Inventory and landscape structure analysis of agrosilvopastoral systems in Florina Regional Unit

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Abstract

In northern Greece, traditional agrosilvopastoral systems (AS.S.) are in danger of being abandoned or converted to intensive monocultures. This could lead to their disappearance and subsequently loss of biodiversity, ecosystem stability and accumulated cultural knowledge. The purpose of this research was to carry out an inventory of the traditional AS.S. in Florina Regional Unit and evaluate them using landscape metrics. The AS.S. were identified and mapped using satellite images and orthophotos. Afterwards, two AS.S. were selected in Petres and Variko areas and landscape metrics were calculated using the program Fragstats. The AS.S. of Florina Regional Unit are 76 which cover an area of 5245,3 ha. The dominant tree species are oaks, poplars, walnuts and alders, while the dominant cultivations are alfalfa, corn, rye and barley. The landscape in the AS.S. of Variko appears to be in transitional stage. The geometric structure is evident in some places only, where the trees are still in linear arrangement. The tree coverage (index CA) is quite small and the distances between them very large (indexes PROX, ENN). In the AS.S. of Petres the absence of hedgerows is visible and the landscape appears to be abandoned. The tree coverage is very low (5,9%), they are scattered in the system (indexes ENN, PROX) and isolated (index LPI). From the analysis of landscape metrics it is concluded that they are a useful tool in interpreting agrosilvopastoral landscapes. Depicting landscape pattern may serve as an interpretative tool to monitor AS.S. abandonment.

Key words: abandonment, metrics, satellite images, Fragstats, GIS.

Introduction

The agrosilvopastoral systems (AS.S.) are complex entities involving at least three distinct components: crops, trees and pasture/animals (Papanastasis 2004) and constitute one of the three types of agroforestry systems. AS.S. provide number of products (food, wood, fodder, medicine, fibre, mycorrhiza etc.) and ecosystem services (increased soil fertility, prevention of soil erosion, increased biodiversity, maintenance of nitrogen and carbon cycle, increased productivity etc.) (Torquebiau 2000). Traditional agrosilvopastoral systems maintain diverse landscape mosaic and are more stable than any other form of conventional agriculture on soil protection.

Over the last few decades, AS.S. face several threats due to land use changes, imposed by a concomitant change of the socio-economic

conditions. In northwestern Greece, traditional AS.S. are in danger of being abandoned or converted to intensive monocultures (Papanastasis 2004). Their preservation is imperative to maintain ecosystem services, environmental benefits and economic commodities as part of a multifunctional working landscape. For these reasons it is necessary to create an inventory of the AS.S. of the area.

Moreover, socioeconomic changes in AS.S. are depicted in landscape structure (Nagendra *et al.* 2004). Therefore, the quantification of landscape pattern is fundamental in understanding the relations between structure and the ecological and socioeconomic processes that govern it (Turner 1989). For this purpose, several landscape metrics have been developed, which quantify landscape heterogeneity (O'Neill *et al*. 1988).

The aim of this study was the inventory of traditional AS.S. in Florina Regional Unit and structure analysis using landscape metrics.

Materials and methods

Study area

The study area was located in Florina Regional Unit in Western Macedonia, Greece (Fig. 1). The climate is characterized as continental, with cold winters, medium annual rainfall (645,7 mm) and mean annual temperature 12 ^{o}C (Mantzanas *et al.* 2008). The area belongs to the sub-humid bioclimatic floor with harsh winters and the sub-Mediterranean bioclimate zone. Phytosociologically, the vegetation of the area belongs to the conformation of thermophilic subcontinental deciduous oaks.

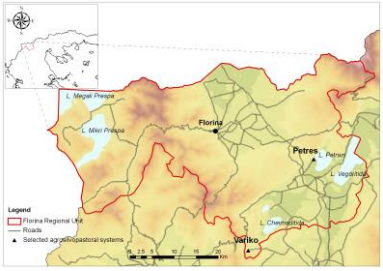


Figure 1. Study area

Methods

The identification and mapping of the AS.S. was accomplished by using satellite images (2002-2009) from Google Earth™ 6.0 and orthophotos (2007-2009) of KTIMATOLOGIO S.A. On-site verification followed to verify the correctness of photo-interpretation and collect additional data. Digitized data of these systems were introduced in the program ArcGIS

9.3.1. (ESRI 2008). Only the AS.S. covering an area over 10 ha were selected for further analysis, which is the minimum management unit area in surveys on agroforestry systems (Papanastasis 1989).

In order to calculate landscape metrics, two characteristic AS.S were selected, Variko and Petres. A square area of 40ha was selected in each AS.S in which the tree canopy was digitized. The formed polygons were imported in raster format to the program Fragstats 3.3 (McGarigal et al. 2002) and ten landscape metrics of a) area, density and edge (Class Area-CA, Number of Patches-NP, Largest Patch Index-LPI, Total Edge-TE, Mean Patch Size Area Weighted-AREA) b) shape (Shape Index Distribution Area Weighted Mean-SHAPE, Perimeter Area Fractal Dimension-PAFRAC), c) isolation and proximity (Proximity Index Distribution Area-Weighted Mean-PROX_AM, Euclidean Nearest Neighbor Distance Distribution Mean-ENN) and d) connectivity (Radius of Gyration Area Weighted Mean-GYRATE), were calculated at class level.

Results and Discussion

Florina Regional Unit has 76 AS.S. which cover an area of 5245.29 ha (9.82 % of the total agricultural land), while the average AS.S. area is 69 ha (Fig. 2). The mean altitude of each system is 827.5 m., the mean slope is 10.7% and the mean aspect is south. AS.S. in Florina Regional Unit occupy mainly the mountainous (72.4 %) and semi-mountainous (27.6 %) zone. 64.5 % of these systems are intensely used and only 2.6 % are abandoned. Regarding the farm crops, 94.7 % are herbaceous and 5.3 % mixed trees and herbaceous. The major crops are alfalfa 27.6 %, corn 19.7 %, rye 19.7 % and barley 10.5 % and the main tree species are oaks (*Quercus* sp.), poplars (*Populus* sp.), walnuts (*Juglans regia*) and alders (*Celtis australis*).

The system of Variko (Fig. 3) is located south of Florina Regional Unit, at an altitude of 739 m, and occupies an area of 107.29 ha. The system of Petres (Fig. 4) is located north of Petres Lake, at an altitude of 726 m and occupies an area of 66.89 ha.

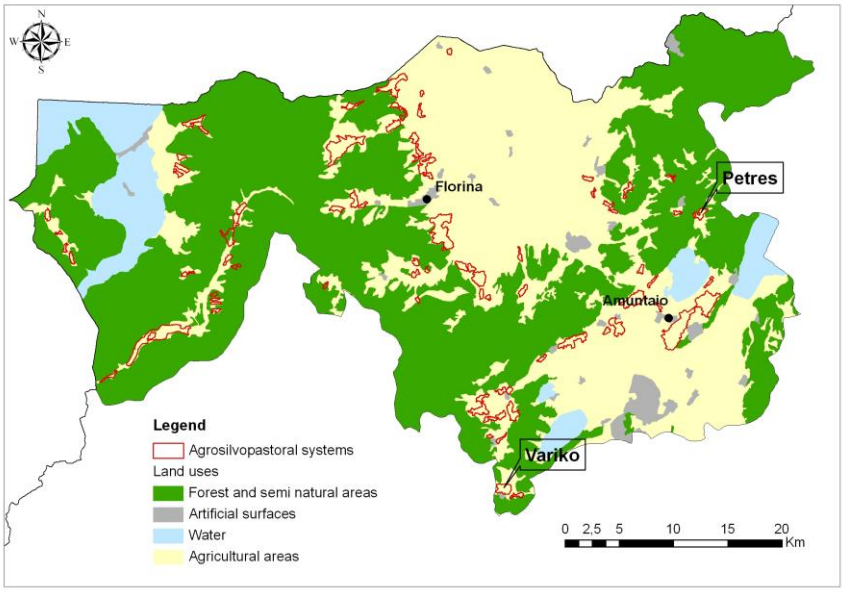


Figure 2. Agrosilvopastoral systems in Florina Regional Unit

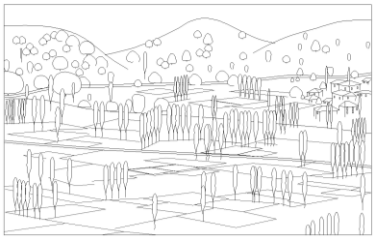


Figure 3. Agrosilvopastoral system of Variko

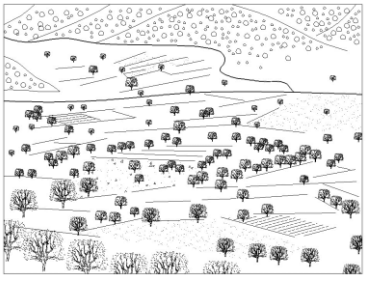
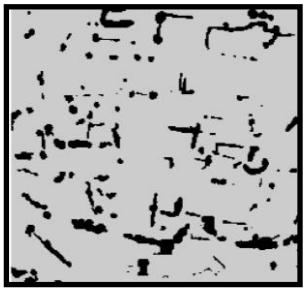
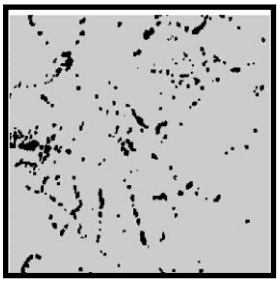


Figure 4. Agrosilvopastoral system of Petres

The selected 40ha square area with the digitized tree canopy for the two systems can be seen in figures 5a and 5b.



a



b

Figure 5. Digitized tree canopy the selected 40ha square in the agrosilvopastoral systems of a) Variko and b) Petres

For the selected AS.S. of Variko and Petres ten landscape metrics were calculated (table 1).

Table 1. Landscape metrics for the agrosilvopastoral systems of Variko and Petres in Florina Regional Unit.

Landscape metric category	Landscape metric	Variko	Petres	Range
Area/density/edge	CA[1] (ha)	4.21	2.36	CA>0
	NP[2]	127	203	NP≥1
	LPI[3] (%)	0.74	0.23	0<LPI≤100
	TE[4] (m)	12520.2	10145.7	TE≥0
	AREA_AM[5] (ha)	0.10	0.03	AREA>0
Shape	SHAPE_AM[6]	1.84	1.45	SHAPE≥1
	PAFRAC[7]	1.27	1.26	1≤PAFRAC≤2
Isolation/proximity	PROX_AM[8]	19.12	33.22	PROX≥0
	ENN_MN[9] (m)	11.36	9.63	ENN>0
Connectivity	GYRATE_AM[10] (m)	17.27	7.43	GYRATE≥0

[1]Class Area, [2]Number of Patches, [3]Patch Index, [4]Total Edge, [5]Mean Patch Size Area Weighted, [6]Shape Index Distribution Area Weighted Mean, [7]Perimeter Area Fractal Dimension, [8]Proximity Index Distribution Area-Weighted Mean, [9]Euclidean Nearest Neighbor Distance Distribution Mean, [10]Radius of Gyration Area Weighted Mean.

In Variko, the landscape seems to be in a transitional stage. There are several hedgerows functioning and some abandoned. The dominant tree species is poplar (*Populus thevestina*) in the boundaries of the fields and along the streams while few, isolated walnuts can be found inside the fields. Metrics NP and CA for Variko area indicate that tree coverage is very small, there are 127 tree patches which are quite isolated (ENN, PROX). The landscape is not dominated by large (LPI) or complex (PAFRAC) patches.

One of the major causes for the creation of this system was the limited available arable land. As a result, the locals were probably trying to exploit the land resources in the most profitable way. One of the reasons that may be responsible for maintaining the landscape was that in '82-'83 the inhabitants of Variko opposed the land consolidation and so a part of the area around the village remained intact. The decline of the local timber industry and the emergence of alternative energy sources have led to the abandonment of the systematic exploitation of poplar. But because the trees create a special microenvironment suitable for the cultivation of beans, reducing soil moisture, protecting crops from strong winds and

helping to maintain relatively low temperatures in the summer, until now they remained for the most part (Sidiropoulou 2011).

In Petres, the abandonment is evident. The dominant tree species is oak (mainly *Quercus trojana*) and almond-leaf pear (*Pyrus amygdaliformis*). Metrics CA and NP show that tree coverage is very low 5.9%, while there are only 203 tree patches. The geometry of the crown of trees is very simple (SHAPE, PAFRAC). The trees are scattered throughout the system (ENN, PROX) and most of them are isolated (LPI). The absence of hedges is visible in the landscape (GYRATE).

In this system, the existence of old, single oak tree in the fields, suggests their use in the past. The trees were used for timber, fruit, charcoal, but especially for fodder. The oak leaves were collected and used as food for animals in unfavorable seasons (winter, dry periods), a practice common throughout Greece (Papachristou and Papanastasis 1994). While in the past the oaks formed hedgerows, today only some individuals remain probably as a result of fragmentation.

Conclusions

The identification and inventory of AS.S. is possible using satellite images and orthophotos. The application of landscape metrics in the selected agroforestry landscapes shows that CA, NP, LPI, ENN, AREA, SHAPE, PAFRAC, PROX and GYRATE could possibly be indicators of abandonment and can capture the landscape structure of AS.S. Landscape metrics can serve as a tool for identification and comparison of different agroforestry landscapes and for the interpretation of socio-cultural conditions that shaped them.

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