Landscape Metrics for Assessment of Mountain Landscape using GIS Applications*

Ileana Pătru-STUPARIU[1], Mihai-Sorin STUPARIU[2], Roxana CUCULICI[1]

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Abstract: Using landscape metrics, we analyze the dynamics of landscape structure and landscape functionality of an area situated at the contact between the mountainous and sub-mountainous regions of the Prahova Valley.

1. Introduction

Sustainable landscape management represents a priority objective of environmental policy. Hence, the implementation of the European Landscape Convention aims at the identification, analysis and assessment of landscape. A better and more accurate assessment of a given area and of its dynamics can be obtained using indicators (e.g. landscape metrics**)**, which quantify landscape structure or pattern. Landscape metrics measure two fundamental aspects of landscape structure: *composition* and *configuration* (Botequilha Leitão et al., 2006). They can be computed at patch level, for a class of patches or for the entire landscape mosaic. The composition metrics describe the variety and abundance of patches, without any reference to their spatial distribution. They measure the number of different land cover types (patch richness), the number of patches, the surface covered by each type (class area proportion) or several diversity indices (e.g. Shannon's and Simpson's diversity indices). Although not spatially explicit, they still have important spatial effects (Gustafson, 1998). On the other hand, the configuration metrics refer to the spatial arrangement and orientation of the patches in the landscape mosaic. These metrics give information about the patch shape, the distance between classes of same type (nearest neighbor distance) or the degree of contrast between patches along patch edges (edge contrast). The aim of our study is to apply this method for landscape assessment of several mountainous and sub-mountainous regions in Romania. For the pilot study, we have chosen an area situated in the region of the Prahova Valley and we computed several landscape indicators corresponding to the years 1989 and 2007.

The study area is located at the contact between the mountainous and sub-mountainous regions of the Prahova Valley (Comarnic-Posada) and has a surface of approx. 6 km^2. We have chosen this region, due to its landscape complexity and pronounced dynamics. The increasing of the real estate investments, the development of the touristic resorts, the Bucuresti-Brasov highway project prove that the Prahova Valley is a region which is permanently modifying its landscape structure and characteristics. Understanding the landscape dynamics for this area could be relevant in order to prioritize the anthropic interventions in this region. In this way, one could prevent the landscape degradation and losing natural, cultural, national or European heritage values.

3. Methodology

3.1 Data collection, data optimization, map production and data analysis

We used maps at a scale of 1:50,000, which were acquired for the year 1989 (Fig. 1). These maps were scanned at 600 dpi and then geo-referenced using Image Analysis – Arc View GIS software (version 3.1) in Stereo70 projection. We also used aerial photographs at a scale of 1:5,000, which were acquired in the year 2007 (Fig. 2). These photographs were registered to a rectified image. In order to obtain a more accurate land-cover-type identification, the photo-interpretation process involved stereoscopic viewing. In the map production system we used geo-database, which

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included feature classes with many elements. Land-cover-type boundaries were digitized using Arc View GIS software (version 3.1). The software was equipped with a symbol library. This library was necessary to represent all land-cover-types. The vector files resulted by the digitization process were transformed into a raster format (grid image). These grids were analyzed with the FRAGSTATS software (version 3.3) developed by McGarigal et al. (1995), obtaining several landscape metrics for the study area.

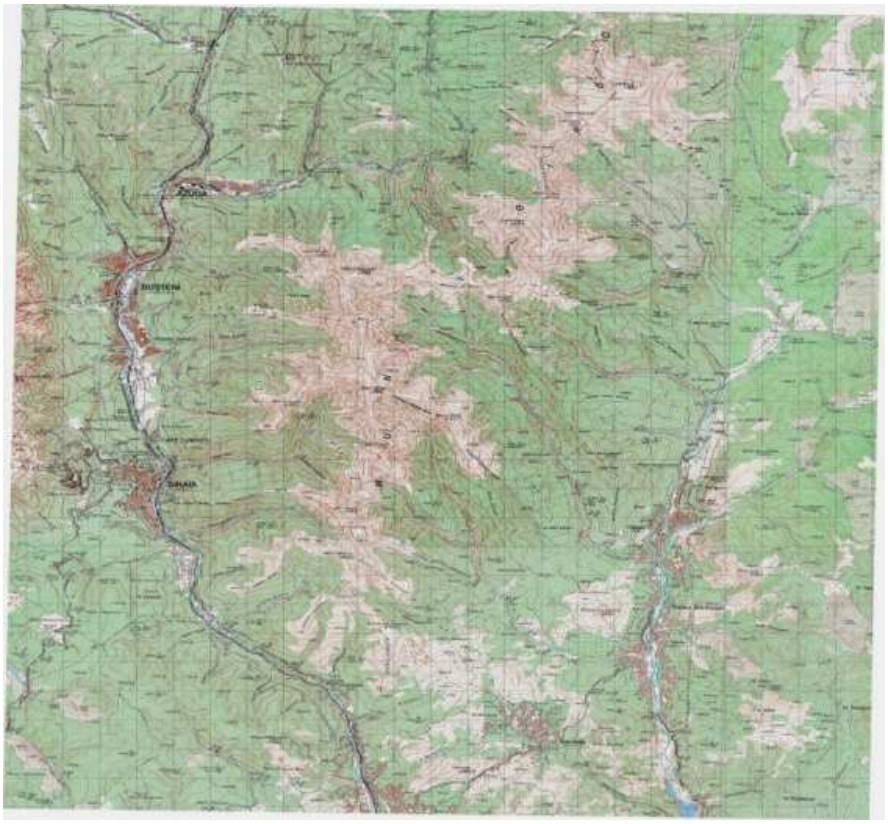

Fig. 1. **Topographic map at a scale of 1:50,000** (edition 1989)

Fig. 2. **Aerial photographs at a scale of 1:5,000** (edition 2007)

3.2. Landscape metrics

We selected for our study the following landscape metrics: Patch Richness (*PR*), Patch Number (PN) and Shape (*SHAPE*). Let us briefly recall the way they are defined and their meaning. The first metric chosen for our study is a composition metric, namely *Patch Richness* (PR). It represents the number of different land cover types (classes) and it is given by the formula:

$$PR = m,$$

where $m =$ number of classes present in the landscape (McGarigal, Marks, 1995). The second metric analyzed in our research is *Patch Number* (PN). It measures the landscape configuration and it is given by the total number of patches:

$$PN = \sum_{i=1}^{PR} P_i$$

where P_i =number of patches of type i. The third metric is *Shape* $(SHAPE)$, which is again a configuration metric. At the patch level, it is a measure of the geometric complexity of the patch. The formula which defines this metric is:

$$SHAPE = \frac{p_{ij}}{f(p_{ij})},$$

where p_{ij} = perimeter (m) of patch j of type i and the function f is given by

$$f(p_{ij}) = \begin{cases} 4n, & \text{when } a_{ij} = n^2 \\ 4n+2, & \text{when } n^2 < a_{ij} \leq n^2 + n \\ 4n+4, & \text{when } a_{ij} > n^2 + n \end{cases}$$

Here n denotes the largest square number smaller or equal to the area a_{ij} of the patch. For the whole landscape, one can compute the mean value, given by the relation

$$SHAPE_{MN} = \frac{\sum_{j=1}^{PN} SHAPE_j}{PN},$$

where $SHAPE_j$ represents the value of the landscape metric $SHAPE$ corresponding to the patch j.

4. Results

For the first metric, Patch Richness, we obtained $PR_{1989} = 4$, respectively $PR_{2007} = 5$. More precisely, the landscape mosaic contained the following land-cover-types in the year 1989: forest, pastures, urban and open areas. These classes were also present in 2007 and a new class appeared: cleared forest, which represents 0.46 % of the total area. For the second selected metric, Patch Number, the results are $PN_{1989} = 27$, respectively $PN_{2007} = 46$. The metric *SHAPE* varies between 1.000 and 3.389 in 1989 and between 1.000 and 4.166 in 2007. For the whole landscape, the mean values are $SHAPE\_MN_{1989}$=1.527, respectively $SHAPE\_MN_{2007}$=1.712 (Fig. 3 and 4).

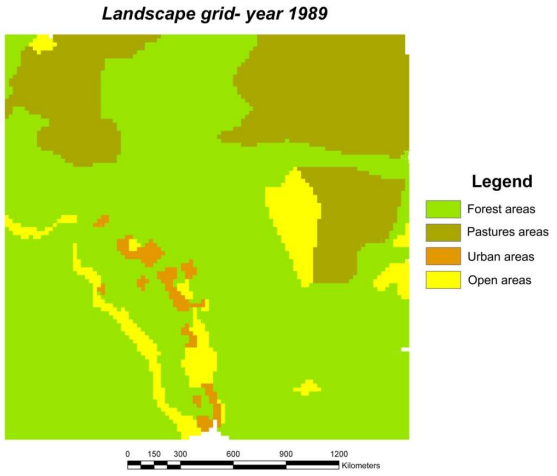

Fig. 3. **Landscape grid map at a scale of 1:50,000** (edition 1989)

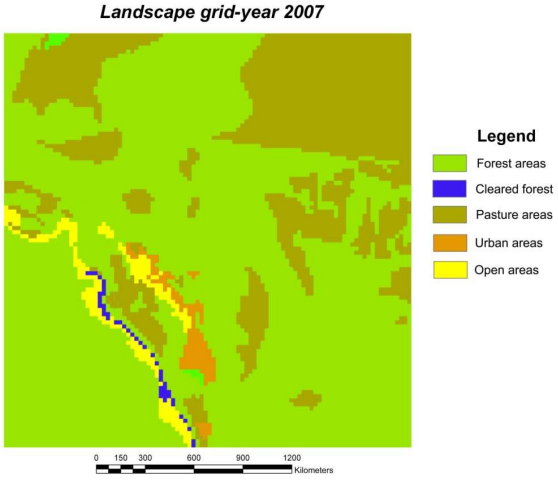

Fig. 4. **Landscape grid map at a scale of 1:5,000** (edition 2007)

5. Conclusion

The use of landscape metrics allowed us to point out more accurately the changes occurred in the landscape structure and in its functionality. We first observe the diversification of the landscape cover types and the growth of the fragmentation degree. An important change of the landscape structure is the appearance of cleared forest, conjugated only with local reforestation. This fact shows that one should adopt efficient deforestation control policies. Concerning the landscape functionality dynamics, we notice that several forest and pasture areas changed their destination, becoming urban areas.

The research will continue by investigating other areas in the same region. We conjecture that the increasing of the fragmentation degree is quasi-ubiquitous in the Prahova Valley. It would be interesting to study the effects of this phenomenon on different wildlife species, on ecological processes or on the quality of people's life .

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[1] University of Bucharest, Faculty of Geography
[2] University of Bucharest, Faculty of Mathematics and Computer Science
E-mail: ileanageorgeta@yahoo.com, stupariu@fmi.unibuc.ro, roxanacuculici@yahoo.com