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Do the passerine traits' dynamic patterns indicate the ecological status of agro-forestry ecosystems? A modelling approach for "Montado" management assessments

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ABSTRACT

Context The "Montado", a human shaped oak agro-forestry dominated landscape of South Western Europe has been experiencing series of changes following the implementation of different agricultural policies. Such changes are responsible for shifting the structure and composition of "Montado" landscape and hence the biodiversity of the system, either by agriculture abandonment or intensification. Traditional oak agro-forestry management practices, which focused on improving the ecological status of a single and common land use (oak agro-forestry), is taken as a conservation paradigm against the perceived changes in the system.

Aims We aimed to identify the effect of oak agro-forestry management on "Montado" biodiversity as indicator for ecological status of "Montado" landscape.

Methods A recently developed spatially explicit Stochastic Dynamic Methodology (StDM) was applied to model the spatial and temporal patterns of the land use/land cover changes and predict responses in biodiversity patterns, with a focus on passerine functional traits (grassland, woodland and generalist species richness), considering scenarios with and without oak agro-forestry management.

Results Model outputs showed that oak agro-forestry management favored the expansion of oak agro-forestry at the expense of other land uses, mainly oak forest and agricultural areas. On the other hand, passerine richness exhibits a gradual decline facing the intensification of oak agro-forestry management practices, with higher declining rate observed for grassland passerine species.

Conclusion The oak agro-forestry management does not seem to improve the ecological status of "Montado" landscape, and neither does its abandonment. Hence the conservation paradigm should focus on improving the multi-functionality of the system than merely focusing on a single and common land use

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1. Introduction

The Common Agricultural Policy (CAP) was responsible for the changing traditional agricultural patterns in Portugal (Fidalgo et al., 2007; Jones et al., 2011). This policy promotes intensive agriculture instead of traditional agriculture, which are being abandoned (Jones et al., 2011). The ''Montado'' (''Dehesa'' in Spain) is a traditional human shaped oak agro-forestry dominated system of Iberian Peninsula that has been experiencing series of changes due to the CAP implementation, compromising land use multi-functionality and biodiversity (Beaufoy, 2013).

The ''Montado'' landscape comprising around 23% of forested land in Portugal (Surovà et al., 2001) characterized by a mosaic of different land use types ensured by the multi-functionality of the typical agricultural practices. This system is dominated by oaks (*Quercus suber* L. and *Quercus ilex* Lam.) and recognized as a single and generic land use type of traditional oak agro-forestry (Pinto-Correia and Godinho, 2013). The ''Montado'' system comprises diverse management options i.e. agriculture, oak agro-forestry including livestock farming and forestry with different ecological roles that contribute to maintain biodiversity as a whole (Beaufoy, 2013). Therefore, the idea of representing the multi-functional ''Montado'' system as a single land use type (oak agro-forestry) has revealed widely differing views on how and what to measure for quantifying the real complexity of such heterogeneous systems (Pinto-Correia and Godinho, 2013).

Traditional management practices in ''Montado'' system has contributed for maintaining the ecological status of the system. These management practices, in the context of this research, include diverse anthropogenic influences in the system, such as shrub clearance, extracting tree barks of oak for its use as wine bottle stopper, diverse agro-forestry activities in the system (Acácio, 2009). According to Pinto-Correia and Mascarenhas (1999), the main agricultural changes are either: (1) the abandonment of oak agro-forestry management or (2) the intensification of agriculture, both altering the structure and functioning of the system. Additionally, the abandonment of oak agro-forestry management is responsible for the expansion of shrub communities on non-fertile and dry lands and for the increasing area of woodland forests on fertile and humid areas (Acácio, 2009). Conversely, the agricultural intensification involving oak forest exploitation for cork, charcoal and livestock production is also responsible for compromising both its health and productivity and for reducing heterogeneity in the system (Pinto-Correia and Mascarenhas, 1999). The conservation paradigm for the entire ''Montado'' landscape is focused on improving the ecological status of oak agro-forestry areas through minimizing either the effect of agricultural intensification or abandonment of oak agro-forestry management (Pinto-Correia and Mascarenhas, 1999). However gearing conservation efforts only on a dominant land cover may not necessarily leads to conservation of a multifunctional landscape like ''Montado''. Hence, the implication of this conservation paradigm on the biodiversity and ecological status of ''Montado'' system is of utmost importance. This particular research is aimed at evaluating the efficiency of this conservation paradigm toward maintaining the ecological status of ''Montado'' landscape using robust ecological indicators.

The use of ecological indicators is crucial for investigating changes taking place in a given environment (Lindenmayer, 1999; Dale and Beyeler, 2001; Carignan and Villard, 2002; Niemi and McDonald, 2004). Although the relations between birds and agricultural changes are complex, some studies have been produced using birds as ecological indicators in agro-ecosystems (e.g. Suárez-Seoane et al., 2002; Santos and Cabral, 2004; Cabral et al., 2007; Sirami et al., 2008). In a previous overview of this problematic in Mediterranean agro-ecosystems, Santos and Cabral (2004) suggested that passerine communities present several characteristics that have justified their relevance as ecological indicators namely: (1) they usually occur in high densities in the studied habitats, (2) they are functionally placed at an intermediate position in the food webs (Moreby and Stoate, 2001), (3) they provide cheap and easy measurements (due to their conspicuous nature) if standard methodologies are applied (Bibby et al., 1992; Ralph et al., 1993), (4) they are sensitive to landscape and agricultural changes from microhabitat to landscape level (Saab, 1999; Carignan and Villard, 2002), (5) for many species, demography, behavior, distribution and phenology are connected with seasonal and spatial changes in farming practices (Ormerod and Watkinson, 2000), and (6) they have the capacity for population recovery in response to good management practices in previously disturbed ecosystems (Kati et al., 2004; Schulze et al., 2004). The use of multiple species as ecological indicators is crucial for understanding the global response of species richness to disturbance at a community level (Kati et al., 2004; Schulze et al., 2004). When these species are grouped into trophic guilds is even more efficient in reflecting the ecological response to land use gradients, both in composition and functioning terms (Santos and Cabral, 2004). The categorization of foraging behavior traits among bird species represent an added-value in order to model distinct response of birds to changes in grassland and woodland ecosystems (Preiss et al., 1997), facilitating to understand the ecological consequences, namely in terms of total bird species richness distribution, associated with the gradient of land use changes expected to occur in the study area.

With regard to how anthropogenic environmental changes will affect the abundance of species, the definition of guilds, traits or richness as indicators within communities in disturbed ecosystems is a great challenge in most ecological integrity studies (Andreasen et al., 2001). Conventionally, such potential indicators are usually estimated by using biological indices, which reduce the dimensionality of complex ecological datasets to a single univariate statistics and ordination methods (e.g. Cabral et al., 2007). Nevertheless, when the time factor is present within the data, biological indices are unable to estimate, in a comprehensible way, the structural changes when the habitat conditions are substantially changing (Jørgensen and De Bernardi, 1997). Therefore, ecological integrity studies have been improved by creating spatially explicit dynamic models that simultaneously attempt to capture the structure and composition in systems affected by long-term environmental disturbances (e.g. Bastos et al., 2012). These are, for instance, the impacts resulting from the implementation of new agricultural paradigms (Santos and Cabral, 2004).