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The Landscape of the Dehesa in the Sierra Morena of Jaén (Spain) – the Transition from Traditional to New Land Uses

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Abstract

This paper tracks the evolution of the area covered by the dehesa in Sierra Morena from the mid 20th century to the present day, in an attempt to identify those areas in which traditional land uses still hold sway and others in which new land uses are appearing in relation to emerging business activities. These new uses have brought about an important transformation in the landscape of the dehesa, which in some areas is being replaced by other more profitable forms of land use, in particular with olive groves. In many areas where the dehesa still exists, livestock farming has been replaced by hunting, which has led to internal changes in the structure of the dehesa with an increase in scrubland. Another emerging land use is tourism-related activities, which many farmers now use to complement their income from livestock and which help preserve the traditional landscape of the dehesa.

Keywords:

landscapes, dehesa, GIS, aerial photographs, Spain

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1 Introduction

The word *dehesa* as used in Spanish is derived etymologically speaking from the word “*defessa*”, which refers to fenced-off areas in which common grazing of the pastures was prohibited (Ezquerria 2009; Ezquerria 2011). Over the course of history other meanings of the word have appeared such as for example in the term *dehesas boyales* which were common lands in which people could graze working animals. The landscape we know today as *dehesa* (or *montado* in Portugal) is an agro-silvo-pastoral system that extends across the west and south-west of Spain and the south of Portugal and is characterized above all by the presence of scattered trees or groups of trees associated with pastures and agricultural areas. In general silvo-pastoral systems are frequently characterized by the interspersing of open pastures with treed pastures. In these areas, the species may have appeared spontaneously or may have been planted. These trees play a specific role, either continually or occasionally, in the livestock production systems, as happens in the *dehesas*. Their presence and distribution is almost always deliberately planned and is not simply the fruit of random natural development. As a result each agro-silvo-pastoral landscape has its own character, which varies according to the different farming procedures and the particular tree species that are encouraged or introduced there (Bellefontaine 2002). Some authors therefore believe that given its etymological origins, the *dehesa* probably first appeared during the Middle Ages and that the *dehesa* we know today probably emerged during the 19th Century (Ezquerria 2009; Ezquerria 2011)

The most common trees in the *dehesa* are cork-oaks (*Quercus suber*) and holm-oaks (*Quercus rotundifolia* or *Quercus ilex*), although in Andalusia there are some *dehesas* with wild olive trees (*Olea europaea* var. *sylvestris*) (Costa 2005) and other tree species such as, for example, Portuguese oaks (*Quercus faginea*). The farming system is characterized by semi-extensive livestock that feed either by grazing on the pastures or browsing on the leaves and the fruit (acorns) from the trees.

The *dehesa* results from the gradual transformation

of the dense Mediterranean climax forest of holm-oaks and cork oaks into a landscape that is a blend of nature and human culture, and constitutes the basic asset of rural society and the rural economy (Schröder 2005). It has also been argued that the *dehesa* is a land use that is well adapted to the environmental constraints of the Mediterranean region, characterized by poor and shallow soil and climatic constraints potential (Pinto Correia 2000; Olea et al. 2006). The extensive integrated use of the natural resources in these areas has created a heterogeneous mosaic that is home to a wide diversity of plants and animals. Some areas can even boast a wide range of endemic species (Pinto Correia 2000). The *dehesa* is therefore a man-made ecosystem, which is structured on two levels, the herbaceous and the arboreal, regardless of the particular land use or management practices, which may vary from one place to the next (Jofre 1999).

The particular charm of the *dehesa* landscape is described well by “Buckley & Masso (1988) the appeal of the *dehesa* lies in the visual variety of its components: they offer spectacular views from the hills, with an attractive regularity provided by the uniform distribution of the trees and a contrast of colours in which the dark green of the trees, visible throughout the year, stands out against the soft green of the pastures in winter, which the dry summer months then turn bright yellow” (in Plieninger 2006).

If we trace the evolution of the *dehesa*, the traditional farming system continued until the mid 1960s, when it went into decline. In the mid 1980s however this process was reversed as a result of a renewed awareness of the importance of this kind of landscape (Morales et al. 2001; Schröder 2005). This new interest in the *dehesa* and its increased role in Andalusia, both from a landscape and an economic point of view, led the Regional Government of Andalusia to promote the Andalusian Pact for the *Dehesa*, which was approved on 2005. The Pact included the following definition of the *dehesa*: „By *dehesa* or *dehesa* system we are referring to the system of use and management of the land based mainly on livestock grazing and also including forestry, hunting and agriculture of an area of grassland and Mediterranean hills and mountains with scattered trees or woodland, which gives rise

to an agrarian system in which the agro-forestry-grazing land management combination encourages important environmental values and sustainable land use, a balanced landscape and high diversity at different levels of integration". More recently in 2010 the Regional Government of Andalusia passed the Dehesa Act (Law 7/2010, of 14th July, for the Dehesa, published in the Official Bulletin of the Regional Government of Andalusia on 23rd July 2010).

However the dehesa has suffered, on one hand, an internal restructuring of the different types of dehesa, and on the other, the replacement of the dehesa by other land uses such as replanted forest, especially with pine trees, or by olive groves.

In this paper we track the evolution of the area covered by the dehesa in Sierra Morena from the mid-20th century to the present day, in an attempt to identify those areas in which traditional land uses

still hold sway and others in which new land uses are appearing in relation to emerging business activities.

2 Study area

The province of Jaén, with a surface area of 13.496 km², is in eastern Andalusia on the high campiña (meadow lands) where the River Guadalquivir rises and extends to the north along the Sierra Morena mountains and to the south and east along the external Betic Cordillera. The study area covers the part of the Sierra Morena that falls within the province of Jaén and its extension into the depression formed by the Guadalquivir river valley. The boundaries of the study area are those of the towns and villages that fall either totally or partially within Sierra Morena (Fig.1). This area covers a total of 4,890 km².



Figure 1: Study area

As a result of its contrasting environments (hills, valleys etc), the altitudes within the study area range from 200 metres above sea level in Marmolejo in the Guadalquivir valley in the south-west of the study area, to almost 1300 metres in the north of the study area at the summit of the Burcio del Pino on the border with the Province of Ciudad Real. In

geological terms, Sierra Morena is dominated by the paleozoic materials from the base of the "Meseta" (granites, slates, quartzites and sandstones) and tertiary materials from the "cobertera tabular" in the area of transition between the sierra and the Guadalquivir valley, above all in the east and south-east of the study area.

The soils in this area, including above all Regosols, Luvisols and Cambisols, are mostly of poor quality and relatively undeveloped. In terms of their component materials we should note the predominance of siliceous, and therefore acid soils, which have developed from the paleozoic materials.

The area has a typically Mediterranean climate with a long summer drought from June to October, although the altitude, orientation and the varying impact of westerly winds can cause local variations. Average annual precipitation ranges from 300 to 800 mm, although in the westernmost part, there are areas with almost 1000 mm. Temperatures show less variation, oscillating between an average of 12°C in the mountain areas to 18°C in the Guadalquivir valley.

As a result of its climatic and edaphic characteristics, the potential natural vegetation in this area would be that of the Mediterranean forest, although this has undergone enormous transformation over time giving rise to what we know today as the dehesa.

3 Materials and methods

Our main source of data for this paper was the digital vector information contained in the map of land uses and covers at a scale of 1:25000 produced by the Regional Government of Andalusia. This database was created on the basis of photogrammetric interpretation of orthophotographs from 1956/57 and 2007. The orthophotographs from 1956/57 are in black and white and have an approximate scale of 1:33000, while the orthoimages for 2007 (in color) have a resolution of 1 metre. This information has enabled us to create maps of the dehesa in our study area in the Province of Jaén for both dates.

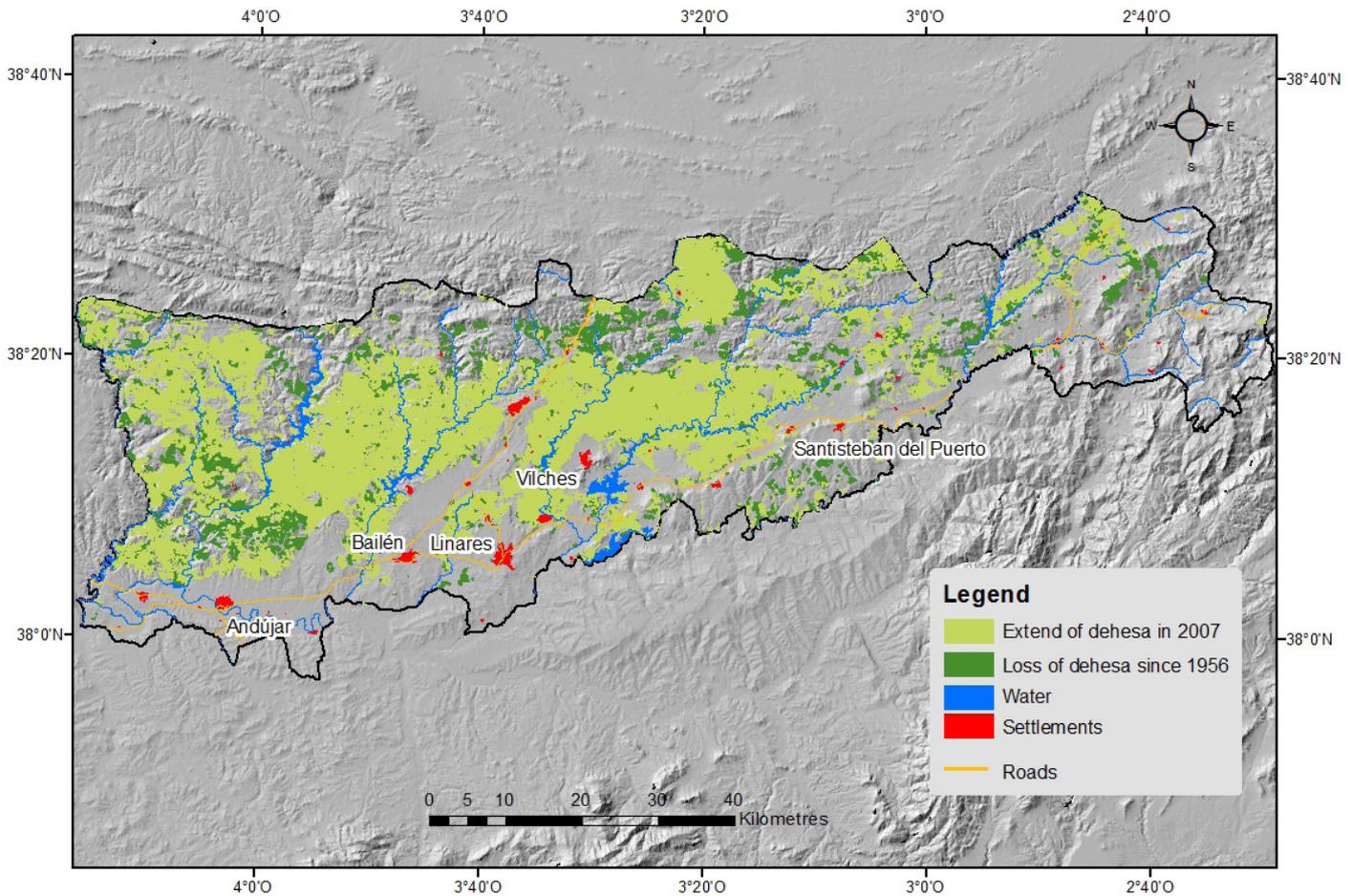
Before drawing up the first map showing the situation in 1956/57, we had to study the categories used in the map of land uses and covers produced by the Regional Government of Andalusia and select those that best matched the definition of dehesa. These

categories were selected according to the criteria proposed in various research studies on the dehesa such as those by Navarro (2000) and Costa (2005), who considered that areas with tree cover of less than 5% or more than 50% cannot be considered dehesas. Costa (2005) distinguishes between spaces with a tree cover of between 5% and 10% and those between 10% and 25%. In our research however, we have decided to group these two categories into one, as the areas with tree cover of less than 10% are very hard to appreciate, given the scale of the study, and because Costa (2005) himself believes that these spaces have an insufficient number of trees per hectare to be considered as dehesas.

We selected the following categories (Paniza 2014):

Categories from the database	Reclassified categories
Scattered scrubland with trees: dense quercus woodland, i.e. those formations with a tree cover of between 25% and 50%.	Dehesa-scrub (25-50%)
Scattered scrubland with sparse trees: scattered quercus woodland, with a tree cover of between 5% and 25%.	Dehesa-scrub (5-25%)
Tree-covered pasture: dense quercus woodlands, with a tree cover of between 25% and 50%.	Dehesa (25-50%)
Tree-covered pasture: scattered quercus woods, with a tree cover of between 5% and 25%.	Dehesa (5-25%)
Herbaceous crops with tree cover: dense quercus woodlands, with a tree cover of between 25% and 50%.	Cultivated dehesa (25-50%)
Herbaceous crops with trees: scattered quercus woodlands, with a tree cover of between 5% and 25%.	Cultivated dehesa (5-25%)

After defining the different categories of dehesa, we then selected them from the original geodatabase, using the “selection-selection by attributes” tool from ArcMap included in the ArcGIS 10 Software (ESRI 2010. ArcGis ©Software. Copyright © ESRI). This produced two new geodatabases with the types of dehesa for the years 1956 and 2007, respectively. These databases enabled us to generate and edit maps showing the distribution of the dehesa in 1956 and 2007 (Map 1).



Map 1: Dehesa, 1956-2007. Source: Geodatabase created by the author. Relief map based on SRTM data (USGS)

In order to obtain data showing the changes in the area occupied by the different types of dehesa in the study area, we used the function “erase”, one of the overlay analysis tools (ArcToolbox) from the GIS. This tool creates a new layer from the entities or portions that fall outside the boundaries of the “erase” layer, which are copied into the resulting layer. In this case the input layer is the one from 1956 and the clip layer is the one made with the data from 2007.

As each layer is based on a geodatabase, we were able to export the results to Microsoft Excel, which processed the information and generated the graphs that enabled us to confirm and compare, both numerically and graphically, the changes in the dehesa landscapes between the two dates. These graphs were also used as support for the spatial analysis of the distribution of the different types of landscape in the study area.

4 Results and Discussion

4.1. Results

The spatial analysis of the dehesa in the study area shows that the area covered by this type of landscape has fallen sharply from 113,966 hectares in 1956 to just 85,251 hectares in 2007 (Fig. 2), a loss of 28,715 hectares, or 25.2 % of the original area covered by the dehesa.

As regards the types of dehesa, if we analyse the three main groups identified above, the dehesas with scrubland and the cultivated dehesas are the types that have suffered most during this period, while the area covered by dehesas with pasture has remained almost unchanged over this period of almost 60 years (Fig. 3).

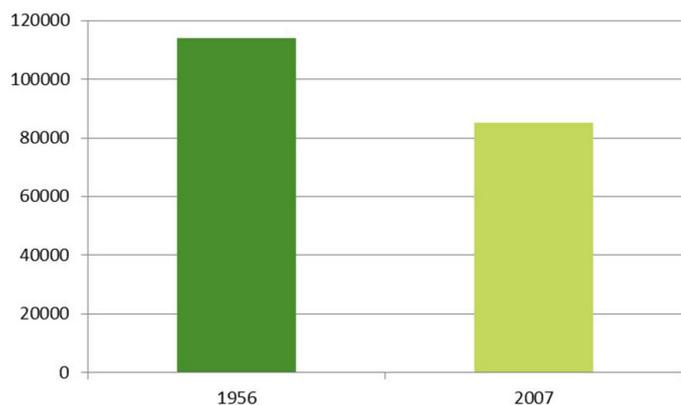


Figure 2: Changes in the area occupied by the dehesa. Hectares. Source: Geodatabase created by the author

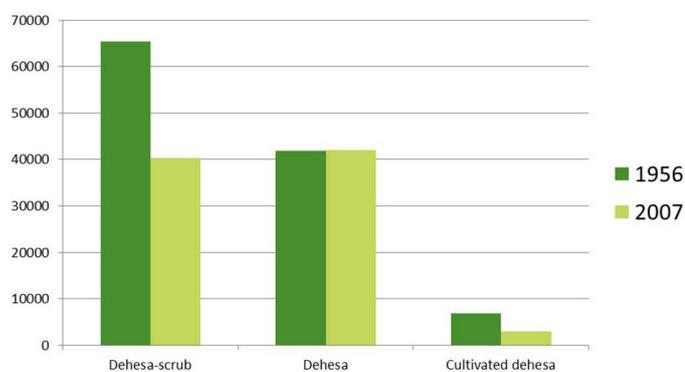


Figure 3: Changes in the three main types of dehesa (hectares). Source: Geodatabase created by the author

If we analyse the changes that have taken place in the six types of dehesa between 1956 and 2007 (Fig. 4), we can see that the different types have evolved in quite different ways over this period. Within the category “Dehesa-scrub” for example, we can see that the dehesa with denser tree cover (25-50 %) has remained almost stable over this period, while the dehesa with sparser cover (5-25 %), which was the most common in 1956 with 37 % of the area defined as dehesa at the time, has lost almost half of the area it initially occupied and is now the third largest category in terms of area. We also observed that the dehesa with pasture has evolved quite differently from the other kinds of dehesa, in that its area has remained stable over the period we analysed (Fig. 3). The two types of dehesa within this category have however changed in different ways, in that the area covered by the denser woodland (25-50 %) has in fact grown, while the dehesa with less tree cover

(5-25 %) has shrunk in size. This may be due to the fact that scrub has been removed from some of the traditional spaces of dehesa-scrub and also to the process of arboreal regeneration in certain dehesas, which has led to an increase in the number of trees per hectare. It may well also have been affected by changes in land use as a result of a fall in livestock farming. The dehesa-scrub may also have benefitted from the gradual abandonment of crops in the cultivated dehesa with a tree cover of between 25% and 50%.

As regards the cultivated dehesa, two important aspects stand out. Firstly, that this category has undergone a sharp fall over the period analysed (Fig. 4) and secondly that even in 1956 it covered a very small area, especially the cultivated dehesa with denser tree cover (25-50 %), given that dense tree cover hinders the growth of the cereals normally cultivated in this area and obstructs the farmers in their work.

Although the cultivated dehesa has practically disappeared in the rest of the province and has fallen away sharply in the study area, it still plays a significant role, perhaps because the activity for which the dehesa has been used traditionally, livestock farming, has remained strong in this area, compared to the rest of the province, where it has largely been abandoned, and due to the fact that in the south of the province this type of dehesa tends to be used for hunting.

If we examine in both spatial and numerical terms the 28,715 hectares that have disappeared over the study period (Fig.5), we observe that the category that has lost most area is the dehesa-scrub with tree cover of between 5% and 25%, which amounts to 54% of the total area lost. This is followed by dehesa with pasture (5-25%) with 19 %, dehesa-scrub with denser tree cover (25-50 %) with 12 % and cultivated dehesa (5-25) with 11 %. A key aspect of the future evolution of the dehesa in the province of Jaén is going to be dehesa with pasture and tree cover of 25-50 %, which as noted earlier, is the only category in which the area has increased during the study period. As can be observed in Figure 5, this category

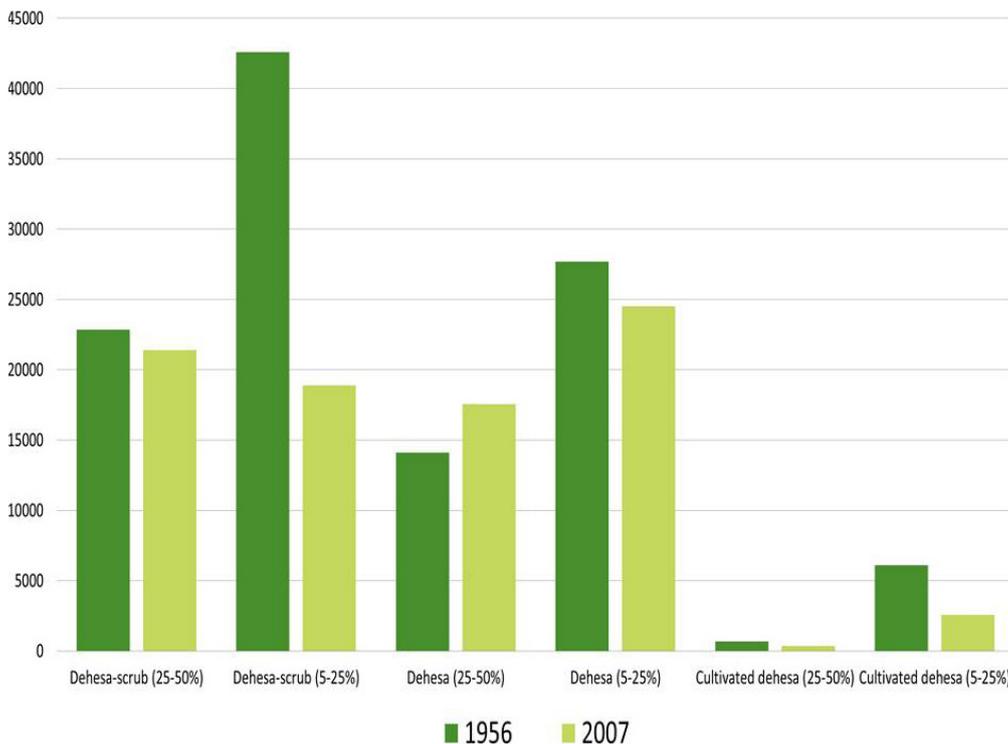


Figure 4: Changes in the types of dehesa. Hectares. Source: Geodatabase created by the author

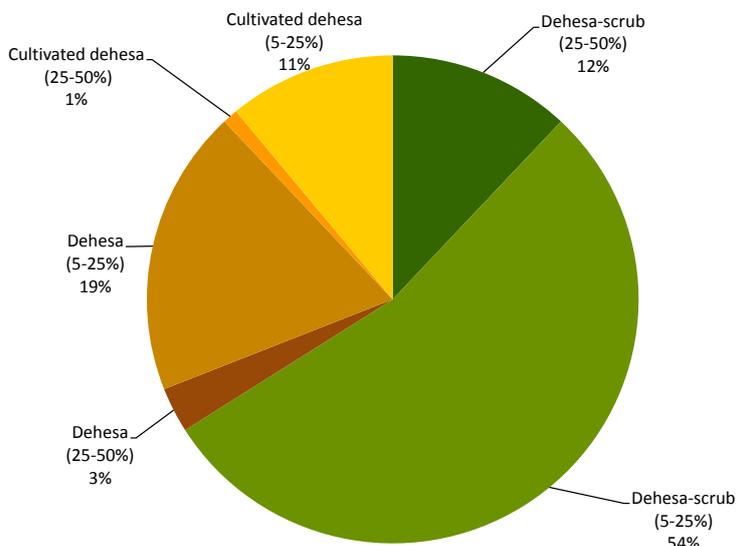


Figure 5: Types of dehesa that have disappeared between 1956 and 2007. Source: Geodatabase created by the author

also accounted for 3% of the total area of dehesa that disappeared over the 60 year period. I believe that this strengthens the hypothesis proposed above that this category has been boosted by the abandonment of the cultivated dehesa with dense tree cover (25-50%), by the natural growth of trees in dehesas that previously had fewer trees and by replanting in certain areas where environmental policies have

promoted the use of autochthonous species.

4.2. Discussion

Our analysis of the spatial and numerical data for the dehesa in this part of Jaén shows a significant reduction in the total area, for which a range of possible causes may be cited. However our analysis

also shows that this is a dynamic process in which some factors can have a positive influence on the maintenance of the dehesa, while others by contrast can have a negative impact on landscape structure.

The factors that have most contributed to the maintenance of the dehesa in the study area include continued livestock farming, which is still an important economic sector in Sierra Morena, as shown by the number of farms. According to statistics from 2011, there are 211 cattle-rearing farms of between 5 and 50 hectares in size (56% of the total) and 89 of between 50 and 100 (24% of the total). There are 75 large farms with over 100 hectares of land, making up 20% of the total. Most of these 75 large farms probably specialize in fighting bulls (Photo 1), which are traditionally raised on large estates, given that according to the agrarian census there are 74 farms in this area that breed fighting bulls (Photo 1). Similarly there are 184 sheep farms (Photo 2) of between 5 and 50 hectares (63 % of the total), 59 farms of between 50 and 100 hectares (20%) and 48 farms with more than 100 hectares (17 %) (INE 2011).



Photo1: traditional Dehesa related with the bull fighting-breeding. Source: the author.

Another factor that may help maintain the dehesa landscape is tourism (Alcántara 2014) In the area we studied, there are 24 rural tourism establishments (Instituto de Cartografía Estadística y Cartografía de Andalucía 2013), some of which, such as the “El Añadío” estate (Photo 3) in Vilches, are directly related with bull-breeding. Another example is the

Almoraduz rural hotel in Santiesteban del Puerto, which offers a range of activities including horse-riding across the dehesa, an example of high quality rural tourism.

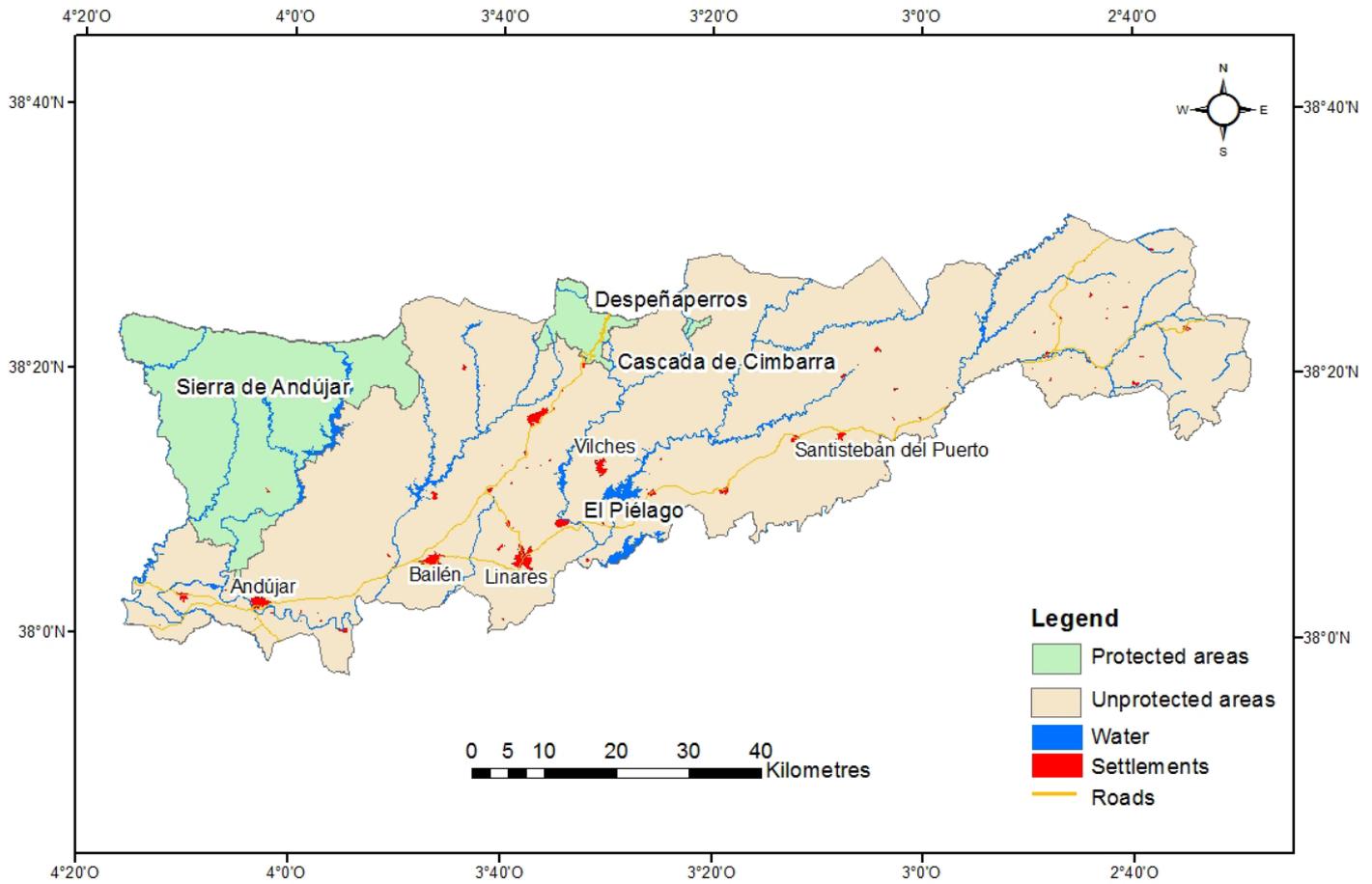


Photo 2: traditional Dehesa related with the sheep-breeding. Source: the author



Photo 3: Dehesa “El Añadío” estate related with the bull-breeding and rural tourism. Source: the author

Two landmark events in terms of the conservation of the dehesa were its inclusion within the Red Natura 2000 network and its designation as a space protected by the Habitats Directive 92/43/EEC. Similarly, the dehesas of Sierra Morena in Jaén have two natural parks (Sierra de Andújar and Despeñaperros) and one Natural Site (Cascada de la Cimbarra) (Map 2), which contribute to the development of a variety of tourism-related activities, including for instance paths through the dehesa areas of the parks. One such path is the Sendero del Rumblar, the guide to



Map 2: Protected areas. Source: Geodatabase created by the author.

which cites the dehesa landscape and the rearing of fighting bulls, as typical features to admire on the walk. (<http://www.juntadeandalucia.es/medioambiente/servtc5/ventana/mostrarFicha.do?re=s&id9>).

Factors that have contributed or contribute to the degradation of the dehesa include the policy of replantation with pine trees (Photo 4) implemented from the second half of the 20th Century onwards, which brought about the greatest transformation in dehesa landscapes in this area. In this case we are referring to replanting work in areas affected by forest fires and in particular in our study area the work associated with the river basins of numerous reservoirs (nine), scattered around the largest area of dehesa in Jaén in Sierra Morena (Paniza 2008; Paniza 2014). Pines were used for this job because



Photo 4: Replantation with pine trees. Source: the author

they grow much more quickly than the quercus trees native to the area. In some cases landowners also decided to plant pines and eucalyptus trees as crops as a means of diversifying their income (Schröder C.

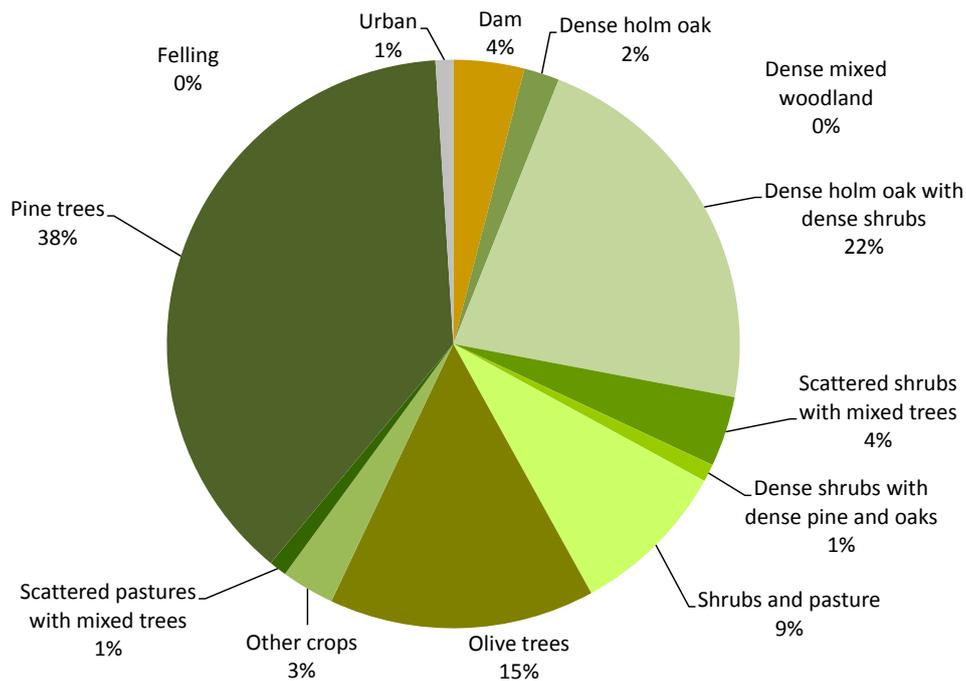


Figure 6: Coverages that have substituted the spaces catalogued as dehesa in 1956. Source: Geodatabase created by the author

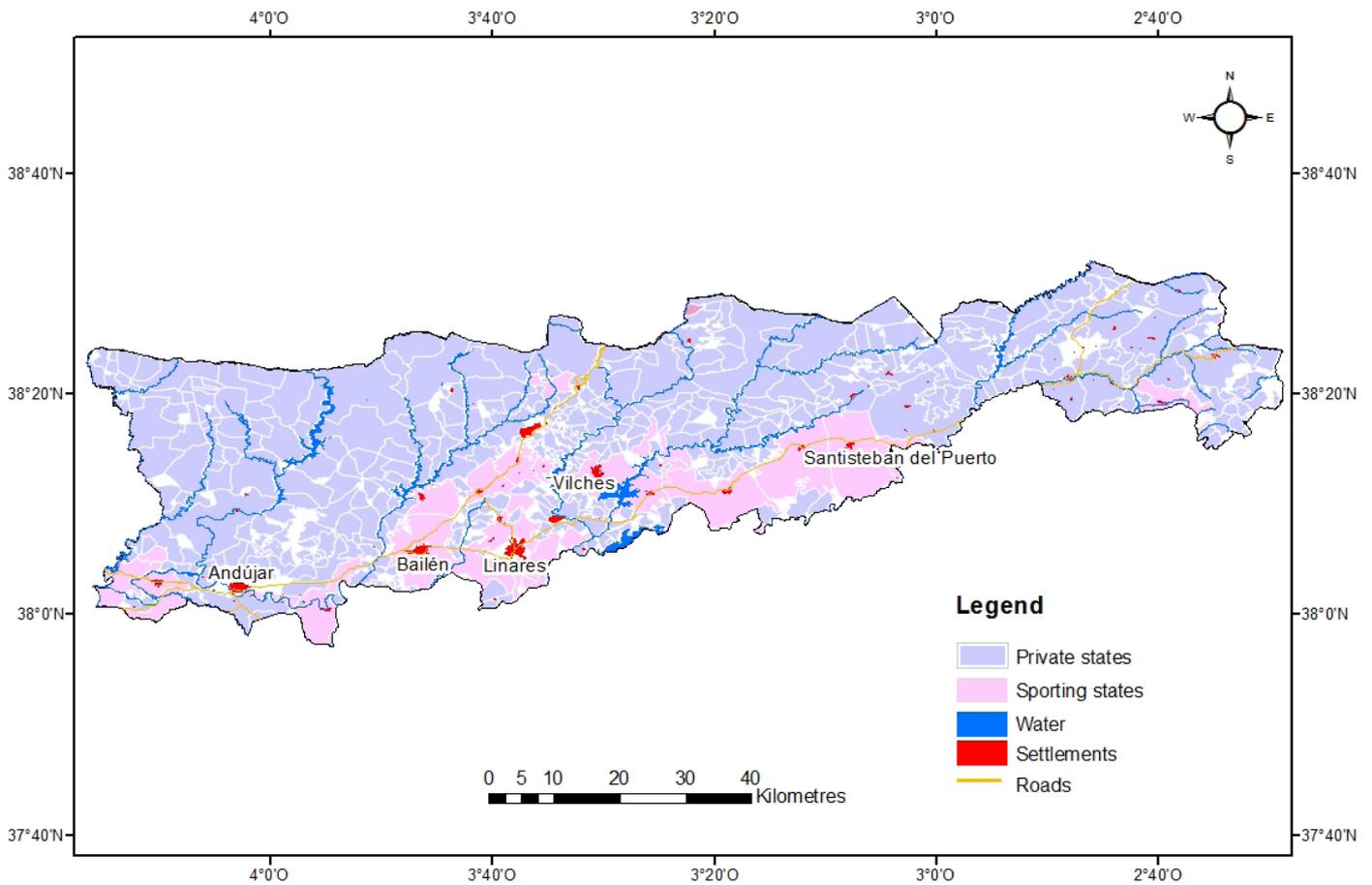
2005). In the study area 38% of the reduction in the dehesa can be attributed to this cause (Fig. 6).

Another factor that contributes to the deterioration of the dehesa structure and therefore to the quality of its landscape, and which in many cases can ultimately lead to its disappearance, is hunting. Almost all of the Sierra Morena is a hunting area (see Map 3), in which there are more private estates than sporting estates run by hunting associations. There are 142 (Instituto de Cartografía Estadística y Cartografía de Andalucía, 2013) establishments devoted to hunting (Photo 5), most of which specialize in big game, in particular deer. For wild animals of this kind shrubs are better than pasture, as they can browse on new shoots and fruit in the summer. The landowners therefore do not cut back excess scrub in these areas, which are often overrun by shrubs and bushes. The increase in scrubland can be clearly observed in Figure 6, as it is in second place in the list of coverages that now occupy land once covered by the dehesa, together with dense woodland (22%) (Photo 6), and land covered only by pasture (9%). Similarly if we observe Figure 6, we can see that the dehesa with shrubs and limited

woodland is the one that has most disappeared over the period we analysed because the lack of scrub-clearing work over the 60 year period has enabled many more bushes to reach tree state. The gradual transition from shrub to woodland is only halted in areas where hunting exerts great pressure on the plant life due to the high density of animals reared in semi-intensive conditions. The areas with most scrubland tend to be on hillsides or areas with steep inclines, which are unsuitable for livestock grazing.



Photo 5: Dehesa with a hunting activity. Source: the author



Map 3: Hunting areas. Source: REDIAM. WMS Terrenos cinegéticos de Andalucía



Photo 6: Dehesa with high coverture of shrubs. Source: the author

These areas are more typically grazed by wild animals, which also use the scrub for hiding.

The conversion of large parts of the dehesa to intensive agriculture is another important factor in

the evolution of the traditional model of land use in rural areas towards the model applied today. The greatest transformations in this direction have taken place in areas in which farming and forestry/grazing activities adjoin or overlap, in which olive groves, often intensively farmed have slowly been eating away at the space occupied by the dehesa (Photo 7), as has occurred with the other crops in the area. The result is that today the province of Jaén is largely covered by a monoculture of olive trees. Olive groves now cover 15% of the area of dehesa that has been lost over the study period. This process is very evident in the areas classified as cultivated dehesa, in which olive trees have replaced cereals, presumably because cereal fields are easier to convert into olive groves than wooded areas. In other cases, as a result of the limited productivity and profitability of cereal crops in the cultivated dehesa where the soil is relatively infertile, they cannot be produced at



Photo 7: Olive groves. Source: the author

competitive prices. This has led to the abandonment of cereal production in many areas in which natural pastures have re-emerged to take their place.

5. Conclusions

In this paper we have shown that the dehesa is an agro-system that has undergone changes both in terms of the total surface area given over to this kind of farming, and of its structure, in that there have also been important changes in the area covered by the different types of dehesa. These changes have led on the one hand to a restructuring of the different types of dehesa, and on the other, to the replacement of the dehesa by other land uses such as replanted forest, especially with pine trees, which are planted in mountain areas as a means of curbing soil erosion. On the flatter areas, the main competition has come from the expansion of the olive groves, which have gradually eaten away at both woodland and pasture. In many cases, the planting of olive trees has led to the cutting down of holm oaks, while in others they have been preserved. We have also noted that traditional activities such as livestock farming and more recent ones such as rural tourism are contributing to the maintenance of the dehesa, in that they enable the landowners in these areas to diversify and improve their sources of income.

As regards the internal structure of the dehesa, we have noticed firstly, that the abandonment of farming has led to a reduction in the cultivated area of the dehesa, which has been substituted by natural pastures and secondly that in some places there has been an increase in the area occupied by scrubland and an increase in the density of the number of trees as a result of reduced farming. This is due in many cases to the absence of livestock, because many estates have switched to big-game hunting, a new business that requires the estates to be fenced, so preventing livestock from grazing the land. The dehesas used for hunting have a higher percentage of forest regeneration than other dehesas that are grazed only by domesticated livestock, due to the fact that they have higher levels of scrubland.

In some cases the abandonment of traditional maintenance activities such as cutting back the scrub and clearing around trees, together with the excessive number of grazing animals also contributes to the destruction of the typical dehesa landscape

The decay of the dehesa landscape results not only in a loss of biodiversity (Leco 2006), but also in a significant decrease in the historical heritage in these areas with the disappearance of numerous architectural features and examples of traditional rural culture.

To sum up, the methodology used in this research has enabled us to evaluate quite accurately the size and the evolution of the dehesa in this part of the province of Jaén over the last 60 years. Our fieldwork has enabled us to corroborate the information obtained from the analysis of the databases, as can be seen in the photographs.

Finally, this work has allowed us to detect the principal dynamics that affect the spaces of dehesa and help us to continue going deeper into the analysis of its landscape, economic and social impacts and evolution.

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