Land cover changes in a valonia oak silvopastoral system in W. Greece – ecological and sociological implications

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Abstract. Silvopastoral systems integrate the complexity of forestry and forage-livestock management in an economically and ecologically sustainable way. However these systems have undergone intensive pressure in the past decades caused by changes in land-uses and in the local socioeconomic priorities that suppressed traditional practices such as livestock grazing. These changes have respectively caused land cover spatiotemporal diversifications and their effects were investigated in a traditional oak silvopastoral system at western Greece under the framework of this study. The temporal land-cover changes were analyzed using aerial orthophotographs for a distinctive time period, from the year 1945 to the years 2007 - 2009. Land-cover was digitized with the use of ArcGis software for the above mentioned time period. Based on the analysis of produced maps, land cover changes are mainly attributed to the human intervention related to land cultivation and livestock grazing.

Keywords: *Silvopastoral systems, Spatiotemporal landcover changes, Geographic Information Systems, Land use human behavior changes, Quercus ithaburensis subsp. Macrolepis.*

1. Introduction

The valonia oak woodlands in Greece cover a relatively small area in various lowland and semi-mountainous regions of the insular and continental parts of the country (Pantera *et al*. 2008) as a result of the intensive human influence, since ancient times and due to their location close or within agricultural fields or urban areas (Pantera 2001). These woodlands, due to their open structure and their combined uses for forest and livestock production, are considered as silvopastoral systems (Pantera 2014; Papadopoulos *et al*. 2015), and are included in the agroforestry systems of high natural and cultural value of Europe (Der Herder *et al*., 2015). The valonia oak woodlands in Greece, as well as in other eastern Mediterranean silvopastoral oak woodlands, have been greatly degraded through forest conversion, illegal lumbering, overgrazing and forest fires (Quezel and Bonin 1980; Pantera *et al*. 2008; Plieninger *et al*. 2011; Schaich *et al*. 2015). The most extensive and continuous, in terms of area, valonia oak forest are found in the western part of the country (Pantera and Papanastasis 2003) and were traditionally used in the past for acorn production, for tannin extraction and use for leather dyes, and for livestock grazing (Pantera 2001; Giannakopoulou 2002). This intensive forest use in the past ceased in 1970 due to lack of economic interest and incentives for acorn cups harvesting. This resulted to the abandonment of these areas which are currently unmanaged and used only for livestock grazing, mainly by goats and sheep. The notably open structure of many stands in the region, are the result of the past usage of the forest for acorn production, activity which required more light in the interior of the stands. However, in the past decades and specifically after the 1960's where agricultural activities outburst and urbanization expanded, many valonia oak forest switched landuse as well as their traditional practices previously included in their management. Additionally, the nomadic livestock raising was also abandoned resulting to a continuous, throughout the year, grazing of the forest. These changes have greatly affected the distribution and structure of valonia oak silvopastoral systems in W. Greece. There is no study on the landuse changes of valonia oak silvopastoral systems. The only available study refers to a part of the Xeromero valonia oak forest and was conducted under a management plan for this forest unit (Hellenic Agricultural Ministry 2005). Similar studies on valonia oak woodlands were conducted for the island of Lesvos, by Plieninger *et al*. (2011) and Schaich *et al*. (2015). The present study represents the first complete attempt to study the whole Xeromero valonia oak forest, which is the most representative forest of the species in Greece and the Balkan Peninsula. The purpose of the study is to investigate landuse changes that occurred in the area and to make an initial attempt for their ecological and social investigation.

2. Material and methods

The study site is the valonia oak forest of Xeromero. It is a state owned forest that includes private land, mostly crops, and livestock grazing activities. The core area of the forest is a line of hills to the West and South of Lake Ozero up to the city of Astakos which is the headquarters of the Xeromero municipality (Fig. 1). The region is characterised by its rich fauna and flora (Vlami *et al*.

2003), as well as its diverse landscape rending ideal for touring and ecotouristic activities. In this work the estimation of the effect of human interventions in the silvopastoral system of the study area, was based on two indicators and, in particular a) to land cover changes and b) to the forest vegetation density changes. The following materials and methods were used for the implementation of this research:

i. To extract the required information over the study area we used available aerial orthophotos from the years 1945 and 2007–2009 (2008 for short). Based on the above material it has become possible to study the differences over a time period of 63 years. The extraction of the main information, for both periods, total digitalization of the study area was implemented. For the digitization of ground cover and geographic analysis we used the geographic information systems software ArcGIS.

ii. For the coding of the land cover and the forest vegetation density, we used the encoding applied by the forest administration (National Special Secretariat for

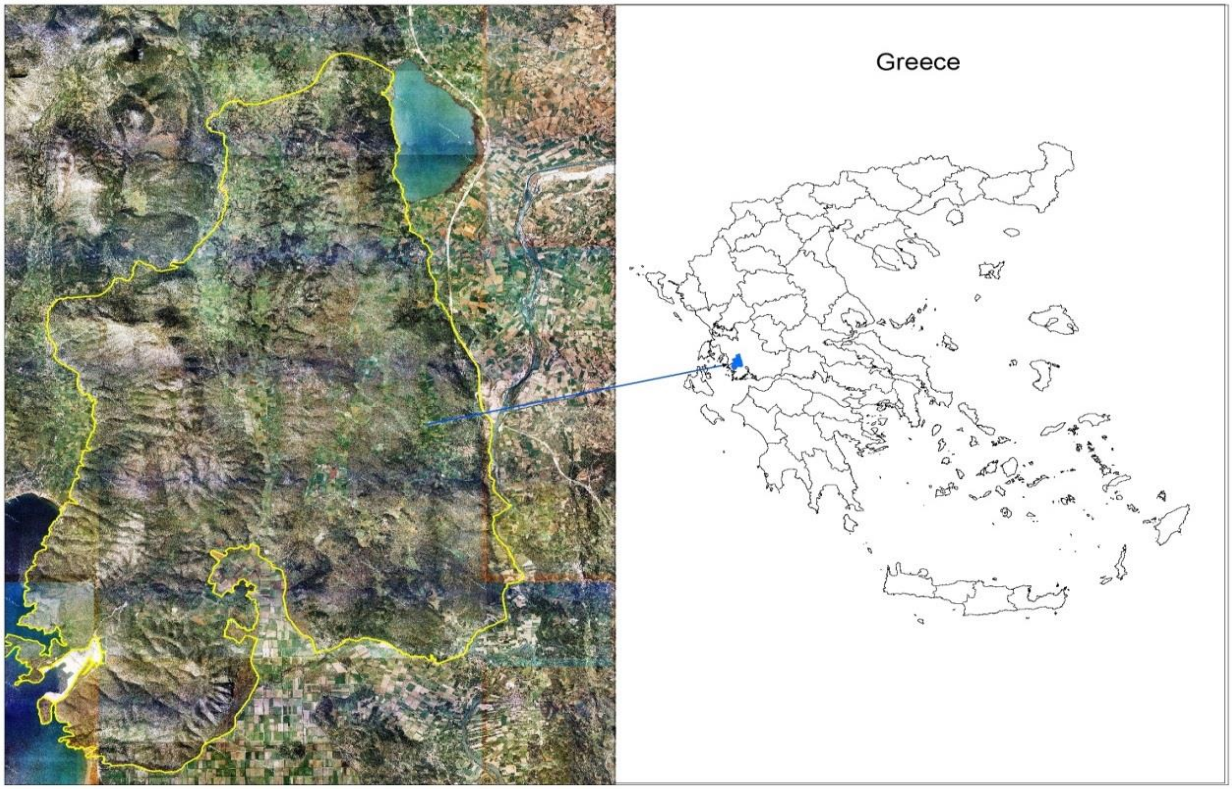

Figure 1. Map of the study area

Table 1. Forest vegetation density coding.

Forest vegetation density class	Coverage (%)	Code
Open	10-40%	1
Almost dense	40-70%	2
Dense	70-100%	3

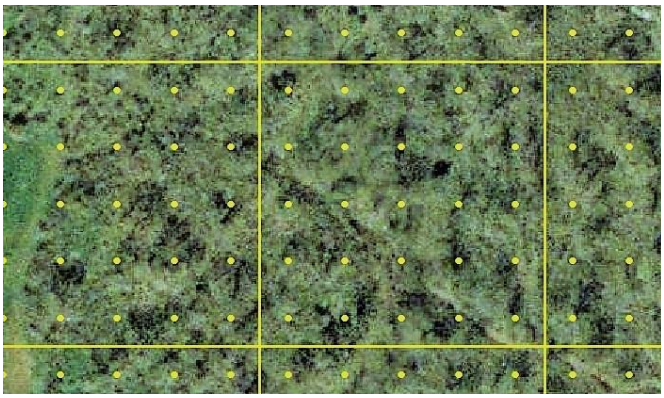

Figure 2. Measurement of vegetation cover density.

Forests). Specifically, the following land cover types were identified in the study area: Agricultural fields (AF), abandoned agricultural fields (AFa), bushes (B), barren land (BL), forest oak (FO), meadows (M), riparian vegetation (RV), urban areas (UA). The density of the forest cover was codified as given in table 1.

The assessment of forest vegetation density was based on sampling methodology. Specifically, two grids were created (fishnets) with dimensions a) 100 m x 100 m and b) 20 m x 20 m respectively (Figure 2). So the grid 100 m x100 m contained 25 points, then by counting the points coincided with the forest vegetation the percentage of land cover density was calculated.

3. Results – Discussion

In Figure 3 is given the chart of the main land cover types. From the chart resulted that the forest areal coverage, as a total (Oak forest and bushes area), was diminished by -3.4%, as well as the meadows areal coverage diminished by -2.6%. Agricultural fields and abandoned agricultural fields areal coverage increased by 5.8%. Meadows diminished by -2.6%. Barren land and urban area had very small areal coverage changes.

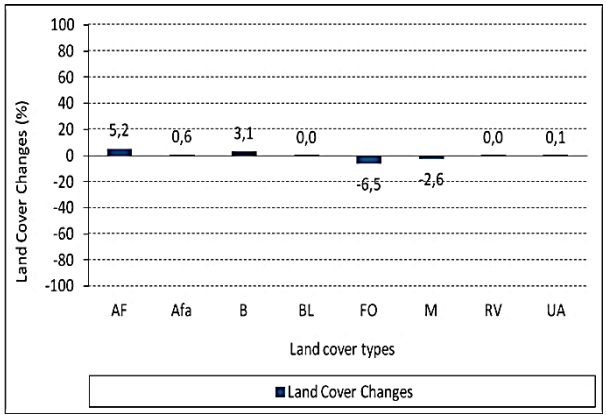

Figure 3. Chart of the main land cover types changes during the study period.

From the above results it is concluded that the agricultural activities of the local population increased by time and some forest area and meadow area changed and became agricultural land. That means that the forested area and meadows suffer from the need for more agricultural land. The low reduce of the forestland is interconnected to the abandonment of the traditional acorn cups collection from valonia oak trees since the 1970's which reduced the interest and, respectively, the protection of the forest by the inhabitants of the local communities.

The forest vegetation density is considered as a composite index that shows the vegetation status. In the study area we suggest that the major factor that affects vegetation density is human intervention and especially livestock grazing. In Figure 4 are given the areal vegetation density and specifically: in a) the vegetation density for high forests and in b) the vegetation density for the bushy areas.

The areal coverage per density class of oak forest changed variously (Figure 4a). Specifically, low density forest coverage (< 40%) increased by 8.7% while the medium density forest coverage (40% – 70%) decreased by -9.6%, the area of height density forest coverage (> 70%) also increased but only by 0.9%. The above results show that a) Low class density forest area increased, mainly, by the degradation of medium class forest area due to human intervention namely, livestock grazing and also by forestation of abandoned agricultural fields, meadows and bush areas b) area of medium class density of oak forest was decreased for the reason mentioned above.

The areal coverage of bushes (Figure 4b) has decreased by -6.5% for the low class density (< 40%), the medium density class (40% – 70%) has also decreased by -1.8%, while the height class density (> 70%) has areal increase by 8.3%. These results mean that thin bushes areas become denser during the study period.

In figure 5 are given the main land cover transformations during the study period. The main comment is that the land cover types mostly keep their area. Only meadows had big fragmentation. In more details, agricultural fields that abandoned partly covered by bushes and oaks and partly transformed to meadows. Meadows transformed mostly to agricultural fields and secondary to oak forest and bush area. Oak forest transformed partly to agricultural fields and bush area, another smaller part transformed to meadow. That means main transformations of oak forests were to agricultural fields and bushes, which indicates that oak forest are incurs the pressure for new land demand and livestock grazing. Bushes, mainly, transformations were to oak forest through natural competition and to agricultural fields.

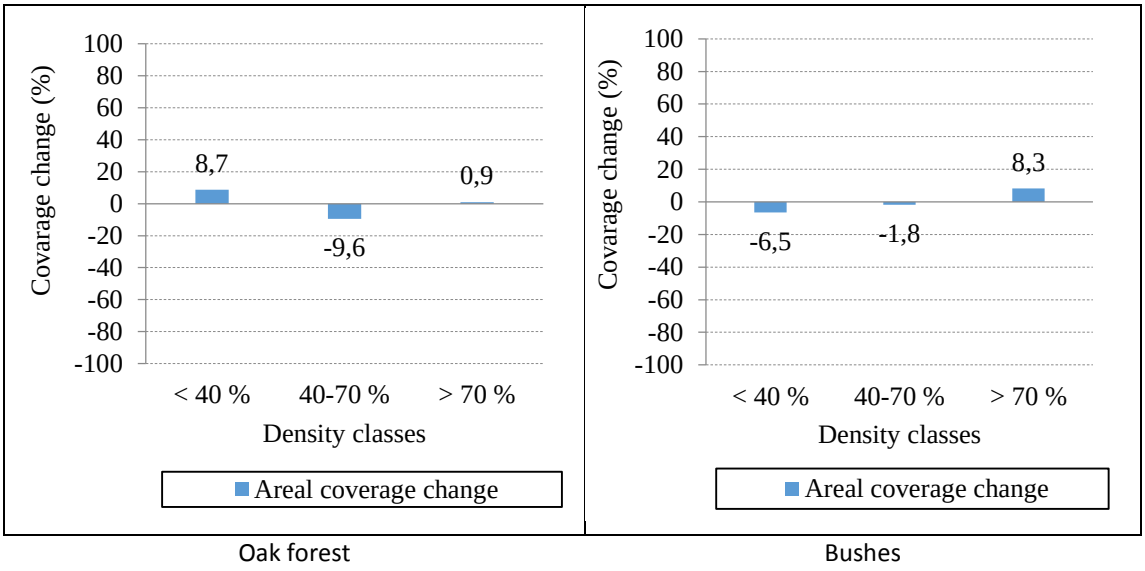

Figure 4. Charts of forest vegetation cover density changes during the study period.

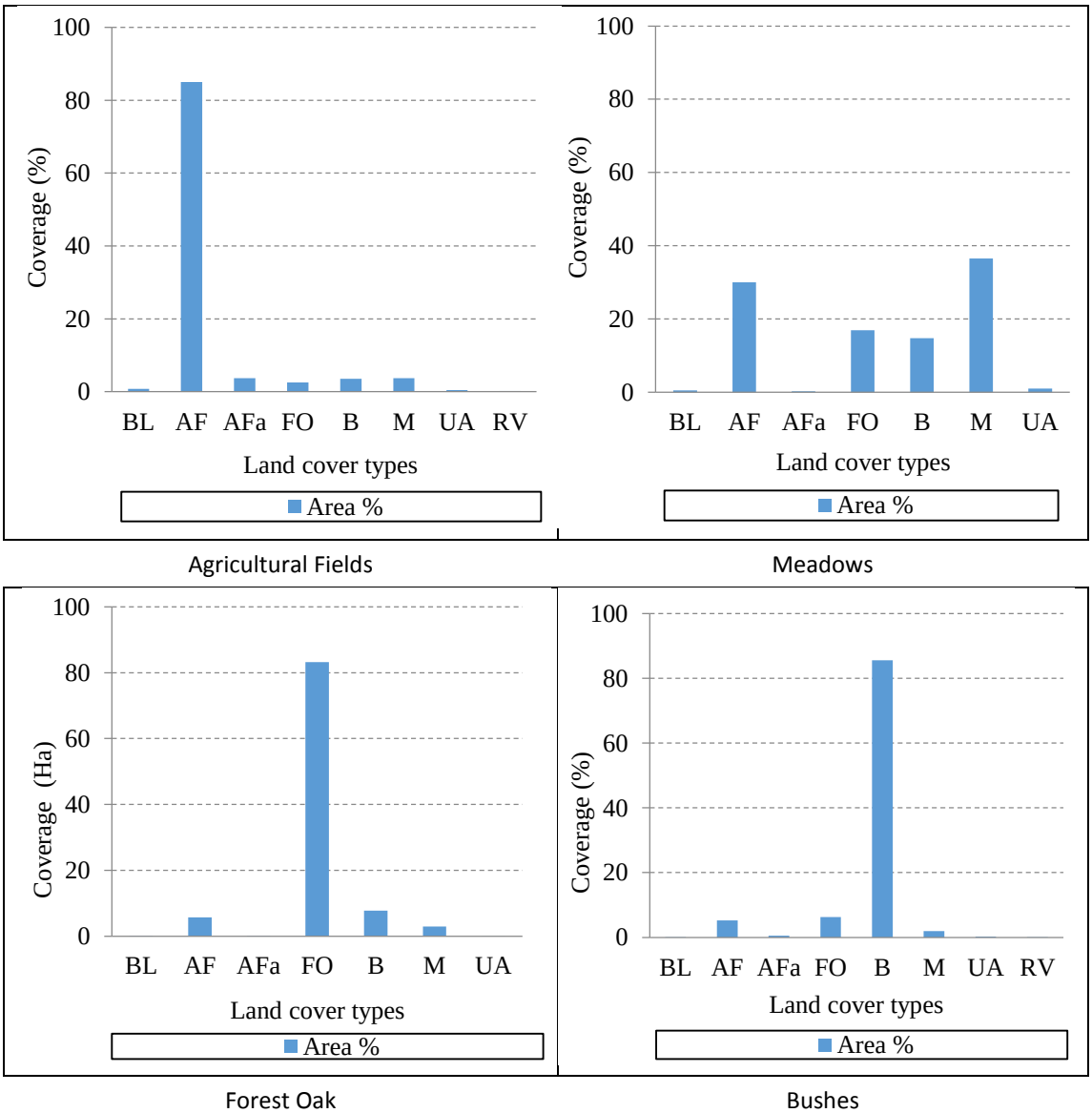

Figure 5. Chart of main land cover types transformations during the study period.

4. Conclusions

Based on the results of this study it is concluded that dynamic changes of land cover and forest vegetation density occurred during the study period. Changes in land cover and vegetation density are bi-directional. Specifically, when people cease using an area, then this area is forested. On the contrary, when people establish a

new settlement over an area, then this takes place against the present land use either that being forest or rangeland. The overall interchange balance is rather against forest land coverage and health. The forest as a whole, valonia oak forest and shrub area, suffers from human intervention through agricultural activities and livestock grazing. Particularly, oak regeneration is poor and necessitates the uptake of management measures, which are not easy to be applied due to significant human presence. This is partly attributed to livestock grazing which is difficult to regulate. Forest management authorities could take new initiatives in agreement to the local societies, in order to improve the regeneration of the system and increase productivity. Further study of the spatiotemporal changes related to proximity of urban areas and the altitude of the landscape needs to take place.

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