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# Survey of olive agrosilvopastoral systems in Chalkidiki, N. Greece

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**Abstract.** Olive (*Olea europea* L.) is an important evergreen tree species of Mediterranean area that is planted in order to produce table olives and olive oil. Olive agrosilvopastoral systems are found in many regions of Greece; in combination with natural vegetation and/or intercropping. These systems are threatened by abandonment or conversion to intensive monocultures. The aim of this study was to identify olive agrosilvopastoral systems in the region of Chalkidiki, North (N) Greece and evaluate their characteristics. In order to achieve this, the Corine Land Cover classification system of land use types was applied on google earth satellite images and onsite observations were conducted. Three different systems were identified; a) silvoarable systems with trees in rows intercropped with cereals, b) silvoarable systems with scattered trees intercropped with cereals, and c) silvopastoral systems with scattered trees with natural vegetation and grazing. These systems were mainly found in the Corine land cover type 223 (olive groves) and occupied 12.052.64 ha of the study area. The majority of the systems were silvopastoral with scattered trees and natural vegetation. The preservation of the agroforestry systems of the area was mainly due to the occupation of the local population with tourism. The adoption of the new CAP agri-environmental measures by farmers could contribute further to their exploitation.

**Keywords.** Corine Land Cover –Silvoarable –Silvopastoral systems–Tree arrangement

## **Enquête sur les systèmes agrosylvopastoraux d'olivier à Chalkidiki, Grèce du Nord**

**Résumé.** L'olivier (*Olea europea* L.) est une importante espèce arboricole de la Méditerranée qui est plantée pour produire des olives de table et de l'huile d'olive. Les systèmes agrosylvopastoraux d'olivier sont identifiés dans de nombreuses régions de la Grèce, en combinaison avec la végétation naturelle et/ou les cultures intercalaires. Ces systèmes sont menacés par l'abandon ou la conversion en monocultures intensives. L'objectif de cette étude était d'identifier les systèmes agrosilvopastoraux d'olivier dans la région de Chalkidiki, Grèce du Nord, et d'évaluer leurs caractéristiques. À cette fin, le système de classification des types d'utilisation des terres « Corine Land Cover » a été appliqué sur les images satellitaires Google Earth et des observations sur le site ont été également effectuées. Trois systèmes différents ont été identifiés: a) les systèmes agrisylvicoles, avec des arbres en rangées intercalées avec de céréales, b) les systèmes agrisylvicoles avec des arbres épars intercalées avec de céréales et c) les systèmes sylvopastoraux avec des arbres épars avec végétation naturelle et pâturage. Ces systèmes se trouvaient principalement dans le type d'occupation des sols Corine 223 (oliveraies) et occupaient 12.052.64 ha de la zone couverte par l'étude. La majorité des systèmes étaient les systèmes silvopastoraux avec des arbres épars et de la végétation naturelle. La préservation des systèmes agroforestiers de la région était principalement due au fait que la population locale s'occupe du tourisme. L'adoption des nouvelles mesures agro-environnementales de la « PAC » par les agriculteurs pourrait contribuer davantage à leur exploitation.

**Mots-clés.** Corine land cover — agro-sylviculture — systèmes sylvopastoraux — arrangement des arbres

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## I - Introduction

The presence of the olive (*Olea europaea* L.) in the Mediterranean dates back from 60,000 to 80,000 years ago according to pollen study analysis (Schultz et al. 1987). The technique of inoculation of wild olives was developed as early as 1,000 BC as well as the co-cultivation with cereals and legumes. The combination of olive trees with livestock was one of the first forms of agroforestry (Schultz et al. 1987). Olive is the most widespread cultivated tree in Greece, covering an area of 700,000 ha (EUROSTAT 2016, den Herder et al. 2017), of which, approximately 125,000 hectares are silvoarable and silvopastoral systems (Papanastasis et al. 2009). According to Pantera et al. (2018), olive trees alone or in orchards are found in all parts of the country with a mild Mediterranean climate. Olive trees are considered to be among the least demanding of nutrients among cultivated trees and that is why they are planted in relatively barren and rocky areas and in soils derived mainly from limestone (Papanastasis et al. 2009). The main products of the olive groves are edible olives and olive oil, while the secondary products include animal feed and firewood.

The cultivation of olives in Chalkidiki is a traditional practice, which increased greatly at the end of the twentieth century, with its area amounting to 26,743 hectares and the production of edible olives and olive oil amounting to 112,870 and 52,250 tons respectively (National Statistical Service 2015). However, in Chalkidiki as in the rest of Greece, traditional agroforestry systems are in danger of being abandoned or converted to intensive monocultures, with consequent loss of biodiversity, ecosystem stability and accumulated cultural knowledge (Sidiropoulou 2013). For this reason, it is considered necessary to locate, inventory and record their characteristics (Sidiropoulou 2013). Specifically in the area of Chalkidiki a first survey was made by Sidiropoulou (2011) where it was found that agroforestry systems with an area > 10 ha occupy 3,652 ha, while later, within the European project AGFORWARD (2014-2017), an experimental surface was installed in a specific area of Kassandra peninsula in order to highlight the advantages of co-cultivation of olive trees aged 80 years with barley and vetch (Pantera 2014, Mantzanas et al. 2016, Mantzanas et al. 2021).

The purpose of this research was the inventory of the olive agroforestry systems of the Region of Chalkidiki and the investigation of their characteristics.

## II - Materials and methods

The research was carried out in the region of Chalkidiki in North Greece, where there is extensive traditional olive grove systems. For the mapping procedure, maps of the pan-European Corine Land Cover Inventory (CLC) 2012 (European Environment Agency 2018) and ArcGIS Geographic Information Systems software were used. From the classification system of CLC 2012, the polygons belonging to the codes '223 - Olive groves', '242 - Complex cultivation patterns' and '243 - Land principally occupied by agriculture, with significant areas of natural vegetation' were selected. In each of these polygons, the percentage of olive agroforestry systems was estimated using satellite imagery (base map Arc GIS). In order for a system to be characterized as agroforestry, the requirements were: the minimum distance between the trees and the minimum distance between the tree rows to be at least 10 m and the total density of trees should not exceed 100 trees / ha.

Furthermore, onsite observations were conducted in order to verify the data of the mapping procedure of the olive agrosilvopastoral systems in the region of Chalkidiki, N. Greece. Additionally, their main characteristics were recorded in representative systems. More specifically, twenty sampling plots were selected in various exposures and slopes. They were distinguished in the following three categories based on the tree layer and the understory vegetation: a) silvoarable systems with trees in rows intercropped with cereals, b) silvoarable

systems with scattered trees intercropped with cereals, and c) silvopastoral systems with scattered trees with natural vegetation and grazing. In each plot; tree density (tree/ha), tree arrangement, total tree height (m), breast height diameter (m) and canopy diameter (m) were measured.

### III - Results and discussion

The total estimated area of agrosilvopastoral systems in the region of Chalkidiki exceeds 12,000 ha and occupies 4,13% of the total area of the region (Table 1). From the initial number of 255 land cover polygons (potential areas of olive agrosilvopastoral systems) of the CLC-2012 program, it was estimated that 38 % of them include agrosilvopastoral systems. Out of these polygons, the olive groves (code 223) include the largest percentage (> 30 %). In total, the average percentage of olive agrosilvopastoral systems among the investigated CLC-2012 polygons was 20 %.

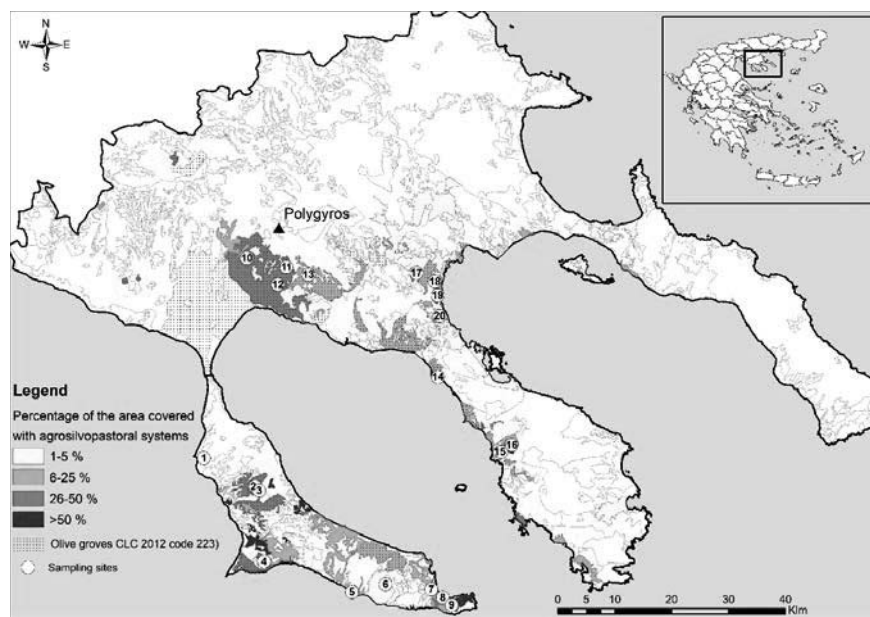
**Table 1.** Number, areas (ha) and percentage (%) of olive agrosilvopastoral systems in Corine Land Cover 2012 polygons, in the region of Chalkidiki.

Corine Land Cover codes	Number of polygons	Total area (ha)	Area of agroforestry systems (ha)	Percentage of agroforestry systems (%)
223 - Olive groves	44	30,700.32	9,325.18	30.37
242 – Complex cultivation patterns	17	9,745.18	748.48	7.68
243 - Land principally occupied by agriculture, with significant areas of natural vegetation	36	21,889.08	1,978.98	9.04
<b>Total</b>	<b>97</b>	<b>62,334.58</b>	<b>12,052.64</b>	<b>19.34</b>

The distribution of the olive agrosilvopastoral areas in the region of Chalkidiki, showed that the largest percentage of them is located in Kassandra peninsula, the western part of Sithonia peninsula and in an area southeast of the city of Polygyros in the center part of the region (fig. 1). All these areas are situated near the coastal lines. In the areas far from the shores, local people are more intensively engaged in the production of olives fruits and olive oil and for this reason the co-cultivation of agrosilvopastoral systems has been abandoned. In these areas' farmers tend to fill the gaps in their olive groves with new trees to increase olive production. In coastal areas, on the other hand, the local people are more actively engaged with tourism and that resulted in conservating the olive agrosilvopastoral areas. According to the same data (fig. 1), Kassandra peninsula maintains the largest number of polygons with dense coverage of olive agrosilvopastoral systems, possibly due to a milder terrain. Olive agrosilvopastoral systems that have been maintained until today in Chalkidiki, may be better utilized in the future, with the adoption by the farmers of the new agri-environmental measures of the Common Agricultural Policy (CAP) (Mantzanas et al. 2017). Of the twenty representative agrosilvopastoral systems that their main characteristics were recorded, the 20 % of them were silvoarable and they were located in Kassandra peninsula (Table 2). Similar results were found in a previous research that was conducted in the area (Sidiropoulou 2011). The silvoarable system with the largest extent (10 ha) was located in Kassandra peninsula and it was the only one with a linear tree arrangement intercropped with oat cereals. The density of the trees in this system reached the number of 60 trees/ha. This was due to the fact that the linear tree arrangement facilitates the agricultural processes allowing higher tree densities in comparison with the scatter tree

arrangement. The other three silvoarable systems, they were also intercropped with cereals but with scattered trees arrangement and low tree density.

**Fig. 1.** Distribution map of olive agrosilvopastoral systems (Corine Land Cover 2012) and sampling sites in Chalkidiki region.



**Table 2.** Characteristics of olive agrosilvopastoral systems in selected areas of Chalkidiki, N. Greece

a/a	System type <sup>1</sup>	Exposure/slope (%)	Tree density (tree/ha)	Tree arrangement <sup>2</sup>	Total tree height (m)	Breast height diameter (m)	Canopy diameter (m)	Understory type <sup>3</sup>
1	SA	W-15	60	L	9	0.85	10	Oat
2	SA	0	30	S	5	0.45	6	Barley
3	SA	0	30	S	6	0.5	5	Barley
4	SA	0	40	S	6	0.6	6	Barley
5	SP	NW-30	40	S	6	0.5	5	NV
6	SP	SW-10	50	S	6	0.5	7	AF
7	SP	NW-20	50	S	6	0.6	7	NV
8	SP	NW-20	60	S	6	0.6	7	AF
9	SP	0	65	S	8	0.6	8	NV
10	SP	0	60	S	4.5	0.5	5	AF

11	SP	0	50	S	4.5	0.55	5	NV
12	SP	0	70	S	4.5	0.8	6	NV
13	SP	SE-5	80	S	4.5	0.4	5	NV
14	SP	0	40	S	5	0.3	3	NV
15	SP	0	40	S	4	0.3	5	NV
16	SP	0	80	S	5.5	0.4	5	NV
17	SP	0	60	S	5	0.45	4	NV
18	SP	0	70	S	5	0.4	6	NV
19	SP	0	90	S	5.5	0.5	7	NV
20	SP	0	70	S	4	0.5	4	NV

Abbreviations: <sup>1</sup>SA: Silvoarable, SP: Silvopastoral, <sup>2</sup>L: Linear, S: Scattered, <sup>3</sup>NV: Native vegetation, AF: Abandoned field

The majority of the systems under study (80 %) were silvopastoral. In three of them, the abandonment of the previous agricultural use was obvious, while only one of them seemed to preserve an almost linear tree arrangement. The majority of the silvopastoral systems appeared a tree density of 40-60 trees/ha, nonetheless one of them had a very high tree density reaching the 90 trees/ha.

Regarding the biometric characteristics of the trees, their average values ranged in 5.3 m height, 0.5 m of breast height diameter and 5.6 m canopy diameter. The characteristics of the trees of the silvoarable system located in the area of the rural prisons appeared much higher values than the average ones and deviated from the other systems. This was probably due to the positive effect of the long term of intensive intercropping with cereals.

## IV - Conclusions

Olive agroforestry is a traditional land use practice in the region of Chalkidiki. The European Corine Land Cover program can be used as an inventory tool for agroforestry systems, however, their distinction into silvoarable or silvopastoral requires on the spot control. The results of the survey showed that 30 % of the area of olive groves is managed in the form of agroforestry. Most of the systems consisted of silvopastoral systems with scattered trees and natural vegetation in the understory. The involvement of the inhabitants with the tourism in the coastal areas resulted in the preservation of the agroforestry systems. Farmers interest in these systems may increase in the future with the adoption of the new agri-environmental measures of the CAP.

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