



Livestock vs. wild ungulate management in the conservation of Mediterranean dehesas: Implications for oak regeneration



Aida López-Sánchez^{a,b,*}, Ramón Perea^{a,c}, Rodolfo Dirzo^c, Sonia Roig^{a,b}

^a Departamento de Sistemas y Recursos Naturales, Universidad Politécnica de Madrid, Ciudad Universitaria, s/n, 28040 Madrid, Spain

^b ECOGESFOR, Ecología y Gestión Forestal Sostenible, Universidad Politécnica de Madrid, Ciudad Universitaria, s/n, 28040 Madrid, Spain

^c Department of Biology, Stanford University, 371 Serra Mall, Stanford, CA 94305, USA

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ABSTRACT

Dehesas are traditional silvo-pastoral systems with scattered oak trees that maintain considerably high biodiversity. Over the last five decades, dehesas have undergone significant management changes, causing a reduction in oak recruitment that threatens their long-term persistence. Here we examine oak regeneration in Mediterranean dehesas of Central Spain under three distinct and representative management regimes for more than 30 years: (1) traditional management of extensive sheep rearing; (2) high commercially-competitive management with extensive cattle grazing, and (3) wildlife grazing, mostly by deer. We found that cattle-grazed dehesas sustained a very low density of young oaks (0.05 young plants per 4 m²), one third and one fifth of that found in sheep and wildlife areas, respectively. We also found differences in young oak densities depending on plant growth stage, revealing that saplings (late-stage regeneration), but not seedlings, were more abundant under traditional sheep management. Overall, the probability of herbivory damage was higher in areas with cattle (0.85 probability) than in areas with sheep (0.68) and wildlife (0.30). Cattle areas presented, by far, the highest intensity of herbivory, with 63% of the plants showing very high browsing levels (>70% of the biomass damaged). For all management regimes, shrubs were important microhabitat (nurse plants) for seedlings but not for saplings or oak bushes. Our results suggest that conservation practices should include promotion of traditional sheep rearing, reduction of cattle stocking rates, protection of saplings and oak bushes, rotational grazing and preservation of some shrubs. We conclude that agriculture policies that favor traditional sheep rearing and sustainable wildlife populations can promote the conservation of these valuable systems.

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1. Introduction

Pasture lands with scattered oak trees, known as dehesas in Spain, are the result of a long-term history of human manipulation, and represent highly diverse landscapes that have been sustained by traditional management (Manning et al., 2006; Underwood et al., 2009). These systems provide important ecosystem services (Eichhorn et al., 2006; Myers et al., 2000; Plieninger and Wilbrand, 2001) but are, currently, under considerable anthropogenic threats, especially climate disruption, land-use change and inadequate management (Blondel and Aronson, 1999; Carmona et al., 2013; Underwood et al., 2009). One major bottleneck in the conservation

of these systems is the lack of oak recruitment needed for population regeneration (Gibbons et al., 2008; Manning et al., 2006; Plieninger et al., 2003). This shortage of tree recruitment is critical and represents a long-recognized threat for the persistence of many scattered oak woodlands worldwide (Bergmeier et al., 2010; Manning et al., 2006; Fischer et al., 2009).

Dehesas define much of Southwestern landscapes in the Iberian Peninsula and are included in the European Union Habitats Directive given their high ecological and conservation values (Díaz and Pulido, 2009; Ramirez and Díaz, 2008). However, their long-term preservation is threatened by limited oak regeneration, mostly attributed to the high intensity and permanent grazing pressure of livestock over the last five decades (Plieninger et al., 2003; Pulido et al., 2001; Tyler et al., 2006). Since the 1950s, many dehesas have suffered strong ecological and socioeconomic changes, including agriculture intensification, abandonment of forestry practices and promotion of higher livestock densities (Díaz et al.,

* Corresponding author at: Departamento de Sistemas y Recursos Naturales, Universidad Politécnica de Madrid, Ciudad Universitaria, s/n, 28040 Madrid, Spain.

E-mail addresses: aida.lopez@upm.es, aida.lopez.sanchez@gmail.com (A. López-Sánchez), ramon.perea@upm.es, ramonp@stanford.edu (R. Perea), rdirzo@stanford.edu (R. Dirzo), sonia.roig@upm.es (S. Roig).

1997). In many dehesas and woodland pastures sheep rearing has been replaced with cattle rearing, mostly due to the higher profitability in regional and national markets (Hartel and Plieninger, 2014) and the actual lack of shepherds willing to conduct grazing management (Carmona et al., 2013). On the other hand, hunting and recreation have become a major economic activity, now occurring in many dehesas (Martínez-Jaúregui et al., 2011; Olea and San Miguel-Ayanz, 2006). Some landowners have abandoned livestock and established perimeter fences to assure independent wildlife management, favoring game harvest (mostly deer kills), trophy quality or wildlife sighting. However, these measures often result in a dramatic increase of wild ungulate densities (Olea and San Miguel-Ayanz, 2006; Perea et al., 2014). Therefore, there is a strong need to compare how different management approaches may affect oak regeneration in order to establish best possible practices that can maximize the conservation and regeneration of these systems.

Previous research has shown notable reductions in oak densities due to different management practices such as agricultural intensification or livestock densities (Plieninger et al., 2004; Plieninger, 2007; Pulido et al., 2001, 2010). For instance, in other pasture lands with scattered oak trees an important reduction in the density of young plants was reported in cattle-grazed areas compared to areas without cattle for more than two decades (Dufour-Dror, 2007; López-Sánchez et al., 2014; McClaran and Bartolome, 1989). However, the comparison of alternative management schemes, involving different grazing animals (cattle, sheep and wild ungulates) has not been hitherto evaluated. In addition, it is necessary to assess the distribution of oak young plants across different microsites, particularly the presence of nurse plants, within these management landscapes in order to evaluate their efficiency as nurse plants and their use in restoration and conservation practices. In many dehesas the woodland is a predominantly represented by old trees, with a scarce representation of seedlings and saplings (Plieninger and Wilbrand, 2001; Plieninger et al., 2003).

This study examines oak regeneration (seedlings, saplings and bushes) under three representative management schemes of the Mediterranean dehesas: (1) traditional management (i.e., extensive sheep pastoralism); (2) a more commercially competitive livestock ranching (i.e., extensive cattle), and (3) new management approaches focused on wildlife hunting and recreational activities (wild ungulate grazing). These three management schemes involve the exclusive presence of sheep, cattle and wild ungulates (mostly deer *Cervus elaphus*), respectively, at least over the last 30 years and under similar ecological conditions in Central Spain. We focus on *Quercus ilex* subsp. *ballota* regeneration since it is the dominant and most representative tree species of the dehesas (Serrada and San Miguel, 2008). We hypothesize that, compared to livestock grazing, management involving wild ungulates (with moderate or low stocking rates) may favor oak regeneration because their higher mobility may reduce the exposure to continuous browsing damage (i.e., high intensity herbivory). Specifically, we predict that: (1) the density of young plants will be lower in the presence of extensive livestock farming (both sheep and cattle) in comparison to wildlife areas; (2) density of young plants will vary with microsite location, higher under shrub/tree canopies than in the open; and plant growth stage, in decreasing order of seedlings > bushes > saplings > juveniles; (3) the probability and intensity of herbivory will be greater in cattle-grazed dehesas in comparison to extensive sheep rearing and wildlife management, and will also vary with plant type and microsite location, higher on accessible plants and in the open than on small plants under shrub protection. With this study we aim to increase our understanding of the long-term impacts of current contrasting

management regimes on oak regeneration in order to provide useful science-based tools for the conservation of these systems.

2. Materials and methods

2.1. Study area

The study was conducted in different oak dehesa systems in Toledo province, Central Spain (39–40°N, 5°W; 300–400 m a.s.l.). The climate is Mediterranean oceanic pluvioseasonal (Rivas-Martínez and Rivas-Saenz, 2014), with a mean annual temperature of 15.1 °C and an average annual rainfall of 571 mm ($n = 30$ years; Weather station 3427C “Oropesa – Dehesón del Encinar”). Rainfall is highly variable both inter- and intra-annually, but occurs mostly in winter (40%). Summers are long (3–4 months), dry and hot (temperatures can reach 40 °C). Frosts are common from November to March. The study area covered 108 km², with homogeneous topographic characteristics (largely flat and open). Soils are sandy (>80% sand) and acidic, and the top soil has low organic matter content (<1%). Vegetation is dominated by open holm oak (*Q. ilex* L. subsp. *ballota* (Desf.) Samp.) woodland, with some scattered cork oaks (*Quercus suber* L.). Shrub cover is low and is mostly comprised of xerophytic and evergreen species (e.g. *Cistus ladanifer* L., *Lavandula stoechas* Lam., *Cistus salvifolius* L., *Genista hirsuta* Vahl, *Rosmarinus officinalis* L.). The herbaceous layer is dominated by sub-nitrophilous Mediterranean annual communities (*Thero-Brometalia*, Rivas-Martínez et al., 2001), and therophytic oligotrophic communities (*Tuberarietalia guttatae*, Rivas-Martínez et al., 2001).

2.2. Study sites

Three sites were selected within the study area. Each site had a distinctly and representative management, at least, for the last thirty years. None of the three sites were subjected to ploughing, shrub-clearing or fire during the last 30 years and, thus, the main management difference was the grazing regime. The first one, hereafter “Cattle”, has been raising cattle (breed “Avileña negra ibérica”) year round for the last 30 years, with stocking rates of 0.33 cow ha⁻¹ (equivalent 0.33 LU ha⁻¹), which represents the typical management (stocking rates) for these systems (Escribano et al., 2002; Plieninger et al., 2004). This study site comprises 142 ha with multiple fences to control cattle movements and prevent wildlife and human access. Wild ungulates (mainly red deer *C. elaphus* L.) enter occasionally at low densities (less than 0.05 ind ha⁻¹, equivalent to 0.007 LU ha⁻¹), when they jump over fences or go through them. The second one, hereafter “Sheep” has been supporting sheep (breed “Talaverana”) year round for the last 40 years, with stocking rates of 1.67 sheep ha⁻¹ (equivalent to 0.25 LU ha⁻¹), representing the typical extensive sheep management (Escribano et al., 2002; Plieninger et al., 2004). This study site comprises 140 ha, and is also fenced to control sheep movements and prevent wild ungulates and human access. Red deer have also been seen but very rarely (owners, pers. comm.) since fences were stronger and better maintained than in the previous site (pers. obs.). Finally, the third site has not supported livestock since 1985. Instead, its management has been devoted to recreational big game hunting, mostly red deer but also some wild boar (*Sus scrofa* L.) for the past 50 years. Stocking rates are 0.37 deer ha⁻¹ (equivalent to 0.11 LU ha⁻¹). This study site comprises 150 ha, and represents the typical deer management (densities) of Mediterranean hunting properties in oak-dominated woodlands and dehesas (Acevedo et al., 2008; Perea et al., 2014).

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