Recognising European pastoral farming systems and understanding their ecology: a necessity for appropriate conservation and rural development policies

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Dehesa grasslands: natural values, threats and agri-environmental measures in Spain

by Begoña Peco, Juan. J. Oñate & Susana Requena

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Introduction

Over the centuries, the Mediterranean basin grasslands have adapted to human and livestock action, which have formed particular patterns of low-intensity land use that are well adapted to the local limitations of the environment. A good example of these agro-ecosystems are some of the holm and cork oak open woodlands on the Iberian Peninsula, known as dehesas in Spain and montados in Portugal. Their importance on a pan-European scale has been acknowledged due to their size (over 2 million ha on the Iberian Peninsula) and their importance for the maintenance of biological and cultural diversity (Joffre et al. 1988, Ruiz 1988).

Dehesas were formed by opening the mainly evergreen woodlands of holm oak (*Quercus ilex* spp. *ballota*) in areas on nutrient-poor and often shallow acidic soils which suffer a severe moisture deficit in summer. In areas with more benign soils and climate, the predominant species is *Q. suber* (cork oak). The vegetation structure consists of a tree layer with a density of 40-100 trees per ha, and a herbaceous stratum. The herbaceous layer is mainly dominated by annual species, particularly legumes and other palatable species adapted to grazing. On a landscape scale, these open forests are mixed with scrubland, generally associated with steeper hillsides or successional stages linked to a low-density grazing and low-intensity cereal cropping with long rotation cycles.

Dehesas are multifunction farming systems used for grazing, sylviculture and rotation cereal cropping. They are mainly grazed by sheep, pig, cattle and goats under an extensive regime that includes transhumance stock movements between summer and winter pastures. The most fruit productive trees are pruned to remove infested branches, broaden their canopy cover and increase acorn production. Acorns and leaves are also used as livestock fodder during dry periods. Cork production in *Quercus suber* dehesas is also an important source of income. Many dehesas are ploughed occasionally for scrub control, and low input cereal cropping is practiced for supplementary livestock and game feeding. Scrub zones have been used traditionally for game management and charcoal is still produced.

This multifunctionality requires very few (if any) chemical inputs, revealing its fine-tuning to the limitations and fluctuations imposed by the physical and biological environment. Although dehesa productivity is low in comparison with modern intensive forms of agriculture, it is useful as an inspiration for agri-environmental policies aimed at maintaining or promoting farming practices that are compatible with nature conservation. Dehesa systems support a wide diversity of plant and animal species. Particularly significant are the bird communities (Díaz et al. 1997) and butterfly species (Viejo et al. 1989), many of which are included in European and worldwide endangered lists. Besides, dehesa grasslands have been described as being amongst the richest plant communities in Europe, with up to 30 spp. found in 20x20 cm plots (Pineda et al. 1981) and up to 130 spp. per 0.1 ha (Marañón 1985). At the landscape level the emerging pattern is enriched with a network of stone walls, hedgerows and traditional buildings, forming a remarkably stable, diverse and sustainable production system adapted to local constraints.

Like many other agro-ecosystems, however, dehesa have been subjected to a two-pronged process of intensification and abandonment in recent decades that is threatening their biodiversity. This paper initially reviews the main factors responsible for grassland diversity at a local and a landscape scale, and then isolates the main threats to these farming systems mainly arising from changes in farming practices and management. The adequacy of the implemented agri-environmental measures for dehesa grasslands is then examined in terms of their general design and specific commitments with a view to assessing their effectiveness for the conservation of the natural values maintained by dehesas.
Factors related to grassland diversity

The high species richness of dehesa grasslands is probably the result of their broad time and space heterogeneity, both natural and human-induced, as well as their long grazing history.

Climate
The long summer drought in the Mediterranean is largely responsible for the annual features of most species in dehesa grasslands. Herbaceous species die off every year at the end of spring after seed production, and the grassland regenerates later following the first autumn rains. Their seed banks are mainly transitory, i.e. most seeds germinate in the autumn after the summer precipitation gap. However, it has been found that almost 50% of species have some degree of persistence, and at least a fraction of the seeds are capable of remaining viable in the soil for more than a year (Ortega et al. 1996).

Another feature of Mediterranean environments is the interannual fluctuations in the amount of rain and its distribution over the year. This variability, along with the latent persistent species in the seed bank, operates as a diversity generating mechanism: the coexistence of species with different germination requirements is allowed (Espigares & Peco 1993), each showing different responses to drought episodes during the seedling establishment stage (Espigares & Peco 1995). Permanent plot monitoring has revealed that fluctuations in the floristic composition linked to precipitation are superimposed on the successional trend. Models of floristic composition dynamics and species richness in dehesa grasslands suggest that annual and autumn rainfall, topography and successional age since last ploughing are the most important variables all of them with a high predictive power (Peco 1989, Peco et al. 1998).

Topography
Due to the limited water and nutrient supply, the undulating relief where dehesas are usually found is also a source of diversity. Slope aspect and the concatenation of well drained ridges and depressions connected by local surface and subterranean flows of water and nutrients, all influence the floristic composition, the productivity and the phytomass of the plant communities (González Bernáldez 1981; Peco et al. 1983a). Groundwater discharge points connected to regional flows also influence the geochemistry and water availability hosting permanent meadow communities (Bernáldez et al. 1989) extremely valuable due to their rarity and diversity.

The phenological and production variability generated by topography and surface and groundwater flows have been internalised by farmers since time immemorial. Traditional managers have designed ad hoc complementary usage systems in space and time, carefully planning the location of gates, watering, salt and stock feeding points, stock shelter management, etc.

Occasional ploughing and itinerant cropping
Another modelling factor in these grasslands is that they have been subject to periodic tilling and very low-input cereal cropping to prevent invasion by scrub, supplement stock feeding and encourage game. Ploughing produces a constant rejuvenation in the grasslands and a mosaic of plots with different ages since the last tillage. The induced secondary succession is characterised by changes in the floristic composition and the structure of the community, generating further diversity both at the grassland plots and landscape levels.

As succession advances, the number of species and the local diversity increase. The spatial distribution of the species across the slopes is not constant over time with a segregation between communities taking place. There is a decrease in the mean niche width and an increase in the number of specialist species (Pineda et al. 1981, Peco et al. 1983b). After ploughing, the relief produced by tillage is what determines the vegetation structure (Sterling et al., 1984), while slope geomorphology becomes more important as succession advances (De Pablo et al. 1982). The phenological behaviour of species also varies with succession from a phenological synchronism in the early stages to a segregation of phenological niches in more advanced ones. During succession, the phytomass and production have also been found to concentrate in the low parts of slopes but to spread uniformly over the slope after ploughing (Casado et al. 1985).

Analyses of the seed banks in these communities in relation to ploughing frequency and intensity (Levassor et al. 1990) have revealed that the number of species and density are maximum at intermediate levels of disturbance. The transitory seed content is extremely high, making them sensitive to changes of use since mature systems are hard to recover from the seed bank if the ploughing frequency increases.

The effect of trees
Due to microclimatic, geochemical and ethological causes, trees generate diversity in the mosaic of the dehesa systems (González Bernáldez et al., 1969).

Tree cover has a heavy microclimatic effect by buffering radiation and lowering wind spin at ground level. Besides, individual trees modify the water balance of the system introducing a spatial variability in water resources (Joffre & Rambal 1993). Animal dung accumulates around trees where the livestock seeks shade. The extensive root system of the holm oak enables nutrients yielded by dead leaves and dung decomposition to be pumped from inaccessible depths for the herbaceous vegetation. All of these factors help
to increase the fertility and hence the productivity of the plant communities installed there, which are clearly different from those in open grasslands.

The holm oak trees have been selectively improved for acorn production since Neolithic times, leading to the propagation of trees with larger fruit, less tannin and a lower production of male flowers. Pollen record analyses show that holm oak distribution area has also been expanded artificially (Reille et al., 1980). Planting the acorns from the best trees and protecting them from herbivore consumption was a traditional practice, which together with the long-term abandonment of certain areas, ensured the persistence and expansion of the tree cover.

Grazing

Grazing animals are generally thought to enhance diversity by means of the direct consumption of competitively dominant plant species as well as by indirect effects such as trampling or dunging that create small-scale heterogeneity (Crawley 1983). Livestock are also an important intermediate and long-distance dispersal mechanism through dung (Malo & Suárez 1995), hoofs, hair and wool (Poschlod et al. 1998). Recent reviews of the effects of grazing animals (Olff & Ritchie 1998) have shown that these effects vary depending on the environment, type and density of herbivores and spatial and temporal scales. For instance, grazing mammals are thought to increase diversity in more productive areas such as temperate grasslands in Europe; meanwhile, in arid or extremely saline environments, they often do not change or may even decrease diversity. Grazing animals managed at low stocking rates can increase plant diversity, while high stocking rates can produce the opposite effect. The optimum levels differ according to the environment and the type of animal. The effect also seems to depend on the evolutionary history, which has permitted the selection of species that can avoid or tolerate herbivory (Naveh & Whittaker 1977), and on the time and space scale of observation.

Both overgrazing and abandonment have negative effects on species diversity, at least at a local scale. In overgrazed zones, excessive fertilisation causes the replacement of species-rich oligotrophic communities with poorer communities associated with artificially N-enriched soils. In extreme cases, overgrazing can compact the soil, causing the almost total elimination of the vegetation cover and erosion problems (Bernáldez & Peco 1991).

Grazing abandonment can produce up to a 70% change in floristic composition (Traba et al. 1999), from communities dominated by prostrate species, legumes and rosetas to others with upright-growth species. Coarse grass facies are extremely sensitive to fire, which is usually followed by scrub encroachment. Typical highly palatable grassland species such as many legumes are lost, even from the seed bank. Despite these enormous changes in the floristic composition, short and long-term studies of grazing abandonment have only detected declines in richness at a local scale.

Figure 1. Cause-effect chain of the intensification/abandonment process in the dehesa. “Diversity” and “productivity” can be interpreted broadly to encompass biological, landscape and cultural dimensions (diversity) and agronomic production as well as other possible outcomes in the context of rural development opportunities (productivity).
While the scrub communities that replace ungrazed grasslands also have a considerable level of richness, there is no doubt that the homogenisation of the landscape and the loss of open pasture communities produces a reduction in diversity at a landscape scale, also detected in other Mediterranean grasslands (Naveh 1974).

One of the features of livestock management in dehesas has been the need for an exclusively seasonal use. This involves moving the herds between and within regions to overcome the low productivity and the severe summer drought in which most grassland species are reduced to seeds. Dehesas were traditionally used in seasonal combinations with mountain grassland and grazed steppes, moving herds of local breeds from one to the other in long-distance (transhumance) and more local movements (transmittertance). This was possible thanks to the organisation of a large network of livestock routes (cañadas, cordeles, veredas and coladas) that are now only used occasionally for transhumance (Ruiz & Ruiz 1985). In addition to medium and long-distance livestock movements, there are internal movements on farms aimed at adapting consumption to local differences in phenology and productivity and to fertilise each field with dung.

Threats to dehesa systems

Dehesa systems are affected negatively by the same dual intensification/abandonment process suffered by many of the extensive farming systems on the Iberian Peninsula in recent decades. The ultimate causal factors of these changes are related to socio-economic trends at the national, regional and local scale (Peco et al. 2000). The two trends and their effects often coexist in small-scale areas and even on a single farm, making it all the more difficult to analyse and monitor the dehesa environmental quality (Peco et al. 1999).

Dehesa intensification specifically involves a series of management decisions, which paradoxically are aimed at improving their intrinsically low productivity (Fig. 1). In most cases, the most probable final destiny of the former dehesa system is the transformation of semi-natural grasslands into mechanised cereal and legume crops of varying intensity, or changes from extensive grazing to livestock husbandry based on grain supply. Dehesa abandonment, on the other hand, involves the cessation of grazing, crop rotation and tree canopy management (Figure 1). The environmental effects of abandonment begin with the loss of palatable species that are adapted to grazing and the invasion by scrub. In addition to this loss of diversity on the local and landscape scale, there is an increased fire hazard due to the excess of accumulated biomass and the subsequent risk of erosion.

Both intensification and abandonment are accompanied by an irremediable loss of traditional farming know-how. Three of these customs are particularly crucial to the working of the system: i) tree layer conservation management and active regeneration techniques, which compensate for the almost total lack of natural regeneration due to grazing; ii) awareness of the space-time distribution of the pasture carrying capacity on the farm as a basis for the differing space-time organisation of its usage; and iii) organisational models of grazing and seasonal resource usage embodied in transhumance and transmittertance.

The loss of the cultural heritage and know-how involved in traditional dehesa management exacerbates the loss of biodiversity caused by intensification and abandonment. The result is an impoverishment of the rural environment and landscape, threatening future opportunities for dehesas under the Agenda 2000 framework.

Agri-environmental measures and dehesas

The Spanish agri-environmental programme has been described and analysed in detail elsewhere (Oñate et al. 1998). Despite the environmental and geographic importance of the dehesa in Spain, only one agri-environmental scheme explicitly targets this unique

<table>
<thead>
<tr>
<th>Table 1. Andalusia Dehesa Conservation Scheme</th>
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<tbody>
<tr>
<td>Applicable rules</td>
</tr>
<tr>
<td>➢ No ploughing is allowed in areas with &gt;10% slope angle and tillage of pastures should be restricted to particular cases of pasture restoration.</td>
</tr>
<tr>
<td>➢ Soil loss and erosion processes (gully formation, landslides, etc.) must be prevented using the appropriate techniques.</td>
</tr>
<tr>
<td>➢ Riparian vegetation 5 metres on either side of riverbanks must be protected from ploughing and the riparian habitat must be preserved from dumping that may pollute the water quality.</td>
</tr>
<tr>
<td>➢ Tree conservation (pruning, clearing, underthinning, shoot removal) and active regeneration must be performed in adequate way and timing. Tree felling is forbidden and fire prevention techniques must be applied when appropriate.</td>
</tr>
<tr>
<td>➢ Stock density must be established according to the circumstances of each field in order to avoid infra- and over-grazing.</td>
</tr>
<tr>
<td>➢ Landscape elements such as stone walls, traditional rural buildings, hedgerows and high natural value woodlots must be preserved.</td>
</tr>
<tr>
<td>➢ Negative impact from accumulated dung, rubbish or new installations must be prevented. Traditional architecture must be preserved in all new buildings.</td>
</tr>
</tbody>
</table>
Andalusian dehesas with extensive pastures on more than 40% of the farm and extensive livestock accounting for more than 50% of the total LU are the target of the specific Andalusia Dehesa Conservation Scheme, implemented in April 1999. Its design acknowledges the range of aspects involved in the maintenance of the environmental and productive values of the dehesa and thus stipulates that the farmer must elaborate and submit for approval a Management Plan for the farm. An integrated set of aspects must be considered in this plan (Table 1). A basic payment (120 Euro/ha) can be complemented with specific premiums depending on particular commitments, e.g. conversion of arable land into pastures on areas with >10% slope, (150 Euro/ha), pasture restoration (30 Euro/ha), erosion remediation (30 Euro/ha), tree regeneration with Quercus and Olea species (66 Euro/ha), conservation of landscape elements (30 Euro/ha), management for public access (30 Euro/ha). A total of 12,000 ha are expected to be included in the scheme.

The Andalusia Dehesa Conservation Scheme contrasts sharply with others that are applicable to extensive grasslands but do not explicitly target dehesa systems. Five schemes containing measures which target extensive grasslands are being implemented in areas where dehesas could potentially be covered. In fact the four Spanish Regions with significant dehesa areas (Andalusia, Castilla-León, Castilla-La Mancha and Extremadura) are all currently implementing grassland schemes that could provide benefits to dehesa systems. These schemes are being applied in National and Natural Parks (Doñana, Cabañeros, Monfragüe), SPAs under the EU Birds Directive (in Extremadura and Andalusia) and mountain areas (in Castilla and León). Each of these schemes may contain some of the independent (and incompatible) measures (Table 2).

### Assessment

The dehesa agri-environmental schemes can be analysed at three levels: i) design and implementation; ii) results of implementation; and iii) environmental effects and outcomes. The first level is used here since data availability on uptake by farmers is fairly limited at the moment and it is still too early for a serious analysis of the effects.

Spain is fortunate to still have large areas covered by dehesas, which would be highly suitable as examples for the promotion of sustainable development in many farming areas of the Mediterranean basin. Paradoxically, the country with the greatest representation of this valuable agri-ecosystem currently only has one scheme that specifically targets dehesas.

### Table 2. Design of agri-environmental schemes targeting extensive grasslands

<table>
<thead>
<tr>
<th>Measure</th>
<th>Scheme</th>
<th>Conversion to pastures LU/ha</th>
<th>Book keeping</th>
<th>Grazing timetetable</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion of arable land into extensive grasslands</td>
<td>Doñana National Park (Andalusia)</td>
<td>&gt; 5% of cropping area (&gt;1 ha)</td>
<td>0.3-1.4</td>
<td>Yes</td>
<td>Yes (seasonal)</td>
</tr>
<tr>
<td></td>
<td>SPAs (Andalusia)</td>
<td>&gt; 5% of cropping area (&gt;1 ha)</td>
<td>&lt; 1.4</td>
<td>Yes (seasonal)</td>
<td>Pasture restoration (event.)</td>
</tr>
<tr>
<td>Stocking density reduction</td>
<td>Doñana National Park (Andalusia)</td>
<td>0.5-0.25</td>
<td>Yes</td>
<td>Yes (seasonal)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SPAs (Andalusia)</td>
<td>&lt; 0.5</td>
<td>Yes (location and seasonal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SPAs and Monfragüe Natural Park (Extremadura)</td>
<td>0.25-0.5</td>
<td>Yes (location and time)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Countryside and landscape maintenance and fire prevention</td>
<td>Cabañeros National Park (Castilla - La Mancha)</td>
<td>0.15-0.5</td>
<td>Manual scrub clearance if slope &lt; 12%</td>
<td>Regulation of communal pastures usage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SPAs and Monfragüe Natural Park (Extremadura)</td>
<td>0.15-0.5</td>
<td>Yes (seasonal)</td>
<td>Mechanical or manual scrub clearance</td>
<td>Regulation of communal pastures usage</td>
</tr>
<tr>
<td>Fire prevention in mountain areas (Castilla y León)</td>
<td>Some abandoned dehesas can benefit from manual or mechanical scrub clearance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The specific interrelationships between farming practices and biodiversity are relatively well known in the case of the dehesa systems, and thus it would be possible in most cases to define management objectives for these habitats and landscapes. The main natural and management-derived factors affecting biodiversity have proven to vary at a quite local scale and all fit into a delicate network of interactions with variations in time and space.

Effectiveness should therefore not be expected from general types of measures such as maximum or minimum stocking density limitations. Only if their stipulations are specified and adapted to each individual situation, or supplemented with others linked to the remaining decisive factors (e.g. tree layer management, erosion control or the conservation of natural habitats), conservation effects will be achieved. The appropriate stocking density is perhaps the most striking example. Its correct space-time definition requires a specific analysis not only of each dehesa, but also of the complementary usage of the dehesa and other extensive grasslands, including the resumption of transhumance and transtermittance.

The Andalusia Dehesa Conservation Scheme is an example of a good design. Through a management plan, it permits the introduction of both general commitments and particular ones under an integrative approach. This allows their specification and detail in each case depending on the local conditions. In consequence, their environmental effects are more likely to be achieved. However, the mechanisms for evaluating the environmental effectiveness of the scheme are not specified. This produces an excessively broad degree of uncertainty in terms of the suitability of the management plan. In addition, the measure does not specify the need for a single seasonal use of the dehesa, nor any support for transhumance or transtermittance. This will most probably lead to the use of supplementary stock feed on the dehesa during the summer drought, which will increase the risk of over-grazing, erosion and soil compacting.

In other regions, the inflexibility and lack of integration of the general schemes that target grasslands makes it difficult if not impossible to adapt them to the dynamics of systems with complex interrelationships such as dehesas. Thus no significant effects in nature conservation can be expected from its application.

Conclusions
- Although the main processes are known, the specific interrelationships between natural and management factors and biodiversity should be further studied and clarified in each region.
- Specific agri-environmental schemes targeting dehesa systems should be designed and implemented in a decisive manner in the affected regions, emphasising:
  - Not only the rehabilitation of dehesas affected by intensification or abandonment, but also the conservation of those that are still in a good state.
  - The desired flexibility in the application of the commitments to local conditions could be achieved with the design of a specific management plan for each dehesa, including the seasonal use of pastures and encouraging livestock movement between areas with different phenology.
  - A link between the system management and biodiversity outcomes focused on achieving the forthcoming EC-Agricultural Biodiversity Action Plan targets.
  - The recovery and dissemination of traditional management know-how and the reinforcement of biodiversity expertise amongst farmers and advisers.

- Finally, an additional priority must be the development of operative evaluation tools for monitoring and assessing the effects and outcomes of the agri-environmental measures.

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References


The European Forum on Nature Conservation and Pastoralism brings together ecologists, nature conservationists, farmers and policy makers. This non-profit network exists to increase understanding of the high nature conservation and cultural value of certain farming systems and to inform work on their maintenance.

Europe's natural and cultural heritage is enriched by the wide variety of regional farming systems which work in harmony with local environmental conditions. However, many of these farming systems are currently under threat. The aims of the European Forum on Nature Conservation and Pastoralism are therefore:

- To increase understanding that certain European farming systems are of high nature conservation and cultural value.
- To ensure the availability, dissemination and exchange of supporting information combining research and practical expertise.
- To bring together ecologists, nature conservation managers, farmers and policy makers to consider problems faced by these systems and potential solutions.
- To develop and promote policy options which ensure the ecological maintenance and development of these farming systems and cultural landscapes.

To achieve its aims, the Forum holds conferences every two years, organises workshops and seminars and produces two issues of the newsletter La Cañada per year. It also conducts research into the ecological relationships on high nature conservation value farmland and into the development of appropriate policies for such areas.

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