17. Mediterranean savanna-like agrosilvopastoral grassland system in Spain, Italy and Portugal

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1. Related practices and hot-spot

Grassland diversification, Agrosilvopastoralism; Grasslands

2. Description of the case study

The typical Mediterranean savannah-like grassland system called *Dehesa* in Spain, *Montado* in Portugal and *Pascolo arborato* in Italy is a UNESCO protected (UNESCO, 2017) multifunctional agro-forestry system aggregating balanced and combined agricultural, livestock and forestry activities. This agrosilvopastoral system is mainly dominated by scattered evergreen oak trees (*Quercus suber, Q. ilex, Q. rotundifolia, Q. faginea, and Q. pyrenaica*) in association with pastures, and sometimes used for crops and/or fallows. In the Iberian Peninsula and the Mediterranean basin, this traditional system is adapted to the unpredictable Mediterranean climate (Moreno and Cubera, 2008) and the local edapho-climatic conditions, which are frequently dominated by shallow soils with low organic matter (Pinto-Correia, Ribeiro and Potes, 2013). Extensive livestock management (mostly beef cattle, sheep, goats and autochthone pig breeds, in mono or mixed systems) is responsible for the ecological features of this system. At a reduced stocking rate, a balance can be achieved between animal pressure and the territory conservation. Moreover, this ecosystem is critical for biodiversity protection because biodiversity-rich areas occur close to or even dependent on some agricultural activity (Pinho *et al.*, 2018).

Although livestock sector represents ~14.5 percent of all human GHG emissions, it is important to distinguish among the existing livestock farming systems when assessing animal production's climate responsibility. Due to the great capability of agrosilvopastoral grasslands to sequester CO_2, pastoral-based production closely represents a carbon (C) neutral system or can even mitigate GHGs (Llorente and Moreno, 2020).

3. Context of the case study

This system covers around 4 million hectares in central and south-western Iberian Peninsula and can also be found in other areas around the Mediterranean basin. The climate is typically Mediterranean, with drastic intra- and inter-annual climatic variability. Rainfall, ranging from 400 to 800 mm, concentrates in autumn and winter followed by a long hot and dries summer. The mean annual temperature ranges from 14 to 17°C. This ecosystem is usually found on shallow (< 50 cm) and acid soils originated from siliceous rocks, which are poor in nutrients (Pulido and Picardo, 2010). Adding to this, the Mediterranean climate determines a rapid organic matter (OM) mineralization leading to the loss of SOC (Cordovil, 2004).

4. Possibility of scaling up

In this ecosystem, livestock takes advantage of the forage resources by not only just comprising grassland but also trees, which are also used as a hydrological stress regulator for the underlying herbaceous stratum (Joffre *et al.*, 1999). Trees are used as a feed complement resource for livestock (e.g. acorns and small branches) and host a diversity of bird species and lichens and supply ecosystem services such as C sequestration, soil quality improvement, erosion prevention, nutrient cycling, water and thermal regime regulations, as well as favour soil biota, mycological heritage and biodiversity. Besides, it also offers cultural, landscape and hunting benefits

(Pinto-Correia *et al.*, 2013). So, in a climate change scenario this system represents a great adaptation strategy, potentially replicable to other parts of the world with similar conditions.

5. Impact on soil organic carbon stocks

There is still limited data on emissions from extensive livestock grazing systems in different types of grasslands. Thus, amount of compensation by the C sequestration capacity of the system by trees, plant biomass and soil organic matter is not available. Following the "soil saturation" concept, pasture soils initially poor in OM tend to have higher C sequestration rates than those of soils initially richer in OM (Llorente *et al.*, 2020; Table 68). Also, soil C storage capacity in this system is around 2.8 percent while the current average soil C content in the region is 1.7 percent or less, confirming the ability to capture and store more C in its soils.

Table 68. Evolution of soil organic carbon stocks of the three presented systems

Location	Climate zone	Soil type FAO (2015)	Baseline C stock (tC/ha)	Additional C storage (tC/ha/yr)	Duration (Years)	Depth (cm)	More information	Reference
Spain	Medi-terranean	Cambisol, Luvisol	72.0	0.83	22	0-20	In dehesa soils, C sequestration seems enhanced by the presence of cattle; F.	Llorente *et al.* (2020)
Sardinia, Italy		Cambisol	42.9	0.65-1.24	37		Values depend on stocking density and grassland management; F.	Francaviglia *et al.* (2017)
Portugal		Several types	0.45-1.91 %SOM	0.71-1.91	4		In montado soils, pasture improvement increases C sequestration and drought resistance; F. M.	Teixeira *et al.* (2011) Cordovil *et al.* (2020)

F: Field experiment, M: Modelling

6. Other benefits of the practice

6.1. Improvement of soil properties

This system protects soil erosion, balances water cycle and increases OM input, among other benefits. The presence of trees, as well as extensive livestock management with a proper stocking rate enhances SOM incorporation into the soils, improves biological activity, and contributes to close nutrient's cycles in the system. These benefits are further increased with the use of diverse pastures, where legume species are incorporated.

6.2 Minimization of threats to soil functions

Table 69. Soil threats

Soil threats	
Soil erosion	Trees and grassland help increase SOM and thereby improve soil structure and reduce soil erosion
Nutrient imbalance and cycles	Nutrient cycles are closed within the system, e.g. N fixation and OM mineralization.
Soil contamination / pollution	Diffuse manure spreading. SOM increased potential fosters soil buffer capacity.
Soil acidification	A good pasture and grassland management will reduce inorganic fertilization need, thus potentially reducing the risk of soil acidification from its application.
Soil biodiversity loss	The spread of manure and the activity of ruminants encourages the diversity of edaphic microorganisms. Diverse pasture and grassland maintain increased biodiversity.
Soil compaction	Low stocking rate and low cropping/soil tillage. These ideal livestock stocking rate depends on the animal, the climate and the type of soil.
Soil water management	Better water cycles balance and water regime. Improves soil structure, water infiltration and water retention through OM build-up.

6.3 Increases in production (e.g. food/fuel/feed/timber)

This multi-productive system includes the processing and fractionation of biomass for feed, food, energy (as firewood and charcoal) and other non-food applications such as cork production. This diversified production system shows a positive opportunity for grassland farmers and their communities.

6.4 Mitigation of and adaptation to climate change

In a climate change future scenario, agrosilvopastoral system represents an efficient mitigation and adaptation strategy, because they account for nearly zero balance between C sequestration and CO_2 equivalent emission of its animal-derived products. It has been reported that grass-fed cattle tend to generate higher enteric methane emissions than feed-fed cattle (Knapp *et al.*, 2019). These are not sufficiently captured through a single CO_2e footprint, indicating a non-significant variation between them under global warming potential (GWP_{100}) where non-grass fed systems generally appear more emissions efficient, and the 100-year global temperature potential (GTP_{100}), grass-fed beef had lower footprints (Lynch, 2019). However, extensive farming represents a relevant decrease in external inputs to the farm. Also, when considering the C sequestration in the agroecosystem linked to the extensive livestock, carbon footprint of animal production could be close to C neutrality (Llorente *et al.*, 2020).

6.5 Socio-economic benefits

The system provides opportunities to engage populations in rural areas through many related activities including sustainable agriculture, forest products, food and feed production, leisure and tourism activities among others. In contrast, intensive farming in similar areas is ending with tourism activities and sustainable agriculture due to the great environmental impact of that kind of farms such as bad smells, flies, or water pollution.

7. Potential drawbacks to the practice

7.1 Trade-offs with other soil threats

Table 70. Soil threats

Soil threats	
Soil erosion	Correct livestock stocking rates are important to avoid soil erosion.
Nutrient imbalance and cycles	Increased biodiversity and SOM promote nutrients cycling
Soil contamination / pollution	If the manure, or any other input, is contaminated this lead to increase soil pollution.
Soil biodiversity loss	When livestock is treated with antibiotics and dewormers the manure could have a negative effect in soil diversity. Stocking rates and grazing management may affect negatively.
Soil compaction	Correct livestock stocking rates are important to avoid soil compaction.
Soil water management	Better water infiltration and retention capacity occurs through increasing OM.

7.2 Increases in greenhouse gas emissions

Eldesouky *et al.* (2018) estimated GHG emissions ranging from 1.0 to 1.8 t CO_2eq/ha/year for Mediterranean grazing livestock, depending on farm size, management, and intensification. Llorente *et al.* (2020) estimated that *dehesa* ecosystem sequesters an average of 3.3 tCO_2eq/ha/year taking into account soils, trees and pasture. Therefore, livestock products derived from Mediterranean savannah-like agroecosystems should be considered as neutral or even negative.

7.3 Conflict with other practice(s) and tools to overcome barriers

The associated extensive livestock production is threatened by low-cost products of intensive farming, thus reducing competitiveness when the market does not pay for quality. Development of labelling systems linking livestock products with its ecosystem services could be a key tool to guarantee the conservation of agrosilvopastoral systems.

7.4 Other conflicts

Abandonment of land, population aging, and depopulation of the Mediterranean basin rural areas have a negative impact on the maintenance of these systems. Young generations show little attraction due to the low level of potential income. Overexploitation of the pastures and the forest and the lack of renewal of the woodland and trees diseases management is accelerating the decline of such systems and compromise their survival and sustainable management.

8. Recommendations before implementing the practice

Climate change impacts are linked to an increased vulnerability of trees to diseases. Oak decline has been occurring across Europe over the past decades due to malpractice, natural causes and uncontrolled diseases. The pseudo fungus oomycete *Phytophthora cinnamomiseria* is thought to be the main cause of holm oak decline (Ruiz Gómez *et al.*, 2019). *Platypus cylindrus* is an ambrosia beetle known to establish associations with six ambrosia pathogenic fungi, contributing to weaken the trees and leading to trees stand decline. The flathead oak borer *Coroebus undatus* F. (*Coleoptera*: *Buprestidae*) is another of the primary pests of cork oak in the Mediterranean region (Fürstenau*et al.*, 2014). Therefore, an integrated management including the use of biocontrol agents like Trichoderma, and the selection of resistant trees, is important to guarantee the sustainability of this ecosystem.

9. Potential barriers for adoption

Table 71. Potential barriers to adoption

Barrier	YES/NO	
Cultural	Yes	Population aging, urbanization. Low potential income of the systems
Social	Yes	Rural areas abandonment.
Economic	Yes	Little incentives to maintain the appropriate tree density. Intensive farming products price to the market. Lack of certification.
Institutional	Yes	Not enough support.
Legal (Right to soil)	No	Heavy legal constraints to forest management.
Knowledge	Yes	More research is needed related to oaks' pests and diseases, and forest management factors that are responsible for forest decline.
Natural resource	No	Water stress from reduced precipitation driven by climate change impacts, increases trees vulnerability to pests and diseases.
Other	Yes	Historical overexploitation of the systems. Livestock density control and pasture management are key factors for the sustainability of this ecosystem.

Photos

Photo 32. Showing savana-like agrosilvopastoral system. Cáceres, Spain, 2019

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