MARTA PÉREZ SOBA • ALFONSO SAN MIGUEL •
RAMÓN ELENA-ROSSELLÓ

COMPLEXITY IN THE SIMPLICITY: THE SPANISH DEHESAS

THE SECRET OF AN ANCIENT CULTURAL LANDSCAPE WITH HIGH NATURE VALUE STILL FUNCTIONING IN THE 21ST CENTURY

How might an agro-forestry system, dating from the Middle Ages, overcome historical changes in human demands and still work efficiently in the 21st century? How could it with a semi-arid climate not only have agricultural value, but also provide an aesthetically outstanding cultural landscape, with biodiversity so high that might be compared with that of moist, tropical forests?

The answer to these questions is found in the Spanish dehesa, a paradigm of successful co-evolution of the socio-economic and ecological demands of a landscape by means of the diversification of structures and an efficient and extensive use of products and services. Dehesas are therefore considered to be one of the best examples of sustainable, traditional agricultural systems in Europe, and one of the most extensive and emblematic High Nature Value (HNV) farmland systems in the Iberian Peninsula. Dehesas have a savannah-like appearance; with dispersed trees, some of them centuries old, and pastures of dense, short grass, mainly used for livestock grazing. They are a good example of livestock systems adapted to their environment. The Mediterranean character of the climate and the low fertility of the soil makes pure arable farming (agriculture) unprofitable. Within this difficult environment, the dehesa has arisen as an ideal form of rational, productive and sustainable land usage. It does not try to maximise the output of any particular product. On the contrary, it tries to use a strategy of efficiency and diversification of structures with the aim of taking advantage of every natural resource (multiple, scarce and unevenly distributed in time and space) of its environment with a minimum input of energy and materials. Due to that diversification and efficiency, the dehesa is a very versatile system that has been able to successfully satisfy human requirements from the Middle Ages up to the 21st century. That is the secret of its survival.

Pedroli B, Van Doorn A, De Blust G, Paracchini ML, Wascher D & Bunce F (Eds. 2007).
Europe's living landscapes. Essays on exploring our identity in the countryside. LANDSCAPE EUROPE / KNNV.

The Spanish *dehesas* are located in western and south western Spain (Figure 1), and they currently cover a large area of about 4 million ha (Olea & San Miguel 2006), which represents about 15% of the total agricultural area. They were created many centuries ago by ancient societies, who thinned oak forests on poor land to turn them into agro-silvo-pastoral (or pastoral-silvo-agricultural) systems.

The sustainability of *dehesa* landscapes faces a main challenge at the beginning of the 21st century. On one hand, they need to keep their cultural functions and provide products and services required by society. On the other hand, preservation of the proper functioning of the system demands traditional management, but the traditional knowledge and the necessary workforce are disappearing in the rural areas. The National Plan for *Dehesas*, which is currently being created in Spain, is seen as a serious attempt to make a coherent strategy in support of this emblematic cultural landscape.

THE LANDSCAPE PROFILE

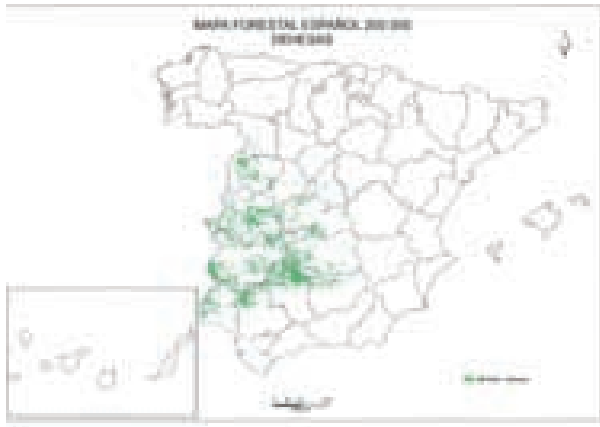


Figure 1. *Map showing the distribution of the dehesas in Spain, according to Ruiz de la Torre (2002)*

The *dehesa* could be considered as a trans-frontier landscape between Spain and Portugal, since the *montados* of southern Portugal (Alentejo) are very similar landscapes. However, one should be careful when identifying this trans-frontier landscape, because the land cover types associated with the CORINE Land Cover classes might differ between the Spanish and the Portuguese interpretation. The CORINE Agro-forestry areas (class 2.4.4) are considered as the main *dehesa* and *montado* class. However, the classes Broad-leaved forest (3.1.1), Sclerophyllous vegetation (3.2.3) and Transitional woodland-shrub (3.2.4) might also cover some types of *montado* systems (van Doorn & Pinto Correia 2007). The major ecosystem types in the *dehesas* are: evergreen sclerophyllous forests (having as the main tree species *Quercus rotundifolia*, *Quercus suber*, *Quercus faginea* subsp. *broteroi*), woodlands or scrub (only on slopes and mountains and there where big game is a major final product).

Different typologies of *dehesas* exist depending on the objective of the classification. The most relevant typologies are based on:

(a) Tree species

Evergreen sclerophyllous trees:
holm oak (*Quercus rotundifolia*), cork oak (*Quercus suber*) (Mediterranean climate)
Semi-deciduous tree species:
Quercus faginea subsp. *broteroi*, *Quercus pyrenaica* (sub-Mediterranean climate)
Deciduous tree species:
Fraxinus angustifolia (valley bottoms)

(b) Production

High forest:
aimed at acorn production for fodder (southwest, i.e., north of Andalucía and the Sierra Morena)
Coppice:
where acorn yields are small and vary between years - aimed at fuel-wood and browse production (central Spain, i.e. north of Extremadura, Castilla-León and Madrid)
Extensive livestock breeding

Figure 2. *Different types of dehesas according to the tree species shaping them:* ***A*** *Holm oak (Quercus rotundifolia) dehesa showing the typical spreading crown of every individual tree, achieved through decades of pruning, with a rotation 10-12 years*

B. *Narrow-leafed Ash (Fraxinus angustifolia) dehesa, a cooler, humid type, showing trees pollarded for browse and fuel-wood*

Figure 3. *Typical shallow and nutrient poor slate soils in a Holm oak (Quercus rotundifolia) dehesa in Extremadura, western Spain*

Biophysical characteristics

The climate of the *dehesas* is usually Mediterranean (including sub-Mediterranean). The summers are long and dry, with temperatures that often reach 30-40ºC. The winters are moderately cold, with infrequent frosts, but still occur every year, with minimum temperatures usually above – 5ºC. The average precipitation, ranging from 500 to 800 mm, is concentrated in the period October-April/May, is irregularly distributed and has strong annual fluctuations. The soils have predominantly developed on acid bedrocks with low soil fertility, particularly regarding phosphorus and calcium.

The topography is generally hilly, sometimes flat, but never rough.
The main features of this landscape are:

(a) Tree species, which are important for livestock and wildlife feeding, the main species of which are: *Quercus rotundifolia* (see Figure 2), *Quercus suber*, *Quercus faginea* subsp. *broteroi*, *Quercus pyrenaica*, *Fraxinus angustifolia*, *Olea europea* subsp. *sylvestris*.

(b) The shrub layer is absent or scarce in traditional *dehesas*, since it competes with trees and grasslands and it provides only poor quality fuel-wood and browse for livestock. However, its importance is high where *dehesas* are aimed at big game activities, e.g., as a source of shelter for wild ungulates (red deer, wild boar and roe deer). There, the main species are: *Cistus* sp., *Retama sphaerocarpa*, *Cytisus* sp., *Quercus coccifera*, *Lavandula stoechas*, *Rosmarius officinalis* and *Erica* sp.; the last is present only when rainfall is high enough (usually over 600 mm).

(c) The livestock of the *dehesas* comprises different types, depending on the main vegetation characteristics and the management available. Sheep are typical and traditional. Merino was the standard breed, though other improved (larger) merino breeds are also used today; e.g., Île de France, Fleischschaf and Landschaf. Nowadays, cattle are also present, because herdsmen are not needed. Cattle breeds used are *Avileña negra ibérica, Retinta, Morucha, Berrendas* and other extensively grazing breeds. Goats are used when scrub is dominant. Game (red deer, wild boar, rabbit, red legged partridge) is currently very important, sometimes more so than livestock.

(d) Grasslands vary, with different types according to the biophysical constraints; i.e., annual grasslands (summer drought and winter cold), perennial grassland on valley bottoms that dies back in summer, and sown pastures (subclover (*Trifolium subterraneum)* and other leguminous species).

(e) Agricultural crops are used with a double aim: controlling the woody vegetation which invades the annual grasslands, and producing food for humans, livestock or wildlife. The main cereal crops (oat, barley, rye and sometimes wheat) are rotated with grass and fallow. The most common cycle is fallow (1st year from February until September), cereal (September 1st year, until June 2nd year), fallow (summer, autumn 2nd year), sub-nitrophyllous natural annual grassland (3rd year until 5th year).

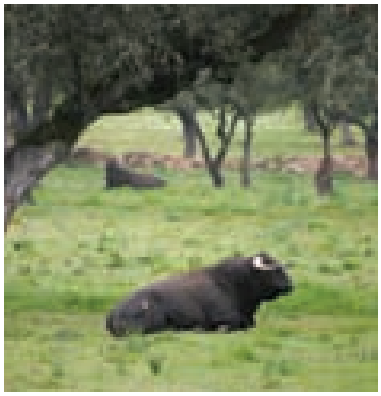


Figure 4A. *Traditional cattle breeds grazing in dehesas. Avileña negra ibérica.*

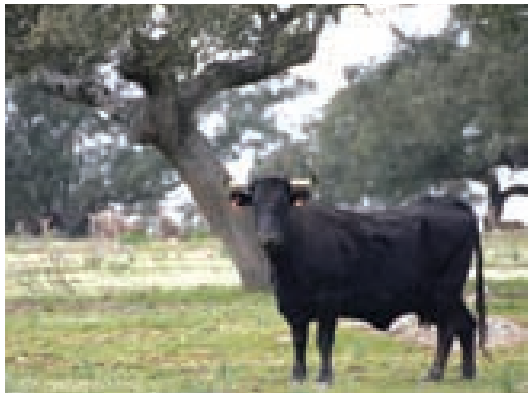


Figure 4B. *Retinta*

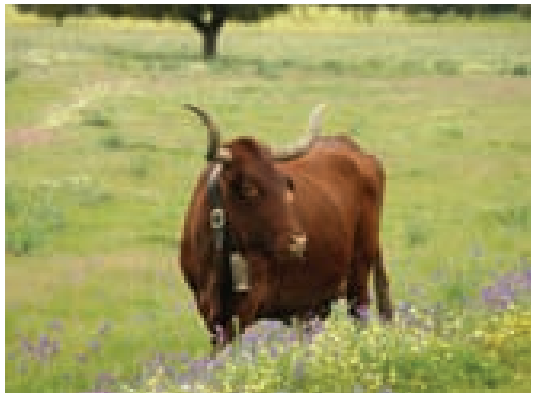


Figure 4C. *Toro bravo*

Ecological characteristics

The open wooded pastures and scrub in the *dehesa* provide wide and diverse habitats with important nature values. For example, they support one of the richest bird communities in Europe (Beaufoy 1998) and the grasslands are very rich in plant species, ranging from from 120 to 180 species/100 m^2 (Marañón, 1985). Several threatened species are found in the *dehesas* and neighbouring areas; e.g., the Iberian imperial eagle *(Aquila heliaca),* the black vulture *(Aegypius monachus)*, and the Iberian (or pardel) lynx *(Lynxus pardina)*.

The multiple functions found in a *dehesa* (see next section on Landscape functions) are heterogeneously distributed throughout the estate, and therefore it is usual to find a mosaic of habitats in each property. Several priority habitat types included in the Annex 1 of the Habitat Directive ('habitat types of community interest whose conservation requires the designation of special areas of conservation') are observed in *dehesas*. For example:

- Coastal: 3170 Mediterranean temporary ponds
- Temperate heath and scrub: 4030 European dry heaths
- Natural and semi-natural grassland formations: 6220 Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea*
- Forests: 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*

1 : Innovative Landscape Policy: the Spanish National Plan for Dehesas

A National Plan for *dehesas* is currently being developed in Spain by the collaboration of two ministries with contrasting points of view: the Ministry of Agriculture, Fisheries and Food and the Ministry of the Environment. This approach, unique in Europe, is aimed at providing the scientific and technical background to elaborate an action plan for the conservation of the dehesa system. It has as its main objectives:

- Definition of the dehesa system
- Establishment of a dehesa system typology
- Digital cartography of the dehesa types of each Autonomous Community
- Description and current situation of every dehesa type in each Autonomous Community
- Establishment of basic guidelines for the management and conservation of every dehesa type
- Review of the legal situation of dehesas
- Stimulation of public recreation and participation in their conservation and management

Landscape functions

Two types of functions are considered. Firstly there are traditional functions; i.e., the production of cork, and wood for fuel or charcoal, livestock production (Iberian pigs, sheep, goats, and cattle), small game, and the breeding of bulls. Secondly, there are functions which have recently been recognised because of the so-called services or indirect benefits that they provide, i.e., prevention of soil erosion, fire prevention, organic soil fertilisation; from the manure produced by the grazing cattle; rural tourism, mushroom gathering (*Amanita*

Tree layer	Major function	*Stability:* structure, landscape, climate, erosion, water and nutrient cycles, shelter, biodiversity, carbon fixation, cultural benefits, fodder. Perennial sclerophyllous species might be considered as permanent fodder reserves for livestock and wildlife
	Species	*Quercus ilex* subsp. *rotundifolia (= Q.ilex ballota)*, *Q. suber* (sclerophyllous and perennial), *Q. faginea*, *Q. pyrenaica* (semi-deciduous) and other less important species
	Density	(15) 20 – 100 (200) adult trees/ha
	Crown coverage	(5) 10 – 50 (70)%
	Basal area	2 – 10 (15) m^2/ha
	Products: mean annual yield	*Fuel wood:* 800-5000 kg/ha-rotation (DM) *Browse (prunings or direct browsing):* 400-1500 kg/ha (DM)(pruning). Direct browsing is important in coppices (usually cold dehesas, with low acorn yield) *Acorn:* (100) 200 – 600 (800) kg/ha, with inter-annual variations *Cork (only Q. suber):* 500-1500 (2000) kg/ha-rotation
	Silvicultural rotations	*Regeneration felling:* tree senescence (150 years for Q. suber and 250-300 years for other species) *Pruning:* 10-15 years *Debarking:* 9-12 years
	Threats	The lack or shortage of natural regeneration of trees in many dehesas is by far their most important threat. In addition, it is getting worse due to the sudden dying-off of many trees, known as seca.

Table 1. *Major features of the dehesa tree layer and its management, according to Olea & San Miguel (2006)*

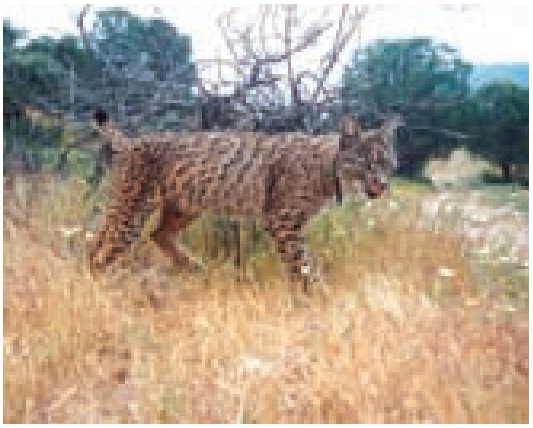
caesarea and other) carbon sequestration, and provision of habitats for plant and animal species (some protected and red list): being aware that other managed systems in the world do not have the high diversity of plant communities present in the *dehesas* (Pineda *et al.* 1991).

The functions of the main features of this landscape are described as follows.

Trees play the fundamental role of general stabilisation, and they provide indirect benefits. However, they also contribute directly to the overall production of the *dehesa*, with acorns, browse, fuel-wood, cork, edible fungi, pollen and other resources. The acorns ripen in winter and constitute an important supplementary food for the livestock and wild fauna (Ruiz 1986). Trees also provide shelter on cold Mediterranean winter mornings, important shade in the hot summers and valuable contributions of organic material and nutrients in autumn (Gómez Gutierrez 1992). The tree layer is an essential component of the *dehesa* system and, as a consequence, sustainable management must be concerned not only with adult trees, but also with their natural regeneration.

Its major features are summarised in Table 1.

Figure 5. *Threatened species for which habitats are provided by dehesas:* ***A.*** *Spanish imperial eagle (Aquila heliaca)*



B. *Iberian lynx (Lynx pardina)*

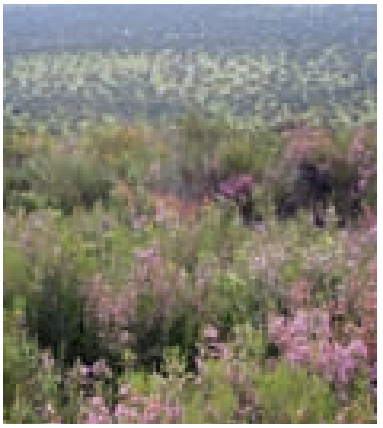


Figure 6. *Dry heaths found in the mosaic landscape of dehesas are a Priority Habitat type included in the Annex 1 of the Habitat Directive (Heath and Dehesa)*

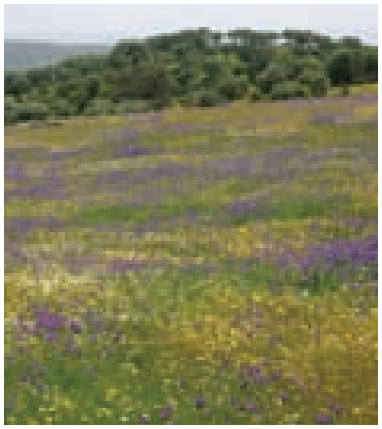


Figure 7. Flowering posio (annual grassland) in a holm oak (Quercus rotundifolia) dehesa in Sierra Morena, south western Spain

The most important function of the *dehesa* is extensive livestock rearing. Therefore, natural pastures, as the main source of fodder for livestock, are an essential component of the system. As a consequence of the Mediterranean climate, natural pastures are usually annual grasslands. However, perennials play a fundamental role in valley bottoms, and particularly in dense swards created and maintained by intense and continuous grazing, known as *majadales*. The management of natural pastures is aimed at increasing their quality (legumes, protein, minerals), since quantity is much less important, due to high variability (up to 200%, according to Olea *et al.* 1990), and the typically uneven seasonal distribution of production. Therefore their management is based upon three fundamentals: rational livestock grazing, legumes and phosphorus (Olea & San Miguel 2006). Suitable management should result in a significant improvement of the quality of natural pastures. However, seasonal periods of shortage of fresh fodder cannot be avoided, so browse, fruits (particularly acorns), crops and supplementary food also contribute to suitable livestock nutrition in the lean periods of summer and winter. The shrub layer is typically absent or sparse.

In addition, cropping is usually carried out in cycles of several years (3-6), with the aim of keeping invasive shrubs out of natural grasslands. Some *dehesa* owners allow other farmers free use of their land when natural pastures are being invaded by aggressive shrubs, usually *Cistus* sp. Extensively grazed livestock is the most important direct product of the *dehesa*, but also a fundamental tool for creating and improving natural and sown pastures and for seed dispersal (Malo & Suárez 1995, Malo *et al.* 2000) and fertility (Gómez-Sal *et al.* 1992). As a consequence, sustainable and extensive livestock management is an essential tool for the preservation of the *dehesa* system and its biodiversity. However, it should be compatible with the presence and regeneration of the tree layer, since trees are browsed and damaged by livestock at different intensities (trees up to 12-15 cm of diameter at breast height, or 20-40 years of age, might be wrecked by cattle, especially if they are fed with concentrates including urea). Different livestock species are required due to the high diversity of the *dehesa* system.

Game species have always been present in the *dehesa* system, but at low densities (with the exception of wild rabbits) since they were considered only as a supplementary source of food.

2 : Transhumance and dehesas: the interdependence of two endangered, sustainable systems

Transhumance is a very ancient livestock practice, found in Neolithic times some 8,000 years ago, that has played a crucial role in shaping the dehesa landscapes in the Iberian Peninsula. The fluctuating climate and topographic complexity of the peninsula determines seasonal variation in the productivity of grazing resources, which in turn requires the transfer of herbivores to areas of complementary production (Gómez Sal & Lorente 2004). Transhumance is the human answer to these needs: the seasonal oscillatory migration of livestock to mountain areas in search of green pastures at the end of spring, and the return to the warm, southern agricultural land in the valleys and adjacent lowlands in autumn. In the most outstanding examples, the transhumant drove roads in Spain (called *cañadas*) link zones which are up to 800 km apart. The different species and breeds of traditional herbivores are perfectly adapted to the difficult biophysical conditions, and transhumance makes it possible to take advantage of the different production patterns of the complementary fodder by moving them from place to place. Unfortunately, the functioning of transhumance is seriously threatened at present by modern pressures such as industrialisation of agriculture, globalisation and modern lifestyle (Herzog et al 2006). For instance, the introduction of transport by rail since the beginning of the 20th century, and later by trucks from the dehesas to the highlands, delays the departure by four or five weeks. The longer stay of the herds in late spring, at the critical time for ecosystem regeneration, has the following negative consequences in the dehesas: overgrazing of pastures, destruction of tree regeneration, pollution and depletion of water spots, destruction of shelter and food resources vital for terrestrial fauna, and disturbance of the reproductive cycles of sensitive plant species (Garzón-Heydt 2004). Therefore the disappearance of the traditional transhumance results in important negative impacts on the sustainability of the dehesas. New ways must be found to maintain transhumance and dehesas, which include EU funded agro-environmental measures, rural development measures, and improved recognition of the environmental services provided by both systems, as well as their significance for sustainable development.

Socio-economic characteristics

There are no official figures, but it is estimated that approximately 90% of the area is in private hands. A significant proportion of the landowners do not live on their properties but in major towns, sometimes far away, and their income does not uniquely depend on the direct yield of the *dehesas*. Therefore, *dehesas* do not only

Figure 8A. *Dehesa's richness in fauna and flora. Crane (Grus grus)*

Figure 8B. *Ladder snake (Elaphe scalaris)*

Figure 8C. *Linaria amethystea*

have a production function but might also have a social function: they can increase social status, and be used as recreation places to stimulate interesting social networks. This fact partly explains why the *dehesa* land price is unusually high (over 12,000 €/ha for good holm oak *dehesas*), despite the progressive reduction in direct economical benefits from the traditional production system (Campos *et al.* 2001).

Regarding the traditional agricultural production, the *dehesas*' management has suffered substantial changes in recent decades, as a consequence of social and economic changes and the EU Agricultural Policy, i.e., a dramatic decrease in the number of shepherds and the consequent decay of transhumant activities, abuse of supplementary feeding, changes in livestock species (cattle instead of sheep), intensification of agriculture (yearly cultivation of land that formerly was only cultivated in 3-8 year rotations). A main consequence of these changes is the disappearance of the traditional knowledge of management methods.

Finally, there are two functions that are increasingly important: (i) game, as shown by the high shooting rights (for one red deer it varies between 1,200€ and 6,000€), and (ii) recreation and rural tourism.

The total economic value of the products and services provided from the multiple use of *dehesas* is summarised in Table 2, and is based on the behaviour of people as consumers. There is a major difficulty when assessing the total economic value: this is the challenge of estimating the values of the present indirect environmental services and of future uses. *Dehesas* have private and public economic values (Campos-Palacín *et al.* 2006). Private economic values are those enjoyed by the *dehesa* owners without paying directly for them, e.g., the recreational and welfare contributions made to their property by habitat conservation (Campos-Palacín & Mariscal 2003). On the other hand, the public economic values are those enjoyed by visitors, who have free access, allowing them to use this environmental amenity for their leisure activities.

	Present uses (active uses)		**Future uses (passive uses)**	
	Direct	**Indirect**	**Option**	**Existence value**
Definition	Products and services with exclusivity or competition in use	Environmental services	Users' willingness to pay for ensuring future use of products and services	Users' willingness to pay for ensuring future existence of a service or product independent of its consumption
Examples	Grazing resources, cork, wood, firewood, livestock, crops, hunting, recreation, mushrooms, wild plants	Habitat sustainability functions, flood damage prevention, carbon fixation, greenhouse gases net emissions saving	Conservation of biological resources for pharmaceutical uses	Preservation of a unique habitat and endangered wild species

Table 2. *Total economic value from multiple use of agro-silvi-pastoral systems (source: Campos-Palacín et al 2006)*

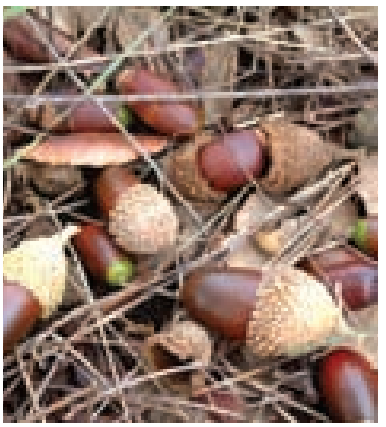


Figure 9. *Acorns, one of the main tree products of dehesa, which ripen in winter and constitute an important supplementary food for the livestock and wild fauna.*

Figure 10. *Cork oak (Quercus suber), showing the dark reddish bark shortly after harvesting. The bark is harvested every 9-12 years as cork. The professional harvesting of cork does not harm the tree and a new layer of cork regrows, making it a renewable resource*

LANDSCAPE CHANGES

Decrease in the area of dehesa landscape

Over the last three decades, 2m ha of Spanish *dehesas* have been seriously altered or destroyed (Beaufoy 1996), leaving 4m ha today. This trend had already started after the Spanish civil war (1936-1939), when lack of food for the population caused some *dehesas* to be transformed into arable fields. After that, successive epidemics of African swine fever dramatically reduced the herds of Iberian pigs, whose meat is one of the main economic products of holm oak *dehesas*. Consequently, many of them disappeared in the period 1940-1970. In addition, agricultural intensification in Spain has given over significant areas of *dehesas* to crops, e.g., cereals, sunflowers, cellulose and fast-growing timber, much of which is irrigated (Figure 11B). The environmental, ecological and socio-economic costs of this process have been high, as is shown by the following indicators: the substitution and loss of ancient cultural knowledge by the application of modern techniques, the deterioration of the landscape and decreases in biodiversity (Campos Palacín 1993, Sumpsi 1996). Conversely, financial profitability has increased and the price support mechanisms have supported the shift from extensive cereal crops to intensive systems.

3 : Agricultural landscapes: recuperation of native livestock breeds

Most native livestock breeds were selected through millennia with the aim of producing meat, wool, milk, work and other products within difficult natural environments and without external aid (energy, materials).

Since the 1960s, the possibility of increasing production, even at the cost of also increasing inputs (foreign breeds, supplementary feeding), usually resulted in crossbreeding. Therefore, many traditional native breeds became endangered and even disappeared. Fortunately, within a decade scientists and managers showed a strong commitment to the problem and started new plans aimed at the preservation of those traditional native breeds. Nowadays there are European and Spanish subsidies aimed at favoring the utilisation of those traditional native breeds and most of them are not endangered. The most typical and traditional livestock breed is the Merino sheep. The native cattle breeds used are *Avileña negra ibérica, Retinta, Morucha, Berrendas* and other extensively grazing breeds.

Changes in traditional management

The traditional use of *dehesas* is characterised by mixed livestock rearing at low stocking densities, employment of hardy regional breeds and an elaborate system of maintenance and exploitation of holm oaks. Livestock production has traditionally been accompanied by arable systems with long rotations and closed nutrient cycles, without external inputs of fodder, fertilisers and agro-chemicals. The changes in needs and lifestyle of the population observed after the 1960s; i.e., increased consumption of energy, use of tractors, use of chainsaws and application of mineral fertilizers, lack of shepherds, dramatic reduction of transhumance, rural migration to urban areas; have resulted in a loss of the traditional exploitation of *dehesas*. Current trends include specialisation, going towards lamb and beef production, and the employment of intensive agricultural practices, like high grazing and stocking levels, or crossbreeding with high-performance breeds (Plieninger & Wilbrand 2001). This causes an alteration in the *dehesa* environment, and in the pasturelands so used, which suffer over-intensive grazing, with reduced time for regeneration.

Other significant changes have taken place in the management of *dehesa* landscapes. Firstly, since the 1960s, hunting has become a major economic activity and now it is often the most important one in many *dehesas*. Wild ungulates, especially red deer (*Cervus elaphus hispanicus*) and wild boar (*Sus scrofa*), are now regarded as expensive, renewable, natural resources, and consequently the *dehesa* owners usually fence their properties. The result is a remarkable increase in wild ungulate densities (usually over 50 red deer individuals/km^2), which creates severe sustainability problems due to: (i) impacts on woody vegetation and fauna, (ii) prevalence of parasites and diseases, which may affect livestock and even human beings, and (iii) genetic loss of plant and animal species (Gonzalez & San Miguel 2004, Gortazar *et al.* 2006).

Figure 11. *Examples of landscape changes in former dehesas, due to agricultural intensification and new recreation activities.*
A. *Period 1956-83: reforestation with eucalyptus of a former dehesa, and later abandonment*

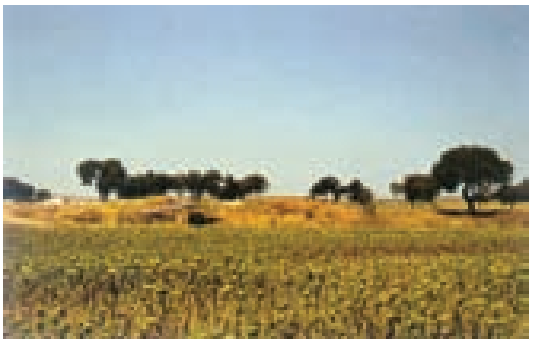


Figure 11B. *Period 1983-98: deforestation and irrigation of a former dehesa for intensification (sunflower crop)*

Figure 11C. *Period 1983-98: tree thinning and final deforestation in a former holm oak dehesa for woody crops (vineyards)*

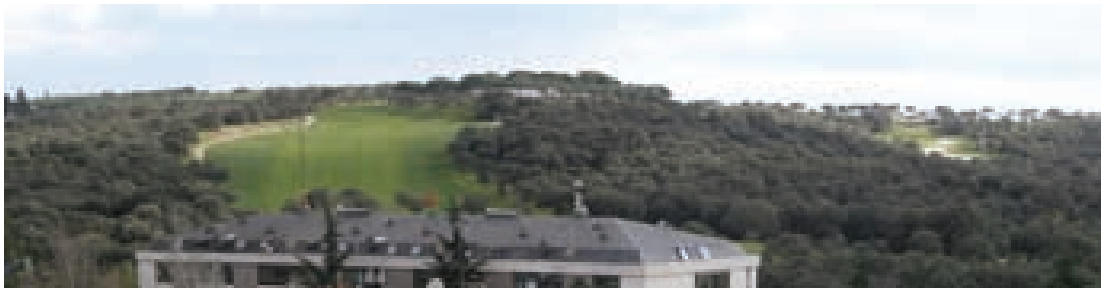


Figure 11D. *Period 1998-2006: golf course developed in a dehesa landscape. These recent additions to recreational activities in the dehesa provide an important socio-economic alternative to the declining animal grazing activities*

Secondly, wild rabbit densities have suffered a dramatic decrease because of myxomatosis, viral haemorrhagic disease and predators (wild boar included). This rabbit decrease has become a major environmental problem (Villafuerte *et al.* 1995, González & San Miguel 2005), since rabbit is the basic prey of many predators (e.g., the Iberian imperial eagle and Iberian lynx) and carrion birds (e.g., black vulture).

Thirdly, red legged partridge, another traditional game species, is also endangered by many problems: including the common introduction of farm-reared individuals (with their parasites, diseases and sometimes different genetic heritage) and predators (wild boar also included).

Finally, wood-pigeon densities have increased, even though they compete with livestock (especially Iberian pig) and wild ungulates for acorns.

4 : Holiday/recreation landscapes

The development of golf courses is a very recent land use change that affects dehesas. In the past, golf courses were located in the vicinity of provincial towns, and in tourist resorts on the south western coasts of the Iberian Peninsula. Recently, golf courses have increasingly been established all over the dehesa area, taking advantage of their aesthetic value (Figure 11D).

The changes in structural and functional values of the dehesa, caused by the building of golf courses, require a deep insight and careful development. Changes in the composition of grass species on the tee and the greens, tree clearing on the fairways between holes, and irrigation during drought periods are among the most important ecological impacts on the traditional dehesa landscapes. Though golf courses are also linked to new tourist resorts, and they too might eventually impact on an important area of the surrounding dehesa.

It is an important challenge to combine, in a sustainable way, the long-established dehesa landscape structure with new recreational activities. Consequently, the functional change from agricultural production to recreation should be carefully planned and monitored to avoid and control the deleterious effects which might eventually lead to the disappearance of the traditional dehesa landscape. Accordingly, the main focus of sustainable management of the recreation landscape should be conservation of landscape character and function, as well as and water management and protection against forest fire at both local and regional level.

Figure 12. *Holm oak (Quercus rotundifolia) trees protected by wire netting from damage caused by too high a population of red deer*

¿Qué tienes tu, negra encina
Campesina,
Con tus ramas sin color
En el campo sin verdor;
Con tu tronco ceniciento
Sin esbeltez ni altiveza, con tu vigor sin tormento
Y tu humildad que es firmeza?
En tu copa ancha y redonda

Nada brilla,
Ni tu verdioscura fronda

Ni tu flor verdiamarilla
...

What do you have, black holm oak
Peasant woman,
With your colorless branches
In the green less countryside patches;
With your trunk colored in ash
no slenderness and no pride,
force without distress
Modesty that is solid?
In your wide and rounded crown
nothing shines
neither your dark green foliage
nor your yellow greenish flower

Antonio Machado: Obras completas. Espasa-Calpe. Madrid. Edición de 1982.ings and celebrations in Moritzburg]

Monitoring of changes in the dehesa landscapes

The recent evolution of the *dehesas* has lately been studied using the Network of Spanish Rural Landscapes (REDPARES), which is the key component of the Spanish System for Monitoring Rural Landscapes (SISPARES). From all REDPARES samples, 22 have being classified as *dehesa* landscapes, divided into (i) 17 samples in which *dehesas* occupy more than 50 % of the land cover, and (ii) 5 samples in which *dehesas* occupy between 25 and 50 % of the land cover (García del Barrio *et al.* 2004). The *dehesa* samples are located in the Duriense, Extremaduriense and Betica Eco-regions (Elena-Rosselló 1997), and are fully representative of the cultural landscapes in these regions, where *dehesa* plays a dominant role.

The trends observed from monitoring the *dehesas* REDPARES samples in the periods 1956-83 and 1983-1998 are as follows.The landscape composition of most of the *dehesas* remained quite stable and very few

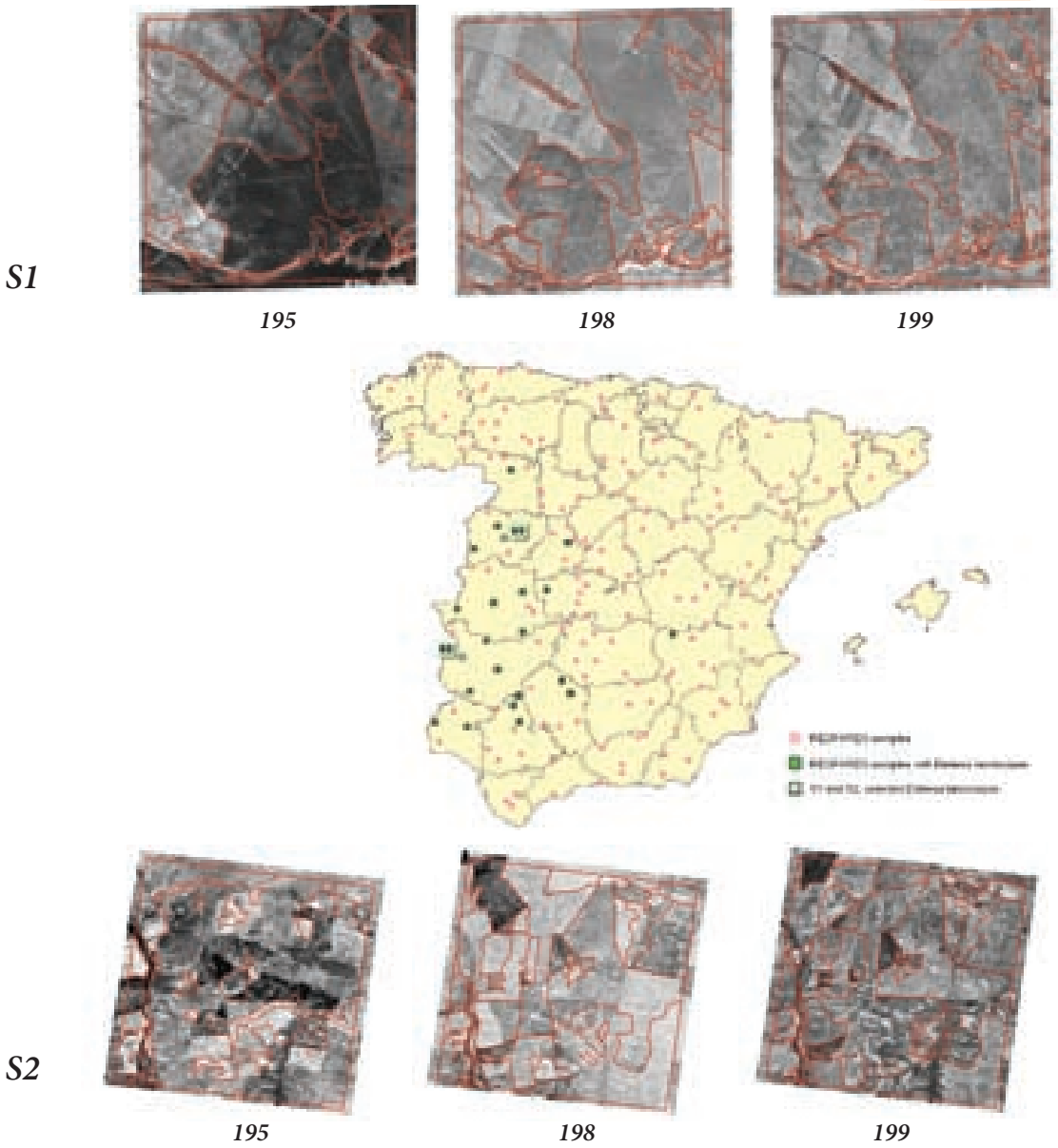


Figure 13. *Dehesa landscape evolution in two REDPARES samples during the 1956-98 period. Changes can be detected by aerial photo-interpretation. S1 (Matilla de los Caños), a good example of the very stable landscapes that had small changes in both composition and configuration features. S2 (La Albuera), one of the few landscape samples that had important changes, including felling for crop intensification and eucalyptus forest plantation*

landscapes changed dramatically. Figure 13 shows the two types of evolution observed in REDPARES landscape samples - few changes or dramatic changes. In the 22 selected samples, *dehesa* cover changed from 69.5 % (1956) to 61.5 % (1983) and 59.1 % (1998). According to these figures, the first period (1956-83) showed a larger variation than the second period (1983-98). The reasons for the cover reduction varied between the two time periods; i.e., crop intensification was dominant during the first period, whereas densification of wooded areas, tree colonisation and scrub development were the main change processes in the second period. Interestingly, changes were mainly driven by geographical factors: *dehesas* located on undulating peneplains remained much more stable than those located on alluvial flatlands; where irrigation programmes changed *dehesas* into arable lands. Finally, those *dehesa* landscapes located in South-western hilly areas changed dramatically, due to reforestation with eucalyptus (Regato-Pajares *et al.* 2004).

Landscape configuration showed the most dramatic changes: *dehesas* became more fragmented, more diversified and more accessible. Consequently, the *dehesas*' connectivity function for wildlife decreased and, ecologically, the landscape became more fragile and vulnerable. These processes became evident during the first period and the process continued in the second one (García del Barrio *et al.* 2004).

5 : Good landscape practice: promoting new initiatives to protect dehesas

There are several initiatives in Spain to protect and promote the sustainable use of dehesas. In 1993, the Global Nature Foundation launched a pilot programme to enhance the sustainable utilisation of wooded grasslands in western Spain. The main objective was to show the relevance and viability of recovering the productivity of the Iberian *dehesas*. The programme was based on a comparative study of the impact of traditional management on the main different types of *dehesas*. The management included: (i) education of young farmers and recording of the traditional knowledge of the older generations, to ensure the transfer of the cultural heritage to new generations; (ii) organisation of seminars, courses, and international field-work camps, to facilitate the exchange of professional experiences and disseminate the results achieved; (iii) restablishment of rural buildings using traditional techniques; (iv) recuperation of native livestock breeds and crop species; (v) reforestation, with autochthonous species, of areas damaged by erosion, and control of shrub growth to diminish fire hazard; (vi) improvement of the habitats of endangered species; (vii) preparation of local home-made quality products with direct marketing and local distribution; and finally (viii) promotion of tourism that respects the environment and rural culture, to improve the economic and social diversification of depressed rural areas. The project *'Dehesas'* was finalised in 1996, but the *Centro de Educación Ambiental "La Dehesa"* in Cáceres (province of Extremadura in western Spain) supports similar initiatives. Link: www.fundacionglobalnature.org

The initiative of Euronatur, *Fundación Mediterraneo* and WWF is interesting as well. They have elaborated a document on *dehesas* and rural development in agreement with representatives from the Autonomous Communities involved, especially Andalusia and Extremadura, which is especially prepared for the FEADER funds of the EU LIFE programme.

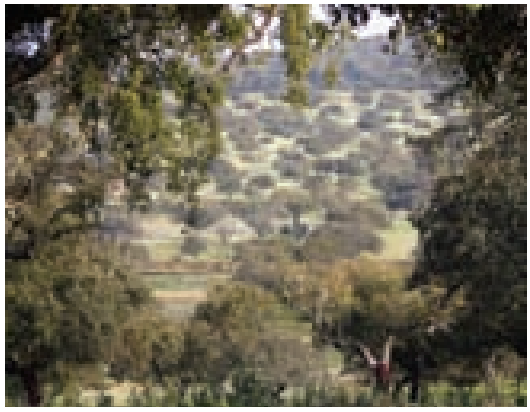


Figure 15. *Holm oak (Quercus rotundifolia) dehesas in Extremadura, western Spain*

Figure 16. *Dehesas and embalse (water reservoir) Peña del Águila (western Spain). The presence of water provides an interesting contrast to the usually dry dehesas landscape*

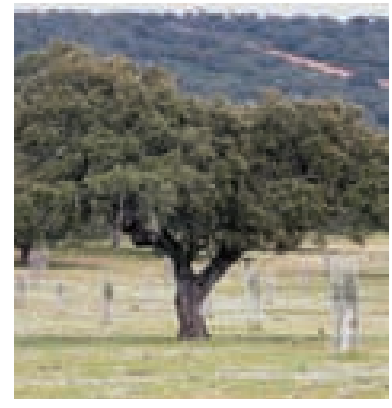


Figure 14. *Increased tree density*

CONCLUSIONS

The sustainability of the *dehesa* relies on the rational equilibrium of its twin uses as a productive, extensive, agricultural system and as a major conservation tool. The latter is becoming increasingly important, due to the demands of a society that is interested in paying for environmental quality, and the preservation of traditional and cultural landscapes. The Natura2000 network is a good example of the political and societal interest in preserving European habitats and species, and represents a significant chance for the conservation of the ecological values associated with the *dehesa* systems. Additionally, the maintenance of *dehesas* includes the preservation of the human factor, i.e. the people involved in their direct management. For the past decade, scientists, NGO's and regional and national administrations in Spain have been engaged in joint efforts to recover the sustainable use of *dehesas*. These efforts are focused on reaching equilibrium between the ecological, social and economical goods and services provided by the *dehesas*. The Spanish National Plan for *dehesas* is a good example of joint efforts between researchers, practitioners and policy makers, to protect conserve and enhance a landscape that forms an intrinsic part of the Spanish Cultural Heritage. In addition, the new Rural Development Policy (2007-2013) is another potential political tool to maintain *dehesas*. The preservation of ecological values will be the specific target in Axis 2, which aims at improving the environment and countryside; in particular biodiversity, and the preservation of farming and forestry systems with a high value for nature, water, and climate change. The maintenance of the socio-economic fabric will be approached in Axis 3, which focuses on improving the quality of life in rural areas and encouraging diversification and, additionally, in Axis 4 (Leader), by supporting the local capacity for employment and diversification.

By way of a conclusion, a SWOT analysis (Strengths, Weaknesses, Opportunities and Threats) was carried out, to highlight the current and future issues which play a dominant role in the evolution of *dehesas* in the Iberian Peninsula (Table 3): partly based on a former analysis (Paixão Ferreira *et al.* 2004):

The *dehesa* provides a wide variety of products and services or environmental benefits: structural and biological diversity, environmental stability (erosion, climate, nutrient and water cycles and decrease of fire hazard), landscape, leisure activities, tourism, cultural heritage and more. It is also the habitat of many protected animal and plant species and communities. As a consequence, despite the fact that it is usually private property, the environmental quality of the *dehesa* system should be a fundamental objective, and its management results should be considered in environmental rent terms (Campos *et al.* 2001). However, as was stated above, that high environmental quality is a consequence of its extensive, integrated and efficient management, and therefore landscape management should be considered as a powerful conservation tool. Since the *dehesa* management must be integrated, policies aimed at promoting that extensive and efficient management should not come from different departments (sometimes with opposite objectives) or be directed according to indi-

Strengths	Weaknesses
• Wide variety of social, economical and environmental services provided • Tradition • Social and private owners support • Increment of land market prices (very high)	• Lack of communication between administrations, i.e. Agriculture versus Environment, at different political levels (EU, Spanish Autonomous Communities) • Unsustainable changes in animal production and hunting systems • EU subsidies (ploughing, crops, cattle breeds)
Opportunities	**Threats**
• Nature2000 network • Increment of societal demand of natural landscapes, biodiversity, quality labels (e.g., meat, cheese, game, honey, fungi) • Rural Development policy 2007-2013	• Increase of livestock density and consequent overgrazing, leading to increased soil erosion and an absent or limited ability of the trees to regenerate • Biodiversity decrease due to intensification of agriculture • Sudden tree death (seca) • Loss of know-how (traditional management) which is essential for the preservation of this ancient agro-silvi-pastoral system

Table 3. *SWOT analysis highlighting the key factors in the current and future development of the dehesa landscapes*

Pedroli B, Van Doorn A, De Blust G, Paracchini ML, Wascher D & Bunce F (Eds. 2007).
Europe's living landscapes. Essays on exploring our identity in the countryside. LANDSCAPE EUROPE / KNNV.

vidual or specific methods. Success requires the holistic consideration of the *dehesa* estate as a system where biodiversity is closely linked with extensive production and sustainable rural development. That proposal has been presented by WWF (WWW/Adena 2006) and is supported by most Spanish Autonomous Communities where *dehesa* landscapes are typical, and also by other environmental NGOs and the scientific community. Examples of the recommendations of the proposal include, e.g., the establishment of a contract between the administration and the private user, creation of a simple management plan that integrates objectives and activities to be performed in a set time period, the definition of monitoring systems, to assess the degree of achievement of the objectives considered in the management plan. LIFE+ Projects, Agro-environmental measures and FEADER will probably play a fundamental role in achieving that goal. For example, three LIFE Projects aimed at the conservation of the Iberian lynx, the Iberian imperial eagle, the black vulture and the black stork, consider agro-silvi-pastoral management as a basic part of the programme (Gonzalez & San Miguel 2004). It is concluded that this kind of integrated management for *dehesa* landscapes, which is environmentally profitable, should be supported by European institutions, as well as by Spanish and regional governments.

REFERENCES

Beaufoy G (1996). Extensive sheep farming in the steppes of La Serena, Spain. In: Mittchell K (ed) The Common Agricultural Policy and Environmental Practices. Proc. Sem. Nature Conservation and Pastoralism European Forum WWF. COPA, Brussels. pp 34-48.

Beaufoy G (1998) The EU Habitats Directive in Spain: can it contribute effectively to the conservation of extensive agro-ecosystems? J. App. Ecol. 35 (6):974-978.

Bolaños F, García del Barrio JM, Regato P, Elena-Rosselló R (2001). Spanish forested landscapes: Classification and dynamics. In: Mander U, Printsmann A. & Palang H (eds) Development of European Landscapes. Proceedings of the 2001 European Congress of International Association for Landscape Ecology. Vol I. pp 258-263.

Bunce, RGH, Pérez-Soba M, Gómez-Sanz V, García del Barrio JM, Elena-Rosselló R (2006). European framework for surveillance and monitoring of habitats: a methodological approach for Spain. Invest. Agrar.: Sist. Rec. Forestales. Vol 15 (3): 249-261.

Campos-Palacín P (1993). Sistemas Agrarios. In: Naredo JM, Parra F (eds) Una ciencia de los recursos naturales. Siglo XXI, Madrid. pp 281-304. [Agricultural Systems; A science of natural resources]

Campos P, Rodríguez Y, Caparrós A (2001). Towards the *dehesa* total income accounting: theory and operative Monfragüe study cases. Investigación Agraria. Sistemas y Recursos Forestales, Fuera de serie 1: 43-62.

Campos-Palacín P, Mariscal P (2003).Preferencias de los propietarios e intervención pública: el caso de las dehesas de la comarca de Monfragüe. Investigación Agraria: Sistemas y Recursos Forestales 12(3): 87-102. [Owners' preferences and public intervention: case study in the dehesas in Monfragüe].

Campos-Palacín P, Ovando-Pol P, Rodriguez-Luengo Y (2006). Comparative analysis of the EAA/EAF and AAS agroforestry accounting systems: theoretical aspects. In: Mosquera-Losada MR, Rigueiro-Rodríguez, McAdam J Proceedings of an International Congress on Silvipastoralism and Sustainable management, Lugo, Spain. pp 324-329.

Elena-Rosselló R (1997). Clasificación Biogeoclimática de España peninsular y Balear, MAPA, Madrid, 446 pp. [Biogeoclimatic Classification of peninsular and Balearic Spain].

García del Barrio JM, Bolaños F, Ortega M, Elena-Rosselló R (2004). Dynamics of Land Use and Land Cover Change in *Dehesa* Landscapes of the REDPARES network between 1956 and 1998. In: Schnabel S, Ferreira A (eds), Catena Verlag. Reiskirchen, Advances in GeoEcology Vol 37, pp 47-54.

Garzón-Heydt J (2004). Recovering transhumance in Spain for long-term nature conservation. In: Bunce RGH, Pérez-Soba M, Jongman RHG, Gómez Sal A, Austad I. (eds) Transhumance and Biodiversity in European Mountains. IALE publication series nr 1. pp 259-263.

Gómez Gutiérrez JM (1992). El libro de las *dehesas* salmantinas, Junta de Castilla y León, Salamanca. [The book of Salamanca's dehesas, Spain]

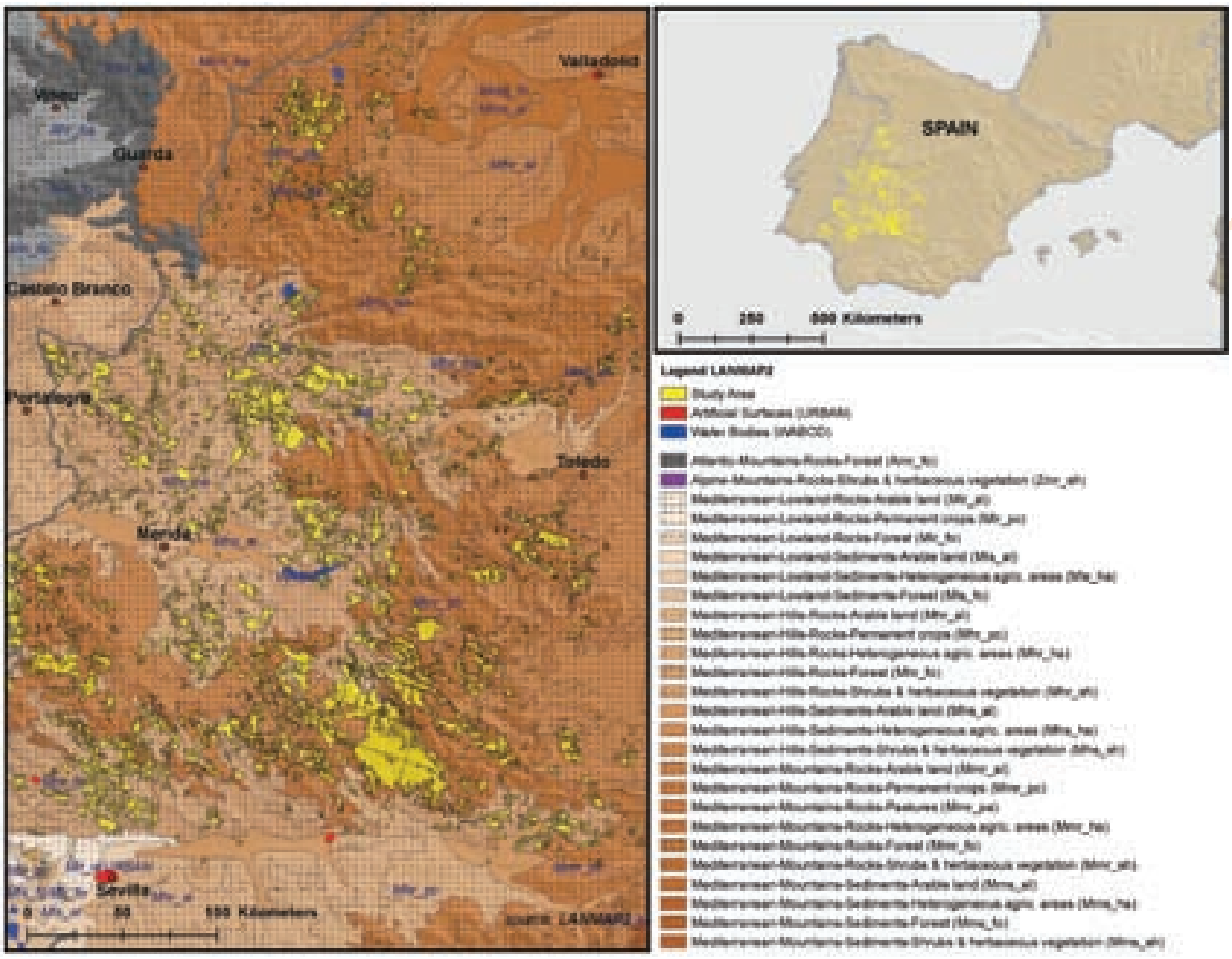
6 : European landscape characterization of the Dehesas in Spain

The Spanish Dehesas are located in the western and southwestern part of Spain, and they currently cover a large are of about 4 million hectares, which represents about 15% of the total agricultural area.

According to the European Landscape Classification the South-western region of Spain is covered by many different landscape types (see legend below), but the following ones are the most important in the dehesa region:

- Mediterranean hills dominated by rocks and heterogeneous agriculture *(Mhr_ha)*
- Mediterranean hills dominated by rocks and shrubs *(Mhr_sh)*
- Mediterranean mountains dominated by rocks and heterogenous agriculture *(Mmr_ha)*
- Mediterranean mountains dominated by rocks and shrubs *(Mmr_sh)*

This Box has been produced by C.A. Mücher, D.M. Wascher and P. Dziamski

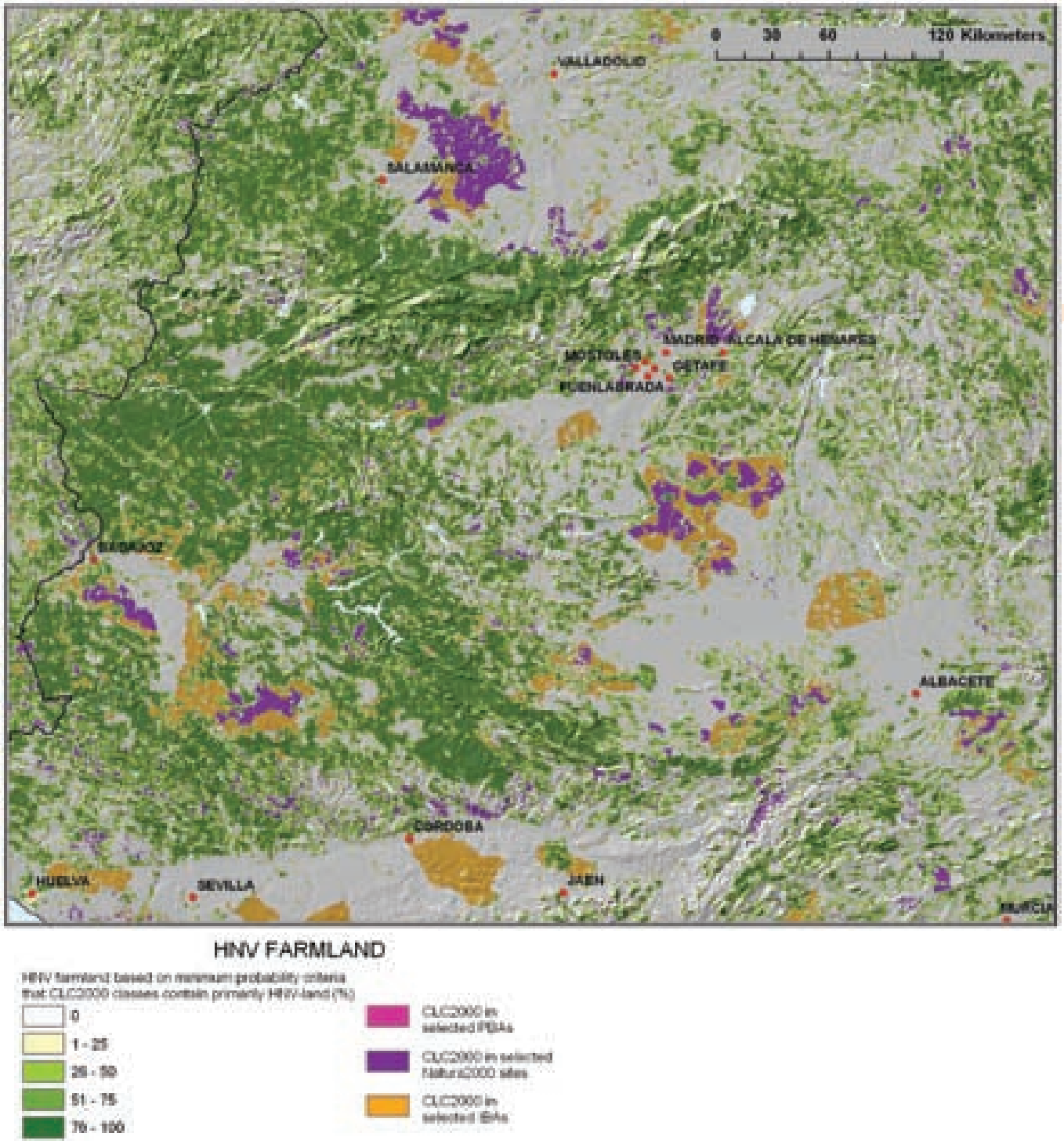


Pedroli B, Van Doorn A, De Blust G, Paracchini ML, Wascher D & Bunce F (Eds. 2007).
Europe's living landscapes. Essays on exploring our identity in the countryside. LANDSCAPE EUROPE / KNNV.

7 : High Nature Value map

Dehesas are well known high spots of European High Nature Value farmland and, as it is shown in the map, they constitute a major part of the HNV farmland areas of central Iberia. Their value is also recognised by the fact that approximately half of their area is either a NATURA2000 site or an Important Bird Area (or both).

This box is a joint product of JRC/EEA.



Pedroli B, Van Doorn A, De Blust G, Paracchini ML, Wascher D & Bunce F (Eds. 2007).
Europe's living landscapes. Essays on exploring our identity in the countryside. LANDSCAPE EUROPE / KNNV.

Gómez-Sal A, Rodríguez MA, de Miguel JM (1992). Matter transfer and land-use by cattle in a *dehesa* ecosystem of central Spain. Vegetatio 100: 345-354.

Gonzalez LM, San Miguel A (2004). Manual de buenas prácticas de gestión en fincas de monte mediterráneo de la red Natura2000. Ministerio de Medio Ambiente, Madrid. pp 327. [Handbook of good management practices in Mediterranean woodland farmyards belonging to the Natura2000].

Gortazar C, Acevedo P, Ruiz-Fons F, Vicente J (2006). Disease risk and overabundance of game species. Eur. J.Wild.Res. 52(2):81-87.

Herzog F, Austad I, Gómez Sal A, Jongman RHG, Pérez-Soba M, Bunce RGH (2006). Policy options to support transhumance and biodiversity in European mountains. Proceedings of the 13th meeting of the FAO CHIEAM Sub-Network on mountain pastures, 15-17 September 2005, Udine (Italy), pp 43- 48.

Malo JE, Jimenez B, Suarez F (2000). Herbivore dunging and endozoochorous seed deposition in a Mediterranean *dehesa*. J. Range Management 53 (3): 322-328.

Malo JE, Suarez F (1995). Herbivorous mammals as seed dispersers in a Mediterranean *dehesa*. Oecologia 104 (2): 246-255.

Marañón T (1985). Diversidad florística y heterogeneidad ambiental en una dehesa de Sierra Morena. An. Edafol. Agrobiol 44:1183-1197. [Flower diversity and environmental heterogeneity in a dehesa of Sierra Morena, Spain]

Olea L, Paredes J, Verdasco MP (1990). Características y producción de los pastos de las *dehesas* del SO de la península Ibérica. Pastos, XX-XXI (1-2): 131-156. [Characteristics and production of pastures in *dehesas* of Southwest of the Iberian Peninsula].

Olea L, San Miguel A (2006). The Spanish *dehesa*. A Mediterranean silvipastoral system linking production and nature conservation. Grassland Science in Europe 11: 3-13.

Paixão Ferreira A, Pinto Correia T, Mata Olmo R (2004). In: Wascher DM, Pérez-Soba M (eds) Learning from European Transfrontier Landscapes, Alterra Wageningen UR, Wageningen, The Netherlands. Alterra report 984. pp 15-17.

Pineda FD, Casado MA, Miguel JM, Montalvo J (eds) (1991). Biological diversity. Fund. Areces, WWF-Adena, Scope. Madrid.

Plieninger T, Wilbrand C (2001). Land use, biodiversity conservation and rural development in the dehesas of Cuatro Lugares, Spain. Agroforestry Systems 51 (1): 23-24.

Ruiz M (1986). Sustainable food and energy production in the Spanish Dehesa. The Food Energy Nexos programme, UNU. The United Nations University. FEN Res. Reports, París.

Ruiz de la Torre J (2002). Mapa Forestal de España. Ministerio de Medio Ambiente. Madrid. [Forest map of Spain]

San Miguel A (1994). La *dehesa* española. Origen, tipología, características y gestión. Fundación Conde del Valle de Salazar, Madrid, 96 pp. [The Spanish *dehesa*. Origin, typology, characteristics and management].

Sumpsi JM (1996). La agricultura española ante los nuevos escenarios de la PAC. Rev. Española de Economía Agraria 176-177: 265-301. [The Spanish agriculture facing the new CAP scenarios]

Van Doorn AM, Pinto Correia T (2007). Differences in land cover interpretation in landscapes rich in cover gradients: reflections based on the *montado* of South Portugal. Agroforest Syst 70 (2): 169-183

Villafuerte R, Calvete C, Blanco JC, Lucientes J (1995). Incidence of viral hemorrhagic disease in wild rabbit populations in Spain. Mammalia 59(4): 651-659.

WWF/Adena.2006. *La dehesa en los programas de desarrollo rural* 2007-2013. Unpublished proposal. Madrid. [The *dehesa* in the 2007-2013 Rural Development Programmes].

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Roberto Vallejo from the Spanish Ministry of Environment, and Prof. Juan Ruiz de la Torre from the School of Forestry (Polytechnic University of Madrid), for providing the high quality digital map with the location of the *dehesas* in Spain. We thank Freda Bunce for her insightful English editing of the manuscript.

Photo's authorship: All photo's are kindly provided by Alfonso San Miguel, except the map of Figure 1 (Ruiz de la Torre), the linx of Figure 5B (Fundación CBD_Hábitat), and the pictures in Figures 11 and 13 (Ramón Elena-Rosselló).