System Report:
Valonia Oak Silvopastoral Systems in Greece

Project name	AGFORWARD (613520)
Work-package	2: High Natural and Cultural Value Agroforestry
Specific group	Valonia oak silvopastoral systems
Deliverable	Contribution to Deliverable 2.4: Detailed system description of a case study system
Date of report	20 January 2016
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Content

AGFORWARD (Grant Agreement N° 613520) is co-funded by the European Commission, Directorate General for Research & Innovation, within the 7th Framework Programme of RTD. The views and opinions expressed in this report are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission.

1 Context

The AGFORWARD research project (January 2014-December 2017), funded by the European Commission, is promoting agroforestry practices in Europe that will advance sustainable rural development. The project has four objectives:

1. to understand the context and extent of agroforestry in Europe,
2. to identify, develop and field-test innovations (through participatory research) to improve the benefits and viability of agroforestry systems in Europe,
3. to evaluate innovative agroforestry designs and practices at a field-, farm- and landscape scale, and
4. to promote the wider adoption of appropriate agroforestry systems in Europe through policy development and dissemination.

This report contributes to Objective 2, Deliverable 2.4: "Detailed system description of case study agroforestry systems". The detailed system description includes the key inputs, flows, and outputs of the key ecosystem services of the studied system. It covers the agroecology of the site (climate, soil), the components (tree species, crop system, livestock, management system) and key ecosystem services (provisioning, regulating and cultural) and the associated economic values. The data included in this report will also inform the modelling activities which help to address Objective 3.

2 General description of the Valonia oak silvopastoral system

Quercus ithaburensis is a characteristic endemic deciduous oak species of the Eastern Mediterranean countries (Figure 1) that appears with two subspecies: i) *Q. ithaburensis* subsp. *ithaburensis* (Tabor oak), found mostly in Anatolia and the Middle East, and ii) *Q. ithaburensis* subsp. *macrolepis* (Kotschy) Hedge & Yaltirik (Valonia oak), found mostly in South-East Italy, South Albania, Greece, Western Anatolia, Israel and North-Western Jordan (Tutin et al. 1993; Dufour-Dror and Ertas 2004).

Valonia oak forms traditional silvopastoral ecosystems in Greece which were of great value in the past (Pantera et al. 2008). Based on Pantera et al. (2008), Valonia oak forests cover an area of 29,632 ha in the form of stands, thickets and groups, in lowlands and uplands of continental and insular Greece (Figure 2). Furthermore, isolated trees are scattered throughout the country. Of this area, 81% is forest land (forest, partially forested areas and rangelands), and 19% is fields or forested abandoned fields and forested lots within agricultural fields. Most of this land is public and community owned (75%) and some (25%) is private or claimed by individuals (Pantera 2001; Pantera and Papanastasis 2003). Agricultural areas with Valonia oaks, that exist mainly on the island of Kea but also in other areas, can be described as agroforestry systems (silvoarable, agrosilvopastoral) combining agricultural, forest and livestock production.

Valonia oak woodlands, due to their open structure and combined use for forest and livestock production, are considered as grazed woodlands and specifically silvopastoral land rather than productive forests (Papanastasis 1996). The understory of such silvopastoral systems is composed mainly of holm oak, almonds, olives, carobs, mulberries, several bushes or dwarf shrubs, providing fodder for sheep, goats, and hogs (Pantera et al. 2008). Valonia oak was used in the past for its wood, acorns as well as for tanning (Grispos 1936; Cristodoulopoulos 1937). A major part of the economy of western Greece, and particularly the region of Aetoloakarnania, during the 17th to 19th centuries, was based on acorn trade and commerce (Giannakopoulou 2002). During the 20th century, human activities have confined Valonia oak to small-forested clusters or isolated individual trees in many areas of continental and insular Greece. The use of low cost chemical dyes has eliminated the large-scale use of acorns in tanning. Compared to the past, the system is now used for grazing, especially by sheep (Pantera and Papanastasis 2003).

Valonia oak systems in Greece are found at altitudes from 0 to 1100 m on various rock and soil types. However, they are more often encountered in mid-altitudes and on shallow to moderately deep limestone soils (Pantera and Papanastasis 2003; Pantera et al. 2008). The species develops in different layers of vegetation and bioclimatic types. However, its optimal distribution and growth of the species is the mesomediterranean layer and the subhumid bioclimate (Pantera et al. 2007). Its forests are open (canopy 0.4-0.5 on average) with the presence of, generally, three vegetation layers. The tree layer consists mainly of Valonia oak with a density of 50-60 trees, on average, per hectare. The middle layer consists of shrub species often with *Phlomis fruticosa* L. being dominant due to overgrazing (Pantera et al. 2008). The understorey is rich in species and includes grasses, particularly annual, legumes and many broad-leaved herbs including *Asphodelus fistulosus* and *Drimia maritima* (Pantera and Papanastasis 2001). A characteristic of Valonia oak systems is the old age of the trees. In many stands, the average tree age exceeds 200 years while in many parts of the country individuals of over 400 years can be found (Papadopoulos and Pantera 2013).

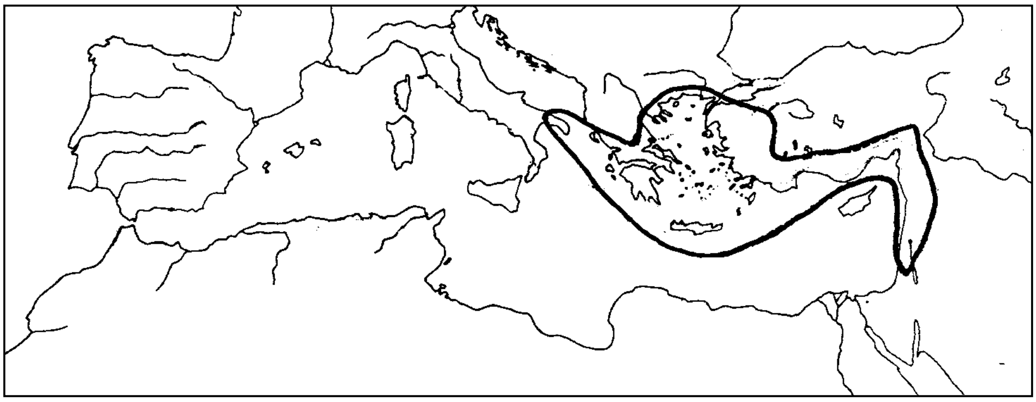


Figure 1. *Quercus ithaburensis* in Mediterranean (modified from Quezel and Barbero 1985)

Agroforestry is a traditional land use system in Valonia oak forest in Greece, where livestock breeders used the forest for grazing while collecting, at the same time, acorn cups from the oaks (Pantera 2014a). In this way they ensured a steady and enhanced economic return every year irrespective of weather conditions and other hazards. However, nowadays farmers are switching Valonia oak silvopastoral systems to olive groves or arable crops. The system is currently used only for grazing, especially by sheep (Pantera and Papanastasis 2003) and in a few areas (island of Kea, Xeromero of Aitolakarnania) for acorn collection for flour production or for tanning, for medicinal and aromatic plants in an effort to resume its traditional uses for ecological purposes and the revival of the Valonia oak forest history (Pantera 2001, 2014b; Pantera et al. 2009, 2015). Besides its activities for production, in some Valonia oak forests activities are presently developing such as rural tourism and ecotourism (Vlami et al. 2003). It should be noted that Valonia oak is on the list of Natura 2000 habitats with code 9350. The economic value of Valonia oak agroforestry systems includes contribution to the enhancement of biodiversity and carbon sequestration (Vrahnakis et al. 2014; Papadopoulos et al. 2015a).

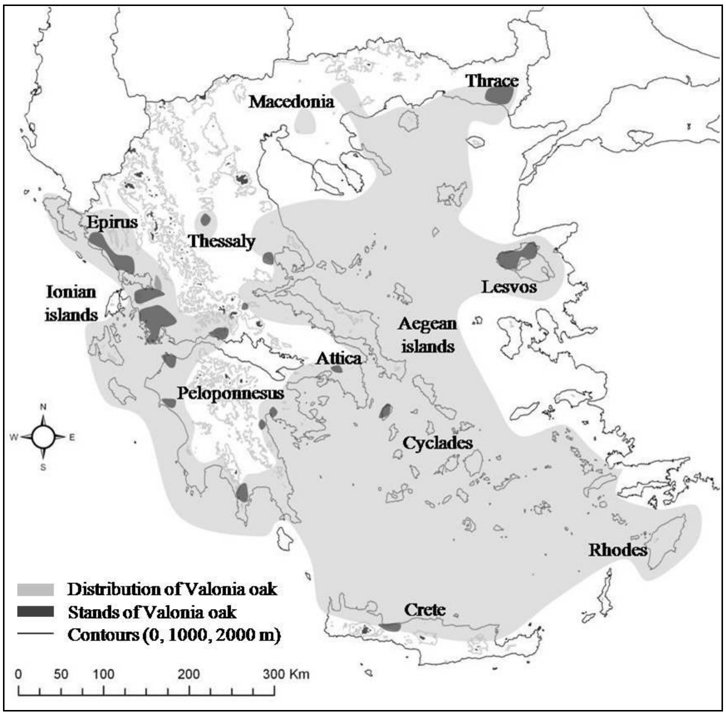


Figure 2. Valonia oak in Greece (Pantera et al. 2008)

Poor or no natural tree regeneration in Valonia oak silvopastoral systems is a common problem and, in combination with the continuous pressure posed by humans on these ecosystems, leads to their steady decline. Based on Pantera and Papanastasis (2003), natural tree regeneration is poor or non-existing in 80.8% of the total area covered by Valonia oak forest in Greece. Consequently, Valonia oak agroforestry systems in Greece are showing a downward trend and degradation in time taking into account historical evidence of their great forest past and the area they presently occupy as residual formations. Based on a Hellenic Agricultural Ministry study (2005), it seems that there is a reduction of oak forests and a simultaneously increase of partially forested areas of Valonia oak and evergreen broadleaved shrublands. An important problem leading to the shrinkage of Valonia oak forests is their reduced regeneration in many areas due to overgrazing or other factors such as fires, competition from herbaceous plants and possibly the old age of the trees (Pantera 2001; Pantera and Papanastasis 2011; Papadopoulos and Pantera 2013). The presence of a dense understorey which, in combination with climatic and site factors, young seedling establishment and development of the forest have been also point out as explanation for the poor tree regeneration (Pantera et al. 2008). Studies in *Quercus ithaburensis* forests in Israel have shown a reduction of tree regeneration by 61-67% in grazed areas compared with non-grazed ones (Dufour-Dror 2007). In this respect, it was considered appropriate to investigate the effects of grazing and understorey vegetation removal on tree regeneration. This problem is studied in a typical Valonia oak silvopastoral system in Xeromero, prefecture of Aitoloakarnania, W. Greece. A general description of the Valonia oak silvopastoral systems in Greece is given in Table 1.

Table 1. General description of Valonia oak silvopastoral systems in Greece

General description of system	
Name of group	Valonia oak silvopastoral systems
Contact	Andreas Papadopoulos
Work-package	2: High Natural and Cultural Value Agroforestry
Associated WP	Use of livestock
Geographical extent	Eastern Mediterranean (Figure 1), throughout Greece (Figure 2)
Estimated area	The total area of valonia oak in Greece is 29632 ha (Pantera et al. 2008)
Typical soil types	Limestone soils (76%), 16.9% volcanic soils, 7.1% on fhlysch, schist, igneous and Neogene rocks (Pantera et al. 2008).
Description	They are open forests of old age trees that, in some occasions, are older than 400 years (Papadopoulos and Pantera, 2013). Most of these are widely open, discontinuous, remnants of old dense forests as a result of their intensive past use resulting in their evolution from high forests to silvopastoral systems. Typical dense forests of the species still exist in W. Greece. The species is also present in the form of individual trees or clusters in agricultural fields in several Aegean islands.
Tree species	*Q. ithaburensis* subsp. *macrolepis*
Tree products	Acorns, acorn cups, wood as fuelwood, artifacts
Crop species	Grass species
Crop products	Grass can be grazed directly by livestock or cut to provide animal feed (silage or hay). If the grass is not grazed or cut, then it needs to be mown
Animal species	Sheep, goats, pigs, cows
Animal products	Meat and all dairy products
Other provisioning services	Tourism, herbs (aromatic and medicinal)
Regulating services	Trees provide shade for the livestock in the summer and shelter in the winter, contribute to C sequestration, regulate water cycle, and protect soil from erosion. Livestock promotes nutrient cycling.
Habitat services and biodiversity	Valonia oak silvopastoral systems enhance biodiversity. Numerous plant taxa were recorded, some of them endemic to Greece or the Balkans.
Cultural services	Enhance employment in rural areas. The history of the tree is related with Greek history and mythology as it is one of the most frequently mentioned species in classical and contemporary literature (Pantera et al. 2009).
Key references	See end of report

3 Field testing of innovations

During a stakeholder meeting organised within the AGFORWORD project at Xeromero, W. Greece (Pantera 2014b), the opinions of the participants where discussed over the possible use of Valonia oak silvopastoral systems for the production of fodder, acorn and acorn cups, wood, medicinal plants and other provisioning and regulating services as well as their protection from existing threats such as low tree regeneration. During a stakeholders' meeting at the Aegean island Kea (Pantera 2014b) farmers expressed their willing to investigate alternative ways of using Valonia oak silvopastoral systems to enhance their income such as cultivation of promising forage grasses under Valonia oak trees.

The working group of the project, taking into account the opinions of the stakeholders, has decided to investigate: i) the Valonia oak natural regeneration capacity, and ii) the improvement of Valonia oak silvopastoral system productivity by sowing promising forage species.

Based on an experimental protocol (Papadopoulos et al. 2015b), for the first experiment 48 experimental subplots were established in Xeromero in mid-May 2015, and at the end of the month we took the first measurements on the number and height of oak seedlings within them. Four different locations (A, B, C and D) were selected which were located near four different sheep holding areas. In each location, three replicated plots (total 12) were established. In each plot two factors (fenced and shrub removal) were combined with the four treatments, with a 20 m^2 sub-plot per treatment. The treatments were i) fenced and cleared of shrubs (FNS); fenced with shrubs (FWS); grazed and cleared of shrubs (GNS); and grazed with shrubs (GWS). The plots within each location were established based on their distance from the sheep holding area (1, 4, 7, 10 close to the area, 2, 5, 8, 11 at an intermediate distance from the area and 3, 6, 9 and 12 away from the area). An inventory of the existing vegetation (species composition and abundance) in the plots was carried out in the various treatments. In October-November the measurements were repeated for the oak seedlings number and height and, for the first time, acorn and acorn cups numbers. The same measurements will be repeated in 2016 and 2017.

The second experiment was established in a silvopastoral system with Valonia oak trees of the Kea Island. In this area, Valonia oak trees are used besides grazing, for cup collection. The farm where the experiment is conducted is privately-owned and the Valonia oak trees are widely grown, used for their acorns and acorn-cups as well as for grazing. Trees are 80-100 years old. Due to the steep slope the field is terraced. These terraces are currently used for livestock grazing, but in the past, they were cultivated with various agricultural crops as well.

Briefly, two different seed mixtures, namely “ISPAAM” (I) and the commercial “Fertiprado” (F) were sown under and away of trees in January 2015. The “ISPAAM” mixture contained 40% *Trifolium subterraneum* cv *Campeda,* 40% *Medicago polymorpha* cv *Anglona*, 10 % *Lolium rigidum* cv *Nurra.* The second mixture “Fertiprado” contained 60.6% *Trifolium subterraneum,* 4.5% *T. michelianum* var *balansae,* 3% *T. vesiculosum,* 3% *T. resupinatum,* 6.1% *T. incarnatum,* 1.5% *T. istmocarpus,* 1.5% *T. glanduliferum, and* 19.7% *Ornithopus sativus.* After sowing, the plots were fenced for protection from grazing. Five replicated plots were established for each treatment: ISPAAM and FERTIPRADO x BENEATH and OUTSIDE of the CANOPY, which combined in a two factor design gives 4 treatments, which with 5 replicates per treatment give a total of 20 plots. Apart of these 20 manipulated plots, control plots with native pasture, both beneath and out of the canopy are included in the study. The first measurements and sample collection of plants, according to the experimental protocol (Papadopoulos et al. 2015b), were taken in May of 2015. The samples were taken to the lab where they were separated, identified, dried out, and weighed. Sowing was repeated in December 2015, while the same measurements and collection of the plants will be held in May 2016. The experiment will be repeated for the third time under the framework of the AGFORWARD project in 2017.

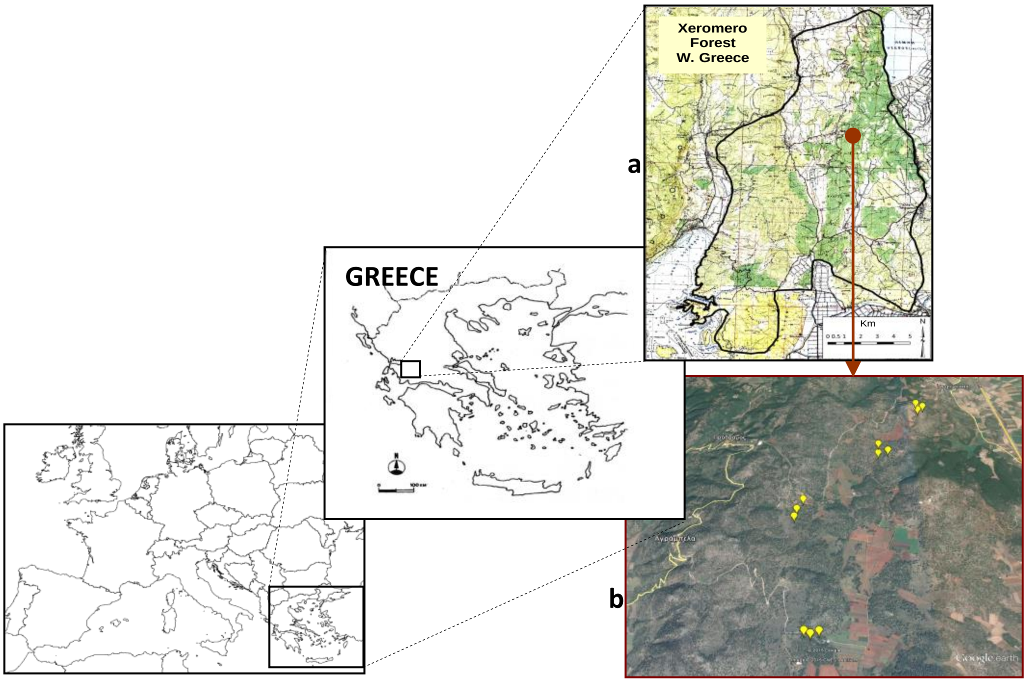
4 Description of the study sites

A description of a specific case study system is provided in Table 2 and Table 3. Missing data will be collected sourced during 2016.

Table 2. Description of the study area of Valonia oak silvopastoral system in Western Greece

Specific description of site	
Area	20153 ha; 120 ha of the specific area-experiment
Co-ordinates	(38,60781 21.215632), (38.606861 21.216354), (38.6055706 21.215676), (38.596905 21.210113), (38.59788 21.207965), (38.595924 21.2077335), (38.585321 21.194012) (38.584223 21.194052) (38.58334 21.194277) (38.567031 21.196781) (38.566316 21.195409) (38.56657 21.195159)
Site contact	Andreas Papadopoulos
Site contact email	ampapadopoulos@teiste.gr
Example photograph	

Map of system



Map of Xeromero forest (a) and satellite image (from [Google Earth)](Google Earth) with the position (yellow points) of the experimental plots in the Valonia oak silvopastoral system (b).

Possible modelling scenarios

Comparison	Effect of Livestock grazing on oak natural regeneration

Climate characteristics

Mean temperature	18.8°C
Mean annual precipitation	938 mm
Drought period	3.5 months from late May to early September
Bioclimatic type	Humid with temperate winter
Details of weather station (and data)	Hellenic National Meteorological Service, Station of Agrinio, data from 1956-2012

Soil type	Leptosols
Soil depth	≤1 m
Soil texture	
Additional soil characteristics	Ca 10.28-10.96 meq (100 g)$^{-1}$, Mg: 1.23-1.31 meq (100 g)$^{-1}$, K: 0,20-0,29 meq (100 g)$^{-1}$, Na: 0.07-0.10 meq (100 g)$^{-1}$, N: 0.18-0.28%, P 0.95-1.25 mg (100 g)$^{-1}$, C: 2.52-4.72%, OM: 4.34-8.15, pH 5.91-5.86 (values are averages of soil samplings under and out of the trees canopy from two locations)
Aspect	Various

Tree characteristics

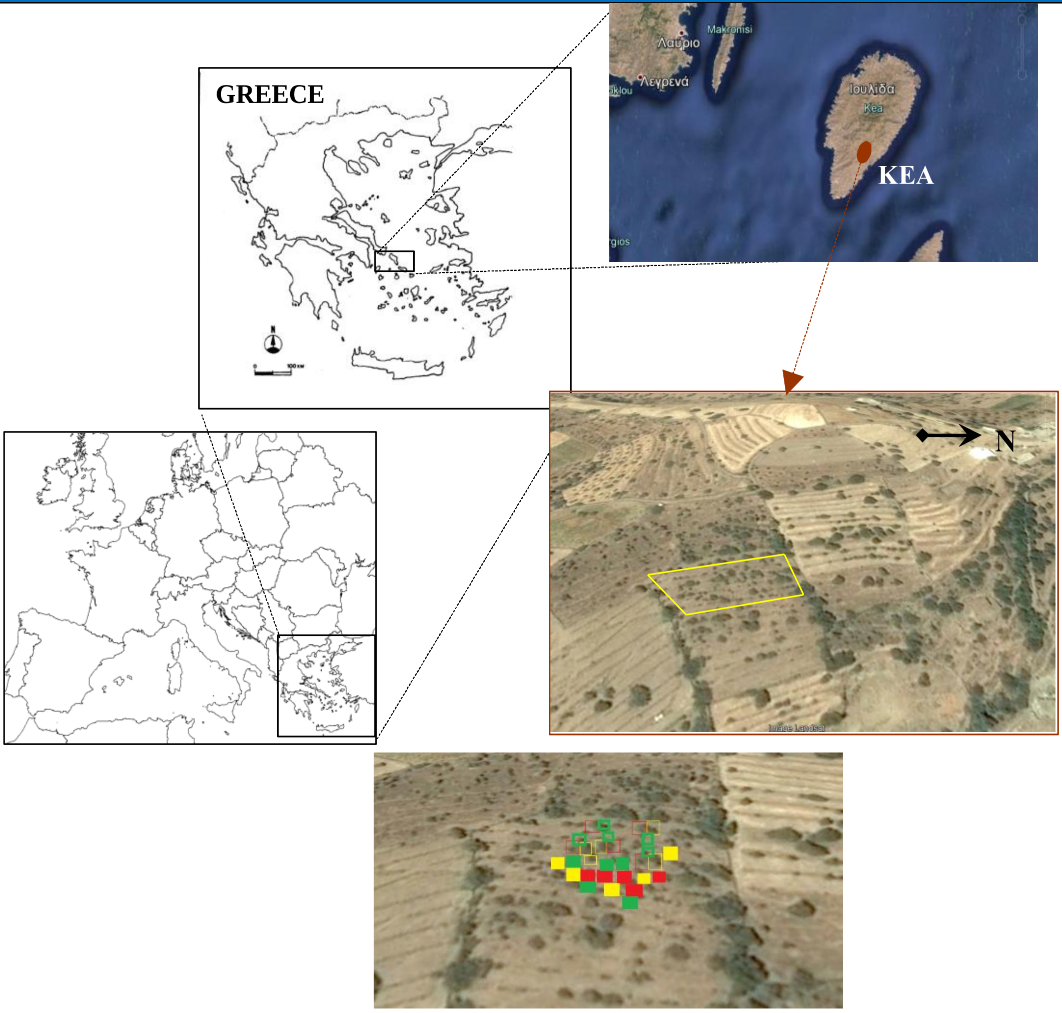
Species and variety	*Quercus ithaburensis* subsp. *macrolepis), Quercus pubescens*
Date of planting	-
Intra-row spacing	-
Inter-row spacing	-
Tree protection	None

Typical yield	-
Typical increase in tree biomass	1472 m^3 ha^{-1} (Hellenic Agricultural Service 2005)
Crop/understorey characteristics	
Species	*Phlomis fruticosa, Paliurus spina-christii, Crataegus monogyna, Asphodelus fistulosus, Asparagus acutifolius, Drimia maritima, Acanthus spinosus, Mercurialis annua, Poa bulbosa, Stellaria media, Galium aparine, Rhagadiolus stellatus*
Management	None
Typical grassland yield	400-1400 kg ha^{-1} (depending on the year)
Fertiliser, pesticide, machinery and labour management	
Fertiliser, pesticides	-
Machinery, labour	-
Fencing	The experimental plots are fenced
Livestock management	
Species and breed	Sheep and goats
Livestock system	Common free grazing
Date of entry to site	The whole year round
Stocking density	5.5 ha^{-1}
Animal health and welfare issues	The breeders described a disease (they called "fever") that causes the death of many sheep
Annual mortality rate	To be included
Requirement for supplementary feed	Yes
Typical level of sheep production	To be included

Table 3. Description of the study area in of Valonia oak agrosilvopastoral system of Kea Island

Specific description of site	
Area	0.5 ha approximately
Co-ordinates	From 37°34'48"N & 24°19'32" E
Site contact	Andreas Papadopoulos
Site contact email	ampapadopoulos@teiste.gr
Example photographs	

Map of system



Map and satellite images from Google Earth of Kea island showing the position of experimental site of Valonia oak agrosilvopastoral systems. Plot treatments are: yellow with mixture of “ISPAM”; red with “Fertiprado”; green with natural grass. Solid squares refer to plots without canopy cover and open squares refer to plots under a Valonia oak canopy.

Possible modelling scenarios

Comparison	Valonia oak and two mixtures and natural grass vs open field, two mixtures and natural grass

Climate characteristics

Mean temperature	17.9°C
Mean annual precipitation	700 mm
Drought period	5 months, from early May to late September
Bioclimatic type	Sub-humid with warm winter
Details of weather station (and data)	Hellenic National Meteorological Service, Station of Karistos, data from 1975-1993

Soil type	Cambisols
Soil depth	≤1 m

Soil texture	
Additional soil characteristics	Ca: 12 meq (100 g)$^{-1}$, Mg: 0.31-1.20 meq (100 g)$^{-1}$, K: 0.14-0.16 meq (100 g)$^{-1}$, Na: 0.07-0.06 meq (100 g)$^{-1}$, N: 0.53-0.32%, P: 0.16-0.90 mg (100 g)$^{-1}$, C: 2.40-5.80%, OM: 4.14-9.99 (values are averages of soil samplings under and out of the trees canopy) pH 7.13
Aspect	East
Tree characteristics	
Species and variety	Valonia oak (*Quercus ithaburensis* subsp. *macrolepis), Quercus pubescens*
Date of planting	-
Intra-row spacing	-
Inter-row spacing	-
Tree protection	None
Typical yield	-
Typical increase in tree biomass	Not available
Crop/understorey characteristics	
Species	**1st mixture (ISPAAM)** *40% Trifolium subterraneum*[1] cv *Campeda, 40% Medicago polymorpha* cv *Anglona, 10 % Lolium rigidum* cv *Nurra,* **2nd mixture (Fertiprado):** *60.6%Trifoliumsubterraneum, 4.5% T. michelianum* var *balansae, 3% T. vesiculosum, 3% T. resupinatum, 6.1% T. incarnatum. 1.5% T. istmocarpus, 1.5% T. glanduliferum, and 19.7% Ornithopussativus.*
Management	This mix was sown at a density of 20 kg seed/ha, buried around 0.5-1.0 cm.
Typical grassland yield	
Fertiliser, pesticide, machinery and labour management	
Fertiliser	Both mixtures were fertilized with 144 kg ha^{-1} of monopotassium phosphate 0-52-34 before seeding.
Pesticides	-
Machinery	-
Manure handling	-
Labour	-
Fencing	The experimental plots are fenced
Livestock management	
Species and breed	Sheep and goats
Description of livestock system	Everyday grazing
Date of entry to site	Everyday
Date of departure	
Stocking density	5.5 ha^{-1}
Animal health and welfare issues	Not mentioned
Annual mortality rate	-
Requirement for supplementary feed	Yes
Costs	

5 Valonia oak silvopastoral system in Western Greece

5.1 Changes in understorey vegetation

At this stage of the research, and due to the fact that there is only one record of the vegetation, no conclusions can be drawn on vegetation dynamics. In total 114 plant species were recorded in late May 2015 in the study area. Differences in plant species were noted based on their location and distance from the shed. The measurements will be repeated in 2016 and 2017.

5.2 Valonia oak regeneration

The number of "seedlings per square metre" (ssm) was measured in May and October. It was treated as a repeated measures variable, meaning that we were interested in examining if the measurements were significantly different between the different periods.

The ssm variable in the two periods was not normally distributed and the Kolmogorov-Smirnov test (Gray and Kinnear 2012) confirmed (ssmMay $p = 0.000 < 0.001$, ssmOct $p = 0.000 < 0.001$, $n = 48$). Table 4 shows the percentiles of the two variables, the minimum and maximum values, and the skewness and kurtosis. It is shown that in the variables there are many zeros in the distributions, meaning that in at least 25% of the measurements there were almost zero seedlings per square metre. In such heavily non-normally distributed variables, the mean values have practically no meaning and therefore it is not proper to apply parametric methods for examining the differences of the variables.

Table 4. Descriptive statistics for seedling density variable (ssm; seedlings m^{-2})

				Quantiles			Skewness		Kurtosis	
	N	Min	Max	25%	50%	75%	Stat	Std. Error	Stat	Std. Error
ssmMay	48	0.000	2.4500	0.0	0.125	0.425	2.692	0.343	6.987	0.674
ssmOct	48	0.000	0.1225	0.0	0.006	0.026	1.779	0.343	1.776	0.674

The measurements took place in areas with the following treatments: FNS= Fenced and cleared of shrubs; FWS= Fenced with shrubs; GNS= Grazed and cleared of shrubs; and GWS= Grazed with shrubs. The distribution of the variables within each treatment was equally not normal. We tried to transform the data to achieve normality. We used the Box Cox transformation technique, which showed that for the ssmMay variable the natural log transformation was the best. Indeed, the ssmMay variable reached normality (Kolmogorov Smirnov test $p = 0.200 > 0.05$). However, it was not possible to normalize the ssmOct variable despite several attempts of transformations (square root, natural log, Box Cox). Therefore, it was decided to work on the original non-normal variables by using non parametric techniques.

The experimental design included ssm as a "within subjects" factor and shrub clearing and grazing as two "between subjects" factors. For the factor "grazing", we used either two levels (grazed and fenced) or four levels (evaluated in situ at the time of sampling): no grazing (Fenced); little grazing; medium grazing; and Intense grazing.

We used the Wilcoxon test for the comparison of the ssm variable in the levels of shrub-clearing and in the levels of grazing. The Wilcoxon Signed Rank test is used for the comparison of two related samples. For the treatment we compared four times the ssmMay and ssmOct variables for each corresponding treatment. We set the significance level at a = 0.05, but we also used the Bonferroni correction, meaning that we used for the four comparisons a significance level a1 = 0.0125. The analysis was performed in SPSS 22.0 (Gray and Kinnear, 2012).

In order to understand the distributions of ssm variable for the interaction of period and treatment, the quantiles for the eight different variables were calculated. The results show that there are some differences in terms of the measurements in May and October in some treatments. Table 5 shows the test statistics of the Wilcoxon test.

Table 5. Results of the Wilcoxon test for the interaction of treatment and period

	Fenced and cleared of shrubs Oct – May	Fenced with shrubs Oct – May	Grazed and cleared of shrubs Oct – May	Grazed with shrubs Oct – May
Z	-2.401[b]	-2.805[b]	-2.143[b]	-1.689[b]
Asymp. Sig. (2-tailed)	0.016	0.005	0.032	0.091
Exact Sig. (2-tailed)	0.014	0.002	0.031	0.102
Exact Sig. (1-tailed)	0.007	0.001	0.016	0.051
Point Probability	0.002	0.001	0.004	0.009

If we do not take into account the Bonferroni correction, there are differences between the measurements in May and October a) in Fence and cleared of shrubs b) in fenced with shrubs, and c) in grazed, no shrubs. Taking into account the Bonferroni correction, only the first two are still valid. The same analysis was performed for the interaction of period and grazing. The Wilcoxon test was used again. In order to understand the distributions of ssm variable for the interaction of period and grazing, the quantiles for the 6 different variables (fenced plots are not included in this analysis) are shown in Table 6.

Table 6. Quantiles of the 6 different variables for grazing and for seedling density (seedling/m2)

		Quantiles		
	N	25th	50th (Median)	75th
Little grazing May	8	0.0500	0.2500	0.6000
Medium grazing May	8	0.0000	0.0250	0.0875
Intense grazing May	8	0.0000	0.1000	0.3250
Little grazing Oct	8	0.0025	0.0250	0.0337
Medium grazing Oct	8	0.0006	0.0025	0.0119
Intense grazing Oct	8	0.0000	0.0075	0.0194

The application of the Wilcoxon test showed that there are no significant differences between the measurements of ssm in the levels of grazing, except from one 1-tailed difference (Little grazing Oct-Little grazing May), but this should be interpreted with caution. Therefore the grazing seems to have no effect on the measurements of seedlings per square meter. It is noted here that the interaction was applied only in the grazed areas (treatments GWS and GNS). Table 7 shows the results of the Wilcoxon test.

Table 7. Results of the Wilcoxon test for the interaction of grazing and period

	Little grazing Oct - Little grazing May	Medium grazing Oct - Medium grazing May	Intense grazing Oct - Intense grazing May
Z	-1.820[b]	-1.016[b]	-1.577[b]
Asymp. Sig. (2-tailed)	0.069	0.310	0.115
Exact Sig. (2-tailed)	0.078	0.344	0.156
Exact Sig. (1-tailed)	0.039	0.172	0.078
Point Probability	0.012	0.016	0.031

Additionally, it was examined if treatment and grazing had an impact on measurements, not taking into account the period. The Kruskal Wallis H test was used which is the non-parametric equivalent for the One Way ANOVA method. The results show that treatment and grazing have no effect on the seasonal measurements of the ssm variable as Table 8 shows.

Table 8. Results of Kruskal Wallis H test for the between subject factors Shrub-clearing and Grazing

	Treatment		Grazing	
	ssmMay	ssmOct	ssmMay	ssmOct
Chi-Square	3.170	3.016	4.182	2.933
df	3	3	2	2
Asymp. Sig.	0.366	0.389	0.124	0.231

For the variables “Acorns per hectare” (acorns) and “Acorn cups per hectare” (acorn cups) we followed similar analysis, though these variables were measured only in October, and not in May. Thus, no within subjects effect is present here. The two variables were non-normal as the Kolmogorov-Smirnov test confirms (acorns $p = 0.000 < 0.001$ and acorn cups $p = 0.000 < 0.001$). Table 9 shows the descriptive statistics of the two variables, which reveal the skewness to the low values and especially zero values. The quantiles for acorns show that at least the 75% of the values in the distribution are equal to zero.

Table 10. Descriptive statistics for acorns and acorn cups variables (acorns/m2; acorn cups / m2)

				Quantiles			Skewness		Kurtosis	
	N	Min	Max	25%	50%	75%	Stat	Std. Error	Stat	Std. Error
Acorns	144	0	640	0	0	0	4.307	0.202	24.604	0.401
Acorn cups	144	0	640	0	80	160	1.263	0.202	1.596	0.401

For testing if the measurements of the two variables are statistically different among the levels of the “between subject” factors shrub-clearing and grazing again the Kruskal Wallis H test was used due to the non-normality of the acorn and acorn cups variables. The analysis showed that there are differences in both factors as Table 11 shows. Treatment seems to have an effect on acorns while grazing seems to have an effect on acorn cups.

Table 11. Results of Kruskal Wallis H test for the between subject factors Treatment and Grazing

	Shrub-clearing		Grazing	
	Acorns	Acorn cups	Acorns	Acorn cups
Chi-Square	10.055	3.622	2.219	7.988
df	3	3	2	2
Asymp. Sig.	0.018	0.305	0.330	0.018

The post hoc analysis was performed both taking into account the Bonferroni criterion and the Dunn-Sidak adjustment for the p values. The following differences were extracted (Table 12 and Table 13).

Table 12. Post hoc differences for shrub-clearing and acorns

Difference	Test statistic	Bonferroni p-value	Dunn-Sidak p-value
GNS – FWS	14.639	0.033	0.200
GNS – FNS	17.958	0.009	0.054
GWS – FNS	15.667	0.023	0.136

In terms of treatment the differences exist in three comparisons, as shown in Table 12, but only for the Bonferroni criterion. However, for the Dunn-Sidak criterion these differences are not valid. For the medium intense difference of grazing in terms of acorn cups, both the two criteria confirm its existence.

Table 13. Post hoc differences for grazing and acorn cups

Difference	Test statistic	Bonferroni p-value	Dunn-Sidak p-value
Medium-Intense	-16.292	0.005	0.014

6 Valonia oak agrosivopastoral systems on Kea Island

6.1 Biomass of grass

The biomass of grass (units: kg ha^{-1}) (dependent variable) for one year on Kea Island was measured. The experiment included two within subject factor a) cultivation (three levels: ISPAAM, Fertiprado, Control) and b) shading (two levels: Shaded, Unshaded). The combination of the two factors creates six variables, namely IS = ISPAAM Shaded, IU = ISPAAM Unshaded, FS = Fertiprado Shaded, FU = Fertiprado Unshaded, CS = Control Shaded and CU = Control Unshaded. All the distributions are non-normal and they are skewed to zero. Table 14 confirms this non-normality giving the basic descriptive statistics for the six levels, together with the Kolmogorov Smirnov (KS) normality test. All the variables, except from the ISPAAM unshaded, have a distribution where the 75% of the values are zero.

Table 14. Descriptive statistics and Kolmogorov Smirnov test of biomass in six variables (median, minimum, maximum and percentile values in kg ha^{-1})

		ISPAAM shaded	Fertiprado shaded	ISPAAM unshaded	Fertiprado unshaded	Control shaded	Control unshaded
KS statistic		0.475	0.502	0.432	0.438	0.461	0.445
p-value		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Median		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Skewness		50.701	50.697	30.180	70.844	70.883	30.568
Kurtosis		320.404	320.295	90.768	610.973	620.399	120.315
Minimum		0.00	0.00	0.00	0.00	0.00	0.00
Maximum		8030.77	6770.67	4730.17	7040.30	2340.90	3210.01
Percentiles	25	0.000	0.000	0.000	0.000	0.000	0.000
	50	0.000	0.000	0.000	0.000	0.000	0.000
	75	0.000	0.000	20.000	0.000	0.000	0.000

Thus, it was not possible to use a parametric test (for example a two within factor analysis of variance would have been suitable) and some non-parametric equivalents were tested. The differences among cultivation, between shading and the interaction of cultivation and shading were investigated.

For the cultivation, the Friedman ANOVA test was used which is able to find differences of distributions in multiple samples. The test statistic was 1.887 (n = 126) and the p-value = 0.389 > 0.05; thus, no difference among cultivations were detected, not taking into account the shading of the cultivations.

For the shading, the Wilcoxon test was used which compares if the median of differences between Shaded and Unshaded equals zero (0). The test statistic was 1034.5 (N = 189) and the p-value = 0.005 < 0.05; thus there was difference in the biomass measured in the shaded area compared to the unshaded one, not taking into account the cultivations. For the interaction of cultivation and shading both the Wilcoxon and Friedman tests were used. Table 15 gives all the possible combinations. As it is shown, there are no differences except from the Control shaded – Control unshaded relationship, which shows that the biomass of grass in the control area is statistically lower in the shaded region compared to the unshaded one.

Table 15. Interaction of cultivation and shading for the biomass of grass

	Wilcoxon test (2 related samples)		Friedman test (multiple related) samples	
	Test value	p-value	Test value	p-value
IS-IU	146.5	0.121		
FS-FU	80.0	0.256		
CS-CU	140.5	0.017		
IS-FS-CS			0.298	0.862
IU-FU-CU			1.723	0.422

5 Acknowledgements

The AGFORWARD project (Grant Agreement N° 613520) is co-funded by the European Commission, Directorate General for Research & Innovation, within the 7th Framework Programme of RTD, Theme 2 - Biotechnologies, Agriculture & Food. The views and opinions expressed in this report are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission.

6 References

Cristodoulopoulos A (1937). Production and use of the oak acorns. Forest Life 87: 51–52 [In Greek].

Dufour-Dror JM, Ertas A (2004). Bioclimatic perspectives in the distribution of *Quercus ithaburensis* Decne. subspecies in Turkey and in the Levant. Journal of Biogeography 31(3): 461–474.

Dufour-Dror JM (2007). Influence of cattle grazing on the density of oak seedlings and saplings in a Tabor oak forest in Israel. ActaOecologica 31:223–228.

Giannakopoulou E (2002). Valonia oak forests (17th-19th centuries): Factor of Economy and Competition Incentive, Conference Proceedings "Valonia oak forest: past, present and future", Messologi, Greece, 17 May 2002. [In Greek].

Gray CD, Kinnear PR (2012). IBM SPSS statistics 19 made simple. Psychology Press.

Grispos P (1936). The acorns extracts in forest industry. Forest Life 44–45: 157–160. [In Greek with English summary].

Hellenic Agricultural Ministry (2005). Protection and Management Study of the Public Forest Ecosystem of Manina-Xiromerou. Forestry Service of Amfilochia, Prefecture Aitoloakarnanias, Conducted by the Geopliroforiki Company. [In Greek].

Hellenic National Meteorological Service (1999). Climatic data from the meteorological stations operated by the Hellenic Meteorological Service (Period 1955-1997). Volumes A and B. Published by the Hellenic Meteorological Service, Athens. 260 p. [In Greek].

Pantera A (2001). Establishment of *Quercus ithaburensis* Decaisne ssp. *macrolepis* (Kotschy) Hedge & Yaltirik) in competence with understory vegetation in sylvopastoral systems. Ph.D. Dissertation. Thessaloniki: Aristotle University of Thessaloniki. 143 p. [In Greek].

Pantera A (2014a). Valonia oak acorn festival in Kea, Greece. Available online:http://www.agroforestry.eu/sites/default/files/pub/docs/kean_Valonia_oak_and_acorn_festival_2014.pdf.

Pantera A (2014b). Initial Stakeholder Meeting Report: Valonia oak silvopastoral systems in Greece. Available online:http://www.agforward.eu/index.php/en/valonia-oak-silvopastoral-systems-in-greece.html.

Pantera A, Papanastasis VP (2001). Grazing effects on forage production and botanical composition in a Valonia oak silvopastoral system. In: Proceedings of the International Conference: Forest Research: A challenge for an integrated European approach, Volume II, Radoglou K (Ed.), 681-687.

Pantera A, Papanastasis VP (2003). Inventory of *Q. ithaburensis* ssp. *macrolepis* (*Quercus ithaburensis* Decaisne ssp. *macrolepis* (Kotschy) Hedge & Yalt. in Greece. Geotechnical Scientific Issues 1/2003: 34-43. [In Greek].

Pantera A, Papadopoulos AM, Papanastasis V (2007). Le rôle des facteurs bioclimatiques sur la distribution de *Quercus ithaburensis* ssp. *macrolepis* (Kotschy) Hedge & Yalt. [In Greek]. XXème Colloque de l'Association Internationale de Climatologie, Carthage, Tunisie, 448-453.

Pantera A, Papadopoulos A, Fotiadis G, Papanastasis VP (2008). Distribution and phytogeographical analysis of *Quercus ithaburensis* ssp. *macrolepis* in Greece. Ecologia Mediterranea 34: 73-82.

Pantera A, Fotiadis G, Aidinidis E (2009). History and Current Distribution of Valonia Oak in Greece. In Woodland Cultures in Time and Space: Tales from the past, messages for the future. Book, Embryo publications.

Pantera A, Papanastasis V (2011). Competitive effects of herbaceous species on water potential and growth of Q. ithaburensis ssp macrolepis seedlings. Proceedings of the 12th International Conference on Environmental Science and Technology. Rhodes 8-10 Sept 2011.

Pantera A, Papadopoulos A, Mantzanas K, Papanastasis V, Fotiadis G, Vrachnakis M, Alifragis D, Ispikoudis I et al. (2015). The contribution of valonia oak silvopastoral systems in Western Greece to local development and the environment. In: Proceedings of the 14th International Conference on Environmental Sciences and Technology, Rhodes, Greece, 3-5 September 2015, CEST-2015_00100.

Papadopoulos A, Pantera A (2013). Dating and tree-rings analysis of Valonia oak aged trees from the Xeromero forest of Aetoloakarnia Prefecture. 16th Panhellenic Forestry Conference, "Protection of Greek-managed forests in times of economic crisis and the challenge of natural forestry", Thessaloniki, 6-9 October 2013, 311-318. [In Greek with English summary].

Papadopoulos A, Zianis D, Pantera A, Vergos S (2015a). Bayesian and classical models to estimate aboveground stand biomass in an oak silvopastoral system. In: Proceedings of the 14th International Conference on Environmental Sciences and Technology, Rhodes, Greece, 3-5 September 2015, CEST-2015_01255.

Papadopoulos A, Pantera A, Mantzanas K, Papanastasis V (2015b). Research and Development Protocol for the Valonia oak silvopastoral system, Greece. Available online: http://www.agforward.eu/index.php/en/valonia-oak-silvopastoral-systems-in-greece.html?file=files/agforward/documents/WP2_GR_valonia_oak_protocol.pdf.

Papanastasis VP (1996). Silvopastoral systems and range management in the Mediterranean region. In: Western European Silvopastoral Systems. Etienne M (Ed.), INRA, Paris, France, 143-156.

Quezel P, Barbero M (1985). Carte de la végétation potentielle de la région méditerranéenne. Feuille N° 1: Méditerranée Orientale. Eds C.N.R.S. Paris: 69p.

Tutin TG, Burges NA, Chater AO, Edmondson JR, Heywood VH, Moore DM, Valentine DH, Walters SM, Webb DA (Eds) (1993). Flora Europaea, Vol. 1 (ed. 2.). Cambridge University Press, Cambridge, UK 581 p.

Vlami V, Zogaris St, Dimopoulos P (2003). Xeromerovalonia oak forest. Aitoloakarnania. Ecotouristic guide. Ministry of Environment., 71p. [In Greek].

Vrahnakis MS, Fotiadis G, Pantera A, Papadopoulos A, Papanastasis VP (2014). Floristic diversity of Valonia oak silvopastoral woodlands in Greece. Agroforestry Systems 88(5): 877-893.