Forest Ecology and Management 354 (2015) 97–103

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Topography and aridity influence oak woodland bird assemblages in southern Europe

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ARTICLE INFO

Article history:
Received 20 March 2015
Received in revised form 24 June 2015
Accepted 25 June 2015
Available online 29 June 2015

Keywords:
Climate change
Woodland management
Climate refugia
Cork oak
Quercus suber
Resource availability
Mediterranean Basin

ABSTRACT

The increasing frequency and severity of drought spells in southern Europe has been associated with reduced growth and increased defoliation and mortality of several tree species, consequently affecting woodland productivity, structure and associated biodiversity. However, topographic variation and associated microclimatic features may buffer against the negative effects of drought at a local level. Here, we aimed to evaluate the influence of topographic variation on oak woodland communities along an aridity gradient. For this, we quantified cork oak woodland structure, bird species richness, abundance, and caterpillar biomass on north- and south-facing slopes along an aridity gradient across the south-western Iberian Peninsula. Drier microclimates on south-facing slopes had lower tree cover and bird richness and abundance than north-facing slopes, and the magnitude of these differences increased markedly from wetter (tree cover and woodland bird abundance ~5–15% lower on south facing slopes) to drier regions (~50–60% lower). This reduction in woodland bird richness and abundance is mainly driven by tree foraging species and likely a response to lower tree cover and resource availability, as caterpillar abundance was also ~50% lower on south-facing slopes. The topographic complexity of the Mediterranean Basin seems to be shaping woodland community-level and trophic chain responses to increasing aridity in Southern Europe. Our results suggest that topographic and microclimatic conditions on north-facing slopes can potentially act as refugia for the high biodiversity characteristic of cork oak woodlands and other Mediterranean landscapes. We discuss cork oak woodland management measures needed to help maximize the resiliency of these Mediterranean socio-ecological systems in the face of climate change.

1. Introduction

Climate change impacts on natural systems are widespread across the globe (Parmesan and Yohe, 2003; Root et al., 2003; Parmesan, 2006) and forest ecosystems are no exception (Allen et al., 2010; Lindner et al., 2010). Nevertheless, there is significant variation in responses to climate change at small spatial scales and topo-geographical features play a very important role in this process by determining local microclimatic conditions (Dobrowski, 2011). The level of variation in climatic conditions in relation to local- and regional-scale habitat and landscape features can be similar to that expected from climate change at larger spatial scales (Suggitt et al., 2011). This suggests that certain microclimatic conditions have the potential to buffer local populations from climate change effects, and highlights the importance of identifying small-scale locations and features with adequate conditions to maintain species when macroclimatic conditions deteriorate. However, our ability to forecast the role of local topographic features on species and community responses to climate change is still poor (Austin and Van Niel, 2010). A better understanding of these local-scale processes is essential to enhance predictions of climate change effects on ecological communities and enable the design of effective management and conservation strategies under a changing climate.

The Mediterranean Basin is both a hotspot for biodiversity (Myers et al., 2000) and climatic change (Giorgi, 2006). Regional

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http://dx.doi.org/10.1016/j.foreco.2015.06.032
0378-1127/

aridity levels have increased over the last decades due to a significant increase in the number of extreme heat and drought events (Diffenbaugh et al., 2007; Hoerling et al., 2012), reinforcing the idea that severe climate change impacts on biodiversity in this region should be expected (Settele et al., 2014). The topo-geographic complexity of the Mediterranean Basin plays a defining role in local microclimatic and biodiversity patterns (Blondel et al., 2010) and, therefore, provides the ideal setting to quantify community responses to microclimatic features during a period of rapid climatic change. Here, we quantify the influence of local topographic features on woodland structure, bird assemblages and their food resources focusing on a key habitat protected under the EU Habitats Directive (92/43/CEE): Mediterranean cork oak woodlands. Cork oak woodlands are socio-ecological systems widespread in the western half of the Mediterranean Basin that support high levels of biodiversity due to their low-intensity agroforestry management (Díaz et al., 1997). Nearly 60% of the global distribution of cork oak woodland is in the Iberian Peninsula and widespread declines in cork oak condition and increasing levels of tree mortality have been reported in this region (e.g. Brasier and Scott, 1994; Regato-Pajares et al., 2004; Costa et al., 2011; Pinto et al., 2011, 2012). This negative trend, observed in most native tree species in Southern Europe, has been associated with recent climatic changes, in particular with increasing drought spells (Brasier and Scott, 1994; Carnicer et al., 2011) and has been shown to vary spatially according to local topographic and microclimatic conditions (Costa et al., 2010). However, the impact of these changes of woodland condition on local biological communities through bottom-up effects across the trophic chain are still poorly understood (Carnicer et al., 2011), particularly at smaller spatial scales.

In this study, we aimed to (i) evaluate the influence of small-scale topographic variation on woodland structure and bird assemblage changes along an aridity gradient, (ii) assess the role of changes in resource availability as a driver of the observed bird assemblage patterns. We hypothesize that woodland structure will respond negatively to drier local and regional conditions, which will in turn affect resource abundance for insectivorous bird species that feed on the trees leading to changes in the abundance and composition of woodland bird assemblages. Conservation management implications for the future of Mediterranean woodland systems are discussed in light of the results observed.

2. Materials and methods

2.1. Study area

The study area, located in south-west Iberian Peninsula (Fig. 1), shows a diverse landscape comprised of vast plains interspersed with hilly areas of complex topography. We sampled north and south-facing slopes in three hilly landscapes with extensive cork oak woodlands across a latitude and aridity gradient, from the southern and drier (Caldeirão), to intermediate (Grândola) and

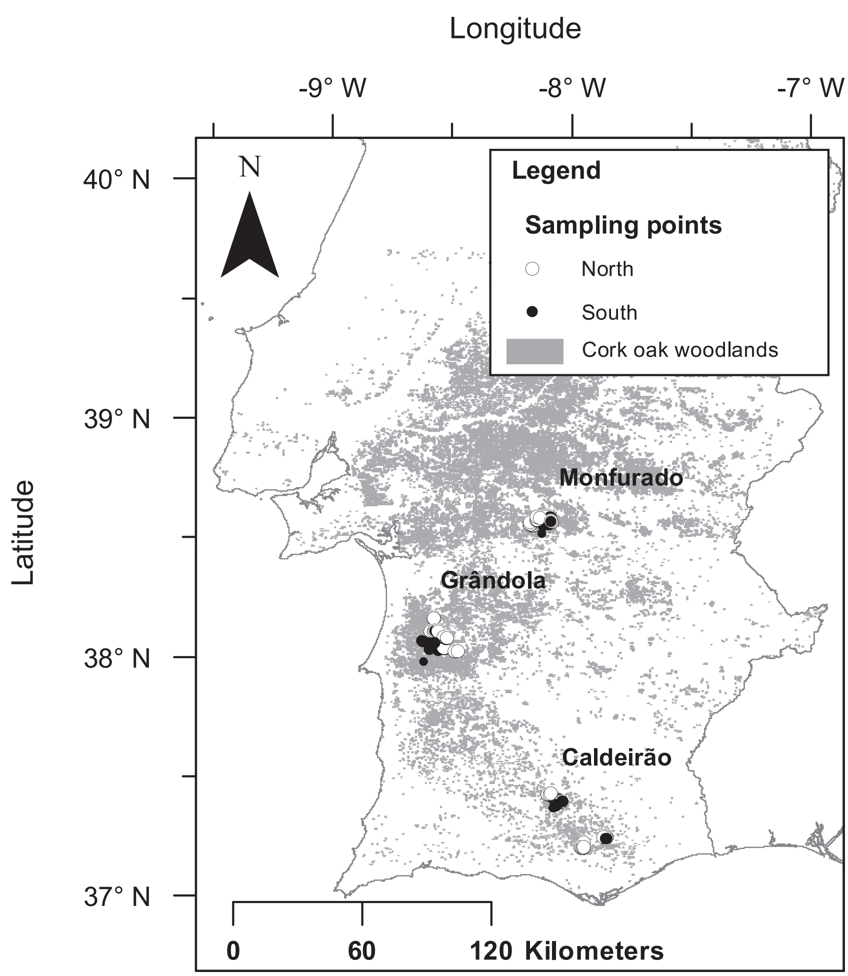

Fig. 1. Geographic location of the three sampling regions, in the south-west of the Iberian Peninsula. Shaded grey areas represent the distribution of cork oak woodlands in the study area, open dots represent north-facing sampling points and filled dots mark south-facing sampling points within each sampling region.