

## GIS and RS soil-vegetation correlations for continental saltlands habitats in NE Romania

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### Abstract

Continental saltlands have a high degree of peculiarity amongst European primary habitats and a prominent *insular* character. The present scientific approach establishes the degree of soil-vegetation correlation in continental saltlands patches as a measure of habitat continuity/fragmentation and soil conservation/degradation. The use of hyperspectral imagery, soil types' distribution and vegetal associations' conservation status reveal disturbances in relation with human induced modifications in comparison with normal plant-soil interdependence. Supervised classifications of LANDSAT satellite imagery along with detailed soil maps, ground truth data provided by accurate GPS positioning and field based plants evaluation are used to perform landscape metrics analyses. The landscape metrics approach is meant to find the balance between extent and grain in the case of saltlands habitats analyses and the degree of patches and classes inhomogeneity. These also give an insight of habitats connectivity and/or isolation in relation with land use topology and soil *multiplexing*. The resulting training sets developed for a representative, protected area in the county of Iași enhance the creation of a comprehensive mask to be used for the evaluation of larger areas in the silvan-steppes of North-Eastern Romania. The model is statistically tested to depict the degree of correlation and confidence. The final goal resides in more proper measures elaboration for the mitigation of continental saltland preservation and natural resources exploitation via agricultural and the associated activities.

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### 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 EU priority habitat) (Order 1964, 2007).

Research on habitats' conservation state focuses, in general, on the biogeographic consequences of the 'insular' character development for various natural ecosystems via evaluation of the reduction and

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degradation degree concerning the phito-pedo-faunistic cover (Saunders et al., 1991). In addition, continental saltlands have their own *insular character* inside the Moldavian Plateau in comparison with, for example, alluvial soils and the appropriate hygrophilous vegetation, chernozems and the appropriate Silva-steppe vegetation or luvisols and the appropriate temperate forests which are more extended and spatially elongated.

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 temperate continental climate displays mean annual temperatures of 9.6° C and mean annual precipitations of 560mm. The soil cover is characterized by the presence of salt-rich soils (Solonchaks) and Haplic Chernozems.

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 integrity at a chosen moment (FRAGSTAT). Our quantification is based on terrain evaluation upon the vegetation cover and the use of Landsat (EROS, 2011) satellite imagery 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 spatial patterns for the entire landscape and the subordinated classes.

The study area, RO SCI 0221 inside the new limits delineated in 2011 by the Romanian Environmental Authorities 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 saltlands. The older natural reserve designated by Law 5/2000 for the salty, continental habitat is classified as IV – IUCN and covers 10.4 hectares (Order 1964, 2007).

## Material and Methods

According to dedicated literature the spontaneous vegetation of Ileana Valley area comprises a number of 15 vegetal associations, as follows: 2 associations pertaining to the pioneer annual halophytic vegetation, succulent vegetation on periodically flooded terrains, 9 steppe continental salts associations, 3 hygrophilous vegetation associations, 1 aquatic association (Mititelu et al., 1987, Chifu et al.2006).

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* Topa 1939, As. *Staticeto - Artemisietum monogynae* Topa 1939, As. *Puccinellietum limosae* Rapaics ex Soó 1936) order;

- zoo-anthropogenic 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).

The approach based on automatic classes' designation may lead to a more rapid estimation of the conservation state, compared to terrain surveys but it can also help in the development of automatic, RS based procedures for ecosystems' management. The degree in which the automatic results, based on Landsat imagery, approximate detailed ecologically homogenous traits is to be considered in creating draft and final correlative maps of ecosystems, soils, habitats and landuse to sustain and validate terrain surveys and reduce time and costs.

The use of automatic classification, within a GIS environment, for the above mentioned area is meant to achieve the quantification of saltland habitats 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 ortho-plans (Romanian Cadastre Agency; 1:5000) consultation and spatial data collected in terrain phases between 2008 and 2011 (saltland patches, dominant *Phragmites* phytocenosis, *Aster tripolium* phytocenosis, etc.). Following the relevance check it resulted that 3 classes display increased homogeneity and 7 classes display increased heterogeneity at the assigned evaluation scale (Landsat 30x30 meters/pixel).

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 landuse 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 landuse classification where a rapid but sufficiently detailed analysis of conservation state is required. (Stoica et al, 2012).

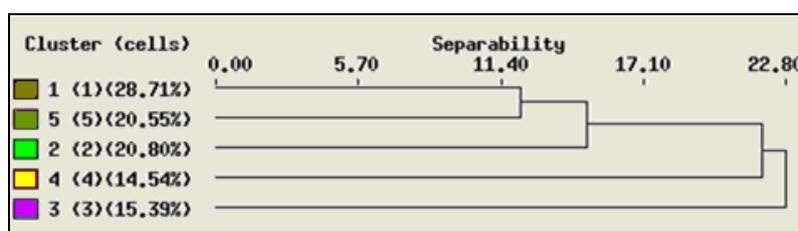


Fig. 1 Separability dendrogram

Based on the ortho-plans, the field 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 and bogs or alluvial deposits with specific vegetation, flat terrain 20.80 %
- class 3, strong degraded lands and scarce vegetation, 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 (Fig. 1).

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/pixel Landsat images the maximum correctly assigned percentage reaches 82.53 %. The check was performed on ortho-plans where pixels from class 2 where interpreted for misplacement in neighbouring classes (Fig. 4 A)

In order to have an alternative validation method the designated classes were compared to vegetation indices obtained from the same Landsat images (2002). The normalized difference vegetation index (NDVI) indicates a proper vegetation conservation state in classes 2 (proper saltlands) and 5 (agricultural with spontaneous vegetation), decreased plants vigour in class 4 (less affected vegetation) and strong vegetation degradation in classes 1 (arable) and 3 (most degraded). The brightness and greenness indices display highest values inside the above designated classes. The green index is less spatially extended compared to NDVI because it designates biomass and not healthy plant’s appearance. The highest brightness index values cover small patches inside the most degraded classes (3 and 1). On the other hand the lowest class value of the simple vegetation index better designates class 3 exceeding 90% in confidence (Kriegler et. al., 1969, Crippen 1990).

In order to correlate soil and vegetation traits the raster representing the 5 designated classes was confronted against the 1:10.000 soil maps elaborated by the Iași County Office for Soil Survey via a grid point values allocation procedure. The raster classes’ values were assigned an equal grid of points that were further used to acquire reference groups and erosion codes. This enhances the correspondence between the habitats and landuse classes and the vector delineating soil groups, soil qualifiers and eroded areas. (Fig. 4 B, C, D)

## Results and Discussion

As far as the soil cover is concerned classes 2 and 5 pertain to low erosion or none as it can be seen from e1 and also have the lowest values of medium and strong erosion. Nevertheless increased values of e1 sustain terrain observation upon zoo-anthropic degradation. Class 5 has higher e1 values and sustains the assumption of less spontaneous vegetation class compared to class 2. Medium and strong erosion is designated by classes 3, 1 and 4 (Fig. 2).

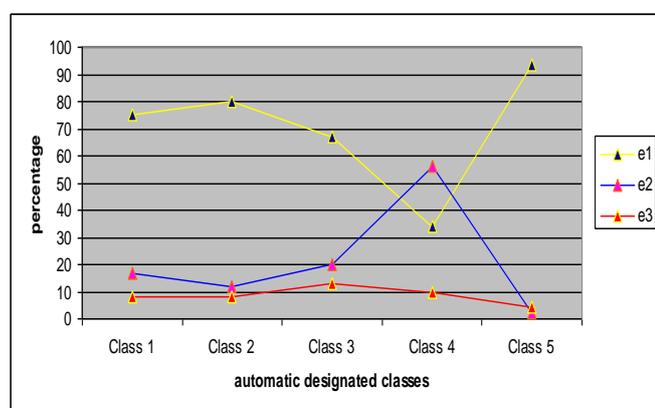


Fig. 2 Classes and erosion correspondence

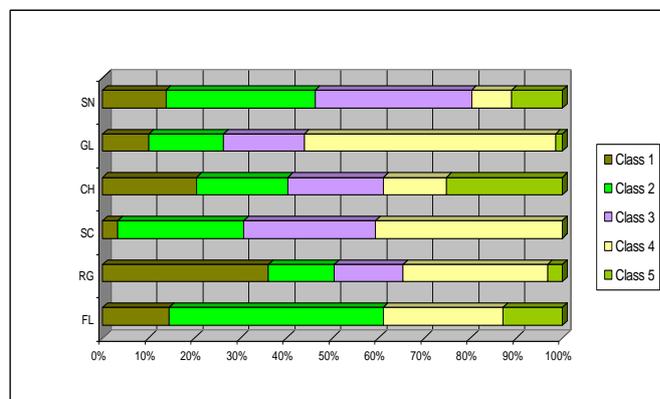


Fig. 3 Classes and WRB correspondence

Chernozems represent the most balanced automatic classes’ distribution while Fluvisols display high content of class 2 with very low cultivated land, infrastructure or other degradation forms. Gleysols display

high degree of class 4 being a buffer zone of the railway that traverses the RO SCI 0221 and hence not well preserved. Solonetz display predominantly class 2, being better preserved than Solonchaks which predominantly display class 4 (Fig. 3).

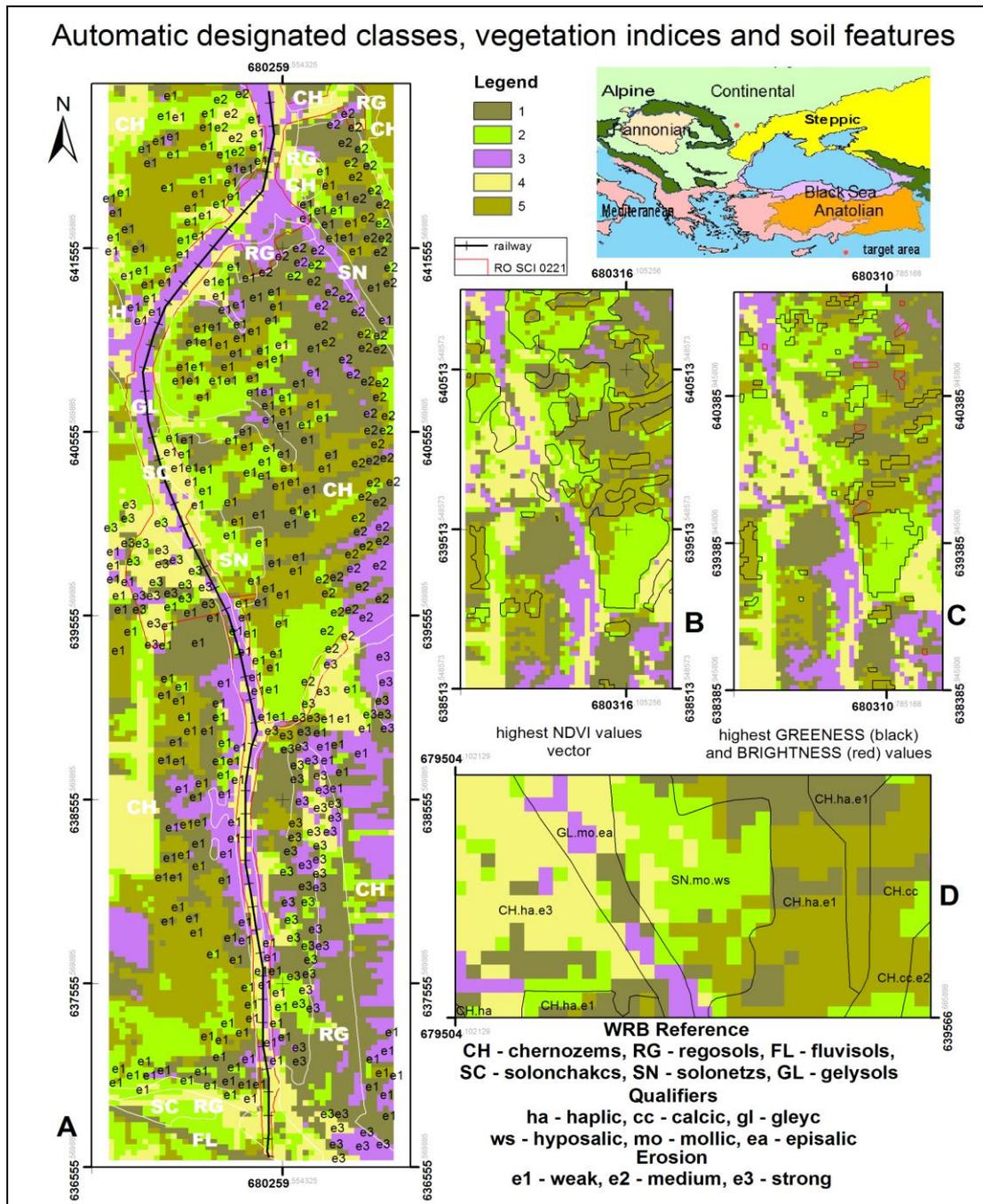


Fig. 4 Classes spatial distribution: soil reference groups and erosion overlay (A), NDVI overlay cassette (B), Brightness/Greenness overlay (C), soil reference groups and qualifiers cassette

In this respect our attempt of assessing and investigating saltlands and wet lands with specific vegetation comes to the following results:

- 1) Solonetz at the valley's bottom include 61.02% of class 2 (proper vegetation) and 21.18% of class 5 (less affected vegetation) both categories representing well preserved vegetation, while Solonetz associated with agricultural exploitation traits include only degraded and strong degraded classes.
- 2) Solonchaks polygons include 41.08 % of class 2 and 56.07 % of class 4 (more affected vegetation)
- 3) Fluvisols polygons include 55,75 % of class 2 and 13,34% of class 5
- 4) the difference is covered by class 1 (arable land) and class 3 (most degraded)

- 5) Gleysols designation is obscured by infrastructure (railway) with large portions of strong degraded traits (class 3).
- 6) strong degraded patches (class 3) appears only on Chernozems and Regosols.

In the study area non-degraded Solonetz are covered by 82.20 % of classes 2 and 5 that depict well preserved vegetation while Fluvisols display 69.09 % of the same classes. The degraded traits of associated halophytic habitats, on Solonetz, can be easily managed in this manner.

Solonchaks have higher degree of class 4 (56.07% affected vegetation) and this can be interpreted as increased brightness and decreased biomass (greenness) compared to Fluvisols and Solonetz. This results in reference group's fair depiction for the above mentioned case.

While Landsat automatic imagery processing enables fair estimates of halomorphic soils and their associated habitats and it can also give a measure of degraded reference groups as in the Gleysols affected by infrastructure. Apart from this peculiar situation of infrastructure traversing the central part of a Natura 2000 site we believe that estimates can have higher accuracy in other, non-resembling situations. Furthermore, all strong degraded soil and vegetation category is included in the Chernozems and Regosols. Considering the above observations we believe that the present procedure can be successfully used in elaborating draft maps for terrain work and for more detailed estimates of ecosystems state at a given date. The availability of Landsat imagery and proper resolution for assessing large land-cover traits should be considered when designating and managing Natura 2000 sites. The present study provides sufficient information on Ileana Valley land-cover percentages and reveals important discrepancies in the dedicated standard forms. The results can further be used for habitats' and management measures dynamics estimations.

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