Research and Development Protocol for the Valonia oak silvopastoral system, Greece

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Work-package	2: High Natural and Cultural Value Agroforestry
Specific group	Valonia oak silvopastoral system
Milestone	Milestone 4 (2.3) Part of experimental protocol for WP2
Date of report	29 March 2015
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Contents

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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 the second objective. It contributes to the initial research and development protocol (Milestone 4 (2.3)) for the participative research and development network focused on the use of agroforestry in high value tree systems.

2 Valonia oak silvopastoral systems in Western Greece

2.1 Background

Agroforestry and specifically silvopastoralism is a traditional land use system in Xeromero, Aetoloakarnania, Western Greece where livestock breeders used the valonia oak (*Quercus ithaburensis* ssp *macrolepis*) forest for grazing while collecting at the same time acorn cups from the oaks. In this way they ensured a steady and enhanced economic return every year irrespective of weather conditions and other hazards. The forest is characterized by the dominance of old-growth valonia oak trees. However there is a gradual abandonment of this kind of combined land use and a tendency to convert the system to a dense forest or olive groves. During a stakeholders' meeting organised within the frame of the AGFORWORD project, it was reported that one of the main problems is the poor regeneration of the trees. This may be due to the high grazing pressure that exists in the region, the old age of the trees (Papadopoulos and Pantera, 2013), or the presence of a dense understorey who, in combination with climatic and site factors affect the regeneration and development of the forest (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 effect of grazing and understorey vegetation removal on tree regeneration which can occur in many parts of the forest because of a lack of management.

2.2 Objective of trial

The aim of the trial is to produce quantitative information about the interaction between livestock grazing, understory vegetation and valonia oak tree regeneration. Key questions include:

1 Do we want valonia trees or not?
2 What are the reasons for the poor tree regeneration?
3 What issues or practices have changed over time?
4 What are the problems that stakeholders are presently faced and why traditional practices are underestimated?
5 To what extent practices based on sound forest management would support the continuation of the system?

2.3 System description

In order to comply with the initial idea of work-package 2 for the silvopastoral system of Xeromero forest -Aitoloakarnania Prefecture (Figure 1), it was decided to thoroughly study the effect of grazing and understory removal on tree regeneration. Grazing has been intensive in previous centuries (Figure 2) without any form of management (Figure 3). Valonia in the area of Xeromero develops mainly in shallow limestone from 0 to 580 m above sea level. The climate is Mediterranean with a mean annual precipitation of 939 mm and mean annual temperature 18.8^{o}C (Table 1). The forest is composed of old-age, open clusters of valonia oak, developing mostly on shallow rocky soils while, in locations of deeper soils, there are individual or small tree clusters of *Quercus pubescens*. Valonia oak stands are typically composed of old trees, only used for grazing. Lately there have been attempts to place value on the forest by using acorn cups for tanning and for the production of ecological dyes.

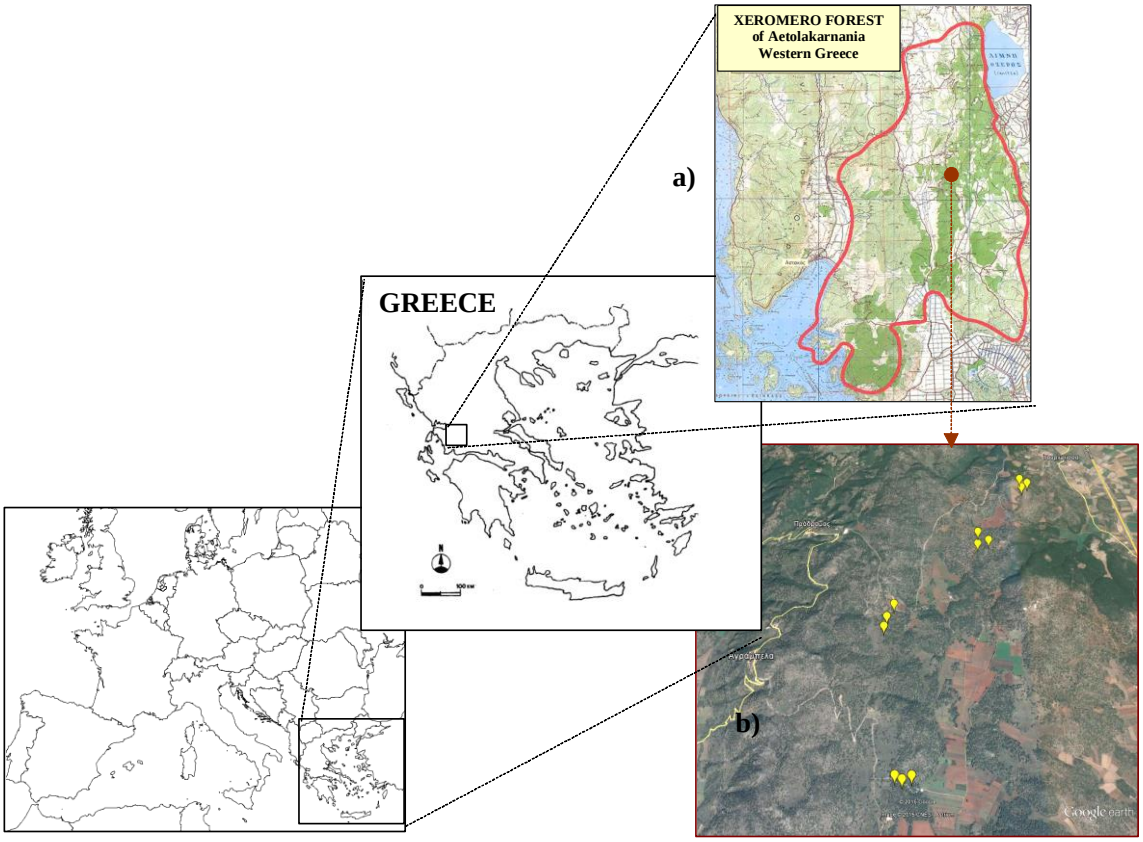

Figure 1. a) Map of Xeromero forest (Vlami et al. 2003) and b) satellite image (from Google Earth) with the position (yellow points) of 12 pair experimental sites in the valonia oak silvopastoral system.

Figure 2. Sheep grazing in valonia oak forest of Xeromero

Figure 3. Valonia oak forest with understorey vegetation

Table 1. Description of the site, with soil, tree, understorey, livestock, and climate characteristics

Site characteristics	
Area:	120 ha approximately
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 address	ampapadopoulos@teiste.gr

Soil characteristics	
Soil type (WRB classification)	Leptosols
Soil depth	≤1 m
Soil texture	
Additional soil characteristics	pH 7.1
Aspect	Various

Tree characteristics		
System	Agroforestry system	Reference system*
Tree species	Valonia oak	Valonia oak
Tree density (spacing)	Approximately 60/ha	60 trees/ha
Tree protection	None	None

Understorey characteristics		
System	Agroforestry system	Reference system*
Species	*Phlomis fruticosa, Paliuru spina-christii, Crataegus monogyna, Asphodelus fistulosus, Drimia maritima, Mercuria lisannua, Poa bulbosa, Stellaria media, Galium aparine, Rhagadiolus stellatus.*	Grass
Coverage	40-70%	

Livestock characteristics		
System	Agroforestry system	Reference system*
Species	Sheep and goats	none
Stocking density	5.5 ha^{-1}	

Climate data	
Mean annual temperature	18.8°C
Mean annual precipitation	938 mm
Details of weather station	Hellenic National Meteorological Service, Station of Agrinio, data from 1956-2012

2.4 Experimental design

To investigate the effects of grazing and shrub understorey on oak regeneration a representative area in terms of vegetation structure and grazing intensity was chosen in the forest of Xeromero (Figure 1). A two way between subjects factor design was used. The two factors were "grazing" and "understorey" (Table 2; Table 3). The main effects and the interactions of the two factors will be examined.

Table 2. Description of four experimental treatments

Treatment A: Fenced valonia oak with shrub understorey	Treatment B: Fenced valonia oak & cleared shrub understorey	Treatment C: Grazed valonia oak & cleared shrub understorey	Treatment D: Grazed valonia oak with shrub understorey
Fenced-ungrazed 8 m x 5 m plots, where the half of the surface (8 m x 2.5 m) will be left with its shrub understorey	Fenced-ungrazed 8 m x 5 m plots, where the half of the surface (8 m x 2.5 m) will be cleared off its shrub understory	Open-grazed 8 m x 5 m plots, where the half of the surface (8 m x 2.5 m) will be cleared off its shrub understorey	Control: Open-grazed 8 m x 5 m plots, where the half of the surface (8 m x2.5 m) will be left with its shrub understorey

Table 3. The treatments associated with the studied factors

Factor	Treatment	N
Grazing	Grazed	24
	Fenced	24
Understorey	With shrubs	24
	No shrubs	24

In this area, 12 pairs of rectangular plots covering an area of 40 m^2 each (5 m x 8 m) will be established in four different grazing allotments by sheep and goats (three pairs per allotment) (Figure 2). These allotments are composed of relatively open stands (40-60% canopy cover with trees aged 150-250 years) and have similar topographic and geological conditions. Half of the subplot will be located under the tree crown and the other half will be away from the canopy. One of the paired plots will be fenced to provide protection from grazing, while the other will remain open to grazing. Each of the 24 plots (protected or not) will be split into two parts; one part will be cleared from the understorey vegetation by clear cutting to investigate its role in tree regeneration. In all the plots, the number of acorns and the oak seedlings and the floristic diversity will be measured.

2.5 Measurements

Measurements will be carried out on the number of seedlings before the summer period (May) to estimate new regeneration (of the present growth season). Plant survival (number of living seedlings) and size (height and stem diameter) will be measured after the 1st, 2nd and 3rd drought period (autumn 2015, 2016 and 2017). In this second period, the number of acorns with a wired frame sized 0.5 m x 0.5 m will be measured in three fixed positions of each subplot (0.5 m from the corner and 1 m from the middle of the fence side (Figure 4). Results will be expressed in numbers per square metre. Vegetation dynamics will be assessed by the measurement of understorey vegetation (species and number per species) at May of each year with the wired frame 0.5 m x 0.5

m. Soil pH, soil organic matter and texture will be measured at the beginning and end of the experiment to compare beneath canopy and out of the canopy protection. The planned measurements to be taken in the two treatments are described in Table 4.

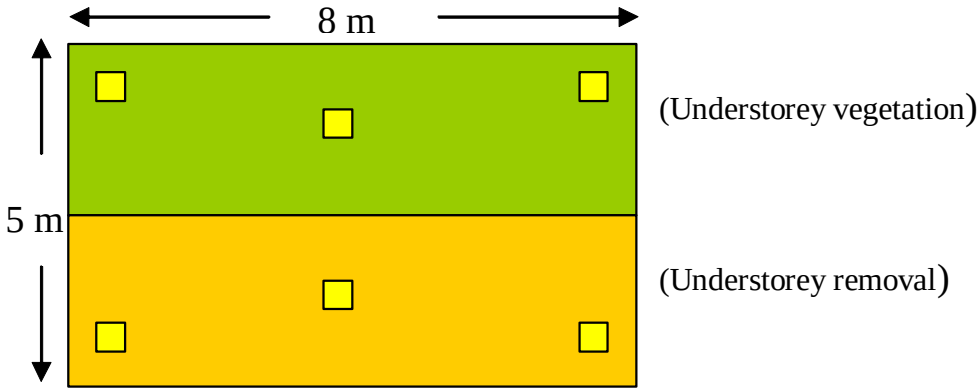

Figure 4. Experimental design with plots split into two sub-plots with and without understorey vegetation removal. Similar plots will be established next to the protected one, with two sub-plots with and without understorey vegetation removal.

Table 4. List of measurements to be taken in the two treatments

Measurements to be taken
• Understorey vegetation (species) • Acorn numbers • Seedlings number and growth characteristics • Understorey species and number per species • Soil changes due to the treatments

3 Valonia oak agrosivopastoral systems on Kea Island

3.1 Background

Agroforestry and specifically agrosilvopastoralism is a traditional land use system on Kea island, in Greece where livestock breeders used the valonia oak (*Quercus ithaburensis* ssp *macrolepis*) forests for direct grazing whilst collecting acorn cups from the oaks (Pantera 2014b). In this way they ensured a steady and enhanced economic return every year irrespective of weather conditions. The forest is characterised by the dominance of valonia oak trees. During a stakeholders' meeting farmers expressed their wish to investigate alternative ways to enhance their income such as the cultivation of grass under the valonia oak trees. In this respect, it was considered appropriate to investigate the effect of oak trees shade on grass development.

3.2 Objective of trial

The aim of the trial is to produce quantitative information about the interaction between livestock grazing, understorey vegetation, and valonia oak tree regeneration. Key questions include:

1 Do we want valonia trees or not?

2 Does valonia oak shading affect understorey grass growth?

3 Do trees effect is species dependent and, specifically, do trees have different effects on the growth of various legume and grass mixtures?
4 What problems do stakeholders presently face and why traditional practices are undervalued?

A number of hypotheses have been developed that include:

- Valonia oak do not affect the growth of leguminous plants,
- Different species and provenances respond differently to tree shade

To respond the questions and assess the validity of the hypothesis, three parallels trials are designed, at three different scales and sites to a) assess the response of legume species to oak shade, b) compare different forage crops rich in legumes, and c) determine the tree effect on soil characteristics.

3.3 System description

In order to comply with the initial ideas from the stakeholder group in Kea, it was decided to thoroughly study the effect of tree shading on grass growth and development. For this reason, a controlled experiment was established within the system. Valonia oak trees are over approximately 100 years old and are only used for grazing.

This study is located in a farm in Kea island (Aegean), owned by Antonis Prohis, a sheep and goat breeder (Figure 5). The site description and characteristics given in the Table 5.

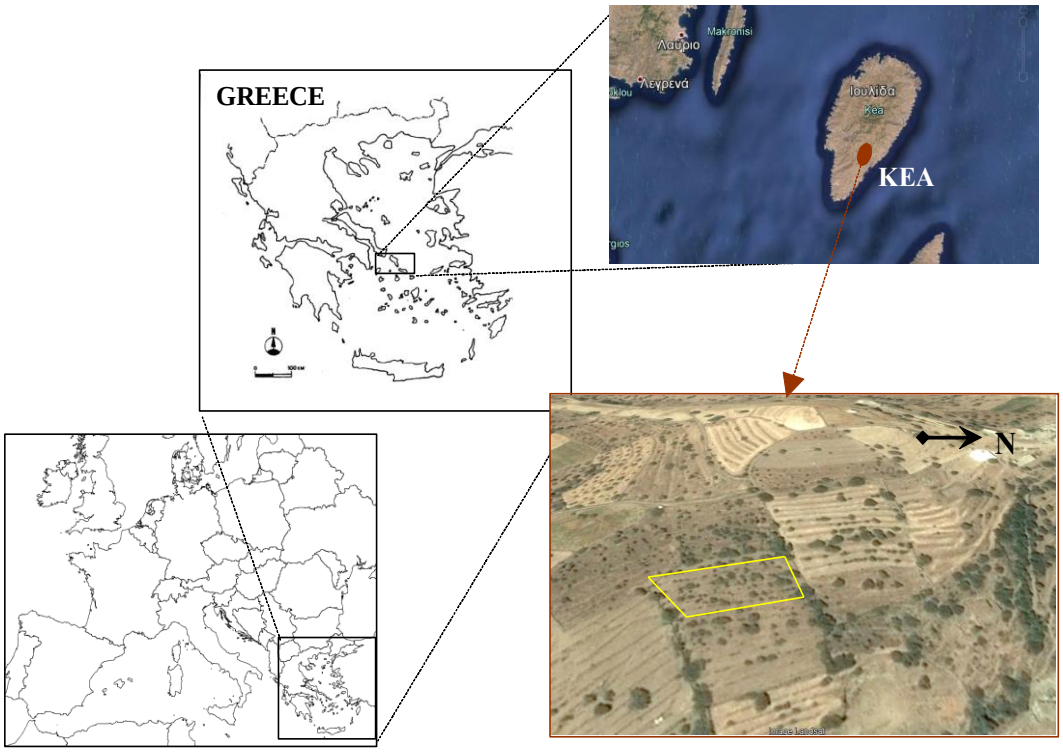

Figure 5. Map and satellite images from Google Earth of Kea island showing the position of experimental site of valonia oak agrosilvopastoral systems

Table 5. Description of the site, with soil, tree, understorey, livestock, and climate characteristics

Site characteristics	
Area:	0.5 ha approximately
Co-ordinates:	From 37°34'48"N & 24°19'32" E
Site contact:	Andreas Papadopoulos
Site contact email address	ampapadopoulos@teiste.gr

Soil characteristics	
Soil type (WRB classification)	Cambisols
Soil depth	≤1 m
Additional soil characteristics	pH 6.65
Aspect	East

Understorey -grass characteristics		
System	Agroforestry system	Reference system*
Species	Valonia oak & two mixtures and natural grass	Open field, two mixtures and natural grass
Coverage	40-70%	

Livestock characteristics		
System	Agroforestry system	Reference system*
Species	Sheep and goats	Sheep and goats
Stocking density	5.5 ha^{-1}	5.5 ha^{-1}

Climate data	
Mean annual temperature	17.9°C
Mean annual precipitation	700.4 mm
Details of weather station (and data)	Hellenic National Meteorological Service, Station of Karistos, data from 1975-1993

3.4 Experimental design

The study includes natural grassland and two commercial mixtures including up to nine forage legume species. One is a mixture commercialized by the company Fertiprado, based in Portugal, and one is a mixture provided by ISPAM-CNR (Istituto per il Sistema produzion e animale in ambiente Mediterraneo; Sassari, Sardinia, Italy). The species in each mixture is described in Table 6. Both mixtures were fertilized with 144 kg ha^{-1} of monopotassium phosphate 0-52-34 before seeding.

Table 6. Description of the two seed mixtures

Seed mixture name and abbreviation	Composition
ISPAAM (I)	40% *Trifolium subterraneum*[1] cv Campeda, 40% *Medicagopolymorpha* cv Anglona, 10 % *Loliumrigidum* cv Nurra
Fertiprado (F)	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*.

[1]For *T subterraneum*, the subspecies include brachycalycinum (6.1%) and yaninnicum (3%), and early maturing (13.6%), mid-season (19.7%) and late-maturing (18.2%) cultivars. This mix was sown at a density of 20 kg seed/ha, buried around 0.5-1.0 cm.

A two way between subjects factorial experiment was used. The between subjects factors were Shading and Seed mixture as shown in Table 7.

Table 7. Description of the two seed mixtures

Factor	Treatment	N
Tree shading	Yes	15
	No	15
Seed mixture	ISPAAM	10
	Fertiprado	10
	Natural grassland	10

The main effects and interactions will be examined. The study followed a randomized block design, with five blocks (Figure 6). Each block includes three 1 m x 1 m plots located in two different microhabitats, three plots beneath oak canopy and three in an adjacent open area (Table 8). Each grouping of three plots includes one plot with Fertiprado, one plot with the ISPAAM mix, and a control plot (native pasture). Figure 6, 7 and 8 illustrates the experimental design followed.

Table 8. Description of the experimental treatments

Treatment description	Plot size	Number of plots
A: Valonia oak and Fertiprado mix	1 m x 1 m	5
B: Valonia oak and ISPAM mix	1 m x 1 m	5
C: Fertiprado mix in the open	1 m x 1 m	5
D: ISPAM mix in the open	1 m x 1 m	5
E: Valonia oaks and natural grass (Control)	1 m x 1 m	5
F: Natural grass in the open (Control)	1 m x 1 m	5

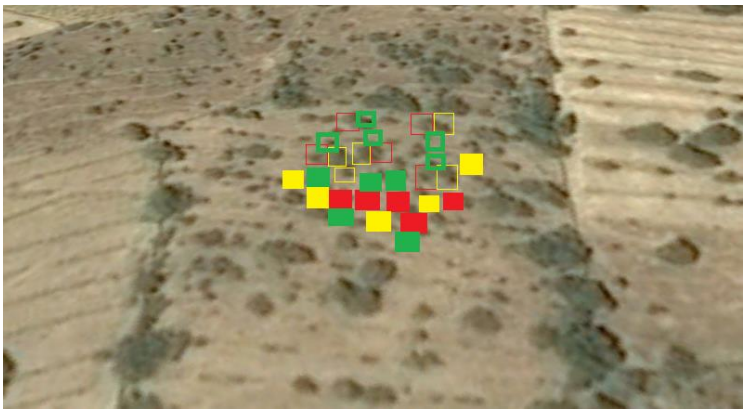

Figure 6. Experimental plots in the system. Plot treatments are: yellow with mixture of seeds; red with *Medicago* sown; green with natural grass. Solid squares refer to plots without canopy cover and open squares refer to plots under a valonia oak canopy.

Figure 7. Experimental area with plots established under the tree (valonia oak) canopy and outside of the canopy

Figure 8. Experimental area with subplots, that were established outside the tree canopy, were sown with two different mixtures

3.5 Measurements

The planned measurements to be taken in the treatments are described below (Table 9).

Table 9. Planned measurements in the experimental treatments

Component	Description of measurement
Pasture component	• Relative abundance per species and per microhabitat, expressed in terms of green biomass. • Average height and density of plants within the squares will be measured as well. • Plants will be sampled at maturity (end May) in 50 cm x 50 cm squares, 1 square per plot. • All biomass within the square will be harvested and stored in carton bag, transported to the lab, dried at 65°C until steady weight and weighed.

4 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.

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