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Mara Almeida[a], Carlos Guerra[ab] & Teresa Pinto-Correia[a]

[a] ICAAM – Instituto de Ciências Agrárias e Ambientais Mediterrânicas, Universidade de Évora, Núcleo da Mitra, Ap. 94, 7002-554 Évora, Portugal

[b] Instituto Politécnico de Viana do Castelo – Escola Superior Agrária, Ponte de Lima, Portugal

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Unfolding relations between land cover and farm management: high nature value assessment in complex silvo-pastoral systems

Mara Almeida[a]*, Carlos Guerra[a,b] and Teresa Pinto-Correia[a]

[a]*ICAAM – Instituto de Ciências Agrárias e Ambientais Mediterrânicas, Universidade de Évora, Núcleo da Mitra, Ap. 94, 7002-554 Évora, Portugal;* [b]*Instituto Politécnico de Viana do Castelo – Escola Superior Agrária, Ponte de Lima, Portugal*

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The high nature value (HNV) concept, proposed by the European Environment Agency, recognizes that specific farming systems support high biodiversity levels, mainly as a result of extensive management practices. The Portuguese *montado* is one of the most significant HNV systems in southern Europe. However, considering the great complexity characterizing these systems both in land management and in landscape structure, a specific context-oriented methodology to assess which *montado* areas are likely to be classified as HNV farmland is needed. In this sense, the aim of this study is to explore a methodological approach which makes it possible to assess land management pressures through land cover information on these complex silvo-pastoral systems. The proposed methodology was tested through a local case study in a *montado* area in southern Portugal, assessing the relation between management practices and a vegetation cover index. Results show that in similar *montado* areas different land management strategies varying in stocking density, but also in type of grazing animals and shrub control practices, configure different vegetation cycles. These results indicate there is a way to develop a straightforward methodology to assess the HNV value of Mediterranean silvo-pastoral systems based on land cover indicators. These would make it possible to assess the HNV of *montado* areas with direct and objective information and independent of farmer's surveys or other farm-based data.

Keywords: high nature value; silvo-pastoral system; land management; vegetation cover

1. Introduction

Mediterranean silvo-pastoral systems, such as the *montado* in Portugal and the *dehesa* in Spain, are broadly classified as high nature value (HNV) farming systems (Pinto-Correia & Carvalho-Ribeiro, 2012), i.e. farmland with high proportion of semi-natural vegetation hosting high biodiversity levels (Andersen et al., 2003). Nevertheless, when considered in detail not all areas where this system occurs can be classified as HNV farmland. In such complex silvo-pastoral systems and according to management practices at the farm unit scale, the balance of the system may be quite different and its biodiversity levels might also vary.

In extensive land use systems, often related to fragile ecosystems, the link between land use and landscape is a fundamental aspect to understand the system's ecological conditions (Perfecto et al., 2009). Physical land cover results from the land use, i.e. decisions by individual farmers (Carmona et al., 2010). Assuming the hypothesis that there is a link between the land use intensity and landscape (Moser et al., 2002), the latter can then be used as an indicator of the former, and therefore, as a predictor for ecological sustainability (Fu et al., 2006; Peterseil et al., 2004). However, the links between landscape and management are complex as changes in land cover and land use are sometimes difficult to interpret, particularly their consequences for biodiversity (Haines-Young, 2009; Valbuena et al., 2008). Such changes are not always the replacement of one type of land cover or land use by another, they are often more subtle and difficult to characterize (Lambin, 1999), although their implications for biodiversity can be as important as a complete transformation (Perfecto et al., 2009). This is even more complex in Mediterranean silvo-pastoral systems, such as the *montado*, due to the underlying fuzziness of the landscapes (Pinto-Correia, Barroso, et al., 2011; Van Doorn & Pinto-Correia, 2007) and also due to the high variability in land management.

Montado areas are the dominant landscape in the Alentejo region, southern Portugal, and are wooded pastoral systems derived from Mediterranean forest ecosystems, where livestock grazing is combined with woodland production. They are particularly significant systems due to their biodiversity associated with both farming and forestry (Canteiro et al., 2011; Godinho & Rabaça, 2011). These areas have been subject to various pressures for farming intensification or extensification, often leading to the reduction of land hosting high levels of biodiversity (Pinto-Correia, Ribeiro, et al., 2011). Therefore, classification of the *montado* areas as HNV

*Corresponding author. Email: mdsa@uevora.pt

farmland, and particularly the application of specific support measures concerning their biodiversity value, needs to be tackled with care and to be based on some differentiation of the land management practices. However, the extensive and adaptive character of the current management strategies of these silvo-pastoral systems makes this assessment challenging, as the options taken by farmers are extremely diverse. As a result of this complexity in management systems and the unperceivable impacts of certain management practices on land cover, the combination of land cover with management type and pressure reveals great complexity and often uncertainty.

In this context, spatially-based approaches at the landscape level may enable a reliable and applicable identification of the *montado* areas that can be classified as HNV farmland. The challenge of classifying the landscape structure in areas of fuzzy land cover such as *montado* has already been overcome (Barroso, Pinto-Correia, et al., 2012; Van Doorn & Pinto-Correia, 2007). The main challenge now is to combine the information on land cover with the assessment of the management type and pressure, making it possible to relate pattern to process. This combination would enable the development of landscape indicators based on aerial images which could give indications on management options and related impacts on the ecological conditions and functioning. If the combination between pattern and process at this level could be made, it would support more effectively the targeting of policy tools, their implementation and monitoring.

Considering the above, the assessment of HNV farmland requires a context-oriented approach able to overcome the limitations of complex silvo-pastoral systems. We hypothesize that through a landscape approach we would be able to progress on a more expedite way, based on reliable indicators, to assess which *montado* areas are more likely to host high biodiversity levels. The aim of the present paper is therefore to present and discuss a methodological approach for the assessment of HNV farmland applicable to complex silvo-pastoral systems, by exploring how land cover data can be combined with management practices in the *montado* system. This exploratory work is based on a case study developed in a *montado* area, in south Portugal, where land managers have been surveyed on their management practices, and aerial images have been analysed.

In the following sections the *montado* silvo-pastoral system is explained, concerning its functioning and current threats to its sustainability (Section 2) and the particular challenges regarding the assessment of HNV in *montado* areas are exposed (Section 3). Subsequently, we explore the possibilities for relating land management to land cover through a local case study in Alentejo region, presenting the applied methodology and the obtained results (Section 4). Finally, a discussion on the proposed methodology and on main results are presented and some final considerations on the scope and contribution of this exploratory work are outlined (Section 5).

2. The sustainability of the montado

Montado (Figure 1(a)) is the dominant land cover in the rural landscape of the Alentejo region (Figure 1(b)). These are complex silvo-pastoral systems whose complexity increases according to the conjunction of the tree cover, with various densities of cork oak (*Quercus suber*) and holm oak (*Quercus rotundifolia*) maintained through natural regeneration, to the agricultural and grazing components of the ground layer, and to the variable soil, climate and topographical conditions (Pinto-Correia, Ribeiro, et al., 2011). The *montado* system is also an acknowledged paradigm of a close relationship between farming and biodiversity, where constraints imposed by natural resources are respected and even turned into potentialities (Bugalho et al., 2011; Eichhorn et al., 2006).

The biophysical characteristics (soil, morphology, climate and water availability) of areas where *montado* most frequently occurs are diverse, with a related strong variability in environmental constraints. Due to this variability in biophysical conditions these areas include significant variations in tree cover and undercover densities and species composition. In turn, this diversity creates different conditions for the present use. The underlying fuzziness of the Mediterranean silvo-pastoral systems (Barroso, Pinto-Correia, et al., 2012) is also a determining spatial and temporal trait of the *montado*: strong variations in land cover composition without clear boundaries, and significant inter-annual variations, even within the same management system.

In addition, *montado* is a system fully dependent on management (Bugalho et al., 2011), thus, its natural value and environmental qualities are closely related, not only to the high variability of the system components, as presented above, but also to the pressures from various farming practices. Grazing intensity is a key factor determining the sustainability of this system, affecting tree cover structure, oaks' natural regeneration and grassland diversity and productivity (Cierjacks & Hensen, 2004; Marriott et al., 2009; Papanikolaou et al., 2011). Information on stocking density and type of grazing animals gives indication on the pressure of grazing activity to which a *montado* area is subject. However, other management practices, such as those related to shrub control techniques and soil mobilization, when combined with different livestock management options, particularly with different levels of grazing intensity, have different impacts on soil structure and on oaks' natural regeneration (Pinheiro et al., 2008; Ribeiro, 2013; Ribeiro et al.,