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Silvopastoralism in Mediterranean Basin:
Extension, practices, products, threats and challenges

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Abstract. Ranching generally causes a progressive deforestation. Nevertheless in Mediterranean countries trees are still present in many pastoral systems, here referred to as silvopastoral systems (SPs). Trees provide products as fruits as human food, fruits or leaves as fodder, wood and firewood, environmental services like patches of soil fertility and shelter for animals, and environmental goods such as carbon sequestration, water yield and quality and reinforced biodiversity. However, most of the SPs locate in marginal areas, have low commercial profitability and are subject to two divergent trends, intensification and extensification or abandonment that compromise their long-term persistence. Here we analyzed current threats/constraints and new challenges for the future of SPs based on experience gained in Iberian dehesas. We stress the need of a comprehensive and categorized map of SPs and a database of management practices as adaptive solutions to environmental and socioeconomical contexts. We propose a set of topics for future research projects that should integrate traditional and scientific knowledge favoring innovative techniques for production of timber and non-timber forest products, livestock, and cultural and environmental values.

Keywords. Dehesa – Encroachment – Environmental goods and services – Regeneration – Scattered trees.

Sylvopastoralisme dans le bassin méditerranéen : Extension, pratiques, produits, menaces et défis

Résumé. *L'élevage provoque généralement une déforestation progressive. Néanmoins dans les pays méditerranéens les arbres sont présents dans de nombreux systèmes pastoraux (systèmes sylvo-pastoraux ; SPs). Les arbres fournissent des produits tels que des fruits pour l'alimentation humaine, fruits et feuilles utilisés comme fourrage, bois et bois de chauffage, des services environnementaux, comme la fertilité des sols et des abris pour les animaux, et des biens environnementaux comme la séquestration du carbone, le rendement et qualité de l'eau, et le renforcement de la biodiversité. Cependant, la plupart des SPs se localisent dans les zones marginales, ils ont une faible rentabilité commerciale et ils sont soumis à deux tendances divergentes, l'intensification et l'extensification, qui compromettent leur persistance à long terme. Ici, nous avons analysé les menaces et contraintes actuelles et les nouveaux défis pour l'avenir des SPs sur la base de l'expérience acquise dans les dehesas ibériques. Nous soulignons la nécessité d'une carte complète et classée par catégorie de SP, d'une base de données de produits et de pratiques de gestion et d'adaptation à des contextes environnementaux et socio-économiques. Finalement, nous proposons un ensemble de sujets pour futurs projets de recherche qui devraient intégrer les connaissances traditionnelles et scientifiques visant à faciliter l'élaboration de techniques innovatrices pour la production de produits forestiers ligneux et non ligneux, produits de l'élevage, produits culturelles et biens et services environnementaux.*

Mots-clés. *Dehesa – Buissonnement – Biens et services environnementaux – Régénération – Arbres disséminés.*

I – Pastoralism, deforestation and scattered trees landscapes

Orography, low soil fertility and climate constraints have hampered the development of large-scale agriculture in many Mediterranean region, where ranching have predominated among land uses (Pardini, 2007). However, grazing in Mediterranean countries and beyond is mostly a long way of deforestation. Grazing mostly cancels opportunities of tree regeneration (Pulido *et al.*, 2010) and periodical fires have been a common management practices, especially in

Mediterranean countries (Grove and Rackman, 2001). Nevertheless, in more marginal, stress-prone regions, different landscapes dominated by scattered trees as grazed forests, anthropogenic savannas, wood pastures (trees as fodder) and grazed plantations still extant (the assemble is here referred to as silvopastoral systems; SPs).

SPs have evolved through centuries and millennia in the Mediterranean Basin, where they currently occupy vast areas in most countries (Papanastasis, 2004). Indeed, scattered trees are still a prominent element of many human-modified landscapes around the world (Gibbons *et al*., 2008). Cultural savannas could occupy more than 5 million km^2 in the Mediterranean, North and South America, Central Asia, South Africa and South Australia (Pulido, unpublished). Oak savannas extend over millions hectares in the Iberian Peninsula (Marañon *et al*., 2009).

A major challenge that grazing systems will face in the coming decades is the need to provide sustainable pasture yields while conserving ecosystem services. The capacity of SPs to sustain multiple functions and products has been emphasized as new needs and challenges have emerged in modern society (Manning *et al*., 2006; Moreno and Pulido, 2009). However, most of SPs are currently facing both environmental and economic threats that might compromise their long-term persistence. Changes in the technological and socio-economic conditions, current agricultural trends and policies are imposing a loss of traditional empirical knowledge, a continuous decrease of profitability of SPs and their products, and system degradation (Pereira *et al*., 2004). SPs need, therefore, of specific policies to solve those threats and reinforce their economical, social and ecological roles. However, there is a complete lack of systematic and detailed knowledge on the extent and constraints of most of these systems. No official data or maps are available on these multilayered systems, resulting in an information failure that precludes the elaboration of specific proposals for management and policy to face current threats.

II – The role of trees in pastoral systems

Scattered trees have been designated as "keystone structures" due to the disproportional large ecological values and ecosystem services they provide relative to the small area they occupy in landscapes. Trees provide multiple woody and non-woody plant products, high-quality food, livestock and game products, recreational or cultural services through multiple activities conducted with a comparatively low environmental impact. SPs supply us also with important ecosystems goods and services such as biodiversity maintenance, carbon sequestration, soil fertilization, microclimate amelioration, shelter for livestock, control against erosion and desertification, increased local water balance (Manning *et al*., 2006; Wallace, 2007).

The consequence of low tree density for tree functioning and productivity of Mediterranean SPs have been evidenced in Iberian dehesas, where scattered trees exhibit much higher water potential, photosynthetic activity and acorn yield than trees growing in dense forest (Moreno and Cubera, 2008; Carevic *et al*., 2010). Indeed, reduced tree density of SPs has been interpreted as a practical management strategy to cope with foreseen aridification of Mediterranean ecosystems (Joffre *et al*., 1999; Manning *et al*., 2006). The positive role of trees for soil fertility in SPs and agroforestry systems is very well documented (see Young, 1997 for a review), as it is the importance of trees on the build up of the soil carbon stock (e.g. Howllet *et al*., 2011) and on the mitigation of deep nutrient leaching (e.g. López-Díaz *et al*., 2011). Finally, the importance of SPs, and more specifically of scattered trees for the maintenance of high levels of biodiversity have been repeatedly reported in Iberian dehesas (Marañon *et al*., 2009).

In spite of the large number of scientific evidences of the positive role of trees in SPs, trees rarely have been actively favored in pastoral systems. The net effect of trees on understory and *vice versa* can vary according to different ecological factors. For instance, trees can favor pasture production through the improvement of soil physical and chemical fertility, but trees and pasture also compete for soil water and light (Moreno *et al*., 2007). A good knowledge of the

effects of mature trees on forage production and the effects of understory structure on tree production (e.g. acorn production) is critical for ranchers to determine the optimal design and management of the system (tree density, thinning and pruning, canopy form and size, fertilization, pasture improvement, encroachment control, grazing regime, periodical cropping…). Similarly, the effects of understory structure on tree recruitment must be taken into account to ensure the stability (long persistence) of the system (e.g. tree regeneration). Pasture production, tree growth and/or fruit production and tree regeneration need be analyzed taking into account the complexity of the overstory-understory.

III – Current trends, threats and challenges

Over the last decades most Mediterranean SPs have faced several threats that compromise their long-term persistence. Changes of the technological and socio-economic conditions and common agricultural policies, with the concomitant lost of profitability, are leading to two divergent trends, intensification of land use in some areas, and land abandonment-encroaching in others (Pinto-Correia, 2000; Papanastasis, 2004). Intensification has resulted in a shift from the traditional farming systems with very low external inputs to a much more simplified system involving intensive management techniques, with partial substitution of extensive, low-intensity grazing for semi-intensive management regime, and decreasing diversity of land uses (Plieninger and Wilbrand, 2001). These authors have denounced a dramatic lost of soil quality and biodiversity, overageing of oak stands due to a prolonged lack of regeneration on SPs, trends intensified with the recent increment of livestock rate or grazing pressure.

Extensification results on woody encroachment of SPs all over the world (e.g. Asner *et al*., 2004; Archer, 2010), and notably in Mediterranean countries (Mazzoleni *et al*., 2004) with important changes on their functioning and productivity. Although in the last two decades an intense debate has been developed on the sustainability of SPs in view of the lack of tree regeneration, it seems that they are resilient enough able to recover to a natural stand structure after set-aside of several years (Pulido *et al.,* 2010). It seems that the trend toward tree loss in SPs is more than compensated by recovery in areas that have been abandoned, protected or devoted to big game hunting in Iberian Peninsula. The true challenge is to integrate the dual objectives, pasture improvement that could play against tree regeneration, and woody encroachment that guarantees soil and tree regeneration and thus, sustainability of the system.

IV – Future prospects

Explicit long-term strategies should be designed to promote management practices that ensure SPs conservation. However, in order to convince landowners, administration and policy-makers a better knowledge is still needed. For instance, studies focusing the conditions under which net balance of trees is positive (facilitation) or negative (competition) for pasture understory are still needed. Similarly, the optimal tree density of SPs under different uses and ecological constraints (namely water shortage) has not been adequately afforded yet. The analysis of consequences and opportunities of woody encroachment of extensive pastoral systems and landscapes also deserve more attention. SPs encroachment could be favorable for regeneration, but it is doubtful whether shrub encroachment would keep stand functioning (e.g., hydric and nutritional tree status, biodiversity) and profitability (e.g., livestock carrying capacity).

From the lessons learned across three decades of scientific studies in Iberian dehesas, but also from the realization of the lack of parallel studies in other SPs across Mediterranean countries, we estimate as priority (i) the elaboration of a comprehensive and categorized map, and the associated database of pastoral systems and grazing strategies within forest and woodland; (ii) compilation of traditional and modern management practices as adaptive solutions to environmental and socioeconomical contexts; (iii) scientific evaluation of environmental services, as reducing forest fires, C storage reinforcements, control of water loss and quality,

and biodiversity preservation, under different environmental and management context; (iv) identification of synergies and trade-offs occurring among products, and among livestock production, ecosystem services and biodiversity; (v) diversification and increment of forage offer (mitigating seasonal shortages) and other marketable products of Mediterranean SPs; (vi) economical evaluation of SPs including environmental goods and services (green accounting).

Research projects should integrate traditional and scientific knowledge to facilitate (i) the elaboration of innovative techniques for the long term production of timber and non-timber forest products; (ii) the elaboration of policy proposals to reinforce the public environmental goods and services provided by SPs; and (iii) the development of effective institutions and governance structures for a effective take-up of the body of knowledge on SPs functioning and valorisation.

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