PRESENT ENVIRONMENT AND SUSTAINABLE DEVELOPMENT, VOL. 6, no. 2, 2012

CONTINENTAL SALT LAND HABITATS CONSERVATION STATE RELATED TO NATURA 2000 SITES. RO SCI 0221 ILEANA VALLEY APPLICATION, IAŞI COUNTY

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Key words: continental saltland habitats, Ileana Valley, GIS, automatic classification

Abstract. The quantification of conservation state for certain priority habitats as those represented by the continental saline soils at Ileana Valley, in Iaşi municipality vicinity, constitutes a present necessity in the frame of the efforts undertaken for biodiversity conservation. The designation of Natura 2000 sites can not remain at the stage of territorial percentages and limits that are more ore less relevantly drawn. The approach based on representative classes and habitats' fragmentation indices may lead to a more precise estimation of the conservation state and of the ecosystems' functionality. The finality consists in the adaptation of certain automatic classification techniques for land use and habitat conservation and their correlation with phytosociological studies, in a GIS environment, in order to enhance a more rapid and less costly monitoring for the evaluation the state of protected areas in relation with various disturbance factors.

Introduction

In accordance with the standard Natura 2000 form, the Salts at Ileana Valley, RO SCI 0221 constitute a protection site for specific habitats in the continental biogeographic region, which includes: 40% *Salicornia sp.* plant communities and other species on wet and sandy terrains (1310), 1% forest border plant communities with tall, hygrophilous herbs from low-lands to high-lands (6430) and 50% salt Pannonian and Ponto-Sarmatic pastures and bogs (1530[*]) (Order 1.964/2007 of the Environmental and Forests Ministry).

Research on habitats' conservation state focuses, in general, on the biogeographic consequences of the "insular" character development for various

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natural ecosystems via evaluation of the reduction and degradation degree concerning the phyto-pedo-faunistic cover (Saunders et. al, 1991).

In our case, the reduction of Salts patches in Ileana Valley, enhanced by human actions and natural causes through the hydric regime increase at the present study time, results in stress factors for the habitats' key species: *Lepidium sp., Camphorosma annua, Halimione verrucifera, Plantago schwarzenbergiana, Salicornia europaea etc.* The drastic reduction of these salty patches may lead to the vanishing of key species resulting in protection inefficiency and site premises loss while other representative salty areas of decreased anthropic pressure are not taken into consideration.

1. Material and method

Landscape ecology and even ecology, in general, greatly relies on the concept of deterministic influence of spatial structure over the ecological processes (Turner et al, 1991).

The habitats in which organisms thrive and develop their vital cycle are spatially structured at many scales and these structures influence their perception and behaviour in the much larger context of higher processes, dynamics and populations' organization (Johnson et al., 1992).

The anthropic activities result in structures' integrity interruption of the ecosystems and may impede, or conversely, facilitate ecological fluxes as territorial movement (Gardner et al., 1993). The interruption of such spatial structures leads to ecological processes functionality loss and, furthermore, to populations decline, ecosystems' health problems and biodiversity outage (Wimberly et al., 2000).

These are strong reasons for increased care on the development of quantification procedures referring to landscape structures, not to mention that these procedures develop important steps in the study of processes-structures relations and result in detailed assessments of ecosystems functionality at a chosen moment (McGarigal and Marks, 1995).

Our quantification is based on terrain evaluation upon the vegetation cover and the use of Landsat satellite imagery (http://www.usgs.gov/) for the delineation of various land-use types and specific habitats spatial distribution that leads to the spontaneous plants conservation state assessment and the designation of certain fragmentation indices for the entire landscape and the subordinated classes.

In order to quantify the degree of conservation in relation with the disturbing factors (settlements, infrastructure, arable lands) the classification was also performed on a more extended surface of 778 hectares and the results were compared with the ones resulting from the classification inside the RO SCI 0221 limits (112 hectares), as reshaped by the Romanian Ministry of Environment and Forests in 2011.

The study area inside the new limits delineated in 2011 comprises 112 hectares, compared to the former 159 hectares and displays medium altitudes of 77 m, reaching 147 m maximum height and 48 m minimum height. In order to have comparable results our classification was also performed on an extended surface of 778 hectares that circumscribes the 112 hectares of RO SCI 0221. The standard Natura 2000 form indicates shares of 15 % arable terrain, 75 % pastures and 10 % of other arable lands inside the RO SCI 0221 Ileana Valley. The older natural reserve designated by Law 5/2000 for the salty, continental habitats is classified as IV – IUCN and covers 10.4 hectares **(**Order 1.964/2007 of the Environmental and Forests Ministry).

Ileana Valley, situated in the southern part of the Jijia-Bahlui Plain, is a resequent tributary of Bahlui river, developed on clay and marl deposits. The climate is temperate continental, with mean annual temperatures around 9.6^{o}C and mean annual rainfall around 560mm. The soil cover is characterized by the presence of salt-rich soils (Solonceaks) and Haplic Chernozems.

According to Mititelu et al. (1987) and Chifu et al. (2006) the vegetation of Ileana Valley reserve comprises a number of 15 vegetal associations, as follows:

- 2 associations pertaining to the pioneer annual halophytic, succulent vegetation on periodically flooded terrains, of the *Thero* - *Salicornietea* (Pignatti 1953) R. Tx. in R. Tx. et Oberd. 1958 (e.g. *Suaedetum maritimae* Soó 1927 and As. *Salicornietum herbaceae* Soó 1927) class;

- 9 steppe continental salts associations pertaining to the *Puccinellio* - *Salicornietea* Țopa 1939 (e.g. *Crypsidetum aculeatae* Wenzl. 1934 em. Mucina in Mucina et al. 1993, *Holoschoenetum schoenoides* Țopa 1939, *Lepidietum crassifoliae* Țopa 1939, *Staticeto* - *Artemisietum monogynae* Țopa 1939, *Puccinellietum limosae* Rapaics ex Soó 1936, *Camphorosmetum annuae* Wenzl 1934, *Obionetum verruciferae* Țopa 1939, *Astero tripoli* - *Juncetum gerardii* Šmarda 1953, *Agrostio* - *Caricetum distantis* Soó 1939) class;

- 3 hygrophilous vegetation associations of the *Phragmiti* - *Magnocaricetea* Klika in Klika et Novák 1941 (e.g. *Eleocharitetum palustris* Ubrizsy 1948, *Bolboschoenetum maritimi* Eggler 1933, *Schoenoplectetum tabernaemontani* Soó 1947) class;

- 1 aquatic association pertaining to the *Potametea pectinati* Klika in Klika et Novák 1941 (e.g. *Parvopotamo* - *Zannichellietum tenuis* Koch 1926) class.

Compared to these previous data, our recent research emphasizes the following general aspects related to vegetation dynamics in Ileana Valley:

- the appearance and massive development of hygrophilous plants communities, mainly reed communities (As. *Phragmitetum vulgaris* Soó 1927) and, consequently, decrease of the halophytic associations as a result of an increased hydric regime;

- more abundant humid ± halophytic communities pertaining to the *Scorzonero - Juncetalia gerardii* Vicherek 1973 (e.g. As. *Astero tripoli – Juncetum gerardii* Šmarda 1953) order. Also as a result of increased hydric regime and the reduction of patches occupied by compulsory halophytic communities of the *Thero - Salicornietalia* (Pignatti 1953) R. Tx. in R. Tx. et Oberd. 1958 (e.g. As. *Suaedetum maritimae* Soó 1927, As. *Salicornietum herbaceae* Soó 1927) and *Puccinellietalia* Soó 1947 em. Vicherek 1973 (e.g. As. *Obionetum verruciferae* Țopa 1939, As. *Staticeto - Artemisietum monogynae* Țopa 1939, As. *Puccinellietum limosae* Rapaics ex Soó 1936) order;

- zoo-anthropic degradation increase as evidenced by the great percentage of ruderal taxa (e.g. *Carduus acanthoides, Chenopodium album, Cirsium arvense, Conyza canadensis, Echium vulgare, Erigeron annuus* subsp. *annuus, Lactuca serriola, Leonurus cardiaca, Malva neglecta, Onopordum acanthium, Picris hieracioides, Crepis foetida* subsp. *rhoeadifolia, Rapistrum perenne, Sisymbrium loeselii, Torilis arvensis, Xanthium spinosum* etc.).

Among the rare taxons identified on the reserve's territory, also mentioned in the Natura 2000 form there are: *Lepidium cartilagineum* subsp. *crassifolium, Stemmacantha serratuloides, Camphorosma monspeliaca, Dianthus guttatus and Plantago schwarzenbergiana* (Romanian Official Monitor, 2008).

Automatic classification of the multispectral satellite imagery enhances the combination of bands' spectral response for the achievement of homogenous spatial distributions on distinct classes. The use of this classification method, based on the association of pixels with close response (iso-data method) allows the separation, combination and elimination of previous gage classes to obtain more natural distributions (Randall, 2001) (Figure 1)

2. Results and discussions

The use of automatic classification within a GIS environment for the above mentioned area is meant to achieve the quantification of Salts habitats, as described before, inside a matrix of more degraded patches pertaining to arable lands, infrastructure or built-up zones. Consequently, a representative number of classes were automatically generated from Landsat imagery (August 2002), classes that comprise the specific habitat, degraded lands, cultivated lands or agricultural un-cultivated lands and portions affected by infrastructure and built-up area. Five classes were designated after orthofotoplans consultation and spatial data collected in field surveys between 2008 and 2011 (saltland patches, dominant *Phragmites* phytocenosis, *Aster tripolium* phytocenosis, etc.). Following the relevance check it

resulted that 3 classes are too homogenous and 7 classes are too heterogeneous to give a realistic map of the situation. (Figure 1).

Unsupervised automatic classification of iso-data type enhances segregation, combination and reallocation of spectral response distribution on the basis of central values (median) and results in classes' redistribution relying on pertaining thresholds. In this manner the resulted distribution fits large land use classes and habitats compared to the prototype classes generated by fuzzy classification or to the reallocation mean values generate by k means classifications. The iso-data classification generates balanced categories via small classes' reallocation and segregation of extended classes. Pair classes, with close spectral response are combined and the median values responsible for classes' allocation are recalculated. The process continues until the median values reach a minimum threshold of oscillation (Randall, 2001).

It seems that this type of classification fits the purpose of representative habitats and land use classification where a rapid but sufficiently detailed analysis of conservation state is required. (Figure 1).

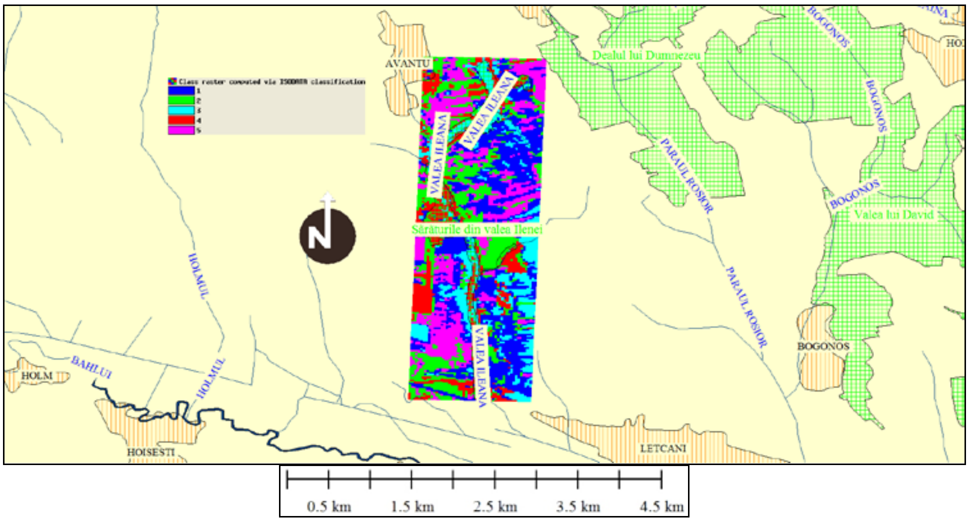

Fig. 1 - Study area positioning and classes allocation. Hatch green zones represent Natura 2000 SCIs

Based on the ortho-plans, the filed collected data and on the association and separability trends, the following 5 classes were described:

- class 1, arable land, degraded land, infrastructure 28.71%
- class 2, representative for the saltland habitats with specific vegetation, flat terrain 20.80 %

- class 3, strong degraded lands, infrastructure (railway, exploitation trails, excavated soil, construction sites) 15.39 %
- class 4, less affected vegetation area, built-up area, landslides, less degraded soil cover, strong declivity 14.54 %
- class 5, agricultural destination, pastures and grass-lands, agricultural uncultivated with sparse spontaneous steppe vegetation, not specific for saltlands, decreased declivity.

Tab. 1 - Association and separability chart for the 5 designated classes; the first value in the cell quantifies association, the second value quantifies separability on the basis of spectral response for the whole area (778 hectares)

	1 (28.71%)	2 (20.80%)	3 (15.39%)	4 (14.54%)	5 (20.55%)
1 (28.71%)	7746	1953 17.673	2542 16.238	893 25.455	2584 12.207
2 (20.80%)	1953 17.673	4921	411 29.746	2151 15.202	2511 13.392
3 (15.39%)	2542 16.238	411 29.746	4001	1347 30.074	143 27.555
4 (14.54%)	893 25.455	2151 15.202	1347 30.074	3606	159 27.050
5 (20.55%)	2584 12.207	2511 13.392	143 27.555	159 27.050	5663

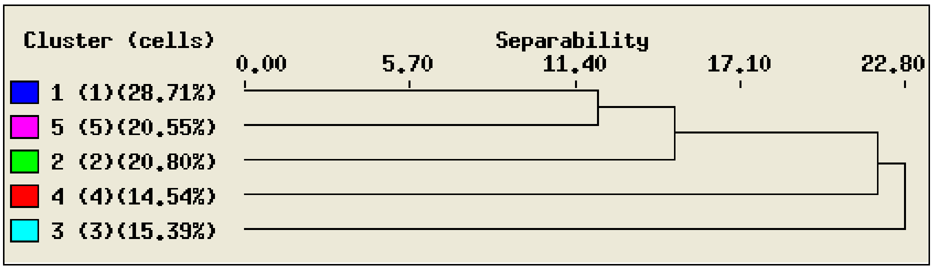

Fig. 2 - Classes' percentage inside the study area and classes' correspondence on the basis of association or separability degree

Class 2 represents patches of proper saltland vegetation surrounding salt "spots" and is positioned mainly on flat land area where drainage is very slow. Class 5 includes less preserved saltland vegetation along with other spontaneous vegetation patches not specific to soil's high salt content. Class 4 designates less spontaneous and less preserved plant species and very low contribution of specific saltland phytocenosis. Classes 1 and 3 include degraded land with scarce spontaneous vegetation. Class 2 was checked for consistency and correct designation using the error matrix method (Aronoff, 2005). This method revealed that on the basis of iso-data automatic class designation on 30x30 m Landsat images the maximum correct percentage to be assigned does not exceed 82.53 %. The check was performed on orthofotoplans where pixels from class 2 where interpreted for misplacement in neighboring classes.

Tab. 2 - Maximum trusted percentage 82.53 %

No.	Total pixels class 2	Inside class 4	Inside class 3	Inside class 5	Inside class 1
Class 2	2153	12	150	90	124

In order to have an alternative validation method the designated classes were compared to vegetation indices obtained from the same Landsat images (2002). The simple vegetation index which represents the fraction of band 4 (near infrared) and band 3 (red) indicates that class 3 (strong degraded land) has little or no vegetation and can be associated with the class of most affected vegetation in the simple vegetation index at more than 90% percent. The normalised difference vegetation index (NDVI) indicates a proper vegetation conservation state in classes 2 (proper saltlands) and 5 (agricultural with spontaneous vegetation), decreased plants vigor in class 4 (less affected vegetation) and strong vegetation degradation in classes 1 (arable) and 3 (most degraded). (Kriegler et al., 1969; Crippen, 1990).

Furthermore, classes' representativity is clearly differentiated in the two target areas, the RO SCI 0221 and the more extended study designation area (778). The study designation area includes RO SCI 0221 as central figure (see Figure 1). Consequently, following pixels' classification, it can be observed that class 2 (representative saltland vegetation) is less conserved in RO SCI 0221 and classes 5 and 4 are better represented. Arable land (class 1) is less represented in RO SCI 00221, while class 3 (strong degraded) is, undesirably, most representative (30.1 %).

To further evaluate the conservation state, the above obtained continuous data (rasters) was used for the designation of habitats' fragmentation stage. The fragmentation indices enhance the evaluation of classes' vigour and spatial disposal within the analysed landscape. In this manner, one can evaluate habitats' conservation state and, hence, their *permittivity* or *aggresivity* for certain species. In our case, the evaluation is upon indices concerned with shape and not with diversity or functionality as we didn't chose a certain taxon for evaluation but a general habitat evaluation. (LaGro, 1991; Legendre and Fortin, 1989; Wiens, 1989).

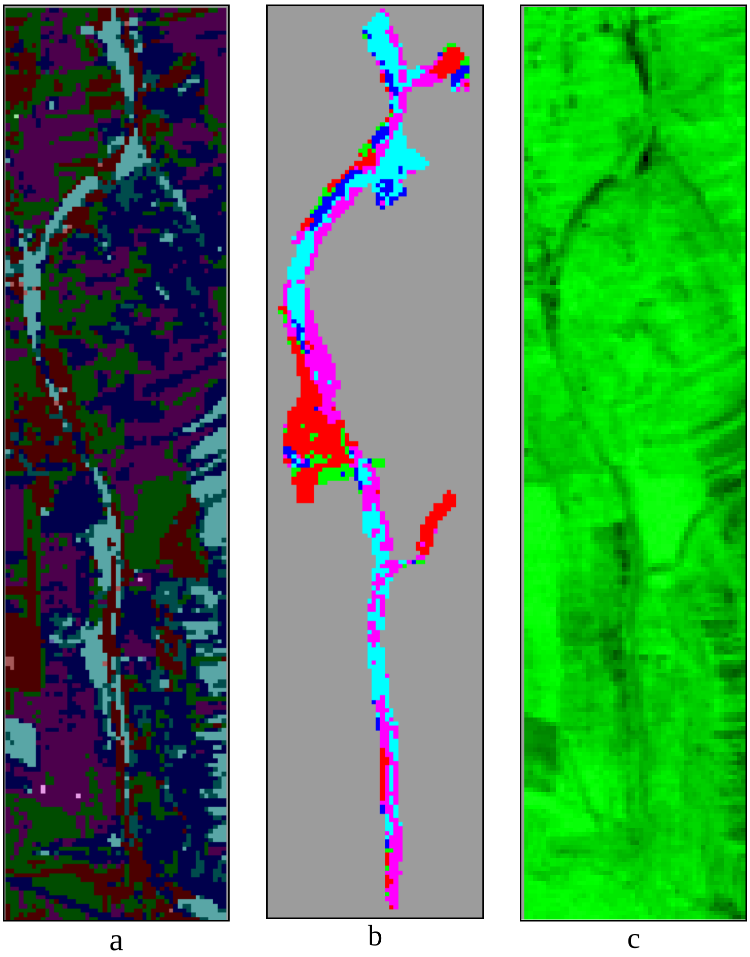

Fig. 3 - a. Simple vegetation index and the 5 designated classes overlap; more than 90% overlap for the most degraded vegetation class (in blue); b. The 5 designated classes territorial representation inside RO SCI 0221 limits; c. NDVI for the entire studied area.

For the sake of quantification three tables of indices were produced, from three different rasters: a general indices table for the entire studied area (778 ha), one table for the northern part and one table for the southern part, both equal in surface. At a general level the northern part reveals a better conservation state as it should be considering its' position far from the main highroads and largest localities. The southern part which includes the main highroad and the largest built-up areas proves more degraded as far as specific vegetation is concerned.

In this context, class 2 (well preserved saltlands) displays a greater number and higher density of patches in the northern part. On the other hand, the dominance index in class 2 is lower in the northern part (5.48) compared to the southern part (8.96) which indicates low aggregation of representative habitats even in the better preserved areas. The total perimeters of class 2 is, otherwise, bigger for the northern part (916) compared to the southern part (798) indicating a higher saltland habitats presence in the north.

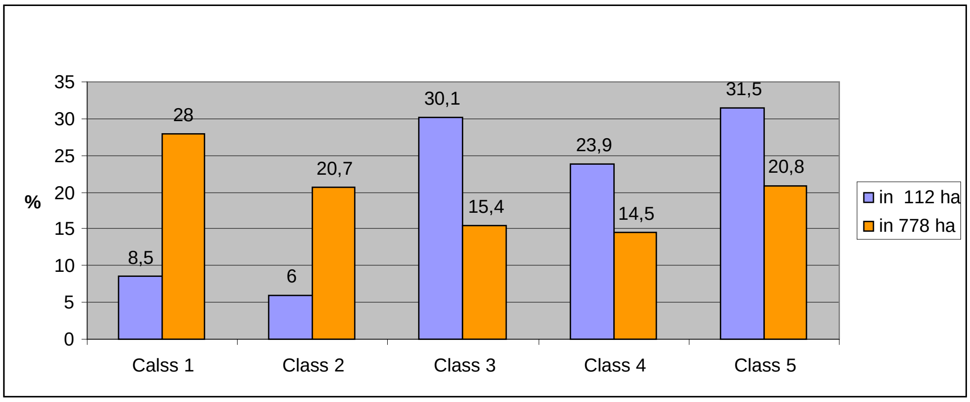

Fig. 4 - Class percentage from total area

Class metrics

Class	total area Total	Percentage of Landscape	Number of patches	Patch Density	Total perimeter	Edge Density	Landscape shape index	Largest patch index
1	2972	28.71	127	12270.53	3644	3520.77	16.56	7.29
2	2153	20.8	166	16038.65	3216	3107.25	17.29	4.02
3	1593	15.39	83	8019.32	2016	1947.83	12.6	3.06
4	1505	14.54	81	7826.09	2068	1998.07	13.26	2.42
5	2127	20.55	103	9951.69	2474	2390.34	13.3	4.29

Landscape metrics

- Total area: 10350
- Number of patches: 560
- Patch Density: 54106.28
- Total perimeter: 13418
- Edge Density: 12964.25
- Landscape shape index: 32.89
- Largest patch index: 7.29

Fig. 5 - Fragmentation indices for the entire studied area 778 ha

Class metrics

Class	total area Total	Percentage of Landscape	Number of patches	Patch Density	Total perimeter	Edge Density	Landscape shape index	Largest patch index
1	574	22.96	37	14800	758	3032	7.9	5.48
2	525	21	50	20000	916	3664	9.96	5.48
3	341	13.64	17	6800	424	1696	5.73	7.68
4	390	15.6	27	10800	618	2472	7.72	4.52
5	670	26.8	27	10800	682	2728	6.56	11.32

Landscape metrics

- Total area: 2500
- Number of patches: 158
- Patch Density: 63200
- Total perimeter: 3398
- Edge Density: 13592
- Landscape shape index: 16.99
- Largest patch index: 11.32

Fig. 6 - Northern part's fragmentation indices

The landscape shape index reveals information upon the classes' aggregation and quantifies fragmentation through the so-called edge effect. In our case the shape index displays high values for class 3 in the southern part which stands for higher percentage of strong degraded land. Class 2 displays a much higher aggregation index in the northern part confirming the higher conservation degree.

Class metrics

Class	total area Total	Percentage of Landscape	Number of patches	Patch Density	Total perimeter	Edge Density	Landscape shape index	Largest patch index
1	815	32.6	29	11600	974	3896	8.4	22.32
2	540	21.6	41	16400	798	3192	8.49	8.96
3	355	14.2	27	10800	512	2048	6.74	2.52
4	303	12.12	17	6800	484	1936	6.91	9.44
5	487	19.48	19	7600	506	2024	5.62	15.56

Landscape metrics

- Total area: 2500
- Number of patches: 133
- Patch Density: 53200
- Total perimeter: 3274
- Edge Density: 13096
- Landscape shape index: 16.37
- Largest patch index: 22.32

Fig. 7 - Southern part's fragmentation indices

Conclusions

The validation of classification precision in relation to the medium resolution Landsat satellite imagery (30x30 m) for saltlands habitats reveal satisfactory accuracy percentages (82.53 % correctly classified) even for less extended zones (778 ha).

The use of automatic unsupervised classifications generates appreciable results, in short time, and may be considered for large landscapes analyses resulting low-medium seized accuracy errors, depending on the resolution of the satellite imagery. The shorter time allocated for the vegetation and habitats RS analyses must be compensated with two or three field survey sessions and good experience in Earth sciences and the related phytosociological domain. The above presented methodology and procedures may sustain more operative monitoring sessions, especially for protected areas. Even if the classification should be confronted with high resolution images (ortho-plans, 0.5 m resolution) the analyses can be satisfactory checked for consistency with aid of vegetation indices maps.

The association and separability matrix is an efficient tool to be used for land use and habitats classification purposes but it must be sustained by proper terrain reconnaissance. Its efficiency resides in the suggestions generated upon the classes' territorial association or separability which for the research or monitoring team may designate specific habitats, degraded areas, phytocenosis patches, etc.

The present study shows that in the case of RO SCI 0221 the representative, priority habitats do not exceed 40% from the total of 112 hectares. This conclusion comes to sustain the vulnerabilities mentioned in the Natura 2000 standard form – railway cross along the Natura 2000 site, intensive grazing and associated activities and urban sprawl. In the case of Ileana Valley Saltlands – RO SCI 0221, the anthropic generated stress upon nature is far more aggressive compared to the other neighboring sites (David's Valley SCI 0265, The God's Hill SCI 0058).

The use of fragmentation indices, mostly shape indices, enhances comparison amongst specific habitats conservation state or amongst habitats and the arable, built-up or infrastructure matrix that surrounds them. This may lead to more proper conservation measures as a result of a more quantifiable and pragmatic monitoring. Consequently, fragmentation studies may sustain hot spot studies and ecological barriers assessments in relation to key species and habitats thriving conditions. In addition the ecosystems resilience may be quantified, especially in association with diversity and functionality studies.

Acknowledgements. This study was carried out with support from project POSDRU/89/1.5/S/49944, coordinated by "Alexandru Ioan Cuza" University of Iaşi.

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