USING IKONOS SATELLITE IMAGES IN CHARACTERIZING BIODIVERSITY IN CONIFEROUS STANDS

UTILIZAREA IMAGINILOR SATELITARE IKONOS ÎN CARACTERIZAREA BIODIVERSITĂȚII ARBORETELOR DE RĂŞINOASE

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Abstract. *Biodiversity, defined as the variability of the life forms within an ecosystem, represents one of the most important characteristics of natural and artificial ecosystems. Conserving a high level of diversity has become one of the requirements of environment preservation, as stated in the conclusions of the Rio de Janeiro Conference (1992). This requirement is also considered a criterion for the certification of forests and wood custody chains. The researches analyze the possibilities of using IKONOS satellite images in characterizing specific and structural diversity of the tree layer in coniferous stands found in the Vanatori Neamt Natural Park. The work routine is based on quantifying spectral diversity and the correlation with the biodiversity indicators computed on the ground inventory basis.*
Key words: structural diversity, IKONOS, pixel values

Rezumat. *Biodiversitatea, definită ca variabilitatea formelor de viață dintr-un ecosistem, reprezintă una dintre caracteristicile cele mai importante ale ecosistemelor naturale şi antropizate. Conservarea unui nivel ridicat al diversității reprezintă una dintre cerințele protecției mediului, după cum menționează concluziile conferinței de la Rio de Janeiro (1992). Această cerință este introdusă şi în criteriile de certificare a pădurilor şi lanțurilor de custodie a lemnului. Cercetările efectuate au scopul identificării posibilităților de utilizare a imaginilor satelitare de înaltă rezoluție IKONOS în caracterizarea biodiversității specifice şi structurale a etajului arborilor din arborete de răşinoase, în cadrul Parcului Natural Vânători Neamț. Modul general de lucru se bazează pe cuantificarea diversității spectrale şi analiza corelației dintre aceasta şi indicatorii diversității specifice şi structurale calculați în baza inventarierilor terestre.*
Cuvinte cheie: diversitate structurală, IKONOS, valori ale pixelilor

INTRODUCTION

The concept of biodiversity holds many levels of analysis, levels that can be addressed differentiated, depending on the scale of the researches. The remote sensing methods have been used in analyzing the biodiversity at the complexes of ecosystems (or landscape) level, by means of land cover types maps derived from the classified satellite or aerial images. More recent studies (Ivits, 2004; Koch, Ivits, 2004; Ivits et al., 2005) applied methods characteristic to the spectral diversity as related to the terrestrial determined biological diversity indices.

The present researches aim at finding some statistic relations between the specific and structural diversity at the level of tree storey from the studied stands and certain elements that can be extracted from the satellite images.

MATERIAL AND METHOD

The main *methods* used are *the comparison* and *correlation analysis.* There are compared values of the diversity indices computed terrestrial or on satellite images, directly, or by some intermediary indices.

The *materials* that were used are represented by four *IKONOS* 4 m resolution multispectral images (blue, red, green and near infrared) and a corresponding panchromatic channel *satellite* images (1 m resolution).

The collection of the data was done simultaneously by specific forest inventory, in circular sample plots. Inventory parameters were *specie*, *diameter at breast height*, *height*). The interpretation of the data from the terrestrial inventory was done in BIODIV programme (Palaghianu, 2009), the result being represented by the values of a suite of specific and structural biodiversity indices: *Simpson* value (D), *Simpson* value(1-D), *Shannon value*, *equity*, *Berger – Parker* value, *McIntosh* value, *Margalef* value, *Menhinick* value, *Glisson* coefficient.

The interpretation of the satellite images presumed the realization of a multilayer image, resulted by overlapping the images taken by IKONOS 2 (blue, green, red, near infrared and panchromatic), image on which there were overlapped the exterior borders of the sample plots on one hand and of the inventoried stand on the other hand. Thus, there have been taken the values of the pixels from each spectral channel in the form of mean, minimum, maximum and standard deviation values, separately for each sample plot.

Aside from these operations, within some statistically inventoried stands (by circular sample plots) have been randomized generated, known coordinate points within a thematic file *point* type. The values of the pixels which correspond to the points from each stand have been grouped to classes and processed then as *Biodiv* experimental distributions. (Palaghianu, 2009).

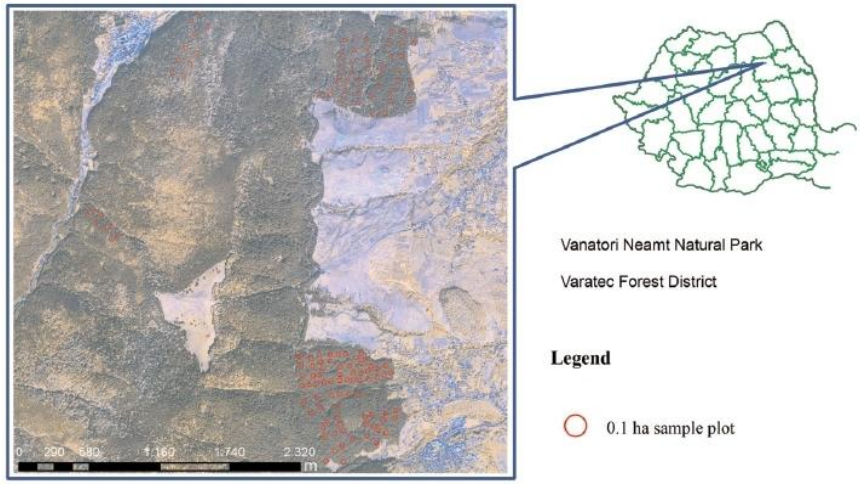

Fig. 1. Research location (Vânători Neamț Natural Park)

The comparative analysis of the terrestrial and satellite data has been done by means of direct comparison (in the case of the calculated diversity indices for both

situations) and by applying the direct correlation between the indices values and the parameters of the images corresponding to each studied stand.

RESULTS AND DISCUSSIONS

In the case of 73 circular sample plots, 1000 m^2 each (parcels 17A, 19A, 20A, 22A) the terrestrial structural diversity was quantified by applying the mentioned biodiversity indices on classes and by processing the frequency values in *Biodiv 1.0*. Given the low specific diversity of the tree storey (stands formed of silver fir and spruce), the experimental distributions of the diameter at breast height, total height, tree volume, and percentage of fir in the structure were preferred for the analysis of structural diversity. The values were analyzed comparatively, for each index (tab.1).

Table 1

The values of the biodiversity indices presented comparatively for the terrestrial and the IKONOS satellite images determinations (calculated using the *Biodiv 1.0* application – Palaghianu, 2009)

Biodiveristy indices	Indices determined from the field data			Indices resulted from measuring the value of the channel pixels				
	Diameter (cm)	(m)	Volume at 1000m^2 (m^3)	Blue	Green	Near infrared	Panchromatic	Red
Simpson Index	0,061	0,173	0,058	0,257	0,186	0,051	0,084	0,206
Shannon –Weaver Index	2,977	1,962	2,951	1,474	1,774	3,160	2,594	1,730
Equity	0,837	0,765	0,955	0,916	0,912	0,938	0,936	0,832
Berger – Parker Index	0,093	0,254	0,099	0,387	0,274	0,097	0,129	0,290
McIntosh Index	0,770	0,638	0,861	0,565	0,651	0,887	0,814	0,626
Margalef Index	4,455	2,421	4,926	0,969	1,454	6,784	3,634	1,696
Menhinick Index	0,771	1,091	2,611	0,635	0,889	3,683	2,032	1,016
Glisson Coefficient	3,088	1,678	3,415	0,672	1,008	4,703	2,519	1,176

In the case of field measurement, it can be noticed that the highest values of the diversity indices are recorded in the case of the basal diameter and tree volume, the two characteristics being thus highly correlated. The values of the structural diversity are comparable with the values of the same indices in the case of the available IKONOS imagery corresponding pixels. Thus, the highest diversity is recorded within the images taken in near infrared and panchromatic channels, fact that can be noticed on the pixels values histograms from these images (data not shown). The values within the near infrared are comparable with the ones resulting in the case of the base diameter and the stand volume.

The diversity of measured heights is comparable to the diversity of the spectral response in the green channel; values comparable can result in the case of the fir percentage in the composition and the spectral response in the blue channel.

Taking into account the fact that the diameters diversity is considered representative enough for the mixed stands (on one hand) and the calculated indices values comparability for this characteristic with the ones resulted for the near infrared pixel value (on the other hand), there have been continued the researches towards the dimensional diversity from the base diameter point of view. An index of spectral signature diversity is the standard deviation of spectral response corresponding to a certain active surface. This index is easy to determine (automatically calculated in *Signature Editor* from *ERDAS IMAGINE 2009*, as well as in *Spatial Analyst* from *ArcGIS 9.3*), but less stable, being influenced by the extreme values which can be met on the fragments of image taken into account. Since we talk about forest vegetation, the extreme values are represented on one hand by the minimum registered for the shadows cast on the trees and on the other hand by other active surfaces which are not representative for the forest environment – surfaces occupied by rocks, streams, and tractor roads etc.

The standard deviation of the near infrared pixel value has been compared, by means of the correlation analysis, with the specific biodiversity indices of the trees and of the structural diversity of the diameters at breast height from the ten inventoried stands.

The bidimensional variation tendencies of the parameters mentioned before proves relative intense correlations, even if the number of observations is relatively low. In the case of specific diversity of the tree layer there were very intense linear correlations between diversity indices values and the standard deviation of pixel values in the near infrared image, with a maximum correlation coefficient in the case of Shannon diversity index (R^2 = 0,825***) (fig. 2.a,b,c).

In the case of structural diversity, the correlation coefficients characterizing the relation between structural diversity indices values and the standard deviations of pixel values have lower values (fig. 2.d,e). The highest values of this coefficient are observed in the case of Shannon (0,433***) and Simpson diversity index 1/D (0,651***).

The use of diversity index computed in parallel on the image and on the terrestrial data gives poorer results then in the case of the standard deviation correlated with the diversity indices.

Thus, after the processing of the pixels values corresponding to the randomized generated points within the inventoried stands, have been obtained comparable results as a size order just in the case of the near infrared images usage (fig. 2.f).

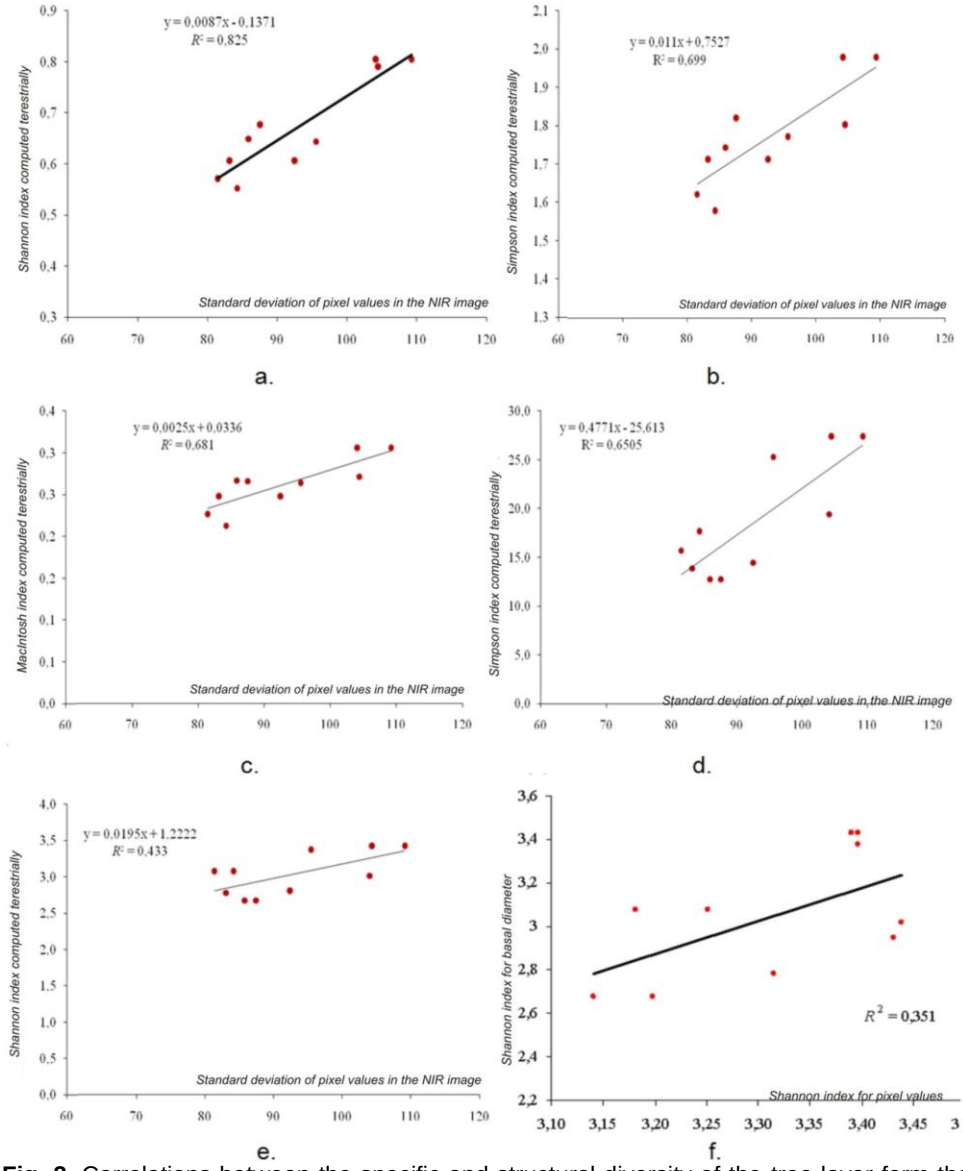

Fig. 2. Correlations between the specific and structural diversity of the tree layer form the inventoried stands and the standard deviation of the corresponding spectral response: a,b,c,d,e – specific (Shannon, Simpson and Macintosh) and structural (Simpson, Shannon) diversity indices correlations of the stand layer and the standard deviation of the spectral response in near infrared; f. correlation between the Shannon index values for the structural diversity of the base diameters and the calculated values on the near infrared images

After successively comparing the terrestrial and on the multispectral image determined values, a maximum of the determination coefficient (R^2 = 0,351) results when comparing the Shannon diversity index which was calculated

depending on the base diameter with the one calculated on the infrared image, by correspondence to the generated points. But in this case too, it can be noticed a lower variation interval at the indices calculated on the images, namely, 3,10 – 3,50, against 2,2 – 3,6 in the case of base diameters.

CONCLUSIONS

1. The values of the base diameters structural biodiversity calculated in the circular sample plots are similar to the values resulted by applying the same indices on the near infrared spectral channel.

2. At a per stand analysis, applied to ten statistically inventoried stands, there can be noticed strong correlations between the Shannon, Simpson and Macintosh indices (computed for the specific diversity of the trees layer) and the standard deviation of the pixels value in the near infrared channel. In the case of the structural diversity, average intensity correlations can be noticed when taking into account the Simpson and Shannon indices.

3. In studying the simulation of randomly generated points in the inventoried stands, there can be noticed an average intensity correlation between the Shannon index terrestrial values for the structural diversity of the diameters and the values computed on the near infrared image.

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