Lessons learnt: Valonia oak silvopastoral systems in Greece

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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 Objective 2, Deliverable 2.5 which is to describe the lessons learnt from innovations within agroforestry systems of high natural and cultural value. Within the project, there were ten stakeholder groups focused on such systems (e.g. grazed forests, semi-open pastures, wood pastures, and bocage). This report contributes focuses on a stakeholder group which focussed on valonia oak agroforestry systems.

2 Background

Valonia oak (*Quercus ithaburensis* subsp. *macrolepis* (Kotschy) Hedge & Yaltirik) is an eastern Mediterranean endemic deciduous tree species, grown naturally in western and southern Anatolia (Turkey), Greece, southern Albania, and very locally in south-east Italy, (Tutin et al. 1993; Strid and Tan 1997; Dufour-Dror and Ertas 2004; Pantera et al. 2008). In Greece, valonia oak occupies 29,632 ha both in continental and insular Greece, mainly in lowlands and hilly forested, agricultural and urban areas. Its absence or low presence in many lowland areas of Greece may be attributed to the intense human interference applied to this zone for many years since ancient times.

The systems formed by this species are considered as agroforestry systems with high natural and cultural value (den Herder et al. 2015) and are distinguished by other oak systems in Greece from the open structure and old age as well of the trees as their typical semi-circular crown with thick branches, and the particular use for acorn production. These systems, due to their location in lowland to semi-mountainous areas and close to urban areas, underwent extensive grazing, deforestation, illegal logging, forest fires and other anthropogenic influences. Particularly the privately owned systems, which are considered as agricultural fields, have been abandoned or changed to other uses (e.g. residential, industrial). Typical cases are those of Attica prefecture, of Kea island and other Cyclades islands where, due to the high value of the land, these areas were converted to residential use.

Two types of valonia oak agroforestry systems can be found in Greece: silvopastoral that involve ancient open woodlands grazed by livestock and agrosilvopastoral that involve cropped arable fields with Valonia oak trees and livestock grazing after the crop harvest. Both systems have significant socio-economic, ecological and cultural value. They support numerous products and traditional uses (grazing, acorn and wood harvesting, collection of aromatic and medicinal plants) and provide numerous ecosystem services. Traditionally, harvesting of acorn cups for leather tanning has been a very important economic activity up to 1970s, significantly contributing to the local economy. In the past few years there has been a growing interest in re-using and re-evaluating the value of these systems within the context of acorn harvesting, organic agriculture and animal husbandry, but also for historical and environmental protection reasons.

An initial stakeholder meeting was organised within the framework of the AGFORWORD project in Xeromero, W. Greece (Pantera 2014). In this meeting, participants discussed the potential of valonia oak silvopastoral systems for production of fodder, acorn harvesting and the necessity of their protection from existing threats. Concerning the protection and conservation of these systems, land degradation and poor tree regeneration in the area were highlighted. Poor or no natural tree regeneration in valonia oak silvopastoral systems is a common problem in other regions as well where the species grows and, in combination with the continuous pressure posed by humans to these ecosystems, threatens the long-term sustainability of the valonia oak system. 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. This may be due to the high grazing pressure that exists in these forests, or the presence of a dense understorey, acorn consumption by wild and domesticated animals, which, in combination with climatic and site factors, confine young seedling establishment and development (Pantera et al. 2008).

On the other hand, during a stakeholders' meeting at the Aegean island Kea farmers expressed their willing to investigate alternative ways of using or re-using the valonia oak agrosilvopastoral systems to enhance their income. During the last decades, the agrosilvopastoral systems in the island have lost their traditional uses (acorn harvesting, firewood and wood collection for charcoal, small scale arable and fodder cropping). Most of the abandoned farmland containing oak trees is located on terraces due to the high slope of the terrain, and is currently used only as pasture with reduced livestock numbers. Given that grazing is an essential element in these oak agroforestry systems, and because of the need to use them as pasture in the summer, it is necessary to improve pasture quantity and quality by sowing drought tolerant species. This improvement will make these systems more attractive for grazing and will contribute to their conservation and reuse, in conjunction with re-launching other past traditional activities.

3 Objective

In order to protect and restore the traditional use of valonia oak systems and taking into account the opinions of the stakeholders, two research studies were carried out:

1) the first was in a typical silvopastoral system of Xeromero, Western Greece where the objective was to protect young trees through grazing exclusion and understorey clearing
2) the second was in a typical agrosilvopastoral system in Kea island of Cyclades, Aegean Sea, where the objective was to improve valonia oak system productivity by sowing shade adapted legumes.

The systems and the experimental protocols of the two studies were fully described by Papadopoulos et al. (2015). A brief description is Table 1 and Table 2.

Table 1**.** Protection of young trees (grazing exclusion) and understorey clearing

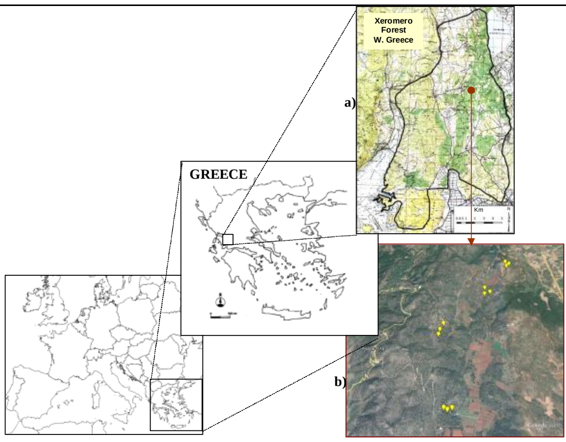
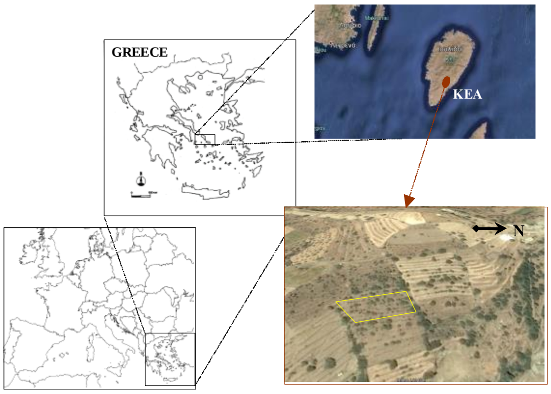
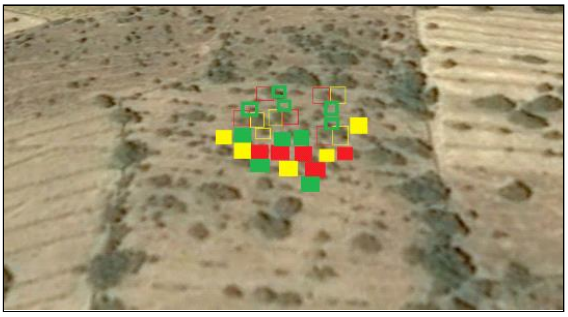
  General view of valonia oak silvopastoral systems in Xeromero, Western Greece.	  Experimental site in the valonia oak silvopasture system in Xeromero, Western Greece.
 <u>Map</u> of Xeromero woodland, with the position of the experimental plots (yellow points) in the valonia oak silvopastoral system.	**Plot treatments:** Four sheep and goat sheds as well as the pathways that the livestock follow daily for grazing were identified and 6 paired plots, 5X8 meters in size each, were established per shed territory, a total of 24 plots. In each pair, one plot was fenced and the other was left free to grazing. Woody understorey vegetation was cleared in half of each plot. Specifically, each of the 24 plots (fenced or not) was split into two parts; one part was cleared from the understorey vegetation by clear cutting and the other was left as a control. In all the sub-plots, the number of oak seedlings, acorns, and the floristic diversity were measured in the years 2015, 2016 and 2017.
Tree component: Valonia oak overstory had a density of 30-60 trees ha^{-1} and crown coverage 20-80%. In certain locations there were also *Quercus pubescens.* Tree age varied between 150-250 years. Average tree height was 10-15 m.	**Pasture/livestock: l**ivestock were composed of sheep and goats (stocking density 5.0-10.0 LU per ha^{-1}). Livestock breeders used separate paddocks for grazing with some of them being overgrazed and others undergrazed. In either case, the shrub *Phlomis fruticosa* dominated in the understorey which depressed valonia oak regeneration. Livestock grazing has been mostly blamed for the low regeneration of the species.

Table 2. Improvement of valonia oak system productivity by sowing shade adapted legumes in an agrosilvopastoral system

 General view of the valonia oak agrosilvopastoral systems in Kato Meria – Kea Island (Cyclades- Aegean sea).	 A certain number of trees was fenced for protection from grazing and received two commercial pasture mixes.
 Map with the location of experimental valonia oak agrosilvopastoral system of valonia oak in Kea Island - Cyclades.	 **Plot treatments:** 24 plots: yellow with mixture of "ISPAAM"; 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). In all the plots the yield were measured for three years (2015, 2016, and 2017). ISPAM: 40% *Trifolium subterraneum*[1] cv Campeda, 40% *Medicago polymorpha* cv Anglona, 10 % *Lolium rigidum* cv Nurra Fertiprado: 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*.
Tree component: valonia oak trees in lines at the edges of terraces with a density of 10-40 trees ha^{-1} and crown coverage of 10-20 %.	**Pasture/livestock:** abandoned arable land on terraces covered with natural pasture (80-100%). It was mainly grazed by sheep and goats (stocking density 5.5 LU per ha^{-1}). Occasionally some terraces are cultivated with cereals, oats, and vetch, with rotating fallow and crops.

4 Results

4.1. Protection of young trees (grazing exclusion) and understorey clearing

The comparison between grazing and no-grazing for three years shows that in the grazed sites there is a statistical significant reduction of the number of seedlings and young saplings (Figure 1) and the number of acorn nuts (Figure 2). Based on the 3-years means, the reduction of the number of seedlings and young saplings in the grazing plots, compared to the no-grazing plots, was 48% in May and 71% in October, while the number of acorns was reduced by about 74%. The difference in the number of seedlings and young saplings in the ungrazed (fenced) plots as compared to the grazed ones was greater in October compared to that of May (Figure 1) could be a result of the consumption of seedlings and young saplings by livestock during the summer. The large reduction in the number of acorns can be attributed, besides grazing animals, to the consumption by rodents not restricted by the fencing. The 21% reduction in the number of seedlings and young saplings in the non-grazed plots between May and October was not statistically significant could be caused by consumption by small wild animals and young seedling mortality caused by the shallow soils and the absence of organic matter as well as the intensive xerothermic period in the study area.

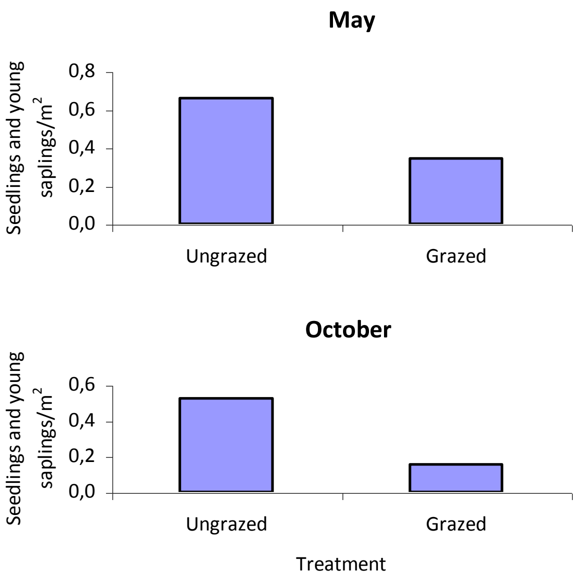


Figure 1. Average number of seedlings and young saplings/m^2 in the grazed and ungrazed (fenced) plots in May and October for 3 years

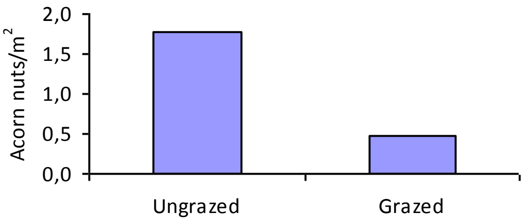


Figure 2. Average number of acorn nuts/m^2 in the grazed and ungrazed plots in October for 3 years

Understorey clearing did not have a significant effect on the number of seedlings and young saplings. However, field observations indicated that seedlings and young saplings of valonia oak were often found within the crown of shrub species such as *Prunus webbii*, *Crataegus monogyna*, *Asparagus acutifolius, Paliurus spina-christi*, which are avoided by the animals and do not create intense shading (Figure 3). These shrubs provide a natural refuge and better growing conditions for young seedlings. On the contrary, the presence of dense and high bush mesh (maquis and guarrigue) is an obstacle to the natural regeneration of valonia oak (Figure 4).

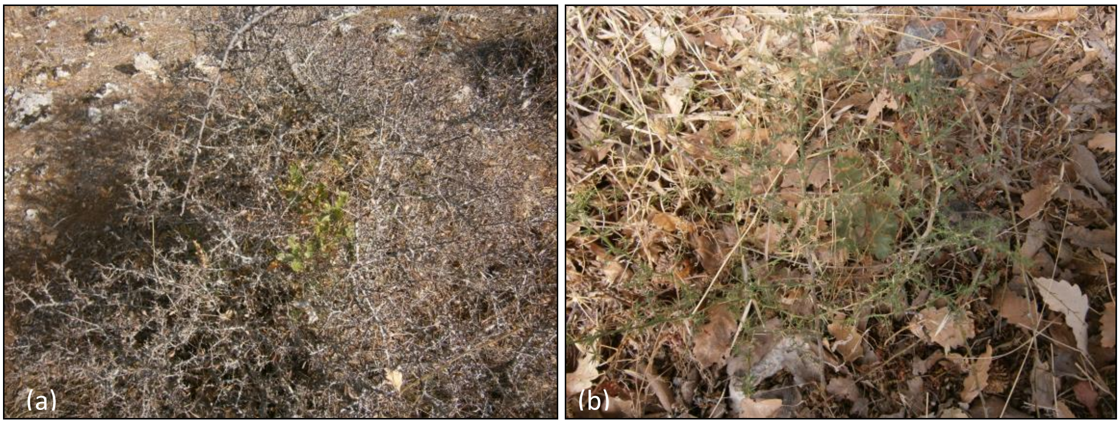


Figure 3. Young sapling of valonia oak inside (a) the crown of a *Crataegus monogyna* and (b) under an *Asparagus acutifolius* in a grazed location

Figure 4. Dense shrub understory in an abadoned valonia oak silvopastoral system.

Based on three years of observations, the average height of the new seedlings varied from 13.2 to 22.8 cm between plots, but with no statistically significant differences between the different treatments. The most notable differences, especially in the last two years of the experiment, were observed in the no-grazed with shrubs treatment where the highest seedlings height is noted. Valonia oak, due to its adaptability to barren soils and droughts, prioritises the development of its root system, which in the first year, under favourable soil conditions, can reach 60 cm in depth (Pantera 2001).

Soil organic matter content has not been substantially altered by grazing. Soil changes are mostly evident in the dry biomass that gradually accumulates in the ungrazed plots as opposed to the grazed ones (Figure 5a) where such a process is inhibited by grazing and by animal traffic. Generally, organic matter accumulation, decomposition and subsequent inclusion in the soil, seems to be slow probably due to unfavourable climate/soil conditions and soil erosion. Soil erosion is frequently evident by the revealing of the parent material superficially and occurrence of paving erosion (Figure 5b).

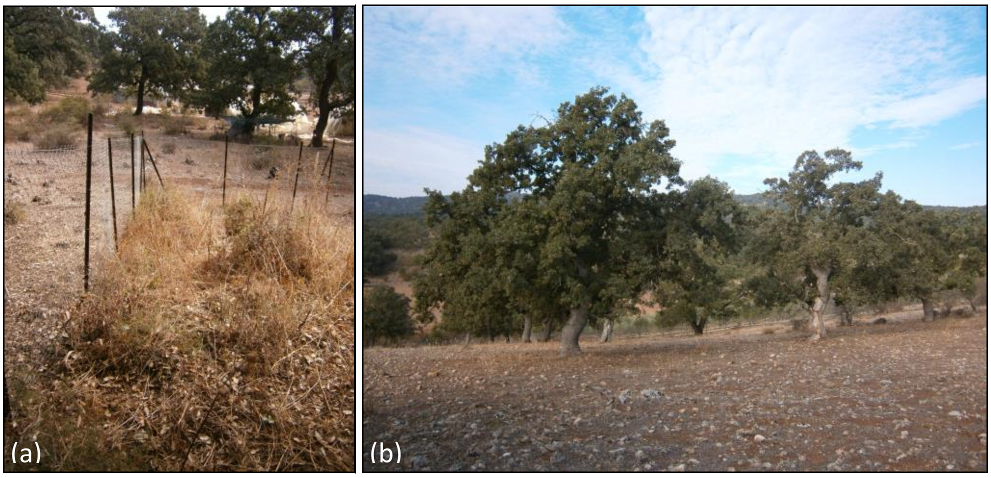


Figure 5 (a) An ungrazed (fenced) plot and (b) an overgrazed location

Based on the 3-year data, there appeared to be slight variations in the vegetation data between grazed and not-grazed (protected) plots. In 2015, when the experiment was established, there were more plant species in the protected plots than in the grazed ones. However, in 2016 and 2017 the numbers of species on the grazed and protected areas were more or less equal (Figure 6). A total of 149 plant species were recorded in the experimental plots. The dominant species were: (a) synanthopic and nitrophilous species directly related to human presence, (b) short low annual herbs and (c) phrygana whose presence is related to intense grazing and dry conditions.

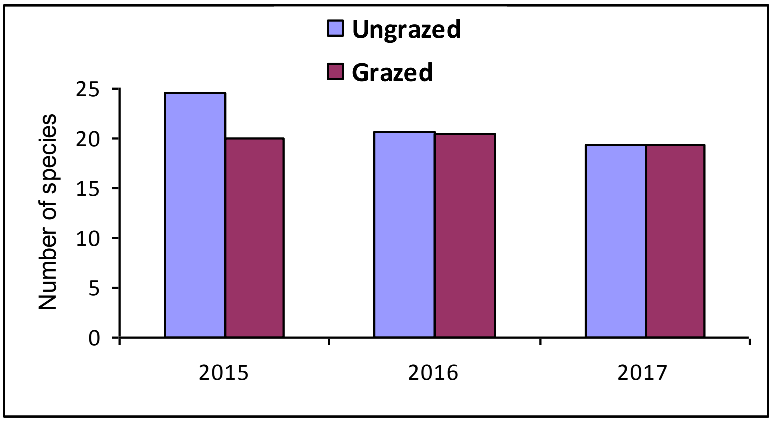


Figure 6. Average number of species in ungrazed and grazed plots.

4.2. Improvement of valonia oak system productivity by sowing shade adapted legume rich forage in an agrosilvopastoral system

The use of commercial seed mixtures with high number of self-reseeding legumes did not result in a statistical significant difference of total yield between the treatments (natural and sown pastures in shaded and unshaded by valonia oak locations) (Figure 7).

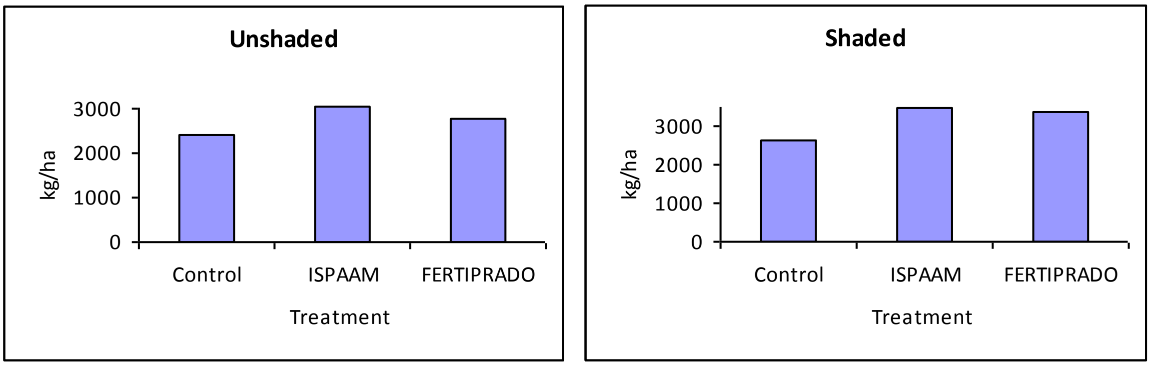


Figure 7. Average total annual dry matter yield per treatment (natural and sown pastures in unshaded and shaded locations), three years after the seeding.

However, an increase in the total yield of legumes was noted in the sown and shaded by valonia oak plots compared to the un-shaded ones (Figure 8). This is mainly attributed to the increased cover of *Trifolium subterraneum* in the sown treatments in the shaded plots (Figure 9). Finally, the increase of legumes coverage in the shaded plots resulted in an increase of nitrogen content of the soil. A similar increase of N due to legumes sowing was evidenced in a similar work by Moreno et al (2017).

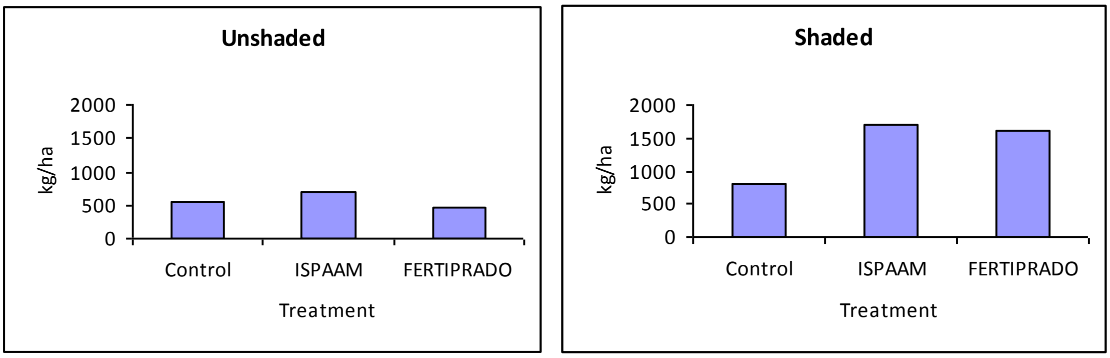


Figure 8. Average annual dry matter yield of legumes per treatment (natural and sown pastures) in unshaded and shaded by valonia oak locations, three years after seeding.

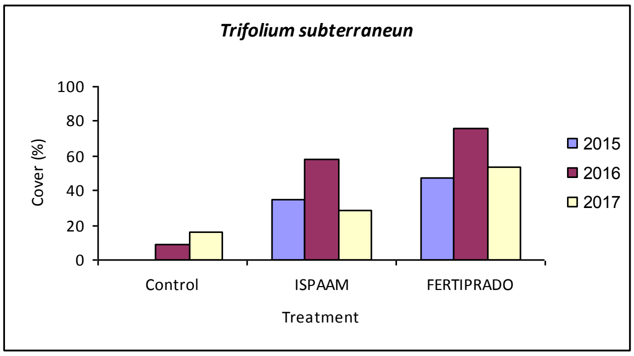


Figure 9. Cover (%) of *Trifolium subterraneum* 3 years after sowing the three treatments (natural and sown pastures) in the areas shaded by valonia oak.

5 Main lessons

It is important to protect, conserve and maintain the economic viability of traditional valonia oak agroforestry systems. Measures should therefore be taken, making use of local stakeholders' knowledge, to ensure the regeneration of valonia oak, to apply sound grazing management in state-owned silvopastoral systems, and to improve the pasture in privately-owned systems.

Livestock overgrazing of the valonia oak silvopastoral systems affects their natural regeneration and growth. Given that grazing is an important traditional activity of the local farmers, it cannot and should not be banned but properly regulated. In cases where natural regeneration problems are caused by overgrazing, the stocking rate and grazing season should be reduced and changed, respectively, or fences established for protection. It is advised that an open tree structure of 40-100 medium-sized trees ha^{-1} should be pursued and maintained, depending on the site conditions. This number corresponds to 20-50% soil coverage by the trees. Such a density favours acorn production, which is the primary use of the trees, and facilitates grazing.

Natural regeneration of valonia oak silvopastoral systems can also be supported by the maintenance of an open shrubby middle-layer. Where there is a dense and tall shrub-layer, it should be thinned to facilitate regeneration and grazing. A well-maintained open shrub middle-layer can provide a stable source of forage to animals, especially during the summer season where herbaceous vegetation is limited. When regeneration cannot be naturally achieved, a useful approach is to sow acorns as young seedlings are more resilient than planted plants to the dry areas and the shallow soils where the valonia oak species often appears.

Valonia oak agrosilvopastoral systems can also be improved by sowing legume seed mixtures, in particular *Trifolium subterraneum*, under trees particularly in dry areas, in cultivated or abandoned systems or where pastures are sought after long-lasting fallows. The sowing of legumes can improve pasture production without the need for increased chemical fertilizers.

The above systems can be productive and economically viable where organic livestock farming is combined with the reintroduction of acorn harvesting for tanning and other uses, small-scale crops with crop rotation and fallows, and agrotourism. They can also contribute substantially to biodiversity conservation and soil protection, and to climate change adaptation in the islands of the Cyclades and the wider Aegean Sea.

6 Acknowledgements

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