and continental climate, but also difficult access and unfavourable conditions for massive human activities, in this bordering ecoregion is developed and remained well-preserved flora and fauna diversity. By the richness and diversity of flora and fauna, Prokletije represents a hot spot / center of alpine biodiversity of the Balkans, but also a biodiversity hot spot of European and world importance. Within the NP Prokletije (Fig. 1.) there are over 1.700 plant species that make 1/2 of Montenegrin flora, or 1/5 of the total Balkan flora. In terms of flora Prokletije is characterize numerous endemic, relict, rare, endangered, pharmaceutical, medical, aromatic and decorative plant species (Bulić and Bušković, 2007).

Data on biodiversity for geographic area of Prokletije are missing or incomplete in many fields that is general situation in Montenegro. In general, knowledge on biodiversity is quite scarce, with significant gaps, lack of inventories for a number of groups, as well as data on population abundance, dynamics, ecology and degree of genetic variations for most species (NBSAP, 2010). These circumstances are of disadvantage in applying adequate biodiversity conservation measures in newly created *National Park (NP) Prokletije* (2009). Area of the NP Prokletije is 16.630 hectares and includes two *Special Nature Reserves*: Hridsko Lake (347 hectares) and Volušnica (605 hectares). The attractiveness of the landscapes in whole ecoregion and this NP may be used for the development of tourism.

Materials and methods

Assessment matrix - Vulnerability of biodiversity for selected PA NP Prokletije is elaborated in the form of a matrix in order to consider most appropriate and feasible data. Simple matrix can provide its further integration in more complex analyzes of vulnerability with other thematically related matrices, such as erosion, water quality, air, health etc.

Graphic modelling - GIS graphic model provide better spatial estimation of Vulnerability Assessment results processed in the matrix, particularly for following key biodiversity aspects of selected PA: protected plant species; forest communities and land use classes of vegetation coverage based on Corine Land Cover

(CLC).

Tables - Data on key biodiversity aspects and assigned vulnerability rates are organized in simple tables.

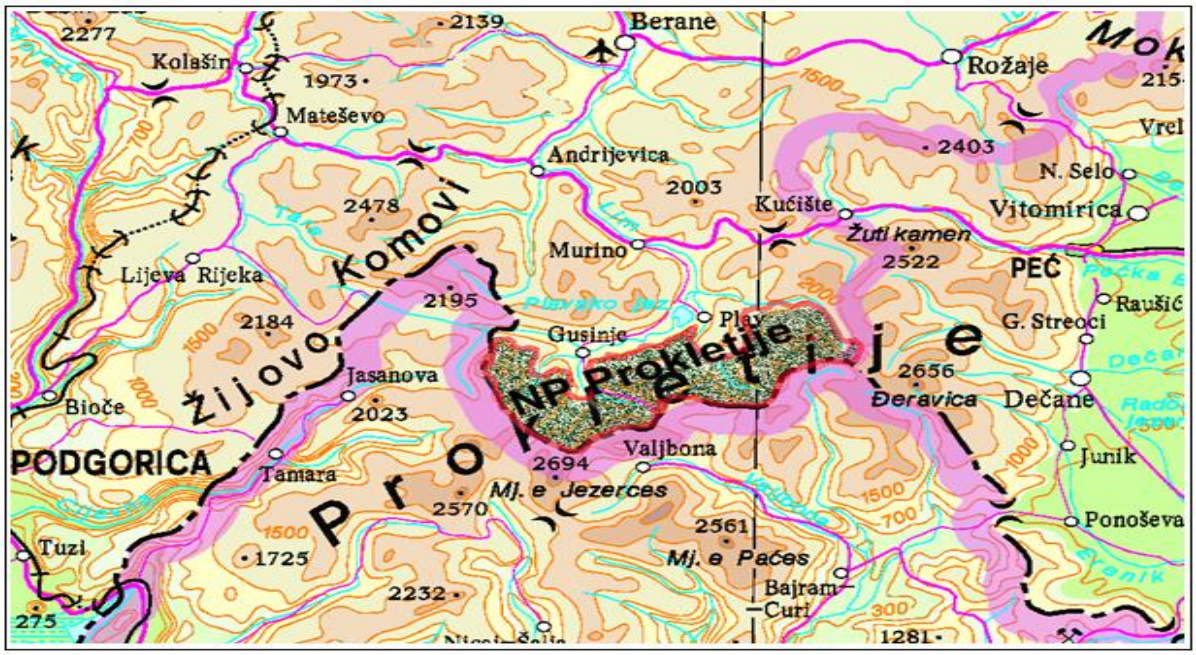

Fig. 1. Location of NP Prokletije in the mountain ecosystem Prokletije (scale 1: 1.000.000).

Results and discussion

As an follow up of the Study course in Tethi and Shkodra, vulneranility of NP Prokletije is studied with the aim to provide practical tool that can suit to more complex methods of Adaptive Conservation Management for wider ecoregion of Prokletije.

Table 1. Explanation of the ranking scale applied for biodiversity vulnerability scoring for NP Prokletije.

Rank	Short name for the rank	Definition
1	*very low vulnerability*	in the case of intervention or land use change, there are no adverse impacts on biodiversity
2	*low vulnerability*	in the case of intervention or land use change, impacts on biodiversity are moderate with relatively small changes in the elements of the environment that can be rehabilitated
3	*medium vulnerability*	in the case of intervention or land use change, impacts on biodiversity are average and usual, changing elements of the environment and difficult to rehabilitate
4	*high vulnerability*	in the case of intervention or land use change, impacts on biodiversity are very high, causing severe changes or loss of the elements of the environment, changes are very difficult to rehabilitate
5	*very high vulnerability*	in the case of intervention or land use change, impacts on biodiversity are very high and impermissible / unacceptable, exceed the threshold of acceptance, causing serious structural changes in the biodiversity and other components of the environment, changes cannot be repaired

The *concept of vulnerability* for biodiversity is methodologically linked to the concept of *sensitivity* as these two concepts are related to the intolerance and efficiency of the ecological responses of species and habitats to the factor of their degradation. Sensitivity is intolerance to negative changes. It is

estimated in relation to the change of a certain threat / impact. Its assessment gives the answer how a species or habitat is tolerant to extreme negative threats. By its fundamental meaning, sensitivity is based on the ecological valence of different organisms.

Sensu lato, the sensitivity of a habitat or species provide their survival, including their reduced resistance to physiological stress, reduced reproductive capacity, reduced growth and mortality. While the sensitivity applied to the level of individual plant / animal species or habitats, vulnerability is applied to a wider spatial / geographic area. Geographic areas with characteristic ecosystems to which is associated a *dominant threat / impact* (including climate change) are most appropriate for the applying vulnerability concept. Among PA, NP Prokletije is such an case.

Table 2. Vulnerability score for protected plant species from Pulević, 1983 and USAID, 2001.

Protected plant species	Rank
Bruckenthalia spiculifolia (Salisb.) Reichenb.	5
Centaurea chrysolepis Vis.	5
Centranthus longifolius Steven	5
Leontopodium alpinum Cass.	5
Lycopodium alpinum L.	5
Narthecium scardicum Kosanin	5
Paeonia mascula (L.) Miller	5
Pinguicula balcanica Casper	5
Pinus heldreichii Christ	5
Pinus peuce Gris.	5
Saxifraga stellaris L.	5
Silene asterias Griseb.	5
Silene macrantha (Pancic) Neumayer	5
Tozzia alpina L.	5
Valeriana pancicii Hal. & Bald.	5
Wulfenia blecicii Lakusic (*W. carnintiaca* auct. Monten. non Jacq)	5

Similar to sensitivity, vulnerability is methodologically assigned to the changes of certain threatening factor (Kershner, 2014) that is assessed in a axiological scale (1-3, 1-5, 0-7, etc.).

The matrix for assessing vulnerability of the biodiversity in selected PA - NP Prokletije is developed in the conditions data o biodiversity are missing or incomplete in many fields, so simple tables are created for ranking / evaluation following categories of data: (i) category of protection and type of PA that provide general information about its conservation values and general habitat types present in the PA and (ii) (protected) plant species and habitats present in the PA, particularly forests due to their multiple ecological importance for other components of the biodiversity.

Since data on biodiversity are missing or incomplete in many fields, the matrix and model for assessing vulnerability of the biodiversity in NP Prokletije is developed on the base of following *categories of available spatial data*:

A. *Rare, endangered and protected species* - As movable organisms, animal species are less suitable for assessing vulnerability of the biodiversity. In the circumstances connected to NP Prokletije, lack of

data on their (spatial) distribution is particular disadvantage. However, their distribution can be linked to certain habitat types, mostly productive ones such as forests and wetlands, or areas that are known as important for their vital functions and survival such as Important Bird Areas (IBA). NP Prokletije is an IBA, same as its neighbouring Plavsko lake. In spatial terms IBA is providing general information about ecological importance of the area (NP Prokletije) doesn't enable vulnerability assessment of the biodiversity within the area of the NP. On the other side, *plant species* are more appropriate for assessing vulnerability of the biodiversity in the PAs and selected NP Prokletije, because data on their distribution (Pulević, 1983), including mapping of protected species (USAID, 2001) are available.

Table 3. Vulnerability score for habitats Natura, 2000 selected from Petrović, D. *et al.* (eds) 2012.

Source of data	Habitat types	Rank
Catalogue of habitat types of EU important of Montenegro. Podgorica - Beograd - Zagreb 2012 (Petrović, D. *et al* (eds))	3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or *Isoëto-Nanojuncetea*	5
	3140 Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp	5
	3180 * Turloughs (temporary karstic fields)	5
	4060 Alpine and boreal heaths	4
	6150 Siliceous alpine and boreal grasslands	4
	6170 Alpine and subalpine calcareous grasslands	4
	6230 * Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (and submountain areas, in continental Europe)	4
	6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	4
	6520 Mountain hay meadows -	4
	7140 Transition mires and quaking bogs	5
	7230 Alkaline fens	5
	8110 Siliceous screes of the montane to snow levels (*Androsacetalia alpinae* and *Galeopsietalia ladani*)	4
	8120 Calcareous and calcishist screes of the montane to alpine levels (*Thlaspietea rotundifolii*)	4
	8210 Calcareous rocky slopes with chasmophytic vegetation	4
	8220 Siliceous rocky slopes with chasmophytic vegetation	4
	8310 Caves not opened to the public	4
	91M0 Pannonian-Balkanic turkey oak –sessile oak forests	4
	91W0 Moesian beech forest	4
	9410 Acidophilous *Picea* forests of the montane to alpine level (*Vaccinio-Piceetea*)	4
	95A0 High oro-Mediterranean pine forests	5

B. *Habitats* - There are the following sources of spatial data on biodiversity:

(i) *Vegetation maps* are relatively good basis for in vulnerability assessment of the biodiversity. If these maps present in small cartographic scale, sufficient accuracy in vulnerability and other assessments

wouldn't be provided, particularly in the graphic modelling of the assessments for relatively small geographical areas such as our selected PA - NP Prokletije that is a part of the mountain range Prokletije. Such an case is with the Vegetation map of Montenegro (Blečić and Lakušić, 1983) that has poor accuracy due to small scale (1: 1.000.000) and consequently very limited use in assessing vulnerability of habitats that are determined by plant communities. Map of Forest associations in Montenegro (Institute for the Protection of Nature, 1995) has slightly larger scale (1: 350.000) that provide better conditions for assessing vulnerability of forest associations / habitats, but also other natural habitats such as grassland / ruderal vegetation.

Table 4. Vulnerability score for vegetative cover from CLC, 2000 and 2006.

Source of data	Land use classes		Rank
Corine Land Cover for years 2000, 2006 – Land use classes	1. Artificial surfaces		
	111	Continuous urban fabric	1
	112	Discontinuous urban fabric	1
	121	Industrial or commercial units	1
	122	Road and rail networks and associated land	1
	131	Mineral extraction sites	1
	132	Dump sites	1
	133	Construction sites	1
	141	Green urban areas	3
	142	Sport and leisure facilities	2
	2. Agricultural areas		
	211	Non-irrigated arable land	2
	222	Fruit trees and berry plantations	3
	231	Pastures	3
	241	Annual crops associated with permanent crops	2
	242	Complex cultivation patterns	2
	243	Land principally occupied by agriculture, with significant areas of natural vegetation	3
	244	Agro-forestry areas	3
	3. Forest and semi natural areas		
	311	Broad-leaved forest	4
	312	Coniferous forest	5
	313	Mixed forest	4
	321	Natural grasslands	4
	322	Moors and heathland	4
	323	Sclerophyllous vegetation	4
	324	Transitional woodland-shrub	4
	332	Bare rocks	4
	333	Sparsely vegetated areas	5
	334	Burnt areas	2
	335	Glaciers and perpetual snow	4
	4. Wetlands		
	411	Inland marshes	4
	411	Peat bogs	5
	5. Water bodies		
	511	Water courses	5
	512	Water bodies	5

(ii) *GIS maps for land use and vegetative cover* include.

(a) *Corine Land Cover (CLC)* provide more accurate basis for assessing vulnerability of the habitats. CLC for Montenegro and neighbouring countries Albania,

Serbia / Kosovo is available in two time series for years 2000 and 2006.

(b) *National database for land use and vegetative cover* is part of the Geospatial Database developed in the Real Estate Directorate of Montenegro in year 2010, in basic scale 1: 25.000. These two GIS cartographic sources have higher accuracy in graphic presenting spatial distribution of land use classes and vegetative cover due to integrating specific habitat types that are standardized and mutually translated in most of EUNIS typologization systems for habitats.

Table 5. Vulnerability score for vegetative cover from Geospatial Database of the Real Estate Directorate, 2010.

Source of data	Vegetation & Land cover types	Rank
Geospatial Database of the Real Estate Administration (2010) - Vegetation & Land cover	2001- Arable land	2
	2003- Orchards	2
	2005- Forest plantations	3
	2006- Broad-leaved forest	4
	2007- Coniferous forests	5
	2008- Mixed forests	4
	2009- Shrubs	4
	2010- Grasslands and pastures	4
	2011- Bushes	4
	2012- Coppices	4
	2014- rocky terrains	4
	2017- lakes	5
	2018- marshlands	4
	2019- water surfaces / rivers	5
	2021- park areas	3

The structure of the matrix and model for vulnerability assessment of the biodiversity

The matrix for assessing vulnerability of the biodiversity in selected PA - NP Prokletije is composed of simple tables that are created for ranking, i.e. assigning value for following categories of data: (i) category of protection and type of PA that provide general information about its conservation values and general habitat types present in the PA and (ii) (protected) plant species and habitats present in the PA, particularly forests due to their multiple ecological importance for other components of the biodiversity. Since scientific inventories of many taxonomic groups are completed or lacking (NBSAP, 2010) existing model for vulnerability assessment is treated as pilot but ready for further completion.

In these circumstances, matrix for assessing vulnerability of the biodiversity in NP Prokletije is structured of complementary, mainly indirect or derivative data.

Vulnerability assessment depends on the efficiency of its scoring system. In the matrix for assessing vulnerability of the biodiversity in NP Prokletije are set following general biodiversity vulnerability scoring *principles*:

A. Higher vulnerability is assigned for:
- Protected species and areas in which are present their population
- Zones in the PA with strict protection regime

Principle: *protected is vulnerable*
- Areas with original – unique ecological values
- Authentic mountain habitat types

Principle: *uniqueness is vulnerable*

-Rich" habitat types that are more productive than others, such as forest and water related habitats.

Principle: *productive is more vulnerable*

B. *Less vulnerable are areas* that are already changed to:

-Urban areas - towns and built-up area (area occupied by buildings)

-Infrastructure and energy corridors

-Zones of the exploitation of mineral resources

-Agricultural areas that are intensively used or planted with allochthonous species, including forest monoculture.

The principle*: less natural is less vulnerable*

Vulnerability scoring system for biodiversity in NP Prokletije

Coherent to aforementioned principles, biodiversity vulnerability score for NP Prokletije is set in the relation to the *possible anthropogenic threats / impacts*, (Kershner, 2014) by applying ranking scale from 1 to 5 (Table 1.). The threats / impacts that cause physical change in physical space and biodiversity of NP Prokletije are following: expansion of construction areas and tourist zones, construction of residential, housing, energy and infrastructure facilities.

Table 6. Vulnerability score for forest associations combined from Blečić and Lakušić, 1983 and Institute for the Protection of Nature, 1995.

Source of data	Forest associations	Rank
(i) Vegetation Map of SR Montenegro (Blečić and Lakušić, 1983), (ii) Map of Forest associations in Montenegro (Institute for the Protection of Nature, 1995)	*Pinetum heldereichii*	5
	Pinetum peucis s. lat	5
	Piceetum excelsae subalpinum s. lat	4
	Piceto - Abieto - Fagetum	4
	Pinetum mughi	5
	Fageto - Abietetosum	4
	Various association types of mountain ruderal vegetation, including *Seslerion tennuifoliae, Festuco pungentis, Nardion* etc	3

A. Vulnerability of rare, endangered and protected plant species

All rare, endangered and protected plant species are assessed as very highly vulnerable (rank 5) due to the nature of their rare and spatially limited populations (Table 2.). Existing literature and maps (Pulević, 1983, USAID, 2001) already provide data on the distribution of protected plant species in the NP Prokletije.

Table 7. Vulnerability score for general habitat types present in NP Prokletije, by categories of protection.

Source of data	Categories of protection	(General) habitat types	Rank
Feasibility Study for NP Prokletije	*Special Nature Reserves (Hridsko lake and Volušnica)*	- water / wet habitats	5
		-forest habitats	5
		-natural grasslands	5
		- rocky / stone habitats	5
	National Park	- water / wet habitats	5
		-forest habitats	5
		-natural grasslands	4
		- rocky / stone habitats	4

B. Vulnerability of habitats

Following sources of data are used for assessing vulnerability of habitats distributed in NP Prokletije:

(i) Catalogue of habitat types of EU important of Montenegro (Petrović, D. *et al* (eds)).

(ii) Vegetation maps (Blečić and Lakušić, 1983, Institute for the Protection of Nature, 1995) and (iii) Land use - vegetative cover (CLC 2000, 2006, Real Estate Directorate - Geospatial Database, 2010). Ecological and conservation values of identified habitats are fundamentally respected in assessing their vulnerability. Due to the different accuracy, content of habitat distribution maps is considered differently, by individual habitat / vegetation types that are mapped. That's why forest habitats are assessed in the rank 4 - 5, wetland – water related habitats in same rank 4 - 5, while grasslands and similar habitats ranked between 3 and 4. The rocks, screes and chasmophytic vegetation are rated equally in the rank 4.

In the assessment are produced vulnerability scores for the habitats / vegetation types distributed in the NP Prokletije, by data sources (Table 3., Table 4., Table 5., Table 6., Table 7.). According to vulnerability score, the most vulnerable habitats in NP Prokletije are forest and water related – wet habitats. Apart from high ecological i.e. biodiversity conservation values NP Prokletije characterize high and very high vulnerability of its biodiversity. In general, typical natural functions of biological but also physical (geology, soil) components of Prokletije mountain ecoregion are determining its vulnerability.

This matrix can be further applied to other PAs in the ecoregion Prokletije, i.e. different neighbouring mountain PAs (in Kosovo: NP Bjeshket e Nemuna, in Albania: NP Tethi and PA Valbona), as well as for preparing Vulnerability Assessment Matrix or Vulnerability Analyses for the biodiversity of entire ecoregion.

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