ANTHROPOGENIC STRESS INDUCED BY LAND USE ON NATURA 2000 SITES IN ROMANIA

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ABSTRACT

Romania's accession to the European Union in 2007 significantly contributed to the Natura 2000 network of protected natural areas: 381 sites covering 17.89% of the country's territory of which 108 SPAs (11.89% of the area) and 273 SACs (13.21%). The Natura 2000 network in Romania is currently being expanded, while the number of sites and the boundaries of some of them are subject to revision.

Evaluation of stress-induced by land use is of great utility for updating the boundaries of Natura 2000 sites. Initiated in The European Union in 1985, Corine program provides, among many different environmental issues, an inventory of land cover in 44 classes, operationally available for most areas of Europe including Romania.

The proposed methodology for evaluation of stress-induced by land use includes two fundamental criteria: stress intensity ranking and weighting based on spatial extension sites.

Ranking stress intensity is achieved with discriminant analysis and factor analysis. Land use spatial weighting for each site is made using block kriging.

Application of the proposed methodology is for the 383 protected areas of type SACs which has a total surface of 4.1×10^6 hectares (17.41% of the Romanian's territory).

The 44 classes of land use (from Corine database) were filtered in three stages: a) the exclusion of non-specific categories for Romania (223-Olive groves, 522-Estuaries etc); b) removing classes with reduced spatial extension (213 - Rice fields; 332 - Bare rocks etc); c) removing classes with reduced weight for each site.

Induced stress level is represented as a percentage on a scale where: 100% corresponds to the maximum stress of land use (continuous urban fabric) and 0% for areas without human activities.

The data are processed using specific software – ArcGis 10.0 for management of spatially referenced data, Surfer 12 and RockWorks 12 for spatial data processing.

Keywords: Natura 2000, CORINE Land Cover, anthropic stress, GIS database, factor analysis, discriminant analysis, block kriging.

INTRODUCTION

The Natura 2000 network in Romania is currently being expanded, while the number of sites and the boundaries of some of them are subject to revision. Under these favorable circumstances article proposes a methodology for reviewing limits Natura 2000 sites based on land use impact.

The updating of the Natura 2000 sites will be based on the ranking of the impact of land use, impact weighted by the surfaces occupied by each type of land use.

Case studies aimed at four categories of Natura 2000 sites with a wide variety of types of land use. Analysis of the four case studies (Comana, Danube Delta, Sighişoara - Târnava Mare and Porțile de Fier) allow the introduction of additional categories of land use other than the 44 from Corine database.

Hierarchy of land use impact in 10 classes is based on the authors' previous studies that used multivariate analysis (discriminant analysis, factor analysis) and geospatial analysis (block kriging) [4].

METHODOLOGY FOR ASSESSING THE OVERALL IMPACT

The proposed methodology for assessing the impact of land use on Natura 2000 sites in Romania involves four distinct phases:

• ranking of the 44 categories of land use in 10 classes

 $(RI_{ki}; k = 1,...,44; i = 1,...,10;$ Table 1) depending on the intensity of the impact on Natura 2000 sites, intensity evaluated on the base of multivariate and spatial analysis [5];

- filtering the 44 categories of land use by intersection with the area of the all 383 Natura 2000 sites, on the base of area for each land use type;
- determining the area of each land use type (44 categories) on the surface of the all 383 Natura 2000 sites (N2000_CLC_k; k = 1,...,44; Table 2);

Table 1. Ranking of impact intensity

CLC Category	RI [-]
311, 312, 313, 321, 322, 324, 331, 332,	
333, 411, 412, 421, 511, 512, 521, 523	1
231	2
141	3
243	4
122, 142, 221, 242	5
211, 222	6
213	7
112, 133	8
123	9
121, 131, 132	10

• calculating the average coefficient of impact on Natura 2000 sites (ARI):

$$ARI = \sum_{k=1}^{k=44} RI_{ki} \cdot \frac{N2000 _ CLC_k}{\sum_{k=1}^{k=44} N2000 _ CLC_k}$$

In addition, to detailing the impact of land use on sites Natura200, 14 new types of land use impact were defined by moving the limits of 14 CLC categories with 25 to 500 m. Classification of new types of land use in the scale of the 10 levels of impact is done by weighting the indices of impact with the areas intersected. Impact index of the new categories (RI_{ki} ; k = 45,48; i = 1,...,10) is one or two levels lower than the index of the extended land use type.

DATABASE

The data integrated in the GIS database are vectors format spatial data for:

- Land use vectorial data; Corine Land Cover 2006 data set, provided by the European Environment Agency [1];
- Boundaries of Natura 2000 in Romania;
- Natura 2000, limits for 273 SACs, provided by the National Environment Protection Agency [2];
- Limits for the biogeographical regions, provided by the National Environment Protection Agency [3].

All date are available or have been converted into Stereo 70 system projection.

Corine Land Cover 2006 data set is provided by the European Environment Agency. The third level in the Corine land cover nomenclature comprises 44 items that are used for the project on a scale of 1:100 000.

In Romania, land use has been separated into 32 categories as per Corine Land Cover 2006 standards (Table 2). There were excluded 12 categories as non-specific of land use for our country (1.1.1., 1.2.4., 2.1.2., 2.2.3., 2.4.1., 2.4.4., 3.2.3., 3.3.4., 3.3.5., 4.2.2., 4.2.3., 5.2.2.).

In order to detail the analysis of anthropogenic stress induced by land use on Natura 2000 sites, we inserted, for some specific CLC category, a buffer zone having widths between 25 - 500 m (Table 2). We classify the induced stress for those category according to the fact that inside the buffer zone the stress is bigger than outside.

Natura 2000 is an european network of protected natural areas which includes a representative sample of wildlife and natural habitats of community interest. It was established not only to protect nature, but also to maintain these natural resources in the long term, to ensure socio-economic resources.

In Romania were identified 6 of the 9 biogeographical regions existing on European Union territory (Continental, Alpine, Pannonic, Pontic, Steppic, Black Sea – Fig. 1). The Natura 2000 network in Romania includes 383 sites of which 108 SPAs and 275 SACs. The sites area varies between 1 and 454,080 hectares, the total surfaces beeing 4,152,220 hectares.

DATA ANALYSIS

The analysis of the stress induced by land use is performed at two levels:

- all Natura 2000 sites in Romania;
- four sites Natura 2000 with specific geomorphological features (Fig. 1):

- o ROSCI0043 Comana;
- ROSCI0065 Danube Delta;
- o ROSCI0227 Sighişoara Târnava Mare;
- o ROSCI0206 Porțile de Fier.

Table 2. Categories of land use for Romania

		RI	Buffer width	RIb	$N2000_CLC_k$	$N2000 _ CLC_k$
No.	CLC Category	[-]	[m]	[-]	[ha]	[%]
1	311 - Broad-leaved forest	1			1380516.8	33.2489
2	312 - Coniferous forest	1			390542.7	9.4060
3	313 - Mixed forest	1			502005.2	12.0905
4	321 - Natural grasslands	1			184028.3	4.4322
5	322 - Moors and heathland	1			62718.3	1.5105
6	324 - Transitional woodland-					
0	shrub	1			152796.8	3.6800
7	331 - Beaches, dunes, sands	1			9074.3	0.2186
8	332 - Bare rocks	1			3996.7	0.0963
9	333 - Sparsely vegetated areas	1			12918.4	0.3111
10	411 - Inland marshes	1			262430.7	6.3205
11	412 - Peat bogs	1			53.5	0.0013
12	421 - Salt marshes	1			5471.1	0.1318
13	511 - Water courses	1			100456.7	2.4194
14	512 - Water bodies	1			79855.6	1.9233
15	521 - Coastal lagoons	1			70406.6	1.6957
16	523 - Sea and ocean	1			153105.5	3.6875
17	231 - Pastures	2	100.00	2	377842.4	9.1001
18	141 - Green urban areas	3	50.00	2	198.9	0.0048
	243 - Land principally occupied					
19	by agriculture, with significant					
• •	areas of natural vegetation	4			94467.0	2.2752
20	122 - Road and rail networks	5	500.00	4	97.7	0.0024
21	142 - Sport and leisure facilities	5	500.00	5	731.4	0.0176
22	221 - Vineyards	5	50.00	3	13050.9	0.3143
23	242 - Complex cultivation	-	25.00	4	45042.4	1 00 40
24	211 New invigored eachly lond	5	25.00	4	45043.4	1.0848
24	211 - Non-Imgaled arable land	6	50.00	4	206351.9	4.9699
25	222 - Fruit trees and berry	6	50.00	3	13683.6	0 3296
26	213 - Rice fields	7	50.00	5	13083.0	0.0290
20	112 Discontinuous urban fabric	/	500.00	7	24712.6	0.0003
27	122 - Discontinuous urban fabric	<u> </u>	200.00	6	138.8	0.0932
20	123 - Tort areas	0	200.00	4	201.6	0.0033
29	121 - Industrial or commercial	0	30.00	4	301.0	0.0075
30	units	10	500.00	8	23363	0.0563
31	131 - Mineral extraction sites	10	50.00	6	2371.3	0.0571
32	132 - Dump sites	10	100.00	6	348.0	0.0084

NATURA 2000 ROMANIA

The 383 Natura 2000 sites of Romania have an total area of 4,152,220 hectares and represents 17.40 % of the whole of Romania (230,391 km²). The impact index for 80 % of all Natura 2000 sites is at minimum level (RI = 1).

The average value of impact index of land use on Natura 2000 in Romania (Table 2, Fig. 1) indicate an reduced stress: $ARI = 1.53 \approx 2$ and additional components introduced by the 14 additional categories does not lead to an index greater than 2.



Fig. 1 Natura 2000 network in Romania and the biogeographical regions

Legend: 1 - Romanian border; 2 - Natura 2000 network; Bioregions: 3 - Steppic; 4 - Pontic; 5 – Pannonic; 6 – Continental; 7 – Alpine; 8 – Black Sea; 9 – ROSCI0043; 10 – ROSCI0065; 11 – ROSCI0227; 12 – ROSCI0206

ROSCI0043 Comana

The Comana site (ROSCI0043) is included in the continental geographic region and covers an area of 26,486.15 ha. The main existing habitats in the Comana site are the meadows, forests and wetlands and freshwater habitats.

The average value of impact index of land use on ROSCI0043 Comana (Table 3, Fig. 2) indicate also an reduced stress: $ARI = 3.58 \approx 4$. Additional components introduced by the 14 additional categories represents an area of 23500 ha (88% of the total area of the site) with an average value of impact index 3.96. By averaging the two indexes result for site Comana a total index $ARI_{total} = 3.92 \approx 4$.

Table 3. ROSCI0043 Comana						
CLC	RI	$N2000 _ CLC_k$				
Category	[-]	[ha]				
512	1	219.321				
511	1	79.595				
411	1	712.200				
324	1	38.402				
321	1	632.625				
311	1	8463.790				
231	2	3336.004				
243	4	852.516				
242	5	1235.228				
221	5	598.741				
211	6	8648.819				
112	8	1526.158				
121	10	142.745				



243: 12 - 231: 13 - 311: 14 - 321: 15 - 324: 16 - 512: 17 - 511: 18 - 411

ROSCI0065 Danube Delta

The Danube Delta site (ROSCI0065) is extended in Pontic and Steppic geographic region and covers an area of 454,080.28 ha. It was recognized as a wetland of international importance especially as water birds habitat.

The impact of land use on ROSCI0065 Danube Delta (Table 4, Fig. 3) indicate an average coefficient of impact: $ARI = 1.56 \approx 2$ and additional components introduced by the 14 additional categories does not lead to an index greater than 2.



CLC Category	RI [-]	Buffer width [m]	<i>RIb</i> [-]	N2000_CLC _k [ha]
331	1			6512.305
523	1			210.121
521	1			67017.715
512	1			46392.105
511	1			11916.396
421	1			5460.244
411	1			220946.125
333	1			27.943
324	1			3909.926
321	1			19767.21
311	1			19759.038
231	2	100	3	2550.751
243	4			449.534
242	5	25	4	91.966
221	5	50	3	94.259
142	5	500	5	214.902
222	6	50	3	4.842
211	6	50	4	45041.172
133	8	50	4	54.636
112	8	500	8	2827.417
123	9	200	6	95.240
132	10	100	6	168.462
131	10	50	6	163.286
121	10	500	8	404.672

Fig. 3 ROSCI0065 Danube Delta Legend – CLC Category: 1-121; 2-131; 3-132; 4-123; 5-112; 6-133; 7-211; 8-222; 9-142; 10-221; 11-242; 12-243; 13-231; 14-311; 15-321; 16-324; 17-333; 18-411; 19-421; 20-511; 21-512; 22-521; 23-523; 24-331

ROSCI0227 Sighișoara - Târnava Mare

The Sighişoara – Târnava Mare (ROSCI0227) site has a surface of 85,812.95 ha and is included in the continental geographic region. It was designated primarily for the conservation of 18 types of natural habitat.

The average value of impact index of land use on ROSCI0227 Sighişoara - Târnava Mare (Table 5) has the value: $ARI = 2.13 \approx 2.5$.

Table 5. ROSCI0227 Sighisoara – Tarnava Mare

CLC Category	<i>RI</i> [-]	Buffer width [m]	<i>RIb</i> [-]	$\frac{N2000_CLC_k}{[ha]}$
313, 411, 333, 324, 321, 312, 311	1			46913.516
231	2	100	3	19496.725
243	4			9983.049
242	5	25	4	700.155
221	5	50	3	352.432
222	6	50	3	2270.266
211	6	50	4	5362.714
112	8	500	8	570.463
121	10	500	8	163.632

Table 4. ROSCI0065 Danube Delta

With the additional components introduced by the 14 additional categories does not lead to an index greater than 3.

ROSCI0206 Porțile de Fier

The Porțile de Fier site (ROSCI0206) is a part of the Continental geographic region and has a surface of 125,559.89 ha. The site has a particularly high conservation value in terms of flora, fauna and geomorphology, besides the great landscape value resulting from the combination of the particular natural elements with those related to human existence.

The average value of impact index of land use on ROSCI0206 Portile de Fier (Table 6, Fig. 4) indicate a reduced stress: $ARI = 1.43 \approx 1.5$. Additional components introduced by the 14 additional categories does not lead to an index greater than 2.

CLC Category	<i>RI</i> [-]	Buffer width	<i>RIb</i> [-]	$\frac{N2000 _ CLC_k}{[ha]}$
313	1	լույ		629.605
512	1			35.096
511	1			9432.785
411	1			103.711
333	1			158.976
332	1			122.830
324	1			5113.378
321	1			2439.643
311	1			84328.48
231	2	100	3	13156.404
243	4			5108.564
242	5	25	4	685.733
221	5	50	3	289.046
222	6	50	3	936.741
211	6	50	4	1677.411
112	8	500	8	1145.055
123	9	200	6	4.767
132	10	100	6	4.176
131	10	50	6	64.714
121	10	500	8	122.782



Fig. 4 ROSCI0206 Porțile de Fier

Legend – CLC Category: 1-121; 2-131; 3-132; 4-123; 5-112; 6-211; 7-222; 8-221; 9-242; 10-243; 11-231; 12-311; 13-321; 14-324; 15-332; 16-333; 17-411; 18-511; 19-512; 20-313.

CONCLUSIONS

Analysis of stress induced by land use provides a suggestive image of the risks and pressures facing the species and habitats in terms of human impact on Natura 2000 sites in Romania.

Globally, more than 88 % of the area of Natura 2000 sites (402,000 ha) are not affected by stress induced by land use, all CLC categories included in this area having RI = 1.

Table 6. ROSCI0206 Portile de Fier

The average value of impact index of land use on Natura 2000 sites in Romania with effect of all additional components leads to an maximum value ARI = 2.

The average values of impact index for the four selected Natura 2000 sites are between 4 and 1.5:

- ROSCI0043 Comana: ARI = 4
- ROSCI0065 Danube Delta: ARI = 2
- ROSCI0227 Sighişoara Târnava Mare: ARI = 2.5
- ROSCI0206 Porțile de Fier: ARI = 1.5

The *ARI* is an effective tool for selecting Natura 2000 sites recommended for boundaries revision:

- Natura 2000 sites with the average values of impact index lower than the overall average in Romania: ARI = 2 does not require redefinition of the current limits.
- Natura 2000 sites with ARI > 2 are recommended for a detailed analysis of land use and revision of the boundaries. Detailed analysis for each site can recommend to reduce anthropogenic stress by changing land use.

For revision of Natura 2000 sites it must be correlated the value of *ARI* with the conservation status of species and specific habitats.

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