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Impact of Olive Cultivation on Biodiversity in Messenia, Greece

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Abstract

The biggest threat and cause to loss of biodiversity have been found to be the intensification of agriculture under the 20th century. Messenia is one of the oldest olive cultivation areas in Greece and the landscape is dominated by olive groves characterized by extensive tillage, which causes serious erosion and might be a threat to plant diversity. Organic olive cultivation is an alternative that aims to preserve and support biodiversity. In this study the plant composition in the edge zones of an organic and a conventional olive grove in Messenia were inventoried to be able to investigate if organic cultivation methods enhance plant diversity. Moreover, other factors affecting plant diversity in olive groves and suggestions for precautions in the olive cultivation sector to support biodiversity are discussed. The results show that the organic olive grove hosted 40 % higher species richness, which indicates, as in other similar studies, that the organic olive cultivation methods have a higher capacity to support biodiversity. By restricting tillage and promoting organic olive cultivation, not only biodiversity would be enhanced; this could also prevent further soil erosion and create a more heterogenic agricultural landscape with higher biological and cultural values.

Key-words: *olive, olive grove, organic olive cultivation, conventional olive cultivation, biodiversity, plant diversity, Messenia.*

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Introduction

The agricultural landscape of the Mediterranean basin

The Mediterranean basin have a long history of human impact since the days of Ancient Greece and the Roman Empire (700-800 BC until 500 AD) that have formed the landscape and the biodiversity patterns in the area (Beaufoy 2001, Sokos *et al.* 2012). The Mediterranean biome supports high biodiversity with a large portion of endemic species and is considered to be a biological "hotspot" (Underwood *et al.* 2009, Sokos *et al.* 2012). Ecological factors in the agricultural landscape include the capacity to support a variety of habitats and species. Therefore changes in the agricultural landscape have a great impact on ecology and biodiversity, and consequently natural resources and ecosystem services, which in turn will affect what humans can benefit from the landscape (Petanidou & Kizos 2008). The biggest threat and cause to the extensive decline of farmland biodiversity including many taxa, especially birds, mammals, insects and plants, have been found to be the intensification of agriculture under the 20th century (Benton *et al.* 2003, Hole *et al.* 2004, Solomou & Sfougaris 2011). In the last 30 years intensification of agricultural practices has increased in Greece, Portugal and Spain following their membership in the European Union in the 1980s (Allen *et al.* 2005). The result of these land-use changes is that traditional low-intensive cultivation in a heterogenic mosaic landscape with integrated grazing is being replaced with modern intensive cultivation in monocultures with increasing use of chemical pesticides, herbicides and fertilizers (Beaufoy 2001, Benton *et al.* 2003, Allen *et al.* 2005). The dramatic changes in the agricultural landscape have led to loss and fragmentation of species rich habitats that have evolved under the human impact of traditional agriculture over thousands of years (Henle *et al.* 2008, Petanidou & Kizos 2008, Sokos *et al.* 2012). Small remnant habitats in road verges, field margins, ditches and midfield islets can support many of the farmland species and are thus very important for the conservation of biodiversity in the agricultural landscape (Benton *et al.* 2003, Cousins 2006).

Olive cultivation in Greece

The olive tree (*Olea europaea*) was introduced to Greece by the Phoenicians from Lebanon around 2000-1500 BC (Palmgren & Gordan 2007, Wingård 2010). According to Greek mythology it was the goddess Athena that presented the olive tree to the Greek gods who were enchanted by the properties of the olive fruit that could be used to make an oil that in turn could be used in food, as a healing medicine and to lighten the houses (Loumou & Giourga 2002, Papiomitoglou 2006, Wingård 2010). The olive tree is famous for its longevity. It can become up to 700-800 years old, with the best olive yield at 50-150 years age (Papiomitoglou 2006, Palmgren & Gordan 2007). The evergreen trees become 15-20 meters high with a wide stem and broad sparse crown with whole leathery dark-green leaves. The first olives appear at an age of 4-5 years and full yield is attained after roughly 20 years (Palmgren & Gordan 2007). Flower buds appear in March, and blooming is in April and May, but only 1-3 % of the flowers form fruits. Pollination varies between different sorts; some sorts are self-pollinating and others need a pollinator. The olive tree has evolved to survive in the Mediterranean climate and thrives even in dry, nutrient-poor, erodible soils where other cultivatable crops are few (Beaufoy 2001, Wingård 2010). It is very endurable to drought and has well

imbedded stomata on the underside of the leaves to minimize transpiration, high osmotic pressure, and to be able to absorb water even from very dry soils and a large root system (Wingård 2010).

The total number of olive trees in the whole world is estimated to be 800 million on a total area of 8.6 million hectare and 95 % of these are found in the Mediterranean basin (Wingård 2010). The three biggest producers of olive oil are Spain with 1 600 000 tons per year, Italy with 400 000 tons per year and Greece with around 300 000 tons per year, which corresponds to 67 %, 17 % and 12 % of the European production (IOOC 2013). Moreover, Greece produces 900 000 tons of table olives per year. Greece is the country that consumes most olive oil in the world; over 25 kg per person per year comparing to 15 kg in Spain and 12 kg in Italy (Wingård 2010).

The value of the olive production in Greece is 18 % of the total value of the agricultural production and 850 000 Greek farmers (approximately 50 % of all the farmers) include olive cultivation in their agricultural activities on a total area of 800 000 hectares, which corresponds to 20 % of Greece's agricultural land (Camarsa *et al.* 2010, Wingård 2010, Solomou & Sfougaris 2011). Olives are cultivated all over Greece; in 51 of the 54 regions. The most extensive olive grove tracts are found on Crete and Peloponnese (Papiomitoglou 2006, Wingård 2010). Olive cultivation is not only of great economical importance, it has a prominent cultural value, which is expressed by the olive's frequent presence in Greek cooking, history, mythology, religion and literature (Loumou & Giourga 2002, Wingård 2010). The average area of an olive plantation in Greece is 2 hectares and produces approximately 800 kg of olive oil per year. The main part of Greece's olive plantations are small scale and family owned. The average age for farmers who have olive cultivation as their main occupation is over 60 years old (Wingård 2010).

Greek olive production have slowly increased from around 150 000 tons per year in the 1960s to around 300 000 tons per year in 2010 (Wingård 2010). From 1991 to 2007 the total area of olive plantations have increased by 15 % from 680 000 hectares (ha) to 800 000 ha. Under the same time the olive oil production have increased with 16-18 % (Camarsa *et al.* 2010, Wingård 2010). The increase is due to new plantations that were incited by EU subsidies and to increased use of irrigation (Camarsa *et al.* 2010, Wingård 2010). In older traditional olive plantations the tree intensity is 40-50 stems per hectare. In new intensified plantations the tree intensity can be up to 300-400 stems per hectare (Beaufoy 2001, Camarsa *et al.* 2010, Wingård 2010). For the most part, olive groves consist of single species orchards (Beaufoy 2001).

Environmental impact of olive cultivation

The development of intensive agricultural practices strives to increase the production, but has resulted in severe environmental degradation (Solomou & Sfougaris 2011). Over 85 % of the world's olive plantations are on dry, highly erodible soils and over 50 % are affected by serious erosion, which is considered to be the most urgent environmental problem associated with olive cultivation (Beaufoy 2001, Wingård 2010). The intensified plantations with tree rows in slopes with mechanized tillage are the ones that cause the most serious erosion (Beaufoy 2001, Allen *et al.* 2005, Camarsa *et al.* 2010, Wingård 2010). Erosion leads to run-off of soil matter and chemical fertilizers, pesticides and herbicides,

into natural water-bodies and water reservoirs as well as reduced productivity capacity, which in turn can lead to increased usage of fertilizers (Allen *et al.* 2005, Camarsa *et al.* 2010). Soil erosion is a result of slope inclination, soil type, rainfall patterns and inappropriate cultivation practices such as intensive tillage that exposes the soil to rainfall, compacts it and reduces its organic content (Beaufoy 2001, Camarsa *et al.* 2010). In Greece, most of the olive groves are situated in hilly areas with shallow soils, hence soil erosion is a widespread problem. In semi-arid areas such as the south coastal area of Peloponnese it can in extreme cases even lead to desertification (Beaufoy 2001). Traditional olive groves with low tree intensity that is adjusted to the contours of the landscape, or planted on terraces with stonewalls, and has a cover crop on the ground, can counteract erosion (Camarsa *et al.* 2010, Wingård 2010). Other environmental problems associated with olive cultivation that have increased since the 1980s when the intensification started, are increased irrigation and increased use of chemical fertilizers, pesticides and herbicides (Beaufoy 2001, Lymperopoulos 2014). Moreover, CO_2-releases from burning branches in field and tractors contribute to global warming (Camarsa *et al.* 2010, Flodin 2011).

Alternative olive cultivation methods

Olive groves can be divided into four categories; (1) intensified conventional plantations, (2) low-intensive traditional plantations, (3) organic plantations, and (4) semi-abandoned small-scale plantations. The intensified plantations are estimated to stand for over 50 % of the olive production, but occupies only 30 % of the total area of olive plantations in the world, whereas traditional plantations stand for 40 % of the production and occupies 50 % of the area (Wingård 2010). Traditional low-intensive olive plantations have the least negative environmental impact and potentially the highest capacity to support biodiversity due to their long continuity, but they are also the least economically sustainable and therefore subjects for abandonment (Beaufoy 2001).

In 2009, 3.94 % of the total agricultural area in Greece was constituted by organic farming, a rapid increase from 0.7 % in 2000 (Solomou & Sfougaris 2011, Angeliki 2013). The organic cultivation methods include biological and mechanical weed and pest control without chemicals, as well as more low-intensive harvesting, pruning and irrigation methods (Beaufoy 2001, Solomou & Sfougaris 2011, Angeliki 2013). The aims of organic cultivation are to minimize the use of non-renewable resources and chemicals resulting in reduced environmentally negative effects, to maintain long-term soil fertility and to preserve and enhance biodiversity (Solomou & Sfougaris 2011, Angeliki 2013).

In conventional olive plantations the ground is harrowed and cleared of ground flora to minimize the competition for water and nutrition, and to increase the water infiltration. The harrowing increases the risk for erosion, disturbs the tree roots and fragments plant communities (Wingård 2010, Flodin 2011, Lymperopoulos 2014). In organic and traditional olive cultivations, the ground flora grows almost freely, and habitats for insects, reptiles, birds and mammals are preserved (Beaufoy 2001, Lymperopoulos 2014). These kinds of olive groves do accordingly host a great variety of plant and animal species, and have an anti-erosion effect (Loumou & Giourga 2002). The ground vegetation in olive groves do also provide cover for soil organisms that contribute to the nutrition input in the soil and can act as a biological defense against pest insects (Solomou & Sfougaris

2013). In general, positive effects of organic farming on biodiversity have been well documented for various crops (Benton *et al.* 2003, Hole *et al.* 2004, Solomou & Sfougaris 2011).

Messenia – an olive dominated landscape

Messenia is a region in the southwestern part of the half-island Peloponnese (Figure 1). Peloponnese and Crete are the regions that have undergone the biggest expansion of intensified olive plantations (Beaufoy 2001, Wingård 2010). Messenia is one of the oldest olive cultivation areas in Greece and olive cultivation has been the main income for its inhabitants for centuries (Giannopoulou 1990). Between 1206-1500 AD Messenia was a Venetian colony and olive oil production was supported for export to Venice. In the years 1685-1688 AD the Venetians occupied Messenia again by defeating the Turks and replanted olive trees through the area (Giannopoulou 1990). Under the 19th century Messenia was occupied by the Ottoman Empire who under the occupation carried through extensive burning and cutting down of olive trees and thus very few of the olive trees in Messenia are older than 130 years (Flodin 2011). After the Turks left Messenia in the 1880s until 1950-1980 most of the agricultural production was focused on currants and grapes, but after Greece's entry to the European Union in 1981 olive plantations increased drastically due to the generous subsidies. Nowadays it is unusual with new olive plantations since all cultivable land in the area already is occupied, however the production is still increasing due to the increasing yield in older trees and more modern and effective cultivation practices (Flodin 2011). In 1990 olive plantations made up 98 % of all agricultural cultivation in Messenia and among fruit trees 83 % were olive trees (Giannopoulou 1990). The local olive sort is Koroneiki, a low-stem type that is used for olive oil production and therefore the fruits do not have to become so big in comparison with table olives and consequently do not need the same amount of water (Beaufoy 2001, Flodin 2011, Lymperopoulos 2014).

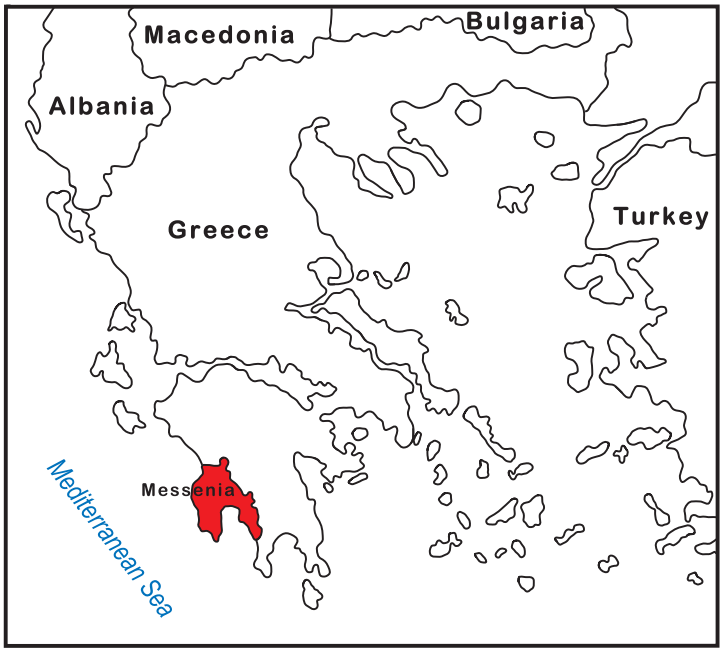


Figure 1. Overview map showing the location of Messenia in Greece. (Drawn in OCAD 11 Professional, F. Kjellström, 2014).

Source: Satellite images from Google Earth (2013).

Aim of study and research questions

The aim of this study is to investigate how different olive cultivation methods affect plant diversity and ultimately all biodiversity in the region of Messenia. Because of the limits of time and resources in the study I have chosen to focus on these three research questions:

I. Does the species richness among plants differ between organic and conventional olive groves?
II. If so, what are the main factors affecting the plant diversity?
III. Is there a need to preserve plant diversity in olive groves and what are the proper precautions?

Material and Methods

Description of study site

The studied olive groves are situated in Messenia; the southwest part of the region Peloponnese in Greece. Messenia borders to the Ionian Sea to the west and the Gulf of Messenia to the south (Figure 1). To the east there are the Taygetus mountain range. Messenia has a total area of 2 991 km^2. From the mountains down to the coast the landscape forms fertile and well-drained agricultural plains. The plains and parts of the mountain slopes are dominated by olive groves. In the area of the study site the landscape is dominated by intensified conventional olive groves. The short Koroneiki-trees stand in row after row and the ground is harrowed and totally cleared of ground flora. There are patches of natural forest vegetation and in the edge zones of the plantations bordering to houses or roads a great variety of wild flowers are standing in bloom. The Greek flora is characterized by great species richness and a high percentage of endemic species fundamentally due to the fact that Greece borders two continents; Africa and Europe, with essentially different species composition and that the country is constituted by a diverse landscape of large mountain ranges and a multitude of islands (Papiomitoglou 2006). The two continents have contributed to a unique mix of species and the mountains and islands form isolated biotopes where many ancient endemic species have been conserved and new species have been formed. There are around 6000 species and over 15 % are endemic (Papiomitoglou 2006). The most species rich families in the Greek flora are Poaceae, Asteraceae, Fabaceae, Caryophyllaceae and Labiateae (Solomou & Sfougaris 2011).

The organic and conventional olive groves that were included in this study are located close to 36°58’06” N, 21°42’67” E, about 2 km north of the village of Gialova on a elevation about 140 meters over the sea (Figure 2). The organic olive grove is approximately 4 hectares with around 1300 olive trees. It borders to a gravel road to the east and south, natural forest to the west and northwest and a conventional olive grove to the north (Appendix A). The conventional olive groves are situated on the other side of the gravel road on the east side of the organic olive grove. Since I did not have the possibility to interview a conventional olive cultivator I could not distinguish between the different groves but they where all harrowed and cleared of ground flora and therefore I made the conclusion that they were cultivated with conventional methods. At some places the soil had been harrowed all the way until the gravel road started and the ground vegetation had

been totally cleared. The studied conventional olive groves bordered to the west to the gravel road and observations from satellite images on Google Earth shows that they all border other conventional olive groves or other roads in other directions (Appendix B).

Figure 2. Overview map showing the location of the study site north of the village Gialova in Messenia. (Drawn in OCAD 11 Professional, F. Kjellström, 2014).
Source: Satellite images from Google Earth (2013).

Field inventory

In the field study the plant species in the edge zones, i.e. plantation margins, of an organic and a conventional olive grove were inventoried to investigate difference in species richness among vascular plants. An interview was carried out with an organic olive cultivator to examine the methods of organic olive cultivation, the differences between organic and conventional methods and the impact on biodiversity.

The field inventory on the organic olive grove was carried out the 12-13th of May 2014. The timing was good since many species were flowering but the inventory can only represent a snapshot of the total species occurring throughout the year. The inventory was made in the edge zones around the plantation that were about 0,5-3 m wide. I used a 0,25 m^2 sample-square in wood, a measuring tape, a Garmin Dacota® 20 GPS-navigator, a notepad and two floras; *Wild Flowers of Greece* (Papiomitoglou 2006) and *Plants of the Peloponnese - Southern Part of Greece* (Strasser 1998).

The used method for the inventory was line taxation with systematically outplaced sample-squares referred to V 02505 in *BIN - Biologiska Inventeringsnormer Vegetation* (BIN – Biological Inventory Norms Vegetation, *my trans.),* a handbook for vegetation inventories by the Swedish Environmental Protection Agency (Liljelund & Zetterberg 1986). BIN states this method to be suitable to obtain comparative figures of species richness in a decided area.

However I could not use straight lines in my inventory since the edge zones were surrounding an asymmetrical plantation in different directions. The 0,25 m^2 size of the sample-square is appropriate for vegetation types with normal sized plants in meadow or small-scaled mosaic ecosystems (Liljelund & Zetterberg 1986). In similar comparative studies in organic and conventional olive groves in central Greece by Solomou & Sfougaris (2011 & 2013) the same size was used to investigate the herbaceous vegetation. I placed the sample-squares with 25 meters distance around the whole plantation in the edge zones to get a general representation of occurring species. For all the sample-squares elevation and position was noted with help of the GPS. Thereafter all occurring species of living vascular plants were noted and photographed. Totally 35 sample-squares were investigated. The total length of the edge zones was approximately 1500 meters.

The inventory of the conventional olive groves was carried out 15th of May 2014. I used the same method as in the organic olive grove except that this time I followed the border between the olive groves and a gravel road to investigate species richness in the edge zones. To make comparison with the organic olive grove possible this inventory was also made in 35 sample-squares in edge zones of a total length of 1500 meters. The edge zones of the conventional olive groves were 0-1 m wide.

Interview method

Under my visit in Messenia I interviewed the owner of the organic olive grove included in my field inventory. The interview was focused on olive cultivation and particularly organic methods and resulted in an open conversation about cultivating and the impact on biodiversity. The interviewee was Nikos Lymperopoulos; organic olive cultivator and nature guide. The interview was on the 13th of May 2014.

Literature review

To be able to answer the research questions in a broader perspective a literature review based on recent scientific articles on the subject was made. The scientific articles were chosen according to their relevance and applicability to the subject.

Project limitations

Since there was only a limited time to make field studies on place in Messenia only a limited amount of data could be gathered for this study. For a reliable ecological comparison study between the edge zones of organic and conventional olive groves with a more general result it would have been necessary to make inventories in more olive groves in different places with different environmental conditions. The inventory in this study is therefore to be viewed as a case study to inspire further studies in the area.

Consequently there was no motivation to make a statistical analysis on the result since the difference in figures in this case is obvious and no general conclusion about the difference biodiversity in edge zones of organic and conventional olive groves can be made.

Other environmental variables that could have been observed and that can have an impact on the result are slope angle and aspect, pH, soil composition and surroundings.

Results

Field inventory

In total 71 species from 25 families of vascular plants were noted in the inventory of the olive groves, where 17 species were found both in the organic and conventional one (Figure 3). In the organic olive grove a total of 55 species and in the conventional olive grove a total of 33 species were recorded (Appendix C & D). 38 species were only found in the organic olive grove and 16 species were only found in the conventional olive grove. The number of species varied from 1-12 species with a mean of 5.5 species per sample-square in the organic olive grove. In the conventional olive grove the number of species per sample-square varied from 0-5 species with a mean of 2.4 species.

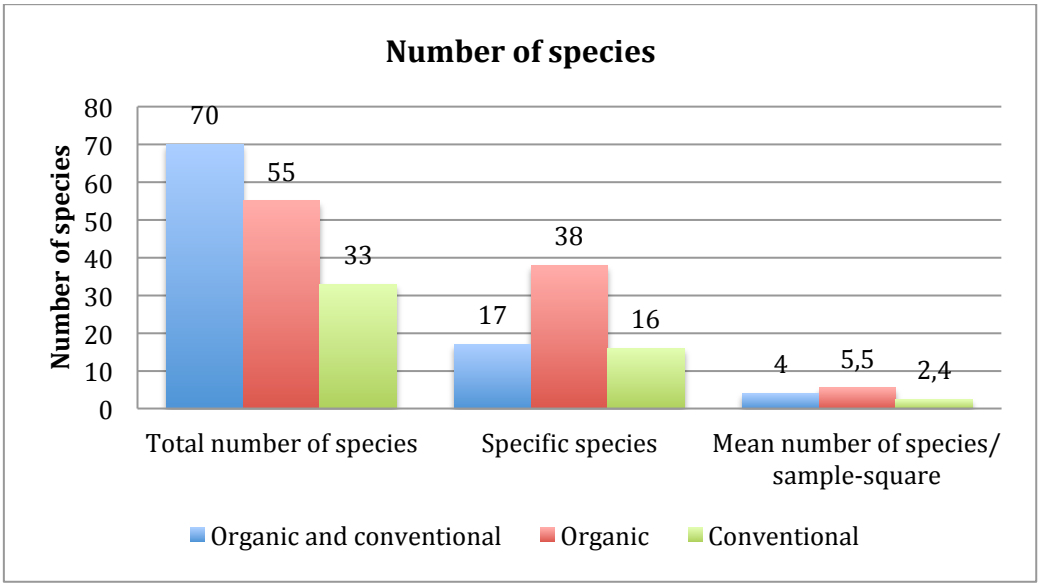


Figure 3. Chart over number of species recorded in field inventory in the olive groves.

The most common species were *Avena sterilis* and *Galactites tomentosa* that occurred in 44.3 % and 37.1 % respectively of all the sample-squares (Table 1). *Avena sterilis* occurred in 65.7 % of the sample-squares in the organic olive grove and 22.9 % of the sample-squares of the conventional olive grove. *Galactites tomentosa* occurred in 54.3 % of the sample-squares of the organic olive grove and 20 % in the conventional olive grove.

Table 1. The occurrence in percentage of sample-squares of nine most common species in the organic respectively conventional olive grove.

Organic olive grove	**(%)**	**Conventional olive grove**	**(%)**
Avena sterilis	65.7	*Avena sterilis*	22.9
Galactites tomentosa	54.3	*Chrysantemum segetum*	20.0
Knautia integrifolia	25.7	*Galactites tomentosa*	20.0
Chrysantemum segetum	22.9	*Knautia integrifolia*	20.0
Ferula communis	22.9	*Hordeum* sp.	17.1
Trifolium campestre	22.9	*Eruca sativa*	14.3
Cistus creticus	17.1	*Lavatera cretica*	14.3
Echium plantagineum	17.1	*Avena* sp.	11.4
Vicia sp.	17.1	*Echium plantagineum*	11.4

The most common families were Fabaceae 20 %, Poaceae, 18 % and Asteraceae 16 % (Figure 4). Other families were Primulaceae, Asparagaceae, Brassicaceae, Gentianaceae, Campanulaceae, Cistaceae, Boraginaceae, Apiaceae, Geraniaceae, Clusiaceae, Dipsasaceae, Cinaceae, Ranunculuaceae, Liliaceae, Fagaceae, Rosaceae, Lamiaceae, Caryophyllaceae, Malvaceae, Papaveraceae, Scrophuliaceae and Vitaceae.

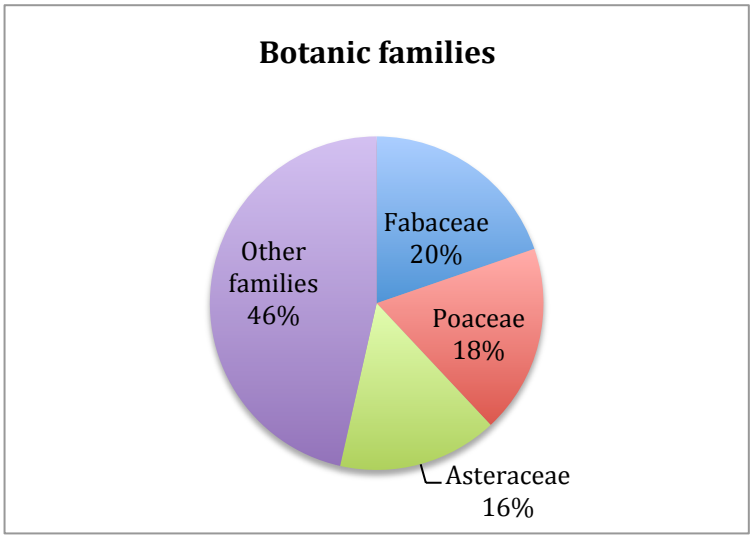


Figure 4. Chart over most common families in the inventory of both the organic and conventional olive groves.

Interview with Nikos Lymperopoulos *(May 13th 2014, Gialova, Greece)*

Nikos Lymperopoulos was born in Gialova and works as an organic olive cultivator and nature guide in the area. Lymperopoulos took over the studied organic olive plantation around year 2000. He inherited the plantation from his grandfather. His grandfather got 2 ha with olive trees from the government before the Second World War in 1937/1938. He had to clear it from bushes and wild vegetation, which was very hard work. After a couple of years Lymperopoulos' grandfather bought another 2 ha. He could not afford to buy new olive trees; instead he got grafts from friends and neighbors. Now Lymperopoulos owns the plantation that is 4 ha big. He wanted to try organic cultivation because of ideology. When he was young he travelled around Europe and learned about ecology and alternative lifestyles. When he came back to Greece he wanted a new calm life far away from the city. In 1945, after World War II, industrialization began in Greece and factories that produced fertilizers were introduced. Lymperopoulos continued to use traditional methods, for example plowing with horses. When Lymperopoulos took over the plantation there were very few organic farmers in the area and he had to come up with organic methods by himself. In the beginning he tried to organize himself with other organic farmers but they were very conspicuous and not open-minded so he decided to work by himself. As other organic farmers he gets a small contribution from the government for producing organic products. He uses a bio-fertilizer from the Netherlands. Moreover he leaves the grass growing freely under the trees under winter and spring and then cuts it in early summer and leaves the cut grass on the ground to decompose to organic matter that can function as extra fertilizer. He usually just leaves the grass as it is but tells me there is another method when you powderize the grass. The cut grass does not only function as a fertilizer but also prevents erosion. He uses organic pesticides before

and after flowering for two different kinds of insects. In late summer from August to October when the nights are warm and wet there is one kind of insect that puts eggs inside the nuts that will rotten and fall down. For this insect there is a pesticide called “vakilos” that constitutes of a parasite that enters the insects and kill them. He only sprays every other tree with pesticides to minimize the use as much as possible. He has to control the trees every day to see if there are any insects and to control the need for water. Lymperopoulos only employs one person to help him and that person cuts the grass in late spring.

The harvest is from the end of October until Christmas. Every tree has a greater harvest every other year and it depends on how you prune the trees. Too many olives on the same tree usually mean worse quality. A medium full tree is best. The harvest also depends on how much fertilizers, nutrients and minerals that are given to the trees. Some olive farmers do not use irrigation. 10 years ago Lymperopoulos dug a 180 m deep well that is abundant with water that he uses for irrigation on the plantation. With irrigation the harvest is doubled. He adjusts the irrigation after the weather and uses drip irrigation. Under the harvest period the olives are sent to the olive oil factory every other day to be pressed with cold water. After that the olive oil is stored for one month before sale.

There are three kinds of trees on the plantation; Koroneiki, Black olive and Table olive. Koroneiki is the most common olive sort in Messenia and is used for olive oil. Black olive is an unusual kind that was brought to Messenia by the king Nestor over 100 years ago. They are also used for olive oil. The olives are more watery and easier to press but the harvest is smaller than Koroneiki. The Black olive has an earlier harvest period. In other plantations they are usually cut down and grafts of table olive trees are transplanted on them. There are only three trees with table olives that Lymperopoulos cultivates for his own use. The table olives are bigger and fruitier. There are 80 Black olive trees and around 1200 Koroneiki olive trees on the plantation. A good year the total harvest can be up to 8000 kg of olives and a bad year around 4000 kg. A normal harvest is around 5000-6000 kg. A normal tree gives around 10-15 kg of olive oil. A big tree that is around 50 years old can give up to 20 kg of olive oil. A 100-year-old tree can give up to 100 kg of olive oil. The olives from Lymperopoulos' plantation are certified by the Greek certification system called DIO that apply the rules for organic farming decided by EU and have a special serial number. He sells the olive oil under his own name. Most is exported to England and Germany since the market for bio-products in Greece is still very small. One liter of organic olive oil is sold for about 14-16 € in Germany and for about 6 € in Greece. Lymperopoulos thinks that this is also caused by the economic crisis in 2008. Because of the high rate of unemployment the demand for cheap products is very high. Lymperopoulos’ olive oil has a very high quality and has won a prize for best organic olive oil in Belgium.

Lymperopoulos thinks that local people in the area lack of education and knowledge about organic methods and ecology and therefore have little or no interest in organic farming methods. Many of the farmers are farming just because they did not have any other choice since it is very hard to find work now that there is an economic crisis in the country. He thinks that many olive farmers use too much fertilizers and pesticides and that leakage of toxins and other chemical substances is substantial. But there is also another trend of young unemployed people from the big cities that choose to move to the countryside with an aim to support themselves and live a more natural lifestyle. These people are educated

and generally have a big interest in organic cultivation and want to learn more. Now there are more and more organic farmers in Messenia and the methods are evolving by research. It is now easier to get help from agronomists specialized in organic farming.

In early spring (end of February until mid of April) there are many low herbs and orchids growing in the olive grove. From April until autumn the high herbs dominate. When Lymperopoulos cuts the grass he usually leaves some flowers around the trees and in the edges of the plantation. He leaves the high grass and herbs as long as possible because they are habitats for insects that otherwise would move to the trees. He continuously controls the trees for insects. Lymperopoulos has observed a lot of animals in his olive grove, for example turtles, hedgehogs, snakes, foxes, mice, wild cats and buzzards. The buzzards were almost gone a couple of years ago after a harsh winter but has come back recently. He thinks that the vegetation in the olive grove is a good habitat for insects that are eaten by birds and reptiles and thus have a great importance for the biodiversity since they are the foundation of the food chain. On three sides the plantation is surrounded by forest and on the last side it connects with a road. By the edge of the forest there are boxes for wild bees to make organic honey. Lymperopoulos has a great interest for wild animals and therefore works as a nature guide in the area to spread knowledge about and support for biodiversity.

Discussion

Does the species richness among plants differ between organic and conventional olive groves?

In the results a clear difference was recorded for species richness. In the organic olive grove 55 species were found, whereas in the conventional only 33 species were found; 40 % less species (Figure 3). Specific species only found in the organic plantation were 38, whilst 16 species were only found in the conventional plantation; 58 % less specific species (Figure 3). Because of the limitations of the study no general conclusions can be drawn from the results, but in this particular case the differences in plant diversity are obvious; the organic olive grove hosted greater plant diversity.

If so, what are the factors affecting the plant diversity?

The traditional olive groves host a flora very similar to the flora of natural Mediterranean ecosystems such as the phrygana; low shrubland on stony, infertile soil characterized by spiny plants containing essential oils, e.g. *Sarcopterium spinosum* and *Cistus* spp., with an undervegetation of herbaceous species and orchids (Loumou & Giourga 2002, Papiomitoglou 2006). The ground flora in olive groves creates habitats for animal species, especially insects, reptiles and small mammals, which in turn are food sources for predators such as birds (Loumou & Giourga 2002, Allen *et al.* 2005, Lymperopoulos 2014). In the inventory no endemic or threatened species were found, but some species characteristic to phrygana such as *Sarcopterium spinosum* and *Cistus creticus.* Since the inventory was made in May, no orchids or other early blooming species were noted. The species richness of plants in olive plantations is mainly dependent on location, soil fertility and cultivation practices (Solomou & Sfougaris 2013). The differing

cultivation methods that likely had an impact on the plant diversity are (Hole *et al.* 2004):

- Use of chemical pesticides and/or herbicides
- Use of mineral-based fertilizers or green manuring
- Tillage
- Irrigation

On a landscape-scale both olive groves were situated on a low hill close to the sea under dry conditions with dry soils. On a microclimate-scale the organic olive grove was protected on three sides by natural vegetation, which created more moist conditions, whereas the edge zones of the conventional olive grove were dry and dusty due to the proximity to the gravel road. The results indicate that the organic olive grove have a plant composition basically defined by the surrounding vegetation; forest and phrygana that have spread to the edge zones of the plantation. The plant composition in the conventional olive grove was limited by space and could also have been affected by pesticides and/or herbicides, and thus was composed of fewer but more tolerant and more competitive species such as *Galactites tomentosa* and *Avena sterilis* that also were common in the organic olive grove. Since the studied olive groves were in close vicinity, some of the plant species have probably spread over the gravel road as well as rests of pesticides and herbicides might have spread from the conventional olive grove to the organic olive grove. As organic plantations often are few and surrounded by conventional plantations it is often the case that the organic plantations are affected by pollutants from the surrounding plantations (Hole *et al.* 2004, Solomou & Sfougaris 2011). However the studied organic plantation bordered to natural vegetation on three sides, which most probably have influenced the plant diversity positively, diminished the risk for pollution from those directions and created a more moist and protected microclimate. These factors as well as the fact that the edge zones of the organic plantation were much wider (1-4 m) than the edge zones of the conventional plantation (0-1 m) might have had stronger impact on the plant composition than the differing cultivation methods. Nonetheless the extensive tillage on the conventional olive grove where all ground flora was cleared, in comparison with the organic olive grove where the ground flora was growing freely and later on cut and left on the ground as a green fertilizer, most probably have had an impact on the plant diversity in the plantation margins. Almost all of the conventional plantations in Messenia are harrowed and cleared of ground vegetation to control weed growth, aerate the soil, mix up moisture in the soil and make the olive grove more visually tidy (Flodin 2011, Sokos *et al.* 2012). The extensive harrowing where the soil is left bare under the olive trees leads to a higher erosion risk as well as drier conditions and compacts the soil so that nutrients are lost (Beaufoy 2001, Allen *et al.* 2005, Camarsa *et al.* 2010, Wingård 2010, Flodin 2011). It might also lead to smaller spreading opportunities for wild plants since they are abolished over and over again and no animals come to seek for food and therefore seed transportation is possible only by wind. Merely very dry tolerant and fast growing species can survive under these conditions. On the other hand in the organic plantation higher freely growing herbaceous species create shady and moister microclimates for smaller more sensitive species and more niches are available. Drip irrigation was used in both olive groves and thus had most probably no effect on the result. The clearing of vegetation in the conventional plantations has also shown to decrease diversity and abundance of

soil organisms, which are very important for soil ecology and fertility (Solomou & Sfougaris 2011). Removing the vegetation also has a wider ecological impact since feeding, hiding and breeding resources for insects, reptiles, birds and mammals thus disappears (Allen *et al.* 2005). In similar comparative studies by Solomou & Sfougaris in 2011 and 2013 and Solomou *et al.* 2013 similar results where the organic olive groves generally hosted a higher plant diversity were achieved. In their study in 2011 Poaceae and Asteraceae were the most important plant families and 56 species were recorded. In 2013 the most common plant families were Asteraceae, Poaceae and Fabaceae, which was the same results as in the present study. Solomou *et al.* (2013) emphasizes the importance of Fabaceae that contributes to the nitrogen level in the soil, improve soil structure, increase the organic matter proportion and provide nectar, seeds and cover for insects and animals. Solomou & Sfougaris' (2011) results indicates that 10 years of organic cultivation in olive groves is a significant period of time to create good conditions for high plant diversity. In a literature review concerning biodiversity in organic fields by Hole *et al.* (2004) 16 out of 17 studies showed that plant diversity was higher in organically managed plantations than conventional plantations. In these studies the differences in abundance and species richness were greater for broad-leaved species from the families Fabaceae, Brassicaceae and Polygonaceae than Poaceae, which suggests that broad-leaved species are less tolerant to herbicides and chemical fertilizers. Noticeably, more rare and declining species were found in the organic fields than in the conventional fields in these studies (Hole *et al.* 2004).

Is there a need to preserve plant diversity in olive groves and what are the proper precautions?

Old olive groves with traditional cultivation host diverse vegetation communities with a rich ground flora and an associated fauna (Beaufoy 2001, Allen *et al.* 2005). The Mediterranean basin is estimated to suffer the greatest proportional loss of biodiversity until year 2100 due to the susceptibility to land-use and climate changes (Underwood *et al.* 2009, Sokos *et al.* 2012). The intensification of olive cultivation is a characteristic example of the omnipresent conversion from heterogenic low-input mosaic landscapes to monogenic high-input landscapes that are now dominating the agricultural areas in Greece as well as the rest of Europe, which leads to fragmentation and loss of species rich habitats (Beaufoy 2001, Allen *et al.* 2005). In a study by Flodin (2011) most interviewed olive cultivators had as the interviewee Nikos Lymperopoulos observed a decrease in numbers among birds and snakes in Messenia since the intensification of olive cultivation began in the 1980s. Lymperopoulos and the interviewees from Flodin's study (2011) suggested that the reason behind the loss of biodiversity was the lack of habitats in the monocultural landscape that now dominates. A thesis that corresponds to conclusions in recent studies concerning loss of biodiversity in agricultural landscapes (Beaufoy 2001, Benton *et al.* 2003, Hole *et al.* 2004, Cousins 2006, Zamora *et al.* 2006, Underwood *et al.* 2009, Andersson 2010, Solomou & Sfougaris 2011, Sokos *et al.* 2012, Solomou & Sfougaris 2013). The plants are the foundation for the biodiversity of insects, mammals, birds and reptiles as primary producers in the ecosystem that provides habitats and feeding and breeding resources and are thus essential to support and conserve biodiversity for the future. Biodiversity have been shown to be higher in traditional olive groves with long continuity and rich ground flora (Beaufoy 2001, Allen *et al.* 2005, Sokos *et al.* 2012). In Greece

there have been few studies concerning biodiversity related to conventional and organic cultivation methods but there is a lack of comparative studies on biodiversity between conventional and organic olive groves (Solomou & Sfougaris 2011). In the studies by Solomou & Sfougaris in 2011 and 2013, organic olive groves in Greece where ground flora was not totally cleared as in conventional olive groves showed a higher biodiversity in form of abundance and species richness among herbaceous plants and birds. This indicates as the present study that the ground flora that is present in traditionally and organically managed olive groves are fundamental to support wildlife biodiversity.

Another important purpose to sustain and enhance ground vegetation in olive plantations is to prevent soil erosion; the most urgent environmental problem associated with olive cultivation that leads to water-pollution and reduced soil fertility (Beaufoy 2001, Allen *et al.* 2005, Solomou *et al.* 2013). The ground vegetation binds the soil with root systems, increases the water infiltration, decreases the water run-off and leads to a higher proportion of organic matter in the soil (Wingård 2010, Flodin 2011). In comparative cultivation experiments the production in non-harrowed olive plantations were higher than in harrowed plantations (Wingård 2010).

To preserve plant diversity in olive groves the primary measure would conclusively be to restrict or forbid intensive tillage in form of harrowing or ploughing. Traditionally the ground of olive groves was used to cultivate other crops, e.g. cereals or vine, or for grazing. Raising sheep in the orchards is an environmentally friendly method; it includes effective weed control, natural fertilizer from manure and promotes plant diversity (Beaufoy 2001). Restrictions or prohibition against tillage can be achieved by law enforcement from the Greek government or the European Union, promotion of organic cultivation and protection and support to traditional cultivation. As the interviewee Nikos Lymperopoulos emphasized there is a lack of knowledge among the olive cultivators and spreading knowledge, information and advices to local farmers could be a key measurement. Flodin (2011) stresses the importance of economical sustainability for the farmers to incite more environmentally friendly cultivation methods, in form of subsidies and support to enlarge the market for Greek olive oil to be sold as a finished product under Greek flag instead of being exported to be bottled in Italy.

On a larger scale, monitoring land-use changes e.g. through remote sensing and develop research databases for biodiversity in agricultural landscapes are substantial to prevent further loss of biodiversity and ecosystems (Beaufoy 2001, Allen *et al.* 2005).

Conclusions

The studied organic olive grove hosted 40 % higher species richness among plants than the conventional olive grove. The plant diversity in the margin zones of the organic olive grove was probably mostly defined by the surrounding vegetation: forest and phrygana. The plant diversity of the conventional olive grove was mainly limited by lack of space and the extensive tillage, but might also have been affected by impact from chemical pesticides. The results indicates as in other similar studies that the organic olive cultivation methods have a higher capacity to support biodiversity, since wild plants as primary producers in the ecosystem that

provides habitats and feeding and breeding resources are the foundation for the biodiversity of insects, mammals, birds and reptiles naturally occurring in traditionally managed olive groves. The ground flora of olive groves is thus essential to support and conserve biodiversity in the Mediterranean agricultural landscape for the future. By restricting or forbidding tillage and clearing of ground flora in olive groves and promote organic olive cultivation not only biodiversity would be enhanced, this could also prevent further soil erosion and create a more heterogenic agricultural landscape with higher biological and cultural values.

References

Allen, H. D., Randall R. E., Amable G. S. & Devereux B. J. (2005): *The impact of changing olive cultivation practices on the ground flora of olive groves in the Messara and Psiloritis regions, Crete, Greece.* Land Degrad. Develop. 17 (2006): 249–273. Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/ldr.716

Andersson, K. (2010): *How important are small remnant habitats for biodiversity in the agricultural landscape?* Master's thesis, Physical Geography and Quaternary Geology, 30 HECs. Department of Physical Geography and Quaternary Geology, Stockholm University, Stockholm.

Angeliki Evliati, M. (2013): *Farmers' perspectives on Common Agricultural Policy –a case study in central Greece.* Master's thesis, Geography, 30 credits. Department of Physical Geography and Quaternary Geology, Stockholm University, Stockholm.

Beaufoy, G. (2001): *The environmental impact of olive oil production in the European Union: Practical options for improving environmental impact.* European Forum on Nature Conservation and Pastoralism and the Asociación para el Análisis y Reforma de la Política Agro-rural.

Benton, T. G., Vickery, J. A., Wilson, J. D. (2003): *Farmland biodiversity: is habitat heterogeneity the key?* TRENDS in Ecology and Evolution Vol. 18 No. 4 (April 2003): 182-187.

Camarsa, G., Gardner, S., Jones, W., Eldridge, J., Hudson, T., Thorpe, E., O'Hara, E. (2010): *LIFE among the olives – Good practice in improving environmental performance in the olive oil sector.* European Commission, Environment Directorate-General. European Union, Belgium. DOI: 10.2779/8360.

Cousins, S. A. O., (2006): *Plant species richness in midfield islets and road verges – the effect of landscape fragmentation*. Biological Conservation 127 (2006): 500-509.

Flodin, C. (2012): *Vem kontrollerar Greklands olivodlingar? Messinien, 1980 till 2012 och framåt.* Bachelors' thesis in Physical Geography. Department of Physical Geography and Quaternary Geology, Stockholm University, Stockholm.

Giannopoulou, A. (1990): *The economical development of the Greek olive-oil industry with special reference to Messenia province.* Doctor's thesis, Department of Economics, University of Salford, Manchester.

Henle, K., Alard, D., Clitherow, J., Cobb, P., Firbank, L., Kull, T., McCracken, D., Moritz, R. F. A., Niemela, J., Rebane, M., Wascher, D., Watt, A., Young, J. (2008*): Identifying and managing the conflicts between agriculture and biodiversity conservation in Europe – A review.* Agriculture, Ecosystems and Environment 124 (2008): 60-71.

Hole, D. G., Perkins, A. J., Wilson, J. D., Alexander, I. H., Grice P. V., Evans, A. D. (2004): *Does organic farming benefit biodiversity?* Biological Conservation 122 (2005): 113-130.

Liljelund, L.-E. & Zetterberg, G. (1986): *BIN – Biologiska InventeringsNormer Vegetation.* Rapport 3278. Metodbeskrivningar. Naturvårdsverket, Solna.

Loumou, A. & Giourga, C. (2002): *Olive groves: "The life and identity of the Mediterranean".* Agriculture and Human Values 20 (2003): 87-95.

Palmgren, L. & Gordan, K. (2007): *Träd och myter i Greklands övärld.* Krilon förlag, Klintehamn. 16 p.

Papiomitoglou, V. (2006): *Wild Flowers of Greece.* Mediterraneo Editions, Rethymno Crete. 258 p.

Petanidou, T. & Kizos, T. (2008): *Socioeconomic Dimensions of Changes in the Agricultural Landscape of the Mediterranean Basin: A Case Study of the Abandonment of Cultivation Terraces on Nisyros Island, Greece.* Environmental Management 41 (2008): 250-266. DOI: 10.1007/s00267-007-9054-6.

Sokos, C. K., Mamolos, A. P., Kalburtji, K. L., Birtsas, P. K. (2012): *Review: Farming and wildlife in Mediterranean agroecosystems.* Journal for Nature Conservation 21 (2013): 81-92.

Solomou, A. D. & Sfougaris A. (2011): *Comparing conventional and organic olive groves in central Greece: plant and bird diversity and abundance.* Renewable Agriculture and Food Systems: 26(4); 297-316 (2011). DOI: 10.1017/S1742170511000111

Solomou, A. D. & Sfougaris, A. (2013): *Herbaceous Plant Diversity and Identification of Indicator Species in Olive Groves in Central Greece.* Communications in Soil Science and Plant Analysis 44 (2013): 320-330. DOI: 10.1080/00103624.2013.741926

Solomou, A. D., Sfougaris, A. I., Kalburtji, K. L., Nanos, G. D. (2013): *Effects of Organic farming on Winter Plant Composition, Cover and Diversity in Olive Grove Ecosystems in Central Greece.* Communications in Soil Science and Plant Analysis 44 (2013): 312-319. DOI: 10.1080/00103624.2013.741914

Strasser, W. (1998): *Plants of the Peloponnese – Southern Part of Greece.* A. R. G. Gantner Verlag KG, Ruggell/Liechtenstein. 350 p.

Underwood, E. C., Viers, J. H., Klausmeyer, K. R., Cox R. L., Shaw M. R. (2009): *Threats and biodiversity in the Mediterranean biome.* Diversity and Distributions 15 (2009), 188–197.

Wingård, S. (2010): *Olivolja och bordsoliver. Rapport 2010:34.* Jordbruksverket, Jönköping. 78 p.

Zamora, J., Verdú, J. R., Galante, E. (2006): *Species richness in Mediterranean agroecosystems: Spatial and temporal analysis for biodiversity conservation.* Biological Conservation 134 (2007): 113-121.

Internet sources

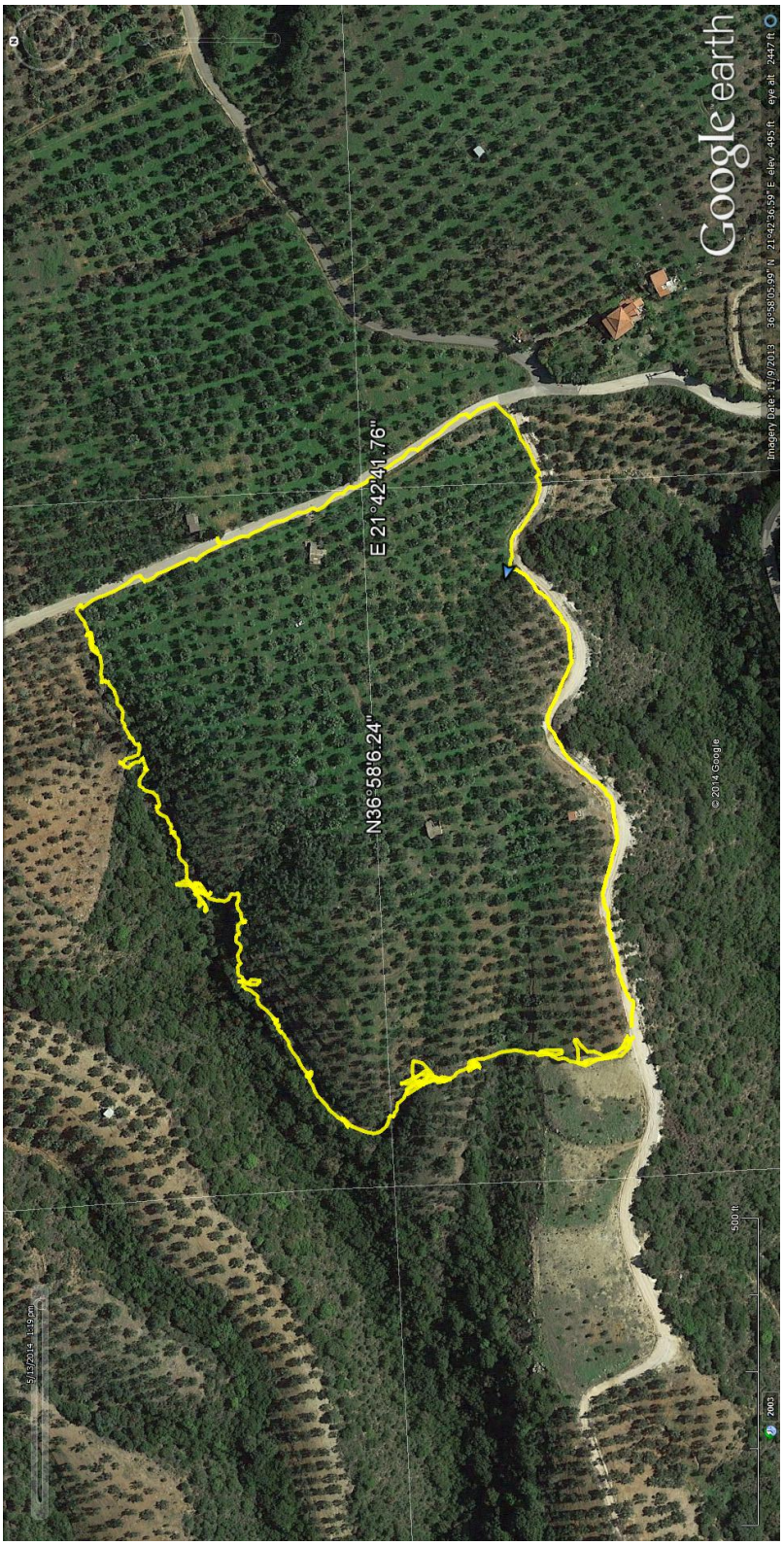
International Olive Oil Council, IOOC 2014.
World Olive Oil Figures
http://www.internationaloliveoil.org/estaticos/view/131-world-olive-oil-figures
Published November 2013. Downloaded: 11-06-2014.

Personal interviews

Nikos Lymperopoulos, organic olive cultivator and nature guide.
May 13th 2014, Gialova, Greece.

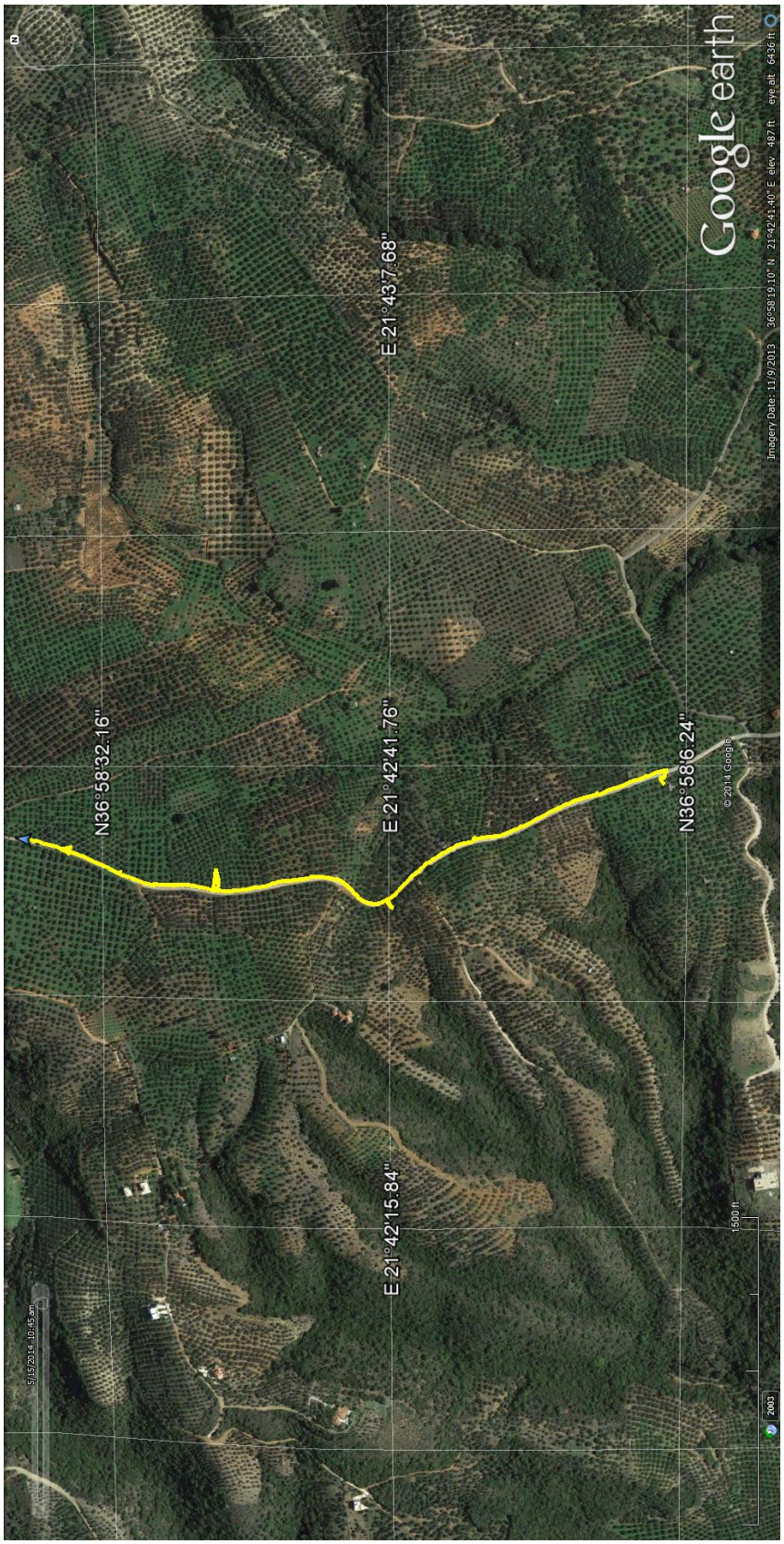
Appendix A

Satellite image from Google Earth (2013) over organic olive grove. Inventory marked by yellow line based on GPS-waypoints.



Appendix B

Satellite image from Google Earth (2013) over conventional olive grove. Inventory marked by yellow line based on GPS-waypoints.



Appendix C

Table with species occurrence in sample-squares 1-35 from inventory of the organic olive grove May 12-13th 2014.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Tot:
Aegilops triuncialis			x		x		x	x																												4
Anagallis arvensis																																x				1
Anthyllis tetraphylla																						x														1
Asparagus acutifolius	x																																			1
Avena sterilis	x	x	x	x		x	x		x		x	x	x						x			x	x	x	x	x	x	x	x	x			x	x	23
Biscutella didyma																																	x		x	2
Blackstonia perfoliata											x										x															2
Briza maxima													x		x																					2
Bromus hordeaceus																						x														1
Bromus lanceolatus	x		x																																	2
Campanula spatulata																			x		x	x														3
Campanula ramosissima														x	x		x																			3
Chrysantemum segetum				x	x	x	x	x				x															x				x					8
Cichorium intybus																																	x			1
Cistus creticus					x			x					x				x	x			x															6
Crepis neglecta													x																							1
Crupina crupinastrum						x																														1
Dorycnium hirsutum															x																					1
Echium plantagineum				x	x			x	x																								x	x		6
Ferula communis															x								x		x	x	x			x				x	x	8
Ferulago sylvatica																	x																			1
Galactites tomentosa	x	x				x	x	x	x		x	x	x						x				x			x	x	x	x	x	x			x	x	19
Geranium purpureum														x																						1
Hordeum sp.							x																x					x	x			x				5
Hypericum empetrifolium																x					x															2
Knautia integrifolia						x							x						x	x		x	x		x				x	x						9
Lathyrus digitatus															x					x																2
Linum pubescens																			x		x															2
Lolium perenne				x								x											x	x										x		5
Lolium sp.											x		x								x	x														4
Medicago scutellata							x		x																											2
Nigella damascena		x									x		x								x															4
Ornithogalum narbonense	x		x			x	x											x																		5
Pallenis spinosa						x			x																											2
Polypogon maritimus												x							x	x		x														4
Polypogon monspeliensis																															x					1
Quercus coccifera															x					x																2
Quercus pubescens																					x															1
Rapistrum rugosum orientale								x																												1
Sarcopterium spinosum										x																						x				2
Scabiosa maritima						x			x																											2
Scorzonera crocifolia										x																							x			2
Sideritis purpurea	x	x						x	x																											4
Silene graeca										x																										1
Sonchus sp.											x								x	x					x			x								5
Taraxacum sp.								x																												1
Tragopogon porrifolius																				x																1
Trifolium angustifolium							x																													1
Trifolium arvense																	x	x			x	x		x												5
Trifolium campestre													x	x			x	x			x	x		x		x										8
Trifolium hybridum												x										x		x													3
Trifolium purpureum					x															x	x														x		4
Trifolium repens																																	x			1
Vicia monantha													x				x																				2
Vicia sp.														x	x				x	x	x						x										6
Total species:	7	4	4	4	5	8	8	8	7	3	6	6	10	4	7	1	6	4	8	8	12	10	6	5	4	5	4	4	4	4	4	3	5	5	5	

Appendix D

Table over species occurrence in sample-squares 1-35 from inventory of the conventional olive grove May 15th 2014.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Tot:
Anagallis arvensis																								x												1
Avena sterilis	x		x	x			x		x					x			x				x															8
Avena sp.											x	x				x			x																	4
Cerinthe major																													x							1
Chrysantemum segetu	x							x	x			x		x				x														x				7
Cichorium intybus																																x				1
Crepis sp.														x																						1
Echium plantagineum	x	x																			x	x														4
Eruca sativa																		x											x			x	x	x		5
Erysimum cuspidatum																					x															1
Ferula communis				x																										x	x					3
Galactites tomentosa		x									x	x	x	x		x													x							7
Hordeum sp.	x	x	x								x											x									x						6
Knautia integrifolia			x	x						x	x			x						x	x															7
Lavatera cretica													x				x												x			x	x			5
Lolium perenne																	x		x																	2
Lolium sp.						x																														1
Nigella damascena							x		x																											2
Papaver dubium								x																												1
Papaver hybridum	x																																			1
Petrorhagia velutina																											x									1
Phalaris paradoxa						x										x																				2
Ranunculus paludosus															x																					1
Quercus coccifera								x																												1
Sorghum halepense																						x														1
Sonchus sp.																															x					1
Taraxacum sp.			x								x																									2
Tragopogon porrifolius											x	x																								2
Trifolium sp.															x																					1
Veronica agrestis																																x				1
Vicia hirsuta																								x												1
Vicia sp.												x																								1
Vitis vinifera																														x						1
Total species:	5	3	4	3	0	2	2	2	3	2	5	4	4	4	3	3	3	2	2	1	4	3	0	2	0	0	1	0	3	3	3	3	3	2	0	