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in

Kyriazopoulos A.P. (ed.), López-Francos A. (ed.), Porqueddu C. (ed.), Sklavou P. (ed.).
Ecosystem services and socio-economic benefits of Mediterranean grasslands

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 114

2016
pages 233-236

The impact of structure and pattern of landscape on grassland ecosystems: the case of Mygdonia basin

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Abstract. The aim of this study was to evaluate the impact of the structure and pattern on grassland ecosystems, using landscape indicators. The research was conducted in five municipal departments in the northwestern part of Mygdonia basin. The spatial allocation of the four different types of landscape structure (grassland, crop fields, tree crops and mountainous crop fields), resulting from the interpretation of satellite image Alos 2008 and indicators of the spatial structure of the landscape were calculated using the Patch Analyst program. The results showed differences between the four types of landscape structure in terms of indicators such as a) class area, the sum of areas of all patches belonging to a given class, b) number of patches for each individual class and c) mean shape index, the average perimeter-to-area ratio for a particular patch type. Most of the area consists of grassland, while the greatest number of patches is found in mountainous crop-fields. Moreover, the patches of these two types of landscape structure have the most irregular shapes, which mean that the inhabitants of each different area have different needs.

Keywords: Patch analysis – Satellite – Physiographic level – Spatial – Indicators.

L'impact de la structure et du modèle de paysage dans les écosystèmes des prairies: le cas du bassin de Mygdonia

Résumé. *Le but de cette étude était l'évaluation de l'effet de la structure du paysage sur la biodiversité des écosystèmes des prairies. La partie nord-ouest du bassin Mygdonia est choisie comme domaine de recherche. La répartition spatiale des différents types de structure du paysage résultant de la transformation de l'image de satellite d'Alos 2008 et les indicateurs de la structure spatiale du paysage ont été calculés en utilisant le programme Patch Analyst. L'analyse des indicateurs a interprété le niveau géomorphologique des cinq départements municipaux de la zone d'étude. Les résultats ont montré des différences entre les quatre types de structure du paysage sur les indicateurs a) CA, b) NUMP et c) MSI. La plupart de la région est constituée de prairies tandis que le plus grand nombre de patches est trouvé dans les cultures en champ montagneux. De plus, les patches de ces deux types de structures du paysage ont la forme la plus irrégulière, ce qui signifie que les habitants de chaque zone différente ont des besoins différents.*

Mots-clés. *Analyse de patch – Satellite – Niveau géomorphologique – Spatial – Indicateurs.*

I – Introduction

Landscape as a general concept is approached from different perspectives. It is the place where mankind developed and organized his life from the beginning of his existence on earth, in various ways and various methods, such as hunting, farming, the cultivation of land, exploitation of forests and the establishment of settlements. Thus, it can be said that today man lives in a landscape which fulfills man's basic and daily needs through a variety of services and goods offered and additionally enables relaxation through the observation of the aesthetic elements (Ispikoudis, 2005).

Traditional agricultural and agroforestry landscapes are characterized by low-intensity systems and land-management activities, providing a high degree of multifunctionality (Jones-Walters, 2008; Pinto-Correia and Vos, 2004; Vos and Klijn, 2000). Such traditional landscapes usually include numerous species of flora and fauna that maintain high biodiversity and represent high aesthetic values and recreational options for people who visit or live within them. These sites allow the harmonious coexistence of man and nature and can be models of sustainable use of land, which is necessary for ensuring the future of man on earth

The study of the structure of landscape and the quantification mosaic stems from landscape indicators, provide information on ecological processes taking place. Specialized indicators, such as indicators on cultural/ rural landscapes and wildlife habitats associated with mosaic, can be very useful in the qualitative and quantitative assessment of the environment (Lausch and Herzog, 2002).

The meaning of each category of indicators of landscape spatial structure is: (a) area measurements: this indicator calculates the area for each patch type (Rutledge, 2003), (b) patch density/patch size: these indicators describe the synthesis of landscapes while considered to be the most basic indicator assessment of their fragmentation (Batistella, 2001; Rutledge, 2003); and (c) shape metrics: these indicators estimate the diversity of patches forms of the landscape, both at class level land use/ land cover. Number of patches (NUMP) describes the ecological processes taking place in a landscape. This indicator characterizes the stability-durability of the landscape in the face of threats. The Mean Shape Index (MSI) captured the shape of patches, which as diverged from value 1 becomes more irregular and calculates the variation of the patches in relation to a perfect geometric shape (Rutledge, 2003).

The aim of this study was to analyze the impact of the structure and pattern of the agricultural landscape of the Northwestern part of Mygdonia basin, Greece, as interpreted by landscape indicators.

II – Materials and methods

The study area consists of five municipal departments located in the northeast part of Mygdonia basin of the prefecture of Thessaloniki where farming is one of the most important economic activities. The total area amounts to 2,059 square kilometers and has a population of 70,000 inhabitants. The main land uses are: grassland: 14,140 ha, forests: 1,820 ha, agricultural crops: 7,760 ha, and other uses: 1,010 ha (NSSG, 1995). It is part of the Para-Mediterranean vegetation zone (*Quercetalia pubescentis*) and belongs to *Ostryo-carpinion* sub-zone in *Coccifera-carpinetum* growth area (Ntafis, 1973). The altitude extends from 80 to 670 meters asl., and according to Mavromatis (1978) the study area has an intense medi-Mediterranean character in low altitudes and as the altitude increases it becomes moderate medi-Mediterranean and sub-Mediterranean up to the highest zone.

According to Zonneveld (1979) the basic structural components of landscape depend on the way they are distributed and create different types of landscape structures, such as: (a) mosaic, (b) grid, (c) dot, (d) dot-grid, and (e) zonation. In our study area we encountered the first four types.

The mosaic structure type corresponds to cultivated land in mountainous areas; the grid structure type corresponds to cultivated land in low areas; the dot structure type corresponds to abandoned areas or grasslands and the dot-grid structure type corresponds to cultivated land with tree crops.

As primary resources in the analysis of the study area characteristics we used satellite image Alos 2008, with panchromatic resolution of 2.5x2.5 meters and the projection system EGSA '87. In the five municipal departments of the study area we applied grids of 1000x1000m with the help of Hawth tools (2010).

The indicators of the spatial structure of the landscape were calculated using the Patch Analyst program and evaluated with level classes modules use/land cover in ArcView 3.2. Of all the available indicators in this study three were calculated and evaluated. These indicators were assessed at the level of class modules use/land cover and classified in relation to the type of patches and their ecological interpretation within three categories, a) area metrics (class area CA), b) patch density/patch size (indicator NUMP) and c) shape metrics (indicator MSI) (McGarigal *et al*., 2004).

III – Results and discussion

The largest percentage of study area included patches of cultivated lands in mountainous parts of these areas (mosaic) and areas for grazing (dot). These two types of landscape structure are the most fragmented and most irregular compared with the other two types, including; cultivated areas in lowland parts of the study area (grid) and tree crops (dot-grid). The class area (CA) indicator presented great diversification for the abandoned area type structure as the NUMP indicator for the cultivated land in mountainous areas. The diversification of the Mean shape index (MSI) between the four types of landscape structure is not so great.

In the study area the three metrics that were used were manifested differentially in the four landscape types. The Class area indicator (Table 1) shows that the grasslands (4287.67 ha) occupied the largest portion of the study area, which also included areas that have been abandoned. These are no longer cultivated and are used as pasturelands. A significant percentage of the patches consist of mountainous crop fields (1478.98 ha), and smaller percentages consist of patches in lowland crop fields (538.67 ha) and tree crops (20.13 ha).

Table 1. Indicator values of structure types in the study area of Mygdonia basin

Structure type	Indicators		
	CA (ha)	NUMP	MSI
MCF	1478.98	252	1.621
LCF	538.67	23	1.47
G	4287.67	109	1.997
TC	20.13	24	1.228

[1]Mountainous crop fields. [2]Lowland crop fields. [3]Grasslands. [4]Tree crops.

The Number of patches indicator (NUMP) (Table 1), which shows the number of patches in each category of landscape structure type found in the study area (Rutledge, 2003), recorded the highest number, 252 patches, for the mountainous crop fields, followed by 109 patches of grasslands, 24 patches of tree crops and the smallest number, 23 patches, recorded for lowland crop fields. The values of the NUMP indicator suggest that in the study area there is differentiation in relation to landscape fragmentation (Rutledge, 2003). The landscape in the study area manifested higher fragmentation in mountainous crop fields and grasslands than in lowland crop fields and tree crops.

On the other hand, the Mean Shape Index indicator (Table 1) presented the lower values for the lowland crop fields and tree crops, which tend to approach the value of 1 (MSI_{grid}=1.47, $MSI_{dot\text{-}grid}$=1.228), while mountainous crop fields and grasslands diverge from the value of 1 (MSI_{mosaic}=1.621, MSI_{dot}=1.997). The above results suggest that in the lowland crop fields and tree crops the shape of patches tend to be regular (Rutledge, 2003; Skouteri, 2005) while in the mountainous crop fields and grasslands have irregular shapes (Rutledge, 2003; Skouteri, 2005). The MSI for the four classes shows a difference of shape complexity between the anthropogenic classes of cultivated land and the grassland/abandoned land. Our results for the MSI indicator are in agreement with the results of O'Neill *et al*. (1988) and De Cola (1989) because mountainous crop fields are not intensively cultivated in contrast with lowland crops fields and tree crops, which reflect the perimeter-conserving tendencies of agricultural development: farmers create rows and consequently blocks (De Cola, 1989) which are also present in grasslands and semi-natural open land.

IV – Conclusions

In the grassland ecosystem of the Mygdonian basin most of the land consists of grasslands (66%). The largest number of patches was found in mountainous crop fields and it shows the extent of the fragmentation in this type of structure of the landscape. Moreover, the patches of these two types of landscape structure have the most irregular shapes.

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