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ASSESSMENT OF THE LONG-TERM EFFECTS OF GLOBAL CHANGES WITHIN THE ROMANIAN NATURAL PROTECTED AREAS

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Abstract

The global changes (climate changes, land cover and use changes, and alterations of energy flows) affect our global phenomena. These phenomena are even more important in the natural protected areas, which are pristine places designated to preserve our biodiversity within the limits of the carrying capacity of ecosystems. The present study used spatial data to look at the effects of global changes within the Romanian natural protected areas. The results indicate that high temperatures and low precipitations menace the protected areas from mountain areas and to a lesser extent those in the wetlands. The transitional dynamics of land cover and use changes do not differ from the national ones and consist of antagonistic phenomena affecting forests (deforestation and reforestation), and, to a lesser extent, agriculture (abandonment and development), waters and wetlands (floods and draughts), and man-dominated systems (urbanization). The findings suggest that unplanned development incurs environmental costs.

Keywords: *Conservation; Climate change; Land cover and use; Agriculture; Wetlands; Deforestation; Reforestation; CORINE.*

Introduction

Canadian researcher Virginia Dale and her colleagues [1] used the term ‘global changes’ to include all man-driven impacts affecting our global environment (climate changes, land cover and use changes, and alterations of the energy flows). These causes are inter-related [2-12] and together constitute a challenge requiring political consensus in order to implement measures aimed at reducing their effects.

Previous studies carried out over the Romanian territory [2, 13-17] suggest that the most important transitional dynamics, resulting into land cover and use changes, are antagonistic phenomena affecting agricultural land (development and abandonment), forests (forestation and deforestation), water (floods, draughts and damming), and urban areas (urban growth, decline, and changes). Similarly, climate changes – manifested through high temperatures and low precipitations – are most likely to peak in the northern part of the country, with values decreasing circularly towards east, south and north, affecting mostly the mountain regions [2].

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One of the strategies used to tackle environmental degradation in general and global changes in particular is the conservation of biodiversity through natural protected areas [14, 19, 20], which form a global network. However, the creation of protected areas, particularly in countries with low environmental awareness [21-22] can generate conflicts with the process of development [23-39], which ultimately results into social issues due to the additional restrictions [40-47].

The Romanian system of natural protected areas consists of few existing areas, declared in accordance with the principles of the International Union for the Conservation of Nature (IUCN) [48] and a series of new areas, especially NATURA 2000 sites, declared during the process of joining the European Union in 2007. The second process was very fast and insufficiently substantiated, resulting into a lawsuit from the European Court [49]. Also, as a consequence of the two, many sites consist of overlapping categories, with consequences over their management [47, 50].

Given the availability of geospatial technology, the studies looking at the effects of global changes used methods based on change detection using remote sensing imagery [51-53] or Geographical Information Systems [54-59], sometimes in conjunction [60-62]. However, if spatial data exist on land cover and use and their changes (CORINE data produced regularly by the European Environment Agency) or existing and predicted climate (DIVA GIS Project) [63-66], there are no available maps of the energy distribution, except for unconventional sources [13].

This study aims to assess the extent and nature of global changes (excepting for energy) within the Romanian natural protected areas using geo-spatial analyses applied to CORINE land cover and use data and DIVA GIS data on actual and predicted temperatures and precipitations.

Data and Methods/Spatial datasets and Methods

The study used several spatial datasets freely available from different Romanian and international agencies, referring to climate changes (available from the University of Berkeley), land cover and use and their changes (available from the European Environment Agency), and natural protected areas (available from the Romanian Ministry of the Environment), detailed in Table 1. Since all spatial analyses were carried out using ArcView/ArcGIS, all data were transformed into a format compatible with the product (shapefile) and projected unto Stereo 1970; all transformations, including sub-sampling of datasets, are also presented in Table 1.

The analysis of data involved several geo-statistical approaches. For the precipitation and temperatures, datasets reflecting changes, computed by subtracting predicted values from the current ones were derived; their spatial analysis consisted of the following steps:

(1) Clipping sub-sets for all protected areas and each particular type according to the national classification, which is compatible with the international one established by the IUCN [48]: (a) reserves of the biosphere, (b) Ramsar sites, (c) NATURA 2000 sites – Sites of Community Importance – Habitat Directive (SCIs), Special Protection Areas – Birds Directive (SPAs), and Special Areas of Conservation (SCAs), (d) parks – including national parks and "natural parks" (protected landscapes, in the IUCN terminology), and (e) national reserves, including strict/scientific reserves and national, regional and local reserves and natural monuments with an area over 5 hectares;

(2) Dissolving the polygon contours for each category, preserving the average value for the entire surface, similar to I. Dutcă, and I.V. Abrudan [67] using the Spatial Analyst extension of ArcView 3.X.

Table 1. Sources of data used in the study

Dataset	Provider	Format	Remarks	Transformations
Climate – actual	University of Berkeley (1)	DIVA-GIS	Produced by the project WorldClim; 2.5 min × 2.5 min	Import in ArcView GIS 3.X, project into Stereo 1970, sub-sample for Romania
Climate – predicted	University of Berkeley (2)	DIVA-GIS	Predictions for 2100 based on 2×CO_2 concentration and CCM3 model; 2.5 min × 2.5 min	Import in ArcView GIS 3.X, project into Stereo 1970, sub-sample for Romania
Land cover & use	EEA (3)	ArcView GIS 3.X	2000 data	Project into Stereo 1970, sub-sample for Romania
Land cover & use changes	EEA (4)	ArcView GIS 3.X	1990-2000 data	Project into Stereo 1970, sub-sample for Romania
Land cover & use changes	EEA (5)	ArcView GIS 3.X	2000-2006 data	Project into Stereo 1970, sub-sample for Romania
Natural protected areas of Romania	Romanian Ministry of the Environment (6)	ArcView GIS 3.X	Only sites of national importance included	None

(1) http://biogeo.berkeley.edu/worldclim/diva/diva_worldclim_2-5m.zip
(2) http://biogeo.berkeley.edu/worldclim/diva/diva_wc_ccm3_2-5m.zip
(3) http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2000-clc2000-seamless-vector-database-5
(4) http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2
(5) http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-3
(6) http://mmediu.ro/articol/date-gis/434

For the data referring to land cover and use and their changes, the steps carried out in the spatial analysis are:

(1) Clipping sub-sets for all protected areas and each particular type, similar to the previous analysis.

(2) Re-classifying 2000 land cover and use data using the following categories: (a) urban – CORINE class 1, (b) agricultural – CORINE class 2, (c) forests – CORINE classes 3.1.1, 3.1.2, and 3.1.3, (d) natural – all features formerly under 'natural' (CORINE class 3) except for the forests, and (e) water (includes 'waters' – CORINE class 4, and 'wetlands' – CORINE class 5). Land cover and use data were used in an attempt to normalize the results based on the particular land cover and use structure of the natural protected areas and each individual type. 2000 data were chosen as a mid-point between the two land cover and use change periods: 1990-2000 and 2000-2006.

(3) Establishing a typology of the 'transitional dynamics' of land cover and use: (a) urbanization – transformations of any other CORINE classes (# 2-5) into 'urban' (# 1) and transformations within the 'urban' class, (b) deforestation – includes transformations of 'forest' (CORINE 3.1.1, 3.1.2, and 3.1.3) into any other class (CORINE 1; 2; 3 – other than 3.1.1, 3.1.2, and 3.1.3; 4; and 5) and other land use transformations within class 3 indicating the deforestation, (c) reforestation, defined as afforestation and reforestation [67] plus the colonization of abandoned agricultural land by forest vegetation [68] – includes land cover transformations of any other class (# 1, 2, 4, 5) into 'forest' and land use transformations within class 3 into CORINE classes 3.1.1, 3.1.2, and 3.1.3 and other land use transformations within class 3 indicating the reforestation, (d) abandonment of agriculture – includes land cover transformations of 'agricultural' (CORINE 2) into other classes (# 1 and 3-5) and land use transformations within class 2 indicating the abandonment of agriculture, (e) development of agriculture – includes land cover transformations of other classes (# 1 and 3-5) into 'agricultural' (CORINE 2) and land use transformations within class 2 indicating the

development of agriculture, (f) floods – includes land cover transformations of other classes (# 1-3) into 'wetland' (CORINE 4) and 'water' (CORINE 5) and of wetlands into water, (g) draughts – includes land cover transformations of 'wetland' (CORINE 4) and 'water' (CORINE 5) into other classes (# 1-3) and of water into wetlands, and (g) unknown – defined as such within the dataset (999-999).

(4) Dissolving the polygon contours for land cover/use and land cover and use changes according to the new typology;

(5) Computation of the area occupied by each category using the X-Tools extension of ArcView GIS.

Further computations were required for the data referring to land cover and use and their changes. In this case, after computing the share of surfaces corresponding to each land cover/use category by the national territory, all protected areas and each type of protected area, and, subsequently, the share of area affected by changes corresponding to each transitional dynamic by the same areas, the two were connected by dividing the share of each transitional dynamic to the one corresponding to the type of land cover/use connected to it: (a) urbanization – 'urban' (b) deforestation and (c) reforestation – 'forest', (d) abandonment of agriculture and (e) development of agriculture – 'agricultural', (f) floods and (g) draughts – 'waters', and (g) unknown – not connected to any class. The result was a number rounded to an integer, reflecting the importance of each transitional dynamic for each category of protected area.

Results and discussion

The present study aimed to assess the potential effects of climate changes and land cover and use changes reflecting the transitional dynamics within the Romanian protected areas.

The potential effects of climate changes are shown in figures 1 and 2. Figure 1 shows the distribution of the difference between actual and predicted temperatures across the different types of protected areas, and figure 2 shows the distribution of the difference between actual and predicted precipitations across the different types of protected areas.

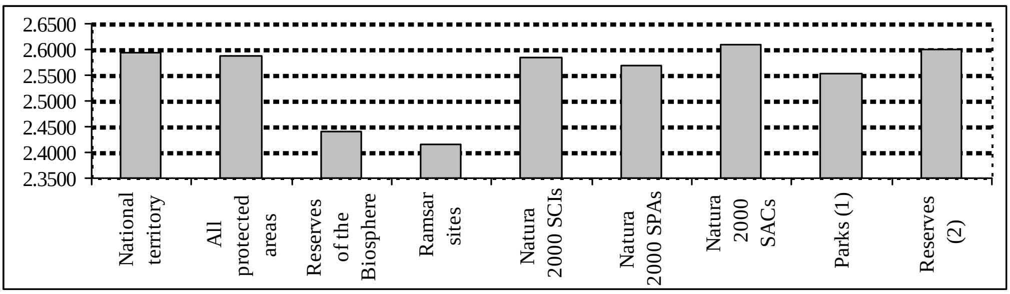

Fig. 1. Distribution of the temperature increase within different categories of Romanian natural protected areas, based on 2100 predictions assuming 2×CO_2 concentration and the CCM3 model

The patterns are very similar, meaning that areas with higher temperatures are also likely to experience a deficit of precipitations. For both categories, NATURA 2000 SCIs and SACs and parks, and all protected areas show values similar to the national average. Natura 2000 SPAs and parks have slightly lower values, indicating milder effects. The overall explanation consists of their geographic location in the alpine regions and wetlands, where the climate is milder than in the plain areas. The largest difference is visible in Ramsar sites and reserves of the biosphere, which are the least likely to suffer from the effects of climate changes [2]. This is mostly due to the large share of the Danube Delta, largest reserve of the biosphere and second largest wetland [69, 70]; through its geographical position, the Danube Delta is not so exposed to climate changes [2].

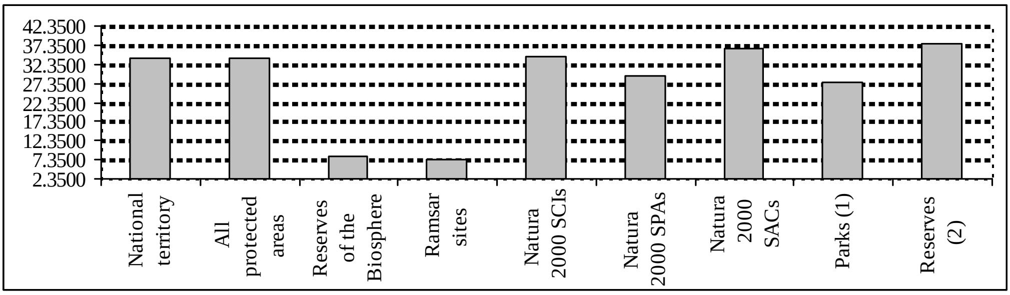

Fig. 2. Distribution of the precipitation deficit within different categories of Romanian natural protected areas, based on 2100 predictions assuming 2×CO_2 concentration and the CCM3 model

The results of the effects of land cover and use changes reflecting the transitional dynamics within the Romanian protected areas are shown in Table 2. The numbers in the table reflect the importance of each transitional dynamic for a certain category, computed by dividing the share of the area affected within that territory by the share of the land cover/use category within the same territory.

The results presented in Table 2 show that the transitional dynamics affecting the Romanian natural protected areas do not differ qualitatively from the national results [14], but their importance is different. For example, although urbanization is not visible in Romania due to the small share of human settlements from the national territory [15], it affects most types of protected areas and is the leading potential impact against Ramsar sites; this is mostly due to the unregulated and often illegal development of aggressive tourist facilities in the Danube Delta [69, 71, 72] and 'Balta Mică a Brăilei', the largest Ramsar sites [73]. Similarly, deforestation and reforestation are leading causes [74] for all categories. Last but not least, the abandonment of agriculture, occurred as a consequence of the restitution of property [74-80], is an important overall transitional dynamic, affecting also Ramsar sites and NATURA 2000 SPAs.

Table 2. Importance of the effects of land cover/use changes during 1990-2000 / 2000-2006 reflecting the transitional dynamics within different categories of Romanian natural protected areas. Gray shading indicates important effects, showed by non-null values.

Transitional dynamic	Categories of territory / protected area								
	National	All protected areas	Reserves of the Biosphere	Ramsar sites	Natura 2000 SCIs	Natura 2000 SPAs	Natura 2000 SACs	Parks	National reserves
Urbanization	0 / 2	0 / 1	3 / 7	6 / 15	0 / 1	0 / 1	0 / 0	0 / 1	0 / 1
Deforestation	1 / 3	1 / 2	3 / 5	3 / 5	1 / 2	1 / 2	1 / 2	1 / 2	0 / 2
Reforestation	1 / 0	1 / 0	4 / 2	4 / 6	1 / 0	1 / 0	1 / 0	1 / 0	1 / 0
Abandonment of agriculture	1 / 0	1 / 0	0 / 0	3 / 0	0 / 0	1 / 0	0 / 0	0 / 0	0 / 0
Development of agriculture	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	1 / 0
Floods	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Draughts	0 / –	0 / –	0 / –	0 / –	0 / –	0 / –	0 / –	0 / –	0 / –
Unknown	0 / –	0 / –	2 / –	0 / –	0 / –	1 / –	0 / –	0 / –	0 / –

These findings lead to the conceptual model presented in figure 3, showing the overall land cover and use changes within the natural protected areas. Similar to the national territory, the changes indicate that, similar to other transition country, Romania did not have a planned development [69, 81]; as a consequence, each land cover/use category was affected by antagonistic phenomena, one leading to its transformation into other classes and the other to its creation through the transformation of other classes:

(1) Due to the property restitution [16, 17, 74-79] agricultural parcels were abandoned, but agriculture was developed elsewhere at the expense of natural land [16] or even forests (which where cut off after the property restitution).

(2) More complex relationships occur with respect to forests. While deforestation became a true 'national drama' [82] due to the property restitution [67, 74, 76, 81, 83-87], but also due to the urban development or climate changes [88, 89], forestation occurred not so much due to planned efforts geared to replanting once forested areas, but through the natural regeneration of forests and transformation of abandoned agricultural land into forests through their colonization by forest vegetation [90-96].

(3) Uncontrolled urbanization [97] resulted into the transformation of forests, other natural land, agricultural land and even wetlands and water into built up areas.

(4) Especially during 1990-2000 floods and draughts were an important transitional dynamic.

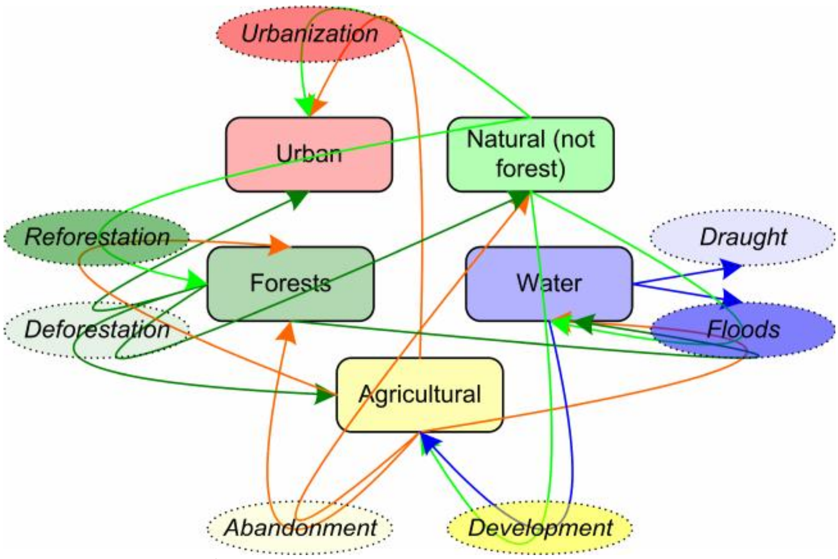

Fig. 3. Schematics of the main transitional dynamics inducing land cover and use changes within the Romanian natural protected areas during 1990-2006

Nevertheless, only by using spatial data it is hard to answer the following questions:

(1) Whether the transitional dynamics threatening the natural protected areas, such as deforestation and urbanization, appeared before the acquisition of the protected status (which questions the declaration of protected areas which are no longer in a pristine state) or after (questioning the efficiency of enforcement);

(2) Whether the decline of agriculture, and abandonment of agricultural land leading eventually to forestation is a consequence of restrictions imposed by the protection status (or preparatory actions), of property restitution, or of the economic decline.

Possible limitations of the study include issues inherent to the use of CORINE data due to changes in methodology and resolution during the two periods covered [68, 98-100].

Conclusions

The present study looked at the potential effects of climate changes and land cover and use changes reflecting the transitional dynamics within the Romanian protected areas. Overall, the findings do not differ from the national ones. The spatial distribution of potential high temperatures and low precipitations is geographical and affects natural protected areas based on their position; those situated at high elevations are more likely to be affected that those in the floodplains or coastal areas, including the Danube Delta.

The transitional dynamics affecting all natural protected areas together do not differ from those affecting Romania; they consist of consist of phenomena with impact forests (deforestation and reforestation), and, to a lesser extent, agriculture (abandonment and development), waters and wetlands (floods and draughts), and man-dominated systems (urbanization). However, the natural protected areas situated in the mountain region are affected more by deforestation and those in the plain areas by urbanization. All these transitional dynamics are characteristic to developing countries. While it is hard to assess whether their effects occurred before or after the acquisition of the protection status, the effectiveness of protection remains debatable. In a broader sense, the processes inferred from this study can be generalized to unplanned development.

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