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The important role of scattered trees on the herbaceous diversity of a grazed Mediterranean dehesa

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ABSTRACT

Scattered trees are considered keystone structures and play an important role in Mediterranean sylvopastoral systems. Such systems are associated with high biodiversity and provide important natural resources and ecosystem services. In this study, we measured the contribution of scattered trees and different grazing management (cattle, sheep and wildlife only) to the diversity of the grassland sward in a dehesa (open holm oak woodland) located in Central Spain. We analyzed alpha and beta diversity through measurement of species richness, Shannon-Wiener, and Whittaker indices, respectively; and the floristic composition of the herb layer using subplots within two adjacent plots (trees present vs. trees absent) under three different grazing management regimes, including wildlife only, during a year. We found a 20–30% increment in the alpha diversity of wooded plots, compared to those without trees, regardless of grazing management. All beta indices calculated showed more than 60% species turnover. Wooded plots were occupied by different herbaceous species in different heterogeneous microsites (under the canopy, in the ecotone or on open land) created by the trees. Livestock grazing modified species composition (e.g. more nitrophilous species) compared to wildlife only plots. In addition to all their other benefits, trees are important to maintaining grassland diversity in Mediterranean dehesas.

1. Introduction

Many different ancient and recently modified landscapes throughout the world include scattered trees (Manning et al., 2006). Open Mediterranean oak woodlands support relatively rich biological diversity (Eichhorn et al., 2006). A scattered distribution of trees may exist naturally, but more often trees occur as legacies of past forests or woodlands that have been cleared or thinned. Trees may have been maintained incidentally or deliberately as part of sylvopastoral systems (Manning et al., 2006; Moreno and Pulido, 2009). Trees are considered keystone elements due to the disproportionally wide range of important ecological functions and ecosystem services they provide relative to the small area they occupy (Manning et al., 2006). Their presence creates microclimates under the canopy with less thermic and hydric variability (Jackson et al., 1990; Power et al., 2003); improves soil structure (Scholes and Archer, 1997; Joffre et al., 1999); increases the amount of nutrients, water and organic matter close to their root systems (Cubera and Moreno, 2007; Rolo et al., 2014); changes plant diversity (Pineda and Montalvo, 1995; Ludwig et al., 2004); provides food resources, shelter or nesting sites for multiple species (Joffre et al., 1999; Tews et al., 2004); increases carbon sequestration (Roig et al., 2010; Bugalho et al., 2011); and adds aesthetic qualities to the landscape, increasing potential for tourism and recreation (Schnabel and Ferreira, 2004). These systems often include livestock grazing which compacts soil, alters soil nutrients and modifies widely herbaceous species composition (Díez et al., 1992; Frank et al., 2002; Piñeiro et al., 2009).

Several studies have analyzed the influence of scattered trees on the diversity of the herb layer. Herbaceous species richness has been shown to be lower beneath the canopy than outside it

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(Marañón and Bartolome, 1994; Fernández-Moya et al., 2010), although these results can change with the annual rainfall (Callaway, 1995). Within the canopy area of influence, studies have revealed that distance from the trunk changes the species composition (Marañón and Bartolome, 1993; Fernández-Moya, 2010), leading to higher alpha diversity at the edge of the crown or ecotone compared to beneath the crown itself (Marañón, 1986; López-Sánchez et al., 2013). At landscape scale, all these tree-related influences increase biodiversity levels overall in Mediterranean environments (Marañón, 1986).

One typical Mediterranean sylvopastoral system is the *dehesa*. Dehesas are considered to be a type of habitat of European Community interest, as per 6310 by the Directive 43/92/EEC (European Commission, 1992). They are among the best remaining examples of low-intensity farming systems in Europe and are associated with relatively high diversity levels while producing important natural resources and ecosystem services (Plieninger and Wilbrand, 2001; Díaz and Pulido, 2009). Plant diversity indices are high (Pineda et al., 1981; Montalvo, 1992) depending mainly on slope dynamics, the distribution and characteristics of scattered trees (González Bernáldez et al., 1969) and livestock management (Carmona et al., 2013). The effects of tree canopy on the diversity and floristic composition of the herb layer in the dehesa system has been thoroughly studied (e.g. Marañón, 1986; Fernández-Moya et al., 2010). Previous research has not, however, directly addressed the response of herbaceous diversity to tree presence or absence combined with grazing management regimes, although grazing by livestock and wildlife is an essential component of the dehesa system. There is not also enough research on the plant species characteristic of open woodlands versus grasslands, and of different grazing regimes within dehesas. Addressing these questions is needed to understand the role of the trees in the overall herbaceous diversity of these systems and to further support the need to preserve the woodlands, including sufficient trees. Unfortunately, sylvopastoral systems are not well-addressed in E.U. conservation policies.

This study focuses on the role of trees in the dehesa. We examined the diversity of the herbaceous layer as a function of the presence or absence of scattered trees, and examined how grazing management of sheep, cattle and wildlife can modify these results. We focused mainly on diversity indices (alpha and beta) and changes in the plant composition as indicators. Specifically, we hypothesized that: i) tree presence increases the general herbaceous diversity of wooded pastures by modifying their floristic composition; ii) alpha diversity of inter-tree gaps (beyond the influence of trees) within wooded zones is the same as that of open grasslands (without trees); iii) herbaceous diversity between wooded zones and open grasslands differs under different grazing regimes; and iv) tree presence/absence and different livestock management regimes generate different herbaceous indicator species.

2. Materials and methods

2.1. Study area

The study was located in a typical dehesa (715 ha) in Toledo province, in Central Spain (39°59′N, 5°8′W; at 350 m asl; Fig. 1). The climate is Mediterranean pluvioseasonal oceanic (Rivas-Martínez and Rivas-Saenz, 2013), with a mean (20 years) annual rainfall of 607 mm (September–August period) and a mean annual temperature of 15.1 °C (López-Carrasco and Roig, 2009). During the study year (2013), the annual (September–August period) and spring (March–May period) rainfalls were 661.1 mm and 251.5 mm, respectively; and mean temperature was 13.3 °C ("Calera y Chozas" and "Alcolea del Tajo" agroclimatic station, http://crea.uclm.es/siar/index.php). In the study year, the annual rainfall was 9% higher than the 20-year average (López-Carrasco and Roig, 2009), considered a medium high precipitation level. Soils at the study site are sandy

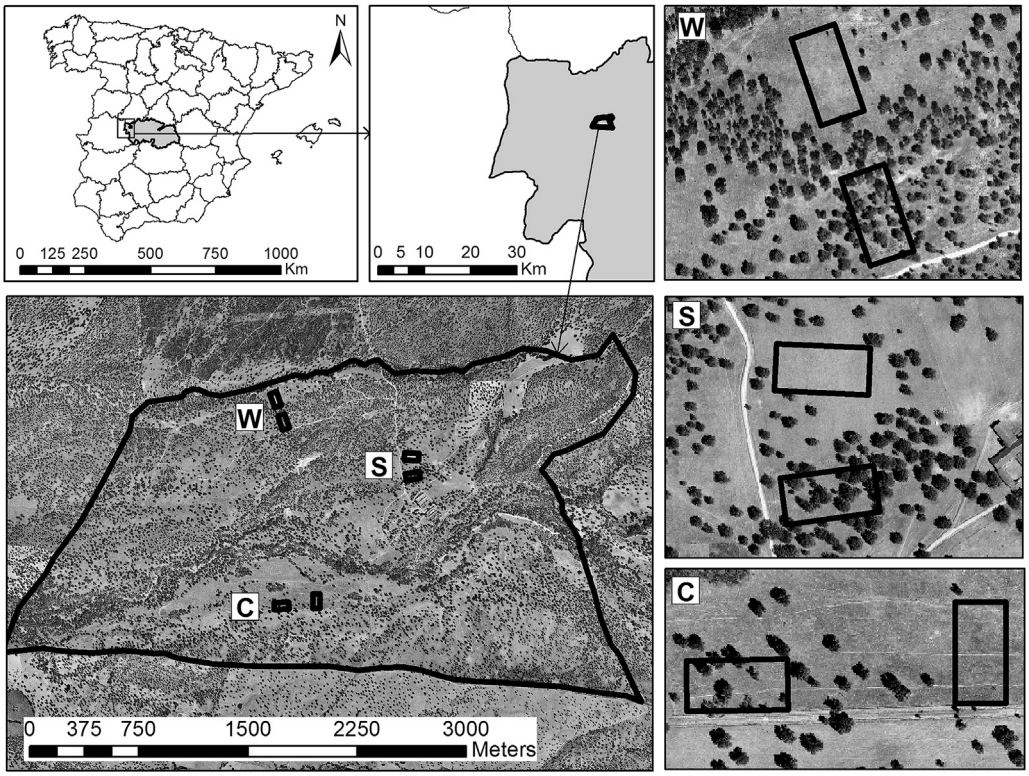

Fig. 1. Location of the plots (100 × 50 m) within the dehesa studied (715 ha) in Central Spain (39°N, 5°W). W: grazed by only light wildlife presence; S: grazed by sheep and light wildlife presence; C: grazed by cattle and light wildlife presence.