

Montado's ecosystem functions and services: the case study of Alentejo Central – Portugal

Teresa Batista¹, José Manuel de Mascarenhas², Paula Mendes³

¹CAAM - Instituto de Ciências Agrárias e Ambientais Mediterrânicas, Universidade de Évora, Núcleo da Mitra, Ap. 94, 7002-554 Évora, Portugal and CIMAC, Rua 24 de Julho 1 7000-673 Évora Portugal, tbatista@cimac.pt (corresponding author)

²CIDEHUS and UNESCO Chair, Universidade de Évora, Palácio do Vimioso, Apartado 94, 7002-554 Évora, mascarenhas_jm@sapo.pt

³University of Évora, Rua Romão Ramalho 59, 7000 – Évora, paulabmendes@yahoo.com

Abstract: Although the concept of ecosystem services is well defined and centred on human use of natural systems, it is not yet consensual. The ecosystem services connect ecology and economy; they allow to integrate ecology into policies and to bring a monetary value.

Even if the authors do not entirely agree with the idea of giving a monetary value to all elements, living and not living, they consider that the concept of ecosystem services can be improved in the sense of a holistic landscape ecological approach.

Montado is a high valued cultural landscape typical from the Southwest of Iberian Peninsula. It concerns a human-shaped ecosystem composed by a mosaic of scattered cork oaks, holm oaks or mix oaks, with a high grazing diversity. The most important products of Montado are cork and other non-timber products. Nevertheless it's highly value is on the ecosystem functions it can provide, namely biodiversity conservation, water cycle regulation, carbon sequestration and soil conservation. These ecosystem services are highly interconnected, and have a lot of dependences in a complex structure.

So, the first goal of this paper is to identify the main Montado ecosystem services that must be valued in sustainable management and policies, in order to prevent biodiversity losses and other types of ecosystem degradation.

Key words: ecosystem functions, ecosystem services, montado; Alentejo – Portugal; multifunctional landscapes

Introduction

Ecosystem functions versus ecosystem services

There are many different definitions of ecosystem functions, that we could synthesize in three groups: as a mechanism with a complex system of interactions, as the relations between parts and wholes, the status of the objects and their internal changes, or finally, “function” can be understood as something that is attributed to a system, independently of its practical use (Jax 2005). This last definition was originally proposed by Odum and Barret (1956) referring to ecosystem functions as: “a set of ecosystem processes operating within an ecological system regardless of whether or not such processes are useful for humans”. Ecosystem functions are also perceived in between ecosystem processes and

services (De Groot et al., 2010), since they are necessary to the production of services but are not services themselves (Boyd, Spencer 2007).

Ecosystem functions can be defined as the interaction between biophysical and biochemical properties and processes in an ecological system that sustain ecological cycles. These includes materials and energy fluxes (e.g., carbon, oxygen, water, mineral nutrients, energy) and processes connecting different levels and trophic scales. Pacala and Kinzig (2002) classify ecosystem functions into tree classes: stocks of energy and materials, fluxes of energy or material processing and stability of rates or stocks over time. Most of these functions provide ecosystem services, which are labels for the “useful things” ecosystems “do” for people, directly and indirectly (De Groot 1992, Braat, De Groot 2012).

Ecosystem services concept is generally centred in human needs and desires and can be understood as those benefits obtained from nature that satisfy human requirements (Daily 1997, Costanza et al., 1997, Fisher et al., 2009, TEEB Foundations 2010), in spite of simultaneously fulfil other species requirements (MEA 2005). These includes air and water purification, droughts and floods mitigation, generation and preservation of soils and their fertility, detoxification and waste decomposition, pollination of crops and natural vegetation, seeds dispersal, control of pests and diseases, biodiversity maintenance, protection of coastal shores, climate stabilization, moderation of extreme weather impacts, provision of aesthetic beauty and intellectual stimulation that lift human spirit (Jansson 2013). In an economic point of view, ecosystem services are externalities since they provide benefits which are not paid for and therefore are not internalized in economic processes. Several organizations and researchers argue that the degradation of ecosystem services can be reversed through Payments for Ecosystem or Environmental Services (PES), which can in turn alleviate poverty and establish a new ‘urban–rural compact’ by transferring funds from ‘consumers’ to ‘providers’ of these services (Pagiola et al., 2005, Gutman 2007). However this is yet quite controversial and difficult to determine. Measure ecosystem services should not be based on market relations, as an excessive focus on economic efficiency can result in uncertainty and be costly to human kind, since biodiversity, habitat integrity or hydrological storage are difficult to measure and describe (Robertson 2004), even with the present technology and scientific knowledge.

In Mediterranean basin the relationship between man and nature remounts up to 10.000 years. Man has managed and disturbed the ecosystem to get services from nature, promoting at the same time additional fluxes and processes and therefore new functions and services. One of the most important example of this relationship is Montados (in Portugal) or Dehesas (in Spain), which are multifunctional agro-forestry-pastoral systems found mainly in the SW of Iberian Peninsula. They are traditional land use systems that includes deciduous *Quercus* sp connected with cultivated land (barley, wheat in rotation with pasture). These multifunctional traditional landscapes are characterized by the persistence of native scattered vegetation throughout the landscape, constructing a heterogeneous mosaic from a variety of grazed, shrubby and cultivated land uses. Montados managed in the traditional way, with low mechanical intervention, have a semi-natural character that preserves many characteristics of the natural system, such as, good adaptation to the natural constraints of the Mediterranean climate and poor soils, having at the same time great complexity, which provides some resilience to changes in the management practices.

Montado's biocultural landscape

Montado's landscape is a particular biocultural landscape. This system is characterized by an open tree stratum dominated by holm oaks (*Quercus rotundifolia*) and/or cork oaks (*Quercus suber*) or other kind of oak trees and an herbaceous layer dominated by annual species and some shrubs, that has been managed by man in a sustainable way for centuries. Cork and Holm oak trees are protected since

1999 (Decree-Law 140/99, April 24 – Annex B-1 republished by Decree-Law 49/2005, February 24; Directive 92/43/CEE, May 21 – Annex I; Decree-Law 169/2001, May 25, with alterations; Decree-Law 155/04, June 30), and Montado landscape is now in the Portuguese national list for the UNESCO World Heritage 2016 – Cultural Landscape application.

Montado is a High Nature Value (HNV) farming system according to the classification proposed by the European Environmental Agency for agricultural and silvo-pastoral systems that, for its extensive nature or diversity, promotes nature conservation (Pinto-Correia in Pereira et al., 2015). Montados landscapes integrates production with biodiversity conservation, culture and identity values. This biocultural formation is 'one of the most aesthetically pleasing and biologically rich landscapes in Europe' (Pinto-Correia, Mascarenhas 2001). The montado is also a quite old land use system. To understand actual functions and services we need to know some of its history.

The Montado along the time

The first reference to the montado is from 824 b.C. and concerns a tax to grazing cattle (Coelho 2007). It covered later not only the tax but also the parcel and the time available to the cattle.

The use of acorns as food resource for humans dates at least from the Chacolithic, ca. 5000 years b.C. (Soares 2016, Oliveira, w/d; Bettencourt et al., 2007, Senna-Martinez 1995). Acorn bread was currently used in Iron Age, and a landscape in which open tree formations alternate with agricultural and pasture areas was being created. In the Roman period the cork was extracted to a wide range of purposes as referred by Varron, Columella, Pliny and other authors (Ciesla 2002). Holms and cork oaks wood was used to make pieces for ship and houses building. In general, the landscape deforestation process seems to continue affecting mainly the ager and saltus areas. The latifundia system developed in the Roman Empire (since the III century, mainly), survived in the Visigoth period (V – VIII centuries), with a predominance of cattle-breeding and agriculture (Riera-Mora 2006).

During the VI century took place a selective bush and wood clearing, with cork oak and olive protection, in order to create pastures and agricultural fields (Mateus, Queiroz, 1993). This means the appearance of the first real montados (Fonseca 2014). The Visigoth Codex (VII century), define rights and restrictions on the use of trees and grazing, and prohibits the cork and holm oaks felling (Vieira 1991). In the Muslim period the montado stock-raising was based on cattle, sheep and goat. After the Reconquest, the black pig breeding (acorns based) spread out although the sheep importance also grows (Riera-Mora 2006). In the XIII century, Portuguese agrarian laws make the first references to the cork oak and holm oak, establishing the forest protection basis of these *Quercus* sp. trees (Natividade 1950).

In the XVI century there was a great regression of the montado due to the use of holm and cork oaks wood to shipbuilding, reason why many Portuguese monarchs had to take protectionist measures, such as: - the Forais Manuelinos, (Bombico, Carneiro 2016), - the Lei das Árvores (Trees Act) in 1546 and 1565 (Mendes 2007), - the planting trees promotion (Dias 1998 cit. by Fonseca 2004). In the second half of the XVIII century, due to population growth, the montado exploitation back mainly for livestock (meat and wool) and the peak of coalmen pressure can be placed in this period. Since the second half of the XVII century (till nowadays) the development of the cork industry associated with the wine production (cork stoppers) took place.

The montado reached its peak, in terms of management balance and complementarity of the various activities, between the end of the XIX century and early XX century (Pinto-Correia et al., 2013). However, mechanization accompanying the intensification of cereal production led to a progressive tree layer elimination. Otherwise during the sixties, the pig-raising became impracticable due mainly to African swine fever and other montado changings took place: the increasing of heavy agricultural machinery; live-stock system intensification and introduction of heavy cattle races, and the tendency to the montado conversion into a silvo-pastoral system (Pinto-Correia and Mascarenhas, 1999). In 1992,

as a result of the allocation of direct aid to production, under the Common Agricultural Policy (CAP), a predominance of cattle production took place in montado, with negative environmental impacts.

Materials and Methods

The study area is located in Alentejo Central, south of Portugal, and integrates about 7500 sqm. The 52 % of this area is covered by Montados.

For the development of this work was carried out an exhaustive survey of the most important studies about the Montado in order to establish all the relationships between the ecosystem, its functions and services.

The authors distinct the main ecological functions from what are goods/products and services that are determined by man intervention. So the main ecological functions identified are (fig. 1):

- Soil protection/enrichment;
- Water flow regulation;
- CO₂ capture;
- Air quality/climate regulation;
- Biodiversity and Wildlife habitat provider (shelter and food);
- Resilience and adaptation.

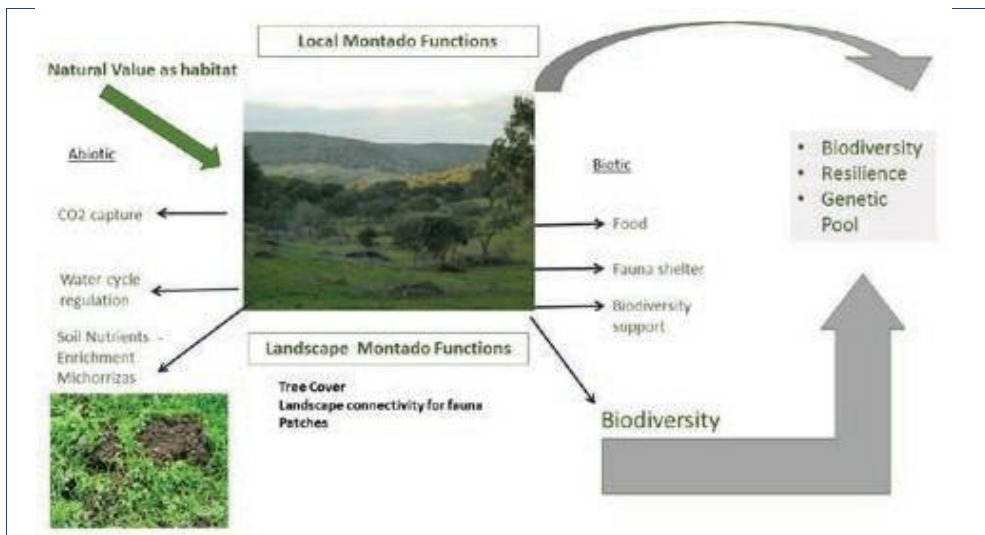


Fig. 1. Montado's ecological functions schema

As goods or products and services, depending on the introduction of disturbances by man in the ecosystem, are (fig. 2):

- Forestry products: cork, wood; charcoal; acorns
- Livestock breeding - cattle, pigs, sheep, goats
- Hunting
- Mushrooms and Aromatics
- Landscape aesthetics and Ecotourism
- Artistic inspiration
- Biological, cultural and intangible heritage;
- Educational, recreational and research pool

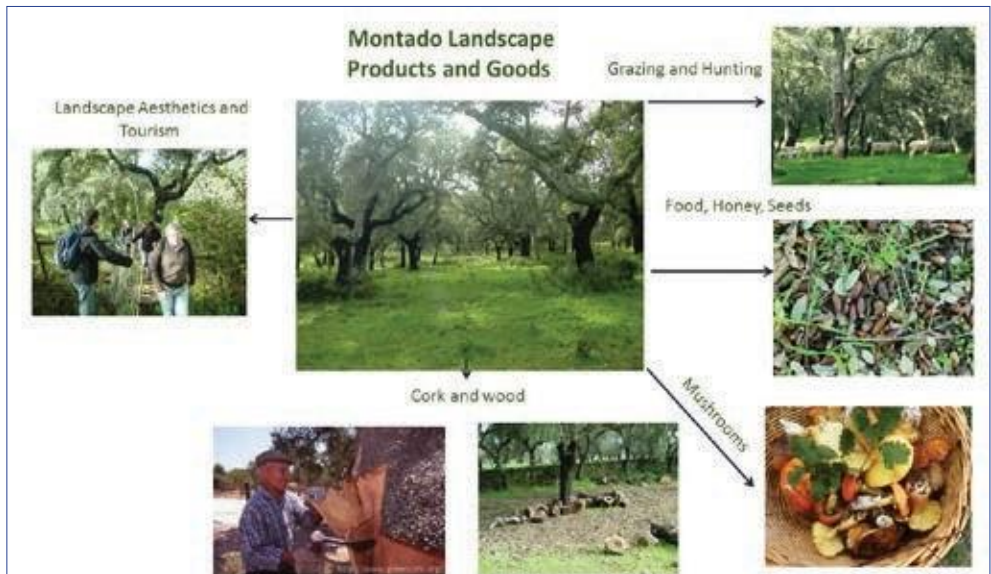


Fig. 2. Montado's products, goods and services schema

Each one of these ecological functions, products and services were analysed based on the bibliography review and also in authors expertize experience.

Results

Montado's ecological functions

Soil protection and water flow regulation

Montado has a fundamental role in soil protection and water flow regulation in Mediterranean conditions. Infiltration and superficial runoff are influenced by the presence of trees and their root systems. Canopy intercept more rain water than the undergrowth grass and they channelize it into the soil along the trunk (Pereira et al., 2008). Often the soil under the canopy is more permeable and has higher water retention capacity than bare soil. Each tree works on montado as a catchment for rain. The canopy is also important to protect the soil from direct rainfall that, particularly in abrupt slopes, may cause landslides and erosion.

Soil conservation is a key aspect of the sustainability of montado. Soil fertility depends on organic matter, resulting from the decomposition of organic waste (e.g., leaves, branches, dry grass). In the case the cork oak trees, the leaves are renewed annually (although it stays green all year). The old leaves (and twigs, fruits and animal excrements living in the montado) fall in soil where it will decompose, adding organic matter and nutrients to the soil. However the main contribution to the accumulation of organic matter in the soil is given by the tinny root system proliferating near the surface of the soil (Pereira et al. 2008). The area under the canopy is then richer in nutrients (e.g. about 50% more nitrogen) plus carbon (about 60%) than in the bare soil.

CO₂ capture

Montados play an important role in carbon sequestration, especially because they are composed by cork and holm long-live trees (e.g. up to hundreds of years) promoting carbon storage over very long periods. Although carbon sequestration in montado may be limited in some situations due to low density of trees, several studies carried out in Portugal, showed the ability of these systems to assimilate and retain carbon. For example, the average (2003-2006) annual carbon sequestration in montado with about 30% coverage by trees was 88 g C per m² (Pereira et al., 2008). This included in this average a very dry year (2005), it can be considered that the normal annual sequestration in this montado do not differ much from a forest of the same type (e.g. *Quercus douglasii* with 40% coverage trees) in California, that is, 156 g C per m² and year (i.e. 5.72 t CO₂ per hectare and year), or a stone pine (*Pinus pinaster*) in Alcácer do Sal (near the Atlantic coast of Portugal), 150 g C per m² and year (i.e., 5.5 t CO₂ per hectare and year) (Correia et al., 2008). In Pereira et al. (2007) also measured carbon sequestration in a holm oak woodland in the South of Portugal, with 21% of tree cover and determine a range from 28 to 140 g C per m² and year.

Recent research conducted by Filipe Costa e Silva, a researcher in ISA- Instituto Superior de Agronomia - Lisbon, reveals that the cork oak maximum photosynthesis activity is obtained in plain summer (July) when other species are already at a state of slipping due to water scarcity. This is also the period of its maximum productivity. This is due to the fact that cork oak renews its foliage between April and May so in July the new leaves are in plain production. They also detected that even in dry years the carbon sequestration is not strictly affected, due to the huge roots system that can find water at deep water reservoirs. Also as preliminary results about the impact of cork extraction, it is observed that this human activity do not affect CO₂ sequestration strictly, even in very dry years, supporting the remarkable resilience of this tree to extreme climate conditions and human management as referred by Filipe Costa e Silva (cit. by Freitas, 2016). Montado is also a long time storage for CO₂ since the trees can leave more than 200 years. According to the same author, one hectare of cork oak capture about 14,7 tons of CO₂ per year.

Biodiversity maintaining

The montado spatial and temporal heterogeneity, promotes a substantial richness of ecological niches. They are characterized by different undercovering types, shrubby and herbaceous with different tree cover degrees giving an agroforestry system with diffuse edges, that makes each montado area different and unique (Pinto Correia et al., 2103). More than 135 vascular plants per 0.1 ha can be found in montado (Díaz-Villa et al., 2003), many of them rare or with protection status like *Narcissus fernandesii*, *b. cavanillesii*, *Armeria pinifolia*, *Centaurea coutinhoi*, *Halimium verticillatum*, *Ruscus aculeatus*, and *Narcissus bulbocodium*.

In montado, more than 28 fauna species with protecting status can also be found, and in addition, cork and holm oak woodlands shelter and provide refuge for approximately a hundred of other animal species that are listed in the annexes of the EU Habitats and Birds Directives. Some of these important species are Critically in Danger or in Danger (table 1), like *Lynx pardinus* (Iberian Linx), *Aegypius monachus* (black vulture), *Aquila adalberti* (Spanish Imperial Eagle) or *Aquila fasciata* (Bonelli Eagle), and even more are with Vulnerable Status (10), for example the *Vipera latastei* (snub-nosed viper) or the *Ciconia nigra* (Black Stork) (Díaz - Villa et al., 2003, Olea, Miguel-Ayán 2006). Montado ecosystems are included as a classified habitat under the EU Habitats Directive (habitat 6310) and also gives shelter to priority habitat 6220* (*poetea pastures*).

Montados provides habitat, food and shelter for many species namely for a large number of bird species that are strongly connected to this ecosystem, like *Elanus caeruleus*, (Black-Winged Kite), *Circus gallicus* (Short-toed Snake Eagle) or *Hieraaetus pennatus* (Booted Eagle). This ecosystem

has a great importance for winter migrating birds like *Vanellus vanellus* (Northern Lapwing) and *Grus grus* (Eurasian crane). The scrub areas and stepper slopes on Montado landscapes gives shelter to other fauna like wild rabbits, hares, lizards, snakes and mice that have a great importance in the food chain for carnivores like *Genetta genetta* (Genet), *Mustela nivalis* (Weasel), *Vulpes vulpes* (Fox), or *Felis silvestris* (Wild Cat) (Regato-Pajares et al., 2004).

Table 1. Fauna species with protection status in montado

Critically in dangerous	In dangerous	Vulnerable
<i>Aegypius monachus</i> <i>Aquila adalberti</i> <i>Coracias garrullus</i> <i>Lynx pardinus</i> <i>Milvus milvus</i>	<i>Aquila fasciata</i> <i>Circus pygarnus</i>	<i>Vipera lastatei</i> <i>Ciconia nigra</i> <i>Accipiter gentilis</i> <i>Grus grus</i> <i>Circus cyaneus</i> <i>Tetrax tetrax</i> <i>Burchinus oediconemus</i> <i>Clamator glandarinus</i> <i>Rhinopholus Hipposiderus</i> <i>Microtus Cabrerae</i>

Montado's products and goods

Cork Production

As above mentioned, cork as raw material for manufactures only acquired an industrial character in the XIX century, first in the region of Catalonia. In Portugal the large manufacturing units were installed at the end of that century. Cork is harvested every 9 years, the first cork is taken out from a 30 years tree. In recent years, experiments in irrigated cork production have been taking place in Portugal and in this case, the first cork is removed from a 8 years tree. The Portuguese montados and cork oak forests produce over 50% of the world's cork. All waste arising from the production of cork stoppers, which is the main one, is transformed into something useful (dresses, shoes, bags, ornaments, floor). Even the cork dust is used for co-generation of electricity. Cork is one of the most effective isolation natural material and it was used to isolate the space shuttle in NASA missions.

Cork products generate approximately €1.5 billion of annual revenue, 70% from the processing of cork for wine stoppers. On average 300.000 tons of cork are produced from cork oak forests annually (Berrahmouni et al., 2007). Cork industry exported 846 million euros in 2014 (Pereira et al., 2008).

Wood production

The wood from *Quercus sp.* trees had a historical importance, namely along the Discoveries Period when used to construct ships. A great part of Portuguese montado was then destroyed. However today, thanks to a protection status, the wood (for charcoal or other uses) comes from pruning after the first virgin cork removing and from trunks and branches of decreasing or sick trees, as sanitary measures.

Livestock raising / Cattling

The most important historical role of montado is pasture, the management of which is centred on three fundamental topics: balanced cattle grazing, vegetables and phosphorus that gives 130 grassland species/ha (Olea, Miguel-Ayaz 2006, Maranon 1985). Suitable management might result in a significant improvement of the natural pastures quality although cyclical periods of fresh feed scarcity cannot be avoided, and in such hunger periods (summer and winter), acorns could contribute

to suitable nutrition of the livestock. This extensive livestock grazing includes presently several types of cattle as bovines, sheep, goats, and Iberian pigs.

Hunting

Game species have always been present in montado as they were considered a complementary source of food. However, since the sixties, the conditions have intensely changed and hunting has become a major economic activity, often the most important one in montados nowadays. Wild ungulates, especially red deer (*Cervus elaphus hispanicus*) and wild boar (*Sus scrofa*), red partridge (*Alectoris rufa*), wild rabbit (*Oryctolagus cuniculus*) and hare (*Lepus capensis*) are viewed as valuable renewable natural resources (Olea, Miguel-Ayán 2006).

Mushrooms

Mushroom diversity in the Mediterranean area is very high: recent research has found more than 3,800 mushroom and truffle species in Andalusia (Spain) (Berrahmouni et al., 2007). In montado ecosystems there is a great diversity of mushrooms namely edible mushrooms with economic value, like *Amanita caesarea* (Caesar's mushroom), *Amanita ponderosa* (silarca), a great number of Boletes species (e.g., *Boletus aereus*, *B. aestivalis* and *B. edulis*), *Cantharellus cibarius* (chanterelle), *Craterellus cornucopoides* (black truffle), and desert truffles: *Terfezia arenaria*, *Terfezia .fanfani* and *Terfezia. Leptoderma* (Pinto-Correia et al., 2013).

Honey

Some of the montado species, namely the scrubby ones, have a great importance for honey production. More specifically, *Lavandula luisieri* (stoechas lavender) and *Lavandula viridis* (yellow lavender, an Iberian endemism) have a great economic value; however, many other scrubby species have a major significance for honey like *Arbutus unedo* (strawberry tree), *Rosmarinus officinalis* (rosemary), *Thymus mastichina* (Mastic Thyme), *Erica australis* (Spanish heath), *Calluna vulgaris* (Ling). Some other grazing land species like *Carlina racemosa* (clustered carline thistle) or *Echium plantagineum* (purple viper's-bugloss) are also used for honey production. The importance of the montados to the beekeeping sector is reflected in the number of beekeepers and apiaries settled in Alentejo and Algarve regions (southern Portugal) where 2500 beekeepers are active, with about 10,000 apiaries. The honey value namely the special types (monofloral, Protected Denominations Origin or from Organic Production) amounts to more than 20 million euros per year (Pinto Correia et al., 2013).

Landscape Aesthetics and Ecotourism

The multifunctional economic activities are inherent to the montado systems nature. However to increase profits, the owners are gradually incorporating new services connected with rural recreation and tourism. The rural landscapes can be evaluated for their bucolic and aesthetic aspects, with no acknowledgment of the role of farming (Pinto-Correia et al., 2008). This is the expectation shared by foreign visitors staying generally for relatively short periods, who walk or go on bicycle or horse tours in this landscape. They can catch an impression based on the aesthetical and environmental quality of the landscape and appreciate natural and cultural heritage. The gentle slopes of the Alentejo montado establish a unique visual experience. The cork and holm oaks dominating in a grand plan are the linear classic Alentejo; a small group of cork and holm oaks between steep pastures combine with a more distant forest that extends as far as the eye can see (Miller 2014). Among the multifunctional strategies on valuable montado landscapes we can quote (Mascarenhas, Rocha, 2011):

- The establishment of interpretation centers or thematic museums (eco-museums, ethnographic museums, etc.) for cultural and educational purposes;
- Low impact rural activities like walking, bike or horse rides;
- Agro-ecological activities, especially agro-biological and sales centres;
- Revitalization and development of family small scale farming.

The definition of small and great walking routes or trails is one of the most positive practice of recreation in this landscape that is now boosted by the local administration.

Archaeological and Architectonic Heritage

Regarding the archaeological and architectural heritage in the montado zones, there are often large structures. The megalithic monuments are very common on land with rocky outcrops. The two most important of the Iberian Peninsula are located in montados landscapes: the Big Dolmen of Zambujeiro, built between 4000 and 3500 b.C., in the transition period of the Final Neolithic - Chalcolithic, and the stone circle of Almendres, a cromlech built in the Neolithic period (5000-4000 b.C.) (Mascarenhas, Rocha 2011). Other important stone circles, dolmens and menhirs in the area of Évora, Pavia, Redondo and Reguengos (Central Alentejo) are also part of the montados landscape as well as numerous habitats of that period. In these landscapes occur also archaeological structures of other times, as the Roman villae (Mascarenhas, Rocha 2011).

In terms of architectural heritage, many farms are home to old mansions, some of which with elements of the Middle Ages or of the XVI century. Most of them date from the XVII, XVIII and XIX centuries as well as religious buildings with heritage value as convents and chapels. The vernacular architectural heritage is also noted in many montados farms. It is a heritage concerning the houses of the farm workers, sheds, stables, barns, wells, threshing floors, and other types of rural structures such as old piggeries, mills and pens. Hydraulic structures like norias, dams, aqueducts, canals, cisterns and tanks are also very common in these farms (Mascarenhas, Rocha 2011).

Intangible heritage

Craftworks

Many craft traditions have passed from generation to generation providing a sense of identity and historical continuity, which allows local communities to perceive this art as a collective cultural heritage. The main products of this creativity are objects in cork, wicker, horn and wood, carved to the razor by the hands of the artisans, in most cases.

Gastronomy

The gastronomy related to montado is based on black pig mainly, and its superior quality products as sausages and hams, on beef meat, such as the traditional montado veal, and mutton, but also on game species. Honey, mushrooms, wild plants for infusion and flavoring, artisanal jams and confectionery products are also valuable.

Local traditions and popular knowledge

The knowledge transmitted by shepherds and other montado workers throughout the generations should be emphasized. Among the ancestral techniques, the pruning of the oaks, responsible for the typical morphology of the montado trees, and the barking of the cork oaks are the most common. In the field of folk medicine, holm oak mosses were very useful for burns and foot blisters. The decoction of its bark gave a very useful tisane in the treatment of sore throat (Salgueiro 2004). Its tannin was good to cure diarrhea and bleedings (Vermelho do Corral, 2014). As for the cork and holm oak acorns, they allowed to make a healthy coffee, once roasted and ground.

Beliefs and Legends

Due to their great longevity and size, the excellence of their morphology, the richness of their uses and their economic value, the oaks are outstanding marks of the places and landscapes in which they occur and are an integral part of the memory and cultural history of the peoples, who have always devoted them a prominent place in legends and literature. During protohistory, oaks were regarded as sacred trees, as cosmic trees, that would link Earth to Heaven and Hell. The ancients also thought that eating oak acorns they could foretell, as the Latin poet *Lucanus* (36-65 AD) wrote (Rodrigues 1998). Among the many legends associated with the montados, a great part are related to the agro-pastoral activities but some of them are also linked with megalithic monuments.

Artistic inspiration

Especially since the nineteenth century, the montados and the oak trees, in general, have been a source of inspiration for the creation of pictorial works. Through painting, the montados become idealized and emotional landscapes. One only loves what one knows, and drawing and painting become means of privileged observation, re-interpreting nature and landscape through creative and sensorial looks that contribute to reinforce their identity (Saraiva 2014).

Discussion

Montado is a High Value Natural Agriculture System according to the classification proposed by the European Environment Agency and is a biological and cultural heritage that is on the Portuguese national list to be included in the UNESCO World Heritage (2016). This important cultural landscape contemplates a set of traditional management practices that have an enormous influence on the existence of ecosystem services. It can be mentioned for example: do not use heavy machinery, do not introduce chemicals, low density of livestock, well-managed planting and harvesting, open areas with good pastures driven. This multifunctional landscape intrinsic to its historical resilience has a lots of intangible heritage connected to its nature, inspirational experiences, that has a great potential for ecotourism.

Finally the importance of montados in soil conservation and protection is crucial in combating desertification, this feature is of particular significance in the Mediterranean area where deforestation, demographic pressure and climate change, are accentuating the risk of desertification. The forests of oak trees, because of its potential socio-economic and ecological value, can be crucial for the formation of forest barriers against desertification.

Human kind is part of the global ecosystem and should not undertake ecosystems as useful things mainly to him. Human understanding should reinforce ecosystems integrity preservation as they are the backbone of life on Earth.

Acknowledgements

To CIMAC for the financial support to this study. To ICAAM-UEvora and CIDEHUS-UEvora research Centers, to institutional support.

References

- Berrahmouni N., Escute X., Regato P., and Stein C., 2007. Beyond cork: a wealth of resources for people and nature. Lessons from the Mediterranean. Rome, Italy: WWF Mediterranean.
- Bettencourt A., Dinis A., Figueiral I., Rodrigues A., Cruz C.S., Sousa e Silva I., Azevedo M., e Barbosa R., 2007. A ocupação do território e a exploração de recursos durante a Pré-História Recente do Noroeste de Portugal. (<https://repositorium.sdum.uminho.pt/bitstream/1822/18187/1/Bettencourt%2520et%2520al%25202007.pdf>) (visited on 12/10/2016).
- Bombico S., Carneiro A., 2016. "Do Mar ao Montado: Evidências da utilização e exploração de cortiça na Lusitânia Romana. From Sea to Montado: Evidences of the use and exploitation of cork in the Roman Lusitania", in Rangel, J.F., Faísca, C.M., Bombico, S. and Mourisco, P. (ed.) *El alcornocal y el precio corchero: una perspectiva histórica e interdisciplinaria. O Montado de sobre e o setor corticeiro: uma perspetiva histórica e transdisciplinar*, Badajoz: Diputación de Badajoz, p.19-43. https://dspace.uevora.pt/rdpc/bitstream/10174/18489/1/Bombico%20e%20Carneiro_Do%20Mar%20ao%20Montado.pdf (visited on 12/10/2016).
- Boyd J., Spencer B., 2007. What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics* 63(2), p. 616-626.
- Braat L.C., and De Groot R., 2012. The ecosystem services agenda: bridging the worlds of natural science and economics, conservation and development, and public and private policy. *Ecosystem Services*, 1(1), p. 4-15.
- Ciesla W. 2002. Non-wood forest products from temperate broad-leaved trees. Rome: FAO.
- Coelho I.S., 2007. A silvopastorícia, uma perspectiva histórica, in J.S. Silva (ed.). *Os Montados. Muito para além das árvores*. Lisboa. Público and Fundação Luso-Americana para o Desenvolvimento, p. 177-209.
- Costanza R., d'Arge R., De Groot R., Farber S., Grasso M., Hannon B., Limburg K., Naeem S., O'Neill R.V., Paruelo J., Raskin R.G., Soutton P., van den Belt M., 1997. R. G. The value of the world's ecosystem services and natural capital.
- Daily G., 1997. *Nature's services: societal dependence on natural ecosystems*. Washington: Island Press.
- De Groot R. S., 1992. *Functions of nature: evaluation of nature in environmental planning, management and decision making*. Groningen: Wolters-Noordhoff BV.
- De Groot R. S., Alkemade R., Braat L., Hein L., and Willemen L., 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological complexity*, 7(3), p. 260-272.
- Díaz-Villa M. D., Marañón T., Arroyo J., and Garrido B., 2003. Soil seed bank and floristic diversity in a forest-grassland mosaic in southern Spain. *Journal of Vegetation Science*, 14(5), p. 701-709.
- Ferreira D.B., 2001. A evolução da paisagem de montado no Alentejo Interior Ao longo do século XX: dinâmica e incidências ambientais, *Finisterra*, XXXVI, 72, p. 179-193.
- Fisher B., Turner R. K., Morling P., 2009. Defining and classifying ecosystem services for decision making. *Ecological economics*, 68(3), p. 643-653.
- Fonseca A., 2004. *O Montado no Alentejo (Séculos Xv a XVIII)*. Lisboa: Ed. Colibri.
- Fonseca A., 2009. História do Montado – do fim da Idade Média ao início da Época Moderna. http://naturlink.pt/article.aspx?menuid=3&cid=8093&bl=1&viewall=true#Go_1 (visited on 17/10/2016).
- Fonseca A., 2014. Breve história do Montado. *Memória Alentejana*. 33/34, p. 14-16.

- Freitas A., 2016. Há uma torre que mostra como os sobreiros ajudam a Terra a respirar. Público 24/10/2016 (<https://www.publico.pt/2016/10/24/ciencia/noticia/ha-uma-torre-que-mostra-como-os-sobreiros-ajudam-a-terra-a-respirar-1748335>) (visited on 28/10/2016)
- Gutman P., 2007. Ecosystem services: Foundations for a new rural–urban compact. *Ecological Economics*, 62(3), p. 383-387.
- Jansson A., 2013. Reaching for a sustainable, resilient urban future using the lens of ecosystem services. *Ecological Economics*, 86, p. 285-291.
- Jax K., 2005. Function and “functioning” in ecology: what does it mean? *Oikos*, 111(3), p. 641-648.
- Joffre R., Rambal S. and Ratte J.P., 1999. The dehesa system of southern Spain and Portugal as a natural ecosystem mimic. *Agroforestry Systems*, 45, p. 57-79.
- Mascarenhas J.M., Rocha A.L., 2011. Récentes tendances du développement durable de paysages de systèmes extensifs: étude comparée du Montado português et du Cerrado brésilien, in *Proceedings of the International conference Landscapes of Everyday Life* (Perpignan and Gerona 16 - 18 March 2011), Séssion Plénière 2, Cestas: Cemagref and Paris: Ministère de l'Ecologie, de l'Energie, du Développement Durable, et de l'Aménagement du Territoire, p.1-20. CD format proceedings.
- Mateus J., Queiroz P., 1993. Os estudos de vegetação quaternária em Portugal; contextos, balanço de resultados, perspectivas in *O Quaternário em Portugal, balanço e perspectivas*, Lisboa: Colibri, p. 105-131.
- MEA 2005. *Ecosystems and human well-being: current state and trends*. Washington, DC: World Resources Institute.
- Mendes A., 2007. O sobreiro ao longo dos tempos, in J.S. Silva (ed.), *Os Montados. Muito para além das árvores*, Lisboa: Público and Fundação Luso-Americana para o Desenvolvimento, p. 77-106.
- Miller R., 2014. Uma outra Visão do Montado: um pintor inglês no Montado Ibérico, *Memória Alentejana*, 33/34, p. 51-52.
- Natividade J.V., 1950. *Subercultura*. Lisboa: Ministério da Economia – Direcção Geral Serviços Florestais e Aquícolas.
- Odum E. P., Barrett G. W., 1956. *Fundamentals of ecology*. Philadelphia: Saunders.
- Olea L., San Miguel-Ayán A., 2006. The Spanish dehesa. A traditional Mediterranean silvopastoral system linking production and nature conservation, *Grassland Science in Europe* 11, p. 3-13.
- Oliveira J. (s/d). O “eterno descanso” no Neolítico do Alentejo Norte. <http://www.chaia.uevora.pt/uploads/pdfs/143481d951ee373de537e2d7d86cdc01ef692dd0.pdf> (visited on 14/10/2016).
- Pacala S., Kinzig A.P., 2002. Introduction to theory and the common ecosystem model. In: Kinzig, A.P., Pacala, S. & Tilman, D. (eds.) *Functional consequences of biodiversity: empirical progress and theoretical extensions*. Princeton University Press, Princeton, US p. 169-174.
- Pagiola S., Arcenas A., Platais G., 2005. Can payments for environmental services help reduce poverty? An exploration of the issues and the evidence to date from Latin America. *World development* 33 (2), p. 237-253.
- Pereira J.S., Mateus J.A., Aires L.M., Pita G., Pio C., David J.S., Andrade V., Banza J., David T.S., Paco T.A., Rodrigues A., 2007. Net ecosystem carbon exchange in three contrasting Mediterranean ecosystems- the effect of drought. *Biogeosciences* 4, p. 791-802.
- Pereira J.S., Bugalho M.N. e Caldeira M.C., 2008. *Do sobreiro à cortiça. Um sistema sustentável*. Santa Maria de Lamas: APCOR Ed.; Lisboa: Instituto Superior de Agronomia. 42 pp.
- Pereira P., Godinho C., Roque I., Rabaça J., 2015. *O Montado e as Aves: Boas Práticas para uma Gestão Sustentável*. Coruche: Câmara Municipal de Coruche; Évora: Universidade de Évora.

- Pinto-Correia T., Mascarenhas J.M., 2001. Montado (Dehesa) of Portugal and Spain, in Green, B. and Vos, W. (ed.), *Threatened Landscapes. Conserving Cultural Environments*, London and N. York: Spon Press, p. 100-101.
- Pinto-Correia T., Barroso F., Menezes H., Taveira R., 2008. Synergies and conflicts between agriculture and noncommodity functions at local landscape level: application to Castelo de Vide, South-east Portugal, in *Proceedings of the 8th European IFSA Symposium*, 6 - 10 July 2008, Clermont- Ferrand (France), p. 571-579.
- Pinto-Correia T., Ribeiro N. e Potes J. (ed.), 2013. *Livro Verde dos Montados*, Évora: ICAAM - Instituto de Ciências Agrárias e Ambientais Mediterrânicas. https://dspace.uevora.pt/rdpc/bitstream/10174/10116/1/Livro%20Verde%20dos%20Montados_Versao%20online%20%202013.pdf (visited on 15/10/2016).
- Regato-Pajares P., Jiménez-Caballero S., Castejón M., Elena-Rosselló R., 2004. Recent landscape evolution in Dehesa woodlands of western Spain. *Recent dynamics of the Mediterranean vegetation and landscape*, p. 57-72.
- Riera-Mora S., 2006. Cambios vegetales holocenos en la región mediterránea de la Península Ibérica: ensayo de síntesis. *Revista Ecosistemas* 15(1), p. 17-30.
- Robertson M.M., 2004. The neoliberalization of ecosystem services: wetland mitigation banking and problems in environmental governance. *Geoforum* 35 (3), p. 361-373.
- Rodrigues A. V., 1998. *Os Lusitanos. Mito e Realidade*. Lisboa: Academia Internacional da Cultura Portuguesa.
- Salgueiro J., 2014. *Ervas, Usos e Saberes*. Lisboa: Marca, 2004.
- Saraiva M. G. 2014. Paisagem de Montado. A experiência de encontros de pintura 'en plein air'. *Memória Alentejana* 33/34, p. 47-48.
- Senna-Martinez J.C., 1995. O Bronze Final no Centro de Portugal: Contribuição para um estudo acerca da etnogénese regional, in: Barbosa, P. (ed.) 2007, *Arte, História e Arqueologia. Pretérito sempre presente*. Lisboa: Ésquilo, p. 17-36.
- Soares J., 2016. Território Mesolítico do Vale do Sado. Caçadores-recolectores semissedentários. <http://www.atlas.cimal.pt/drupal/?q=pt-pt/node/88> (visited on 12/10/2016).
- TEEB Foundations 2010. *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations*. London and Washington: Earthscan.
- Vermelho do Corral A., 2014. O Sobreiro Extra Montado. *Memória Alentejana*, p. 33/34, 36-37. Vieira J. A., 1991. *Arborização e desarborização em Portugal*. Lisboa: Informação DGF 8, p. 8-15.