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GIS QUANTITATIVE ASSESSMENT OF 1990-2006 DEFORESTATIONS WHITIN ROMANIAN NATURAL PROTECTED AREAS

Alexandru-Ionuţ Petrişor *

"Ion Mincu" University of Architecture and Urbanism / National Institute for Research and Development in Constructions, Urbanism and Sustainable Spatial Development URBAN-INCERC, Bucharest, Romania

ABSTRACT: Sustainability implies conservation, as part of the goal to preserve for the future generations a part of the current environment in a pristine state. This condition implies that human impacts must not be allowed in their perimeter, as they affect the carrying capacity of ecological systems, but also the fact that only those sites where the environment is in an almost natural condition can acquire protection. The present study takes into account one of the main drivers of global changes, i.e. land cover and use alterations, and, using CORINE data, attempts to assess the extent of deforestations during the two periods covered by these data within the perimeter of natural protected areas. Results indicate that all natural protected areas, regardless of their geographical location, have been affected by recent deforestations, questioning the effectiveness of their protection.

Keywords: land cover and use changes, CORINE, conservation, natural protected areas, global changes

INTRODUCTION:

Sustainable development, aimed at equally satisfying current and future needs (Brundtland, 1987) involves an integration of three traditional pillars – economic, social and environmental (Bugge and Watters, 2003) and a fourth newer cultural one (United Cities and Local Governments, 2010). In terms of concrete actions and reference to the environmental pillar, sustainability implies assessing the environmental impact of socio-economic activities as part of the care for future generations, restoring the ecological systems affected by earlier impact through ecological engineering, and safeguarding a part of the current environment for the future via natural protected areas (Ianoş *et al*., 2009; Petrişor and Petrişor, 2014).

Therefore, conservation is an essential part of sustainable development. However, unlike the 'zero growth' model, sustainable conservation is not seen as preservation of systems in an intact state, but maintenance within the carrying capacity limits (Petrişor, 2011). Several essential principles in designating natural protected areas include the fact that their environment must be in a pristine, nearly-natural state, unaffected by anthropogenic impacts and that such areas must be representative for their biogeographical space, while accounting for vulnerable and fragile systems (Petrişor, 2011; Grec and Ardelean, 2013). In this regard, the Romanian biogeographical diversity is relatively well covered, with a focus on key areas for conservation, such as the wetlands (Petrişor, 2010), coastal areas (Stan, 2013; Petrişor, 2014) and mountain regions (Petrişor, 2009).

In terms of impacts, Dale *et al*. (2011) introduced in the scientific literature the term 'global changes' to refer all the major anthropogenic impacts affecting the ecosphere: land cover and use alterations, climate changes and modifications of energy flows. Among them, land cover and use changes are particularly useful for assessing long term trends induced by socio-economic drivers inducing their transitional dynamics, due to their relationship with the other constituents of global changes (Ianoş *et al*., 2011; Jozsa *et al*., 2014).

Previous studies carried out in Romania showed that the most important changes were paired antagonistic phenomena affecting forests (deforestation and re/afforestation) and agriculture (development and abandonment), and urbanization (Petrişor *et al*., 2010; Ianoş *et al*., 2011; Petrişor, 2012; Petrişor *et al*., 2014). One of the limitations of carrying such regional long-term studies based on transitional dynamics assessed based on land cover and use change data on all possible changes is the fact that the researcher must take unbiased decisions with respect to defining the phenomenon based on the initial or final change; for example, deforestations were defined as transformations of forests in a different land cover or use class, while urbanization was defined as transformation of some class into an urban/built up area; however, it is hard to decide whether a transformation of a forest into an urban area is deforestation or urbanization. From this perspective, it is more productive to carry out unilateral assessments, focusing on unique phenomena.

Furthermore, these studies indicated that 'desk studies' can be misleading without correlations with the field data. While deforestations can be clearly defined as 'loss of forests', the reverse phenomena requires some fine tuning; afforestation is defined as a conversion of other land-use into forest, or increase of the canopy covers over the 10% threshold through plantations or natural regeneration, while reforestation is the re-establishment of forest formations after a temporary condition decreasing the canopy cover below 10% due to anthropogenic or natural causes (Dutcă and Abrudan, 2010).

The global importance of forests resides of the ecosystem services provided by them (Xiao *et al*., 2000). The loss of forests represents, as the previous

Correspondence: Assistant Professor Alexandru-Ionuţ Petrişor, PhD, "Ion Mincu" University of Architecture and Urbanism, str. Academiei, nr. 18-20, sector 1, cod 010014, Bucharest, Romania, telephone: +4-(021)3077133, fax: +4(021)3123954, e-mail: alexandru_petrisor@yahoo.com

studies have showed, a serious issue for Romania (Ursu *et al*., 2007; Lawrence, 2009; Dutcă and Abrudan, 2010; Mortan, 2011; Petrişor, 2015; Costea, 2013). During the process of transition to an open market economy, property restitution included forests returned to people who did not have a use for it, but took the opportunity to make a fast profit by cutting them off and selling the wood; due to its extent, the phenomenon caused a socio-economic drama (Roman, 2009).

Although the previous studies quantified the extent of impacts manifested over the Romanian territory using land cover and use data, none of them addressed the natural protected areas. Previous studies have showed an overall decreasing capacity of the national system of protected areas to cover the biogeographical diversity effectively (Iojă *et al*., 2010), resulting into a lawsuit from the European Commission (Cojocariu *et al*., 2010). Since Romania has been affected by environmental impact during the communist regime and afterwards, during the transition period, the conservation decision is hard to take, as the International Union for the Conservation of Nature (IUCN) guidelines require, among others, that areas designated for protection must be in a pristine condition (International Union for the Conservation of Nature, 1994), and, obviously, no impact-generating activities should be allowed after their declaration.

Despite of the fact that Romania started building up a system of natural protected areas compliant with the IUCN guidelines on specific categories since the 1980's, its designation did not always properly account for biodiversity (Szatmari *et al*., 2014), the protection status was not always enforced, and there were only few declared areas. Most of them were declared in 2007, in relationship with Romania joining the European Union.

This study attempts to assess quantitatively, using geo-spatial techniques, the relationship between the current Romanian system of natural protected areas and alterations of land cover and use during the economic transition, covering the period from its beginning until the moment before completing the national system of natural protected areas (1990-2006).

MATERIALS AND METHODS:

This study integrated three datasets, summarized in Table 1:

(1-2) Land cover and use changes data covering periods 1990-2000 and 2000-2006 and land cover and use data for 2000 and 2006: the third level of this classification was used, focusing on the three categories corresponding to forests: broad-leaved forests (311), coniferous forests (312) and mixed forests (313); deforestations were defined as transformations of each class into another one different from the three (Commission of the European Communities, 1995). The spatial resolution differs among the two data sets – minimum mapping unit of 25 hectare and minimum width of linear elements of 100 meters for CORINE and 5 hectares for CORINE changes (Kleeschulte and Bütter, 2004). Moreover, methodological changes in the production of data between 1990-2000 and 2000-2006, respectively 2000 and 2006, affect their spatial resolution and definitions of classes (Jansen, 2007; Pelorosso *et al*., 2009; Verburg *et al*., 2011).

(5) Data on natural protected areas from Romania contain information on the following types: (a) scientific reserves, natural reserves and natural monuments with an area greater than 5 hectares, (b) national parks and natural parks (protected landscapes according to IUCN), (c) Sites of Community Importance, (d) Special Areas of Conservation, (e) Special Protection Areas, and (f) area where the Convention on the Protection and Sustainable Development of the Carpathians is applied, even though the latter cannot be considered a natural protected area in the true meaning of this concept, as protective actions are only recommended, but not compulsory within its perimeter. Categories (c), (d), and (e) were established through the Natura 2000 Programme of the European Union.

The datasets were overlaid for a visual and quantitative analysis of information; geo-processing was performed using the Spatial Analyst extension, and areas were computed using the X-Tools extension. The area affected by changes was computed as a percentage of the total area of each type of area, but also as a percentage of the total forested area within all protected areas belonging to that type. In this second case, the initial area was defined as the area at the end of the period plus the area lost through the changes. This definition was preferred to the alternative of reporting to the one from the beginning due to the lack of data on land cover from 1990.

Tab. 1.
Specifications on the data used in the study: dataset, provider, location, format, remarks and transformations.

No.	Dataset	Provider	URL	Format	Remarks	Transformations
1	Land cover and use changes data	CORINE (Coordinated Information on the European Environment) Land Cover 1990 - 2000 changes	http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2	ArcView GIS 3.X	1990-2000 changes data Resolution: 5 hectares	Project into Stereo 1970, subsample for Romania
2	Land cover and use changes data	CORINE (Coordinated Information on the European Environment) Land Cover 2000 - 2006 changes	http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-3	ArcView GIS 3.X	2000-2006 changes data Resolution: 5 hectares	Project into Stereo 1970, subsample for Romania

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3	Land cover and use data	CORINE (Coordinated Information on the European Environment) Land Cover 2000 seamless vector data	http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2000-clc2000-seamless-vector-database-5	ArcView GIS 3.X	2000 data Resolution: 25 hectares	Project into Stereo 1970, subsample for Romania
4	Land cover and use data	CORINE (Coordinated Information on the European Environment) Land Cover 2006 seamless vector data	http://www.eea.europa.eu/data-and-maps/data/clc-2006-vector-data-version-3	ArcView GIS 3.X	2006 data Resolution: 25 hectares	Project into Stereo 1970, subsample for Romania
5	Natural protected areas	Romanian Ministry of the Environment and Sustainable Development	http://mmediu.ro/articol/date-gis/434	ArcView GIS 3.X	Not all types of protected areas legally defined are available	No transformation needed

RESULTS AND DISCUSSION:

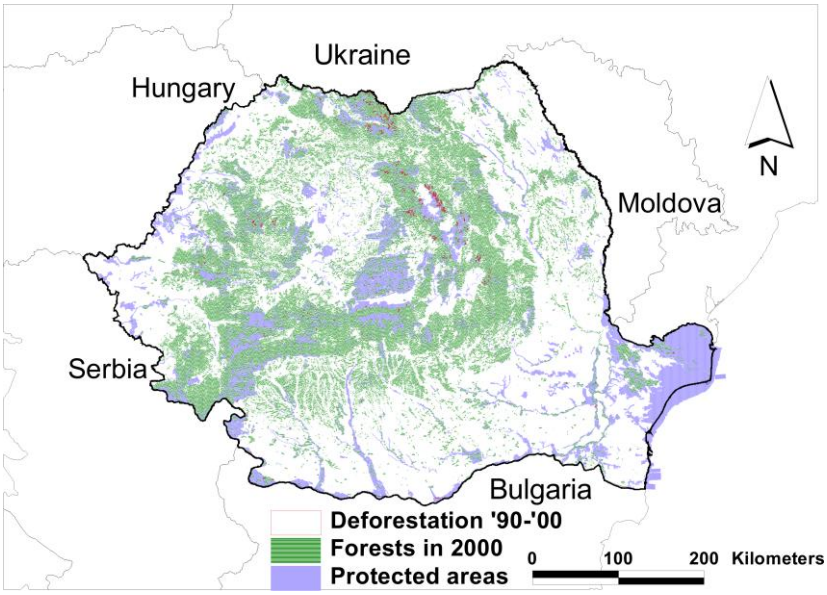

Fig. 1. Deforestations occurred during 1990-2000 within the Romanian natural protected areas. The image displays the protected areas (blue), forests at the end of the period (green) and deforested areas (red).

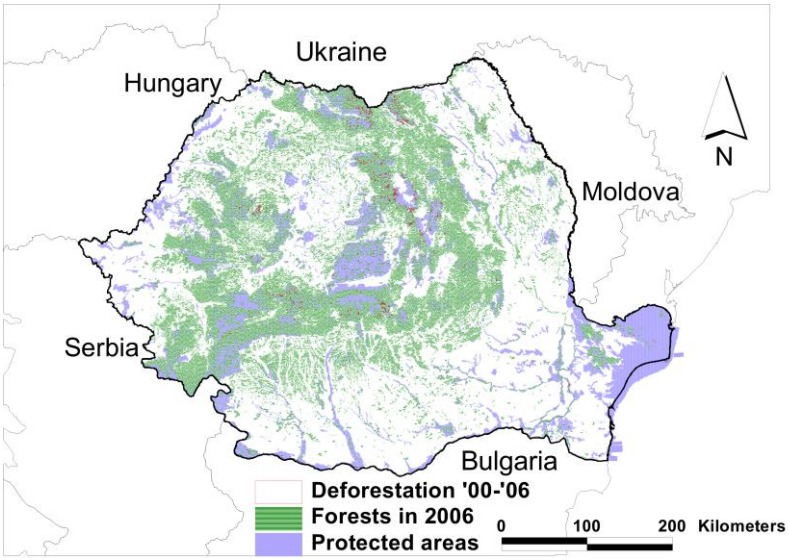

Fig. 2. Deforestations occurred during 2000-2006 within the Romanian natural protected areas. The image displays the protected areas (blue), forests at the end of the period (green) and deforested areas (red).

The raw results are displayed in the maps presented in Figures 1 and 2, showing the overlaid spatial distribution of all natural protected areas (regardless of their type), forested area in the end of the period, and

areas affected by deforestation during 1990-2000 (Figure 1) and 2000-2006 (Figure 2), and Table 1, showing the computational results. The maps show that deforestations were concentrated during the first period in the forests situated in north-eastern Carpathians, as indicated by other previous studies (Petrişor, 2012; Petrişor *et al*., 2014), and during the second period in all Carpathian massifs.

Tab. 1.
Extent of the deforestations occurred during 1990-2006 within the Romanian natural protected areas.

Category	*Area*	*Deforested area*						*Forest area*	
		1990-2000			*2000-2006*			*2000*	*2006*
		Area	*% protected area*	*% forest area*	*Area*	*% protected area*	*% forest area*		
All protected areas	56902.04	266.69	0.47	0.97	249.53	0.44	0.90	27312.26	27389.71
Carpathian Convention	68860.29	225.93	0.33	1.15	212.77	0.31	1.08	19487.10	19560.90
Parks (national parks and protected landscapes)	16638.91	72.88	0.44	1.00	47.77	0.29	0.66	7187.10	7189.40
Reserves (scientific & natural reserves, natural monuments)	2511.46	4.68	0.19	0.34	7.93	0.32	0.57	1392.35	1385.80
Ramsar sites	6271.51	3.97	0.06	0.96	2.09	0.03	0.55	408.98	380.49
Biosphere reserves	6616.89	14.93	0.23	2.11	6.66	0.10	0.99	692.70	666.60
Natura 2000 SCIs	41521.53	195.75	0.47	0.86	175.82	0.42	0.78	22450.06	22500.90
Natura 2000 SPAs	36936.14	162.58	0.44	1.09	154.03	0.42	1.03	14728.60	14754.79
Natura 2000 SACs	1934.91	11.92	0.62	0.85	5.06	0.26	0.36	1382.72	1393.99
Total	56902.04	755.23	1.33	1.07	572.74	1.01	0.81	69851.63	70042.10
% (area within protected areas per total area)	100.00	35.31	-	-	43.57	-	-	39.10	39.10

In order to assess whether there are any consistent trends during the two periods, correlations were computed between the share of areas affected by deforestations within the total area per type of reserve and forested area per type of reserve (Figures 3 and 4). The correlation is very significant during the first period ($r = 0.92$, $n = 10$, $p < 0.001$), and marginally significant during the second one ($r = 55$, $n = 10$, $0.05 < p = 0.09 \leq 0.1$). The strong correlations shows on that the intensity of deforestations was even and did not depend on the type of area, but on the share of its surface covered by forests), suggesting that regardless of the fact that some protected areas already had a protection status before 2007, this was not enforced. Moreover, deforestations were not seen as an impediment to declaring new areas, but merely as means to control the deforestations through new protective restrictions.

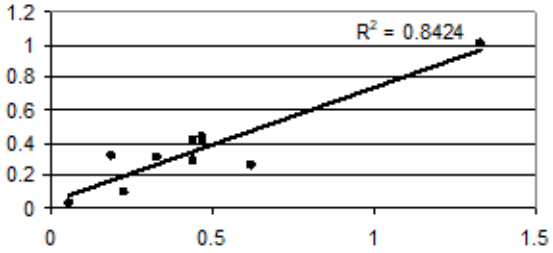

Fig. 3. Correlations between the share of areas affected by deforestations within the total area per type of reserve and forested area within the Romanian natural protected areas during 1900-2000.

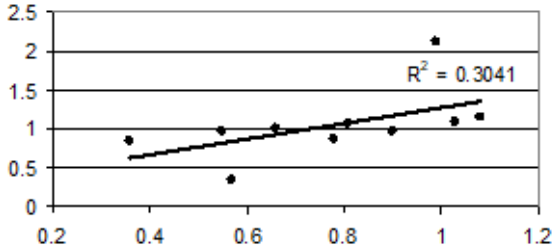

Fig. 4. Correlations between the share of areas affected by deforestations within the total area per type of reserve and forested area within the Romanian natural protected areas during 2000-2006.

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Provided that most of the Romanian protected areas are situated in the mountain region (Petrişor, 2009), which are mostly covered by forests, the results indicate that all types of protected areas were affected by deforestations. However, this is not necessarily the only explanation; Figure 1 shows significant deforestations even within the small forested area situated into the Danube Delta Biosphere Reserve, which is a typical wetland. It has to be stressed out that the Danube Delta became a Biosphere Reserve, a Ramsar site and a World Heritage site in 1991, and the law on its foundation was issued in 1993; therefore, the 1990-2000 deforestations occurred after the moment when it acquired a protection status due to its poor enforcement (Meiţă, 2010; Buhociu *et al*., 2013; Meiţă *et al*., 2014).

Similarly, Romania adopted the Convention on the Protection and Sustainable Development of the Carpathians, known as the Carpathian Convention, in 2003; although the territory under its incidence is not a real protected area (for this reason, it is not represented in Figures 1 and 2), its adoption by Romania implies the agreement to actively take all required measures to ensure an effective protection of the area (Popescu and Petrişor, 2010). In theory, this was achieved by including most of the surface in natural protected areas, but the protection status was not really enforced, as indicated by the deforestations occurred during 2000-2006.

These examples indicate that despite of the protection status, deforestations occurred at the same rate, suggesting that the protection status was not enforced. Part of the explanation resides in the fact that, despite of their protection status, many natural protected areas lacked a custodian, or, if they had one, they had no management plan (Iojă *et al*., 2010).

Last but not least, the study presented here has several limitations. Some have been already pointed out and refer to the fact that CORINE data are not consistent in terms of the methodology used to produce them across the two periods, with respect to their spatial resolution and definition of classes (Jansen, 2007; Pelorosso *et al*., 2009; Verburg *et al*., 2011). Another issue relates to the fact that, without field studies, it is hard to assess the true extent of deforestations due to the resolution of data (5 hectares), or the real explanation (e.g., temporary conditions, natural causes etc.). The most important limitation is the fact that computing the share of deforested area from the forested one had to use the final forested area as a reference instead of the initial one as a reference due to the lack of 1990 data. This is visible in Table 2, where for the second period the two possible references were used. The results of correlation analysis indicate that using the proper reference results into a significantly higher extent of deforestations ($r = 0.99$, $n = 10$, $p < 0.001$).

Tab. 2.
Variation of the share of areas affected by deforestations within the total area per forested area during 2000-2006 based on the reference year.

Category	*Reference year*	
	2006	*2000*
All protected areas	0.90	0.91
Carpathian Convention	1.08	1.09
Parks (national parks and protected landscapes)	0.66	0.66
Reserves (scientific & natural reserves, natural monuments)	0.57	0.57
Ramsar sites	0.55	0.51
Biosphere reserves	0.99	0.96
Natura 2000 SCIs	0.78	0.78
Natura 2000 SPAs	1.03	1.05
Natura 2000 SACs	0.36	0.37
Total	0.81	0.82

CONCLUSIONS:

The study assessed quantitatively, based on spatial analyses, the deforestations occurred within the Romanian protected areas during 1990-2000 and 2000-2006. The results clearly indicated that deforestations occurred within each type of protected area, in significant correlation with the share of its forested area. While at a first glance it appears that deforestations occurred before the areas achieved their protection status (raising the question on protecting an area which was no longer in a pristine state), several important examples (Danube Delta Biosphere Reserve and area under the incidence of the Carpathian Convention) show that deforestations occurred in already protected areas, indicating that the protection status could not be enforced.

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