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## USING SPATIAL METRICS TO ASSESS THE EFFICACY OF BIODIVERSITY CONSERVATION WITHIN THE ROMANIAN CARPATHIAN CONVENTION AREA

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**Key words:** conservation, CORINE, ecological regions, biogeographical regions, transitional dynamics.

**Abstract.** The alpine region is of crucial importance for the European Union; as a result, the Carpathian Convention aims at its sustainable development. Since sustainability implies also conservation through natural protected areas, aimed at including regions representative for the national biogeographical space, this article aims at assessing the efficiency of conservation. The methodology consisted of using spatial metrics applied to Romanian and European data on the natural protected areas, land cover and use and their transitional dynamics. The findings show a very good coverage of the Alpine biogeographical region (98% included in the Convention area, and 43% of it protected within the Convention area) and of the ecological region of Carpathian montane coniferous forests (88% included in the Convention area, and 42% of it protected within the Convention area). The dominant land cover is represented by forests (63% within the Convention area, and 70% of the total protected area). The main transitional dynamics are deforestation (covering 50% of all changes area within the Convention area and 46% from the changed area within its protected area) and forestations – including afforestation, reforestation and colonization of abandoned agricultural areas by forest vegetation (covering 44% of all changes area within the Convention area and 51% from the changed area within its protected area) during 1990-2000 and deforestation (covering 97% of all changes area within the Convention area and 99% from the changed area within its protected area) during 1990-2000. The results suggest that the coverage of biogeographical and ecological zones is good, especially for the most relevant ones, but deforestations are a serious issue, regardless of occurring before or after achieving the protection status.

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## Introduction

The mountain regions are of crucial importance for the cohesion policies, as underlined by key Romanian and European Union documents (Popescu and Petrișor, 2010a, b), but vulnerable to economic, accessibility, environmental, and demographic issues (Antonescu, 2014) which are serious threats to their high biodiversity (Borsdorf and Braun, 2008). For this reason, and aiming for the sustainable development of these regions, several countries agreed to adopt Convention on the protection and sustainable development of the Carpathians, also known as the Carpathian Convention, signed in Kyiv, Ukraine, in 2003 (Popescu and Petrișor, 2010a). Romania was part of the convention from the beginning.

However, the efficacy of the natural protected areas is debated (Petrișor *et al.*, 2016); Iojă *et al.* (2010) found out that the national system of natural protected areas consists of overlapping categories to a considerable extent, resulting into a lawsuit from the European Commission (Cojocariu *et al.*, 2010).

Previous studies have showed that land cover and use changes are the main drivers of environmental degradation in Romania, and the main transitional dynamics associated to them are urbanization, deforestations and the abandonment and development of agriculture (Petrișor, 2012; Petrișor *et al.*, 2010, 2014). The development gaps within the mountain area and its dramatic change of traditional socio-spatial structures (Gellrich and Zimmermann, 2007) can be a consequence of their remoteness and protection status (Petrișor, 2015a), and also resulted into important land use changes (Munteanu *et al.*, 2014).

This paper aims to use spatial metrics applied to Romanian and European data on the natural protected areas, land cover and use and their transitional dynamics to assess the efficiency of protected areas.

## 2. Data and methods

The study used several datasets, freely available from the European Environment Agency and the Romanian Ministry of the Environment, Waters and Forests, presented in Table 1. Data were processed by re-projecting and sub-sampling subsets for Romania, clipping and dissolving contours based on sub-categories, and ultimately computing areas using the X-Tools extension of ArcView GIS 3.X. The analyses were aimed at assessing the coverage with natural protected areas, comparing the share of biogeographical and ecological regions and land use categories within the Carpathian Convention perimeter and within the natural protected areas declared in this perimeter.

The land cover and use changes were analyzed for the two periods (1990-2000 and 2000-2006) using the methodology developed by Petrișor (2012),

which consists of grouping changes by the underlying transitional dynamic. In this study, we used a simplified variation of the classification scheme, which grouped all the phenomena implying the regeneration of forests (afforestation, reforestation, and colonization of abandoned agricultural areas by forest vegetation) under a unique category, “forestation”.

**Table 1.** Specifications on the data used in the study: dataset, provider, URL, remarks and transformations.

Dataset	Provider	URL	Remarks	Transformation
Land cover and use changes data	European Environment Agency	<a href="http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2">http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2</a>	1990-2000 data Resolution: 5 hectares	Project into Stereo 1970, subsample for Romania
Land cover and use changes data	European Environment Agency	<a href="http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-3">http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-3</a>	2000-2006 data Resolution: 5 hectares	Project into Stereo 1970, subsample for Romania
Land cover and use data	European Environment Agency	<a href="http://www.eea.europa.eu/data-and-maps/data/clc-2006-vector-data-version-3">http://www.eea.europa.eu/data-and-maps/data/clc-2006-vector-data-version-3</a>	2006 data Resolution: 25 hectares	Project into Stereo 1970, subsample for Romania
Ecological regions	European Environment Agency	<a href="http://www.eea.europa.eu/data-and-maps/data/digital-map-of-european-ecological-regions">http://www.eea.europa.eu/data-and-maps/data/digital-map-of-european-ecological-regions</a>	2003 data	Project into Stereo 1970, subsample for Romania
Biogeographical regions	Romanian Ministry of the Environment, Waters and Forests	<a href="http://mmediu.ro/new/?page_id=5178">http://mmediu.ro/new/?page_id=5178</a>	2007 data	None needed
Natural protected areas	Romanian Ministry of the Environment, Waters and Forests	<a href="http://mmediu.ro/new/?page_id=5178">http://mmediu.ro/new/?page_id=5178</a>	Not all types of protected areas legally defined are available	None needed
Limits of the Carpathian Convention	Romanian Ministry of the Environment, Waters and Forests	<a href="http://mmediu.ro/new/?page_id=5178">http://mmediu.ro/new/?page_id=5178</a>	Date unspecified	None needed

### 3. Results and discussion

Table 2 shows the general coverage of the Carpathian Convention area of implementation by natural protected areas. The results indicate that the Carpathian Convention covers approximately 1/3 of the Romanian territory, and its area is better covered by natural protected areas (38% compared to 24%).

Most categories have a better coverage within the Carpathian Convention area, especially Natura 2000 sites, national parks, and protected landscapes. Biosphere reserves are less covered because the Danube Delta Biosphere Reserve, largest biosphere reserve in the world (Meiřă *et al.*, 2014), is not situated in mountain region. Similarly, Ramsar sites, characteristic to wetlands, are underrepresented in this region.

**Table 2.** Coverage of the Carpathian Convention area of implementation by natural protected areas

Category	Carpathian Convention		Romania	
	Area (km <sup>2</sup> )	%	Area (km <sup>2</sup> )	%
Total area	689	-	2384	28.89
Protected area	263	38.23	569	23.87
<b>Types of protected areas</b>				
National parks, protected landscapes	96	13.93	166	6.98
Ramsar sites	0	0.07	63	2.63
Scientific and natural reserves, natural monuments	16	2.33	25	1.05
Biosphere reserves	9	1.24	66	2.78
Natura 2000 SCIs	228	33.07	415	17.42
Natura 2000 SPAs	143	20.77	369	15.49
Natura 2000 SACs	18	2.64	19	0.81

**Table 3.** Coverage of the biogeographical and ecological regions by the natural protected areas declared within the Carpathian Convention area of implementation.

Type of region	Romania	Carpathian Convention (CC)		Protected areas within CC	
	Area (km <sup>2</sup> )	Area (km <sup>2</sup> )	% Romania	Area (km <sup>2</sup> )	% CC
<b>Biogeographical region</b>					
Black Sea	23.17				
Pannonian	140.10	0.12	0.08	0.04	3.80
Steppic	372.20				
Continental	1347.31	196.77	14.60	688.71	35.00
Alpine	500.67	491.53	98.18	2125.67	43.25
<b>Ecological region</b>					
Balkan mixed forests	344.72	0.86	0.25	8.38	97.27
Carpathian montane coniferous forests	535.16	468.64	87.57	1957.42	41.77
Central European mixed forests	363.68	9.45	2.60	24.78	26.21
East European forest steppe	178.24	0.00	0.00		
Pannonian mixed forests	702.80	208.37	29.65	816.18	39.17
Pontic steppe	247.11				
Black Sea	7.89				

The coverage of biogeographical and ecological regions is presented in Table 3. The results suggest a very good coverage of the Alpine

biogeographical region (98% included in the Convention area, and 43% of it protected within the Convention area). A very small portion of the Pannonic area and an important part of the Sub-Carpathians are also part of the Convention area, and some of their biodiversity is included in natural protected areas. The coverage of ecological regions is similar; the most important is the ecological region of Carpathian montane coniferous forests (88% included in the Convention area, and 42% of it protected within the Convention area). Also, out of the 30% Pannonian mixed forests within the Convention area, 39% are included in natural protected areas.

**Table 4.** Land cover and use of the natural protected areas declared within the Carpathian Convention area of implementation.

Land cover/use	Carpathian Convention (CC)		Protected areas within CC	
	Area (km <sup>2</sup> )	%	Area (km <sup>2</sup> )	%
Broad-leaved forest	221.22	32.19	96.29	34.31
Mixed forest	107.82	15.69	52.44	18.68
Coniferous forest	104.58	15.22	46.88	16.70
Pastures	82.98	12.07	25.86	9.21
Transitional woodland-shrub	34.09	4.96	14.39	5.13
Non-irrigated arable land	28.51	4.15	4.82	1.72
Complex cultivation patterns	24.29	3.53	5.30	1.89
Natural grasslands	23.52	3.42	15.33	5.46
Land principally occupied by agriculture, with significant areas of natural vegetation	21.26	3.09	6.61	2.36
Continuous urban fabric	17.97	2.61	1.86	0.66
Moors and heathland	7.04	1.02	6.35	2.26
Fruit trees and berry plantations	6.31	0.92	0.63	0.22
Water courses	1.51	0.22	0.80	0.28
Sparsely vegetated areas	1.29	0.19	1.22	0.44
Water bodies	1.28	0.19	0.68	0.24
Industrial or commercial units	0.94	0.14	0.08	0.03
Mineral extraction sites	0.61	0.09	0.20	0.07
Inland marshes	0.57	0.08	0.30	0.11
Bare rocks	0.43	0.06	0.40	0.14
Vineyards	0.38	0.06	0.08	0.03
Sport and leisure facilities	0.26	0.04	0.05	0.02
Dump sites	0.19	0.03	0.05	0.02
Beaches, dunes, sands	0.12	0.02	0.03	0.01
Peat bogs	0.08	0.01	0.01	0.00
Green urban areas	0.03	0.00	0.01	0.00
Port areas	0.00	0.00	0.00	0.00
Road and rail networks and associated land	0.03	0.00	-	-
Construction sites	0.01	0.00	-	-

Table 4 shows the land cover and use according to the most recent data (2006). The dominant land cover is represented by forests (63% within the Convention area, and 70% of the total protected area), followed by pastures (12% within the Convention area, and 9% of the total protected area). As it their sum suggests, the territory of the Convention consists mostly of natural features (85%), with a higher percentage included in natural protected areas (91%).

The anthropogenic pressure against the natural protected areas within the Convention territory was assessed looking at the transitional dynamics presented in Table 5. The main pressures are deforestation (covering 50% of all changes area within the Convention area and 46% from the changed area within its protected area) and forestations – including afforestation, reforestation and colonization of abandoned agricultural areas by forest vegetation (covering 44% of all changes area within the Convention area and 51% from the changed area within its protected area) during 1990-2000 and deforestation (covering 97% of all changes area within the Convention area and 99% from the changed area within its protected area) during 1990-2000.

**Table 5.** Transitional dynamics of land cover and use changes within the natural protected areas situated in the Carpathian Convention area of implementation.

Transitional dynamic	2000-2006				1990-2000			
	Carpathian Convention (CC)		Protected areas within CC		Carpathian Convention (CC)		Protected areas within CC	
	Area (km <sup>2</sup> )	%	Area (km <sup>2</sup> )	%	Area (km <sup>2</sup> )	%	Area (km <sup>2</sup> )	%
Abandonment of agriculture	0.05	1.02	0.01	0.24	0.38	3.12	0.05	1.03
Deforestation	4.40	97.15	2.12	98.82	6.09	49.53	2.27	45.98
Development of agriculture	-	-	-	-	0.27	2.21	0.07	1.52
Draught	-	-	-	-	0.00	0.02	0.00	0.06
Floods	0.00	0.03	0.00	0.05	0.01	0.08	0.01	0.20
Forestation	0.02	0.46	0.01	0.48	5.46	44.37	2.50	50.84
Unknown	-	-	-	-	0.05	0.42	0.02	0.34
Urbanization	0.06	1.35	0.01	0.41	0.03	0.25	0.00	0.02

The forest restitution following almost half century of socialist regime, when forest was owned by the state, resulted into a true national drama. The main reason is that the forests were not returned to those who owned them, but to the next generations who lost the psychological and social connection with them, and had no feelings for the property, but instead saw it as means for making an immediate profit. The result was that forest covering large portions were cut off and sold out for wood, with benefits directed sometimes outside the

Romanian borders (Roman, 2009; Knorn *et al.*, 2012; Vanonckelen and Van Rompaey, 2015; Niță, 2015). The situation was aggravated by the protection status, imposing constraints to local economies (Petrișor, 2015a, Stan *et al.*, 2013).

Although these changes are present even within the protection status, a diachronic analysis cannot ascertain whether these changes occurred before or after the acquisition of the protection status (Petrișor, 2015b), since CORINE changes data cover the periods 1990-2000 and 2000-2006, but most protected areas were declared in 2006-2007. Regardless of the true answer, the protection status is questionable; if changes occurred before, the question is how could the protection status be awarded to an area that was no longer in a pristine state; if it occurred after, the efficacy of protection is debatable (Petrișor, 2015b).

Other possible limitations of the study are due to the issues associated with the use of CORINE data, such as the spatial resolution and definitions of classes, which changed from one period to the other (Peloroso *et al.*, 2009; Verburg *et al.*, 2011).

### Conclusion

This study aimed to assess the efficiency of the natural protected areas within the perimeter of the Carpathian Convention using spatial metrics applied to Romanian and European data on the natural protected areas, land cover and use and their transitional dynamics. The results suggest that the coverage of biogeographical and ecological zones is good, especially for most relevant categories, but deforestations are a serious issue, regardless of occurring before or after achieving the protection status, especially since forests are the main land cover/use of the area.

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