Journal of
Plant Ecology

Data Paper

# Aprisco Field Station: the spatial structure of a new experimental site focused on agroecology

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**Handling Editor:** Bernhard Schmid

**Received:** 31 March 2022, **First Decision:** 7 April 2022, **Accepted:** 24 April 2022, **Online Publication:** 29 April 2022

## Abstract

The Dehesa ecosystem provides important social and economic values across the Iberian Peninsula. Assessing the temporal dynamics of this system under climate change is important for the maintenance and conservation of these highly valuable ecosystems. Here, we present the baseline data of an observational plot network in the Dehesa that will form the foundation for monitoring long-term dynamics and for experimental manipulations testing the mechanisms driving resilience within the Dehesa. The initial surveys indicate that the forest structure is typical for the Dehesa, which suggests it is an exemplary site for examining temporal dynamics of this ecosystem. We present these initial data to encourage collaborations from international scientists *via* either direct experimental projects or meta-analyses.

***Keywords*** agriculture, Dehesa, economic value, *Quercus ilex*, spatial structure, temporal dynamics, woodlands

野外农场工作站：一个新的农业生态试验点的空间结构

**摘要：**Dehesa生态系统对整个伊比利亚半岛有着重要的社会和经济价值。在气候变化下评估该系统的时间动态对于维护和保护这些极具价值的生态系统非常重要。本论文展示了Dehesa生态系统一个观测样点的基础数据，这些数据为在Dehesa生态系统内进行长期动态监测，以及开展检验森林恢复力驱动机制的实验模拟奠定了基础。初步调查表明，Dehesa的森林结构是典型的，说明其是研究该生态系统时间动态的典型样地。我们展示这些基础数据是为了鼓励国际科学家通过直接实验项目或meta分析进行合作

**关键词：**农业，Dehesa，经济价值，冬青栎(*Quercus ilex*)，空间结构，时间动态，树林

## INTRODUCTION

The Dehesa ecosystem, a wooded pastureland found throughout the Iberian Peninsula, supports unique biodiversity while providing important cultural and agricultural, and therefore economic value. This system is traditionally used extensively both for forestry and agriculture (either cultivation of annual crops or pasture). This managed ecosystem may be highly sensitive to climate change and overexploitation due to the lack of tree regeneration and low tree diversity observed at many sites throughout the Dehesa (Moreno and Pulido 2008). However, manipulative experiments exploring practices to improve regeneration through diversification and direct research on the forest dynamics within this system remain limited (Pulido *et al.* 2010; Rolo *et al.* 2013). Here, we present an initial survey of the vegetative structure at a new long-term research site within the Dehesa ecosystem that will provide a platform for exploring biotic interactions and dynamics under climate and land use change with the goal of providing novel mitigation practices for agricultural managers.

The Dehesa covers approximately 3.5 million ha of land on the Iberian Peninsula, the majority in the south-west, where it represents the main land use type (Oppermann *et al.* 2012). As such, the Dehesa

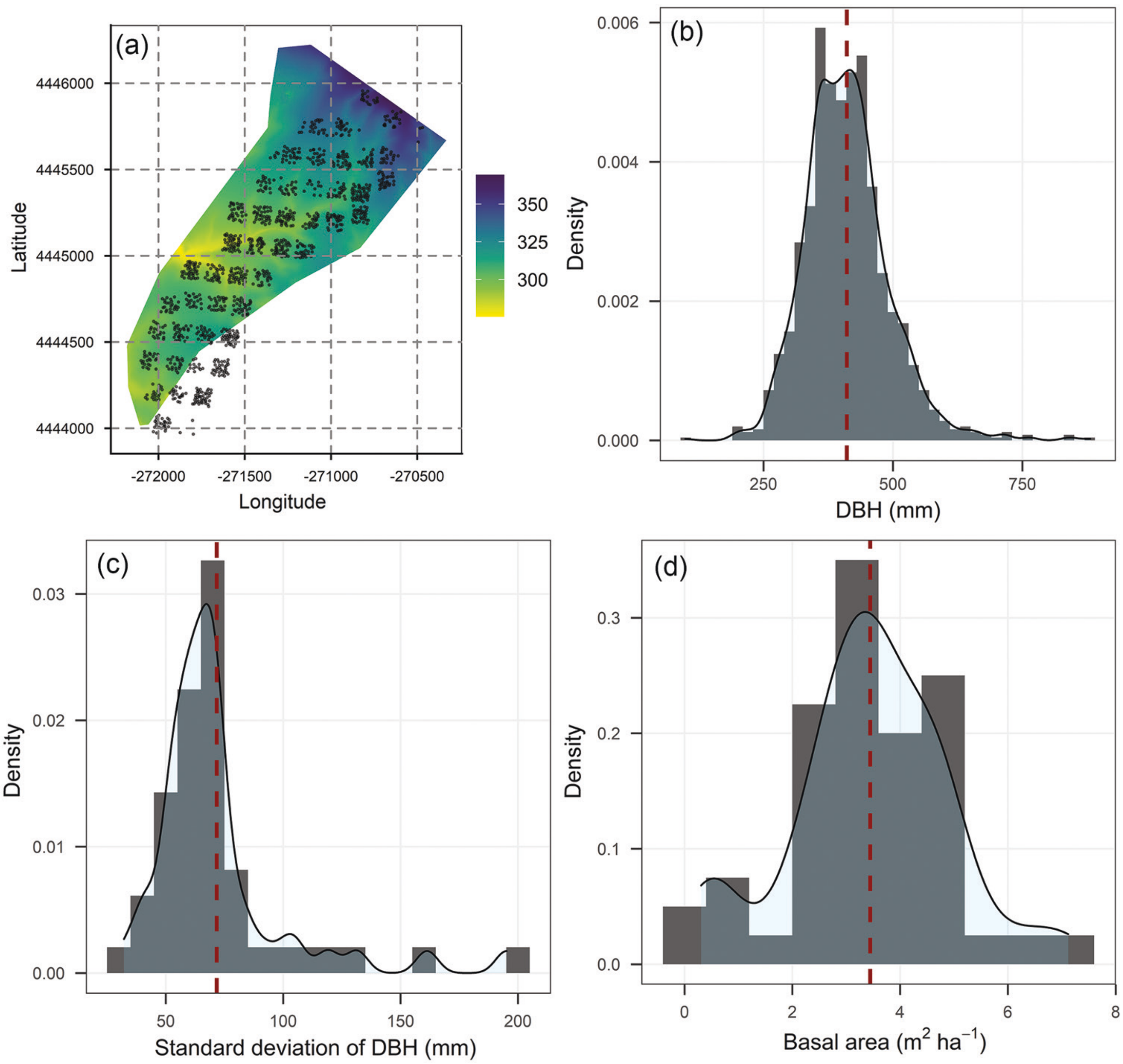


**Figure 1:** Plot coverage and distributions of tree size, variation and forest density. (**a**) Map of the plot distribution of the 50 1-ha plots. The map is presented with a universal transverse mercator projection in the 31N zone of the WGS84 datum. Colors are meters above sea level. The points represent individual trees measured within each 100 m × 100 m plot. Histograms of tree (**b**) DBH, (**c**) within hectare variation in DBH and (**d**) basal area per hectare from the measured ground data. The dashed red line is the mean of each variable.

is the most common agroforestry system in Europe (Eichhorn *et al.* 2006). The high environmental and socioeconomic value of Dehesa systems is acknowledged in the fact that it is listed in the EU habitat directive as habitat with community-wide interest.

Recent modeling studies suggest that the Dehesa *per se* is not very sensitive to increasing drought frequency and intensity with ongoing climate change, this in particular due to the conservative land use behavior of the farmers (Martínez-Valderrama *et al.* 2021). However, tree regeneration was shown to be highly sensitive to climate change, in particular year-round drought, without any major influence of land use on this sensitivity (Díaz *et al.* 2021). This suggests that while we might not expect any major impact of climate change on the Dehesa in the short term, a reduction in precipitation and an increase in temperature might limit tree regeneration and profoundly affect the Dehesa ecosystem in the long term.

The present study, including a survey of the current state of the woody vegetation constituting the Dehesa of the Aprisco Field Station (located at the southern foothills of the Sierra de Las Corchuelas), serves as a baseline for the long-term monitoring of this highly valuable, but sensitive, managed ecosystem. The farm will allow extensive research activities around the agroecology of the ecosystem and aims at an increased understanding of the crucial drivers that may sustain the ecosystem in the long term.

## MATERIALS AND METHODS

### Study site

The Aprisco Field Station is in central Cáceres, a northwestern province in the Comunidad de Extremadura covered by large areas of the Dehesa ecosystem. It is approximately 30 km south of Plasencia and comprises an area of 150.85 ha, with the main agricultural infrastructure at the northeast corner of the property (coordinates of the field center: 39.812876 N, −6.000896 W). Sheep, red deer, Iberian pig and wild boar are the main grazing impact on the Dehesa landscape at this site. The woodland is predominately *Quercus ilex* with intermittent *Quercus suber* and *Olea europaea* with very few additional species. The shrub layer is predominantly *Retama sphaerocarpa* and *Cistus ladanifer*, with interspersed *Ulex eriocladus*, *Crataegus monogyna* and *Daphne gnidium*.

The climate is a typical Mediterranean climate consisting of approximately 600 mm of annual rainfall with a dry season from June to September with minimal rainfall and a wet season from October to May with the heaviest precipitation typically falling November and May. The average annual temperature is 28 °C with an average summer high of 38 °C and an average winter low of 4 °C. The soils are Alfisols and Entisols typical of the region with a low organic matter content (1.84%), total *N* of 0.12% and a relatively high clay content but drainage varies across the site due to heterogeneity in rock content and bedrock depth.



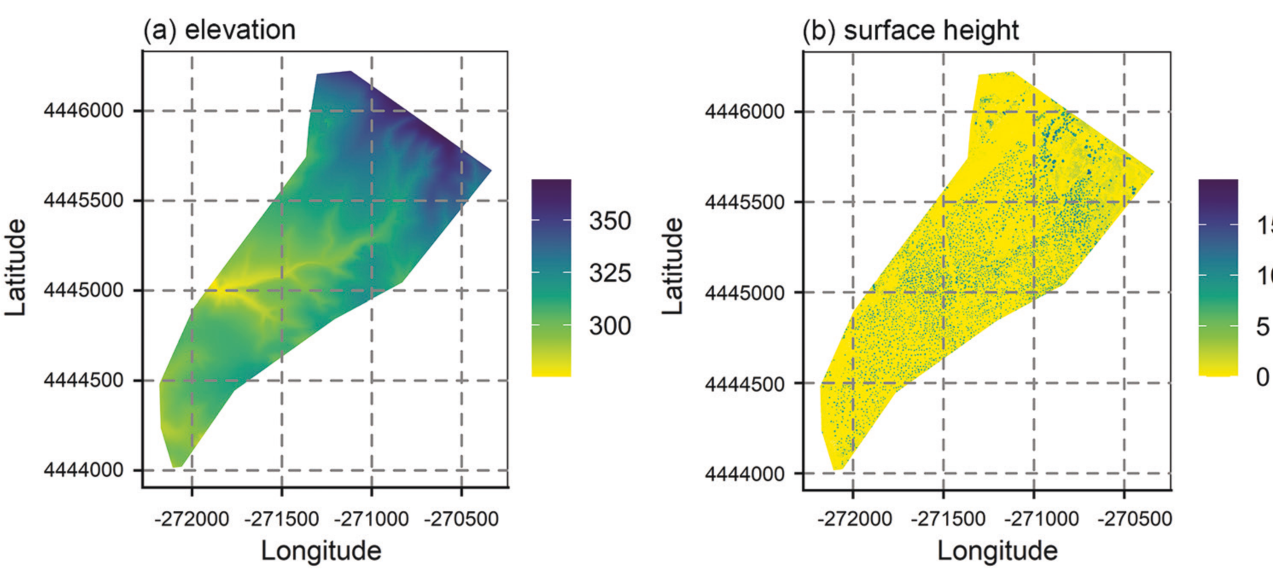


**Figure 2:** Remotely sensed digital elevation and surface map. Maps are presented with a universal transverse mercator in the 31N zone of the WGS84 datum. The scales are meters for (**a**) elevation and (**b**) surface height maps.

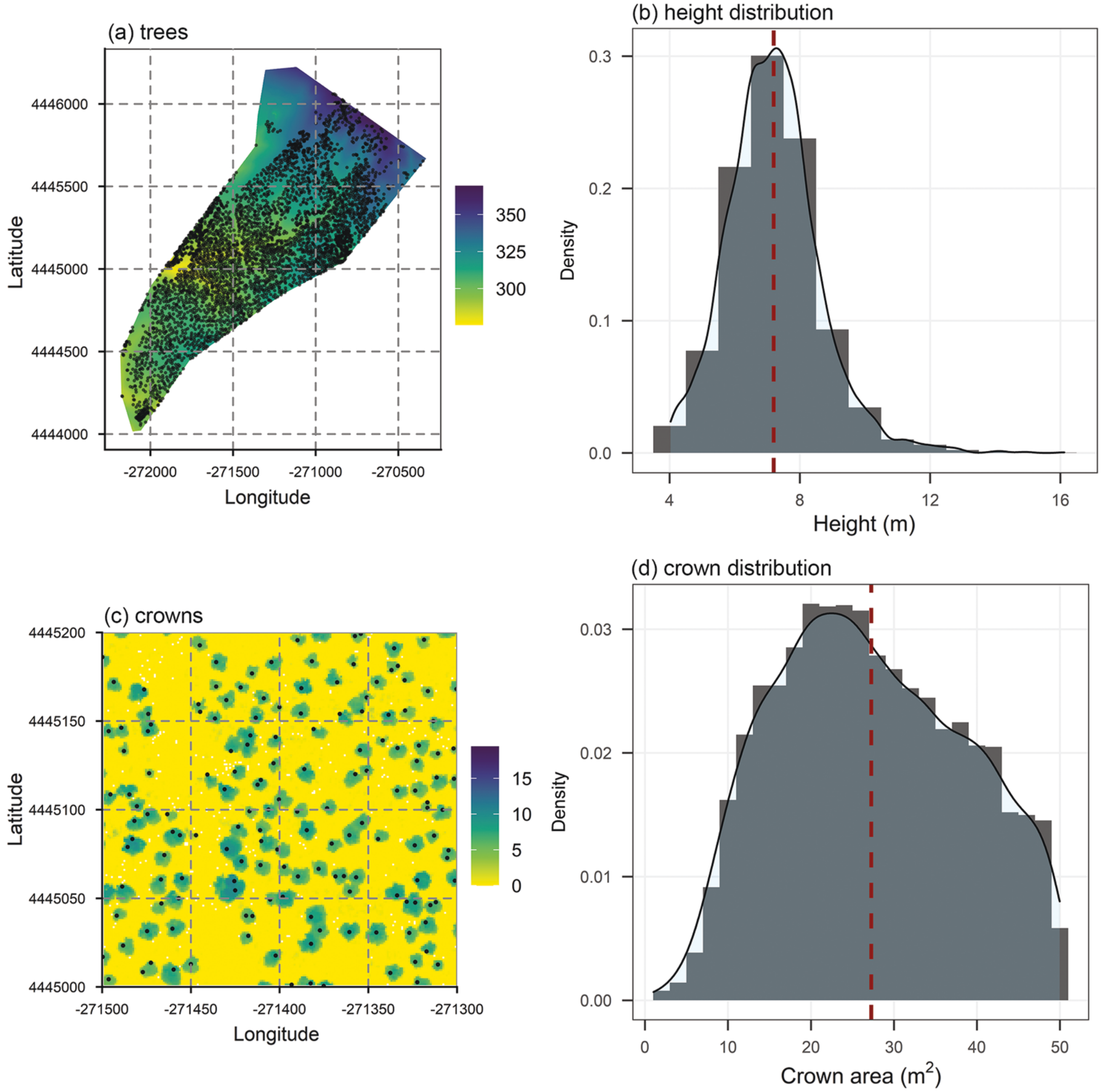


**Figure 3:** Remotely sensed trees and crown areas. Maps are presented with a universal transverse mercator projection in the 31N zone of the WGS84 datum. The scales are meters for (**a**) elevation and m2 for (**c**) crown area. Panel c is a zoom into a 1-ha section of the site as an example of the crown area estimates, with superimposed coordinates of the tree trunks measured on the ground. Panels **b** and **d** are the distributions of height and crown area estimated from the remote sensing measurements.

## Baseline assessment

We used two approaches to assess the topography and vegetative cover of the field site. We sampled a systematic grid of 1-ha plots (50 in total) distributed within the property boundary (some plots were offset to fit within the boundaries). All trees with a diameter >1 cm at breast height (DBH) were tagged, identified to species and measured for DBH. The plots were measured between the 19 October 2020 and the 11 November 2020. In addition, we flew a Spidex Pro drone (Quaternium, Valencia, Spain) with a 24-megapixel camera (Sony ILCE 6000) and a 16-mm lens to generate a digital elevation model (DEM) and a digital surface model (DSM), which was used to assess vegetation cover and height. The drone covered ~142 ha, but it missed a section of the southeast corner of the site, which contained seven of the 1-ha ground sampling plots (~9 ha).

### Analysis

Species diversity, diameter distributions and basal area per hectare were calculated from the ground measurements. Height, canopy size per tree and tree canopy cover per hectare were estimated from the DEM and DSM layers using the R statistical software (version 4.1.0; r-project.org). The vwf function in the ForestTools package was used to estimate maximum height for every tree with a minimum detection height set to 5 m to avoid classifying shrubs as trees. Based on these maximum tree height estimates, we used the mcws function in the ForestTools package to delineate tree crown area around each identified tree. Furthermore, we calculated the average area per hectare covered by shrub species (<3 m height). We performed simple linear models to assess relationships between tree size and slope and elevations to understand the heterogeneity in size distributions. Slope was log transformed to meet assumptions of linearity.

## RESULTS

Across the entire 50-ha sample, we tagged 1249 trees and only four were not *Q. ilex* with two *Q. suber* and two *O. europaea*, indicating a very low level of tree diversity. On average, there were 25 trees per ha ranging from 1 to 44. The DBH was normally distributed (Fig. 1a) around a mean of 411 mm (95% CI: 406–416). However, plots ranged from homogenous in DBH (sd = 32 mm) to fairly heterogenous (sd = 195 mm), especially since the minimum tree size encountered had a DBH of 99 mm (Fig. 1a and b). Basal area was low on the site ranging from 0.3 to 7 $m^2$ $ha^{-1}$ (Fig. 1c).

The DEM from the remotely sensed data showed an average elevation of 315 m (range = 275–369, Fig. 2a). The DSM found an average surface height of 1.0 m (range = 0–16.5 m, Fig. 2b). The analysis of tree heights identified 4218 trees (Fig. 3a) with a mean height of 7.19 m and a narrow distribution (95% CI: 7.15–7.23 m, Fig. 3b). The analysis of tree crowns (Fig. 3c) found an average area of 27.3 $m^2$ (95% CI: 26.9–27.6, Fig. 3d) with maximum areas of 50 $m^2$. Shrub cover was estimated as 12% of the site (Fig. 4) with an average height of 1.24 m (95% CI: 1.24–1.25). Shrub cover was highest on the northeast area of the site at higher elevations and on average steeper slopes.

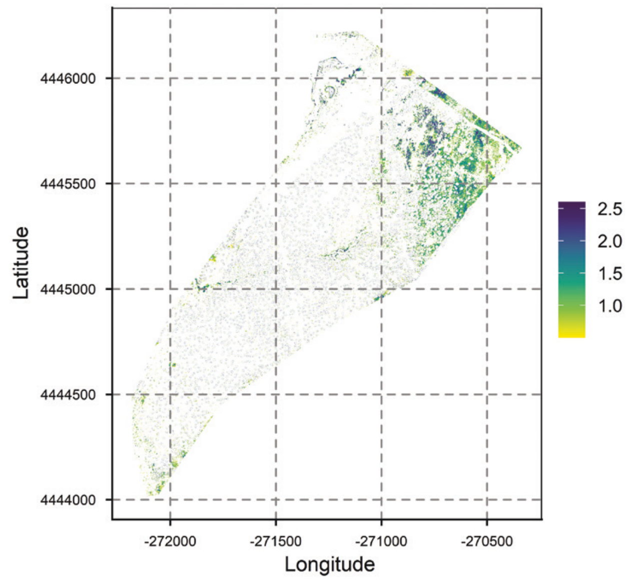


**Figure 4:** Remotely sensed shrub height. Maps are presented with a universal transverse mercator projection in the 31N zone of the WGS84 datum. The scale is meters.

We found significant positive relationships between elevation and tree DBH ($R^2$ = 0.05; $F_{1,1047}$ = 56.3, $P$ < 0.0001) and height ($R^2$ = 0.02; $F_{1,4102}$ = 88.9, $P$ < 0.0001) but not between elevation and crown area (Fig. 5a, c and e). We also found significant positive relationships between slope and tree height ($R^2$ = 0.03; $F_{1,4102}$ = 117.9, $P$ < 0.0001) and crown area ($R^2$ = 0.004; $F_{1,4422}$ = 16.6, $P$ < 0.0001) but not between slope and DBH (Fig. 5b, d and f). Therefore, metrics of tree size increased with both elevation and slope.

## DISCUSSION

The Dehesa of the Aprisco Field Station demonstrates a narrow distribution of similarly sized trees at relatively low tree density. This is common to the Spanish Dehesa ecosystem, as demonstrated by other studies that found striking similarities in tree density (22.7 trees per ha), DBH (380 ± 95 mm) and tree height (7.48 ± 1.50 m) but larger tree crown areas (48.8 $m^2$) at other sites in Extremadura (Pulido *et al.* 2001). The observed basal area of trees is also well within the range of Dehesa ecosystems in the region (2–10 $m^2$ $ha^{-1}$; Moreno and Cáceres 2016). Compared with a closed holm oak forest with 70–200 trees per ha, the Dehesa is in general characterized by a lower density of trees with a narrower size distribution and larger trees in terms of DBH, canopy height and tree crown area (Pulido *et al.* 2001). This suggests that historical tree clearing of forests to create the Dehesa

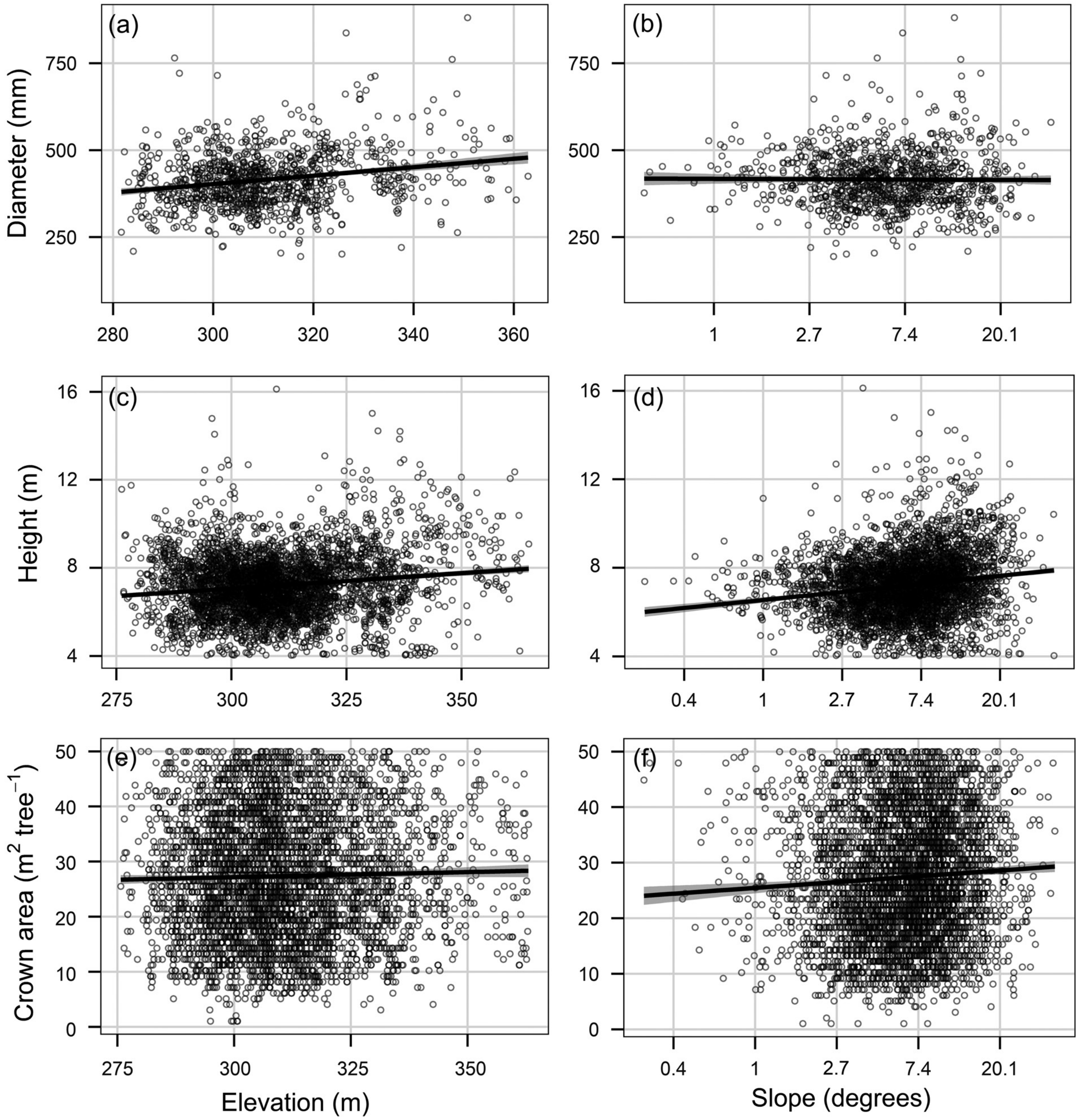


**Figure 5:** Relationships between topography and tree size. The relationship between elevation and DBH (**a**), height (**c**) and crown area (**e**) showed a positive trend for all metrics, but it was only significant for DBH and height. The relationship between slope and DBH (**b**), height (**d**) and crown area (**f**) showed a positive trend for all metrics, but it was only significant for height and crown area. Slope was analyzed on the log scale, but the *x*-axis is presented on the normal scale for interpretation.

at our field site was not random but followed criteria that maintained trees of a similar size likely driven by acorn production and spacing.

The newly established long-term experimental research site Aprisco Field Station represents a typical Dehesa ecosystem in Spain. As such, the observations and activities that will be conducted on the site might be representative to a large proportion of Dehesa systems in the Iberian Peninsula. Experimental research activities at the site might want to focus on the regeneration of holm oaks, the diversification of the tree layer or new agroecological practices for production, but also observational studies investigating changes in biodiversity over space and time.


## *Funding*

M.J.O. was funded by the Comunidad de Madrid with an Atracción de Talento Investigador Modalidad I Fellowship (2018-T1/AMB-11095).

### *Acknowledgements*

We would like to thank C. Carbonell Solís for permission to access the property.

*Conflict of interest statement*. The authors declare that they have no conflict of interest.

### *Authors' Contributions*

M.J.O. and C.S. designed the plot network and carried out the first census. M.J.O. carried out the data analysis and M.J.O. and C.S. wrote the data manuscript. E.P.C. organized the remote sensing measurements and provided site permissions.

### *Data Availability*

Data are available at Zenodo (doi:10.5281/zenodo.6467665).

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