Biological Conservation 146 (2012) 14–23

Contents lists available at SciVerse ScienceDirect

Biological Conservation

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

Forest fuel management as a conservation tool for early successional species under agricultural abandonment: The case of Mediterranean butterflies

Maria João Verdasca [a], Ana Sofia Leitão [a], Joana Santana [b], Miguel Porto [c], Susana Dias [d], Pedro Beja [b,*]

[a] Museu Nacional de História Natural e da Ciência, Universidade de Lisboa, Rua da Escola Politécnica 58, 1250-102 Lisboa, Portugal
[b] CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Campus Agrário de Vairão, Universidade do Porto, 4485-601 Vairão, Portugal
[c] Centro de Biologia Ambiental, Departamento de Biologia Vegetal, Faculdade de Ciências de Lisboa, Universidade de Lisboa, C2 Campo Grande, 1749-016 Lisboa, Portugal
[d] Centro de Ecologia Aplicada Prof. Baeta Neves, Instituto Superior de Agronomia, Tapada da Ajuda, 1349-017 Lisboa, Portugal

ARTICLE INFO

Article history:
Received 15 July 2011
Received in revised form 5 October 2011
Accepted 28 October 2011
Available online 17 December 2011

Keywords:
Disturbance ecology
Ecological succession
Forest management
Landscape mosaics
Mediterranean butterfly assemblages

ABSTRACT

In cultural landscapes there are often negative biodiversity consequences of agricultural abandonment and subsequent scrub and forest encroachment, due to homogenization and the loss of early-successional habitats. The common forestry practice of removing understory vegetation to prevent fire hazard (fuel management) probably has the side-effect of ameliorating these consequences, but it is uncertain whether it effectively restores habitats for early-successional species. Here we examine the influence of time since fuel management and management frequency on butterfly assemblages, using a chronosequence of cork oak (*Quercus suber*) stands spanning about 70 years. Overall species richness increased immediately after management and abundances peaked about 2–3 years later, while both declined thereafter for about 10–20 years to pre-disturbance levels. Richness and abundances were also much higher in recurrently managed stands. Most life history groups showed successional trends similar to the overall species richness and abundances, though consistent positive effects of fuel management were only observed for species with univoltine life cycle, herbaceous layer feeding, larval overwintering, and intermediate body size. Individual species were largely associated with recent and recurrent management, though a few specialists occurred most often in undisturbed stands. These findings suggest that fuel management at <10 years intervals is strongly positive for butterfly assemblages in landscapes under land abandonment. However, to maintain the overall forest biodiversity it is critical that patches of undisturbed habitat are also retained at the landscape scale.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction

Rural depopulation and the abandonment of extensive agricultural and pastoral activities, normally followed by scrub and forest encroachment, are widespread in many regions worldwide, particularly in Europe (Baur et al., 2006; Moreira and Russo, 2007; Bugalho et al., 2011; Lupp et al., 2011). Although this process might be seen as an opportunity for recreating long since lost wilderness (e.g., Lupp et al., 2011), it is also a cause of conservation concern due to the widespread decline of species requiring early-successional and edge habitats (Baur et al., 2006; Moreira and Russo, 2007; Bugalho et al., 2011). Addressing this problem has often relied on some type of agri-environment scheme, whereby subsidies are paid to farmers for maintaining activities that otherwise would be economically unsustainable (Stoate et al., 2009). Despite its value, this approach is not always feasible at sufficiently large temporal and spatial scales due to high costs and to difficulties in engaging farmers in these voluntary schemes (Stoate et al., 2009; Espinosa-Goded et al., 2010). Complementary tools are thus needed to restore early-successional habitats in landscapes suffering land abandonment.

Conservation problems associated with land abandonment are particularly acute in Euro-Mediterranean forest landscapes (Bugalho et al., 2011), where they are coupled with the mounting occurrence of high-intensity wild fires (Xanthopoulos et al., 2006). Although fire is considered the main ecological mechanism promoting successional heterogeneity in Mediterranean landscapes (Grove and Rackham, 2001; Blondel et al., 2010), it is also socially and economically unacceptable due to catastrophic wildfires causing significant losses of human lives and livelihood (Pausas et al., 2008). Because of this, fire suppression is at present the main tenet of forest management policies in Mediterranean Europe, involving silvicultural treatments to reduce fuel accumulation and thus preventing the violent progression of wildfires (Xanthopoulos et al., 2006). Fuel reduction is often achieved by mechanical cutting of understory shrubs and small trees, while prescribed burning tends to be much less used due to logistical and technical difficulties (Xanthopoulos et al., 2006). The management of forest fuels

* Corresponding author. Tel.: +351 252 660411; fax: +351 252 661780.
E-mail address: pbeja@mail.icav.up.pt (P. Beja).

0006-3207/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biocon.2011.10.031

can thus have the positive side effect of restoring early-successional plant communities to forest landscapes where these have been lost through land abandonment and fire suppression policies (Santana et al., 2011; Porto et al., 2011). However, it remains uncertain what animal communities are associated with these habitats, and how they change with time since management and management frequency. This information is critical to enhance the conservation value of fuel management in Mediterranean landscapes.

This paper examines the long-term consequences of fuel management on butterfly communities in Mediterranean cork oak (*Quercus suber*) forests, which are particularly valuable from both socio-economic and biodiversity standpoints (Bugalho et al., 2011). Butterflies were considered particularly adequate, because they represent a diverse group of invertebrates that tend to be strongly responsive to successional changes in vegetation composition and structure (Steffan-Dewenter and Tscharntke, 1997; Balmer and Erhardt, 2000; Sanford, 2002; Poyry et al., 2006). Furthermore, there is evidence for land abandonment negatively affecting woodland butterflies, requiring silvicultural operations such as coppicing to recreate heterogeneous early-successional habitats and thus to restore diverse assemblages (Smallidge and Leopold, 1997, Benes et al., 2006, Freese et al., 2006). Here we hypothesize that fuel management may have comparable positive effects on butterfly assemblages, by removing understory woody vegetation (Santana et al., 2011) and favoring early-successional herbaceous communities (Porto et al., 2011). We further hypothesize that positive effects on early-successional species should be short-term, unless there is recurrent management at short intervals (<10 years) (Porto et al., 2011). These hypothesis were examined using a 70-year chronosequence of forest stands with different management histories, analysing how the time since the last fuel management event and management frequency affects butterfly assemblages, in terms of (i) overall species richness and abundance; (ii) species richness and abundances within life history groups; and (iii) assemblage composition in terms of species and life history groups. Results were then used to discuss the implications of fuel management for biodiversity conservation in Mediterranean landscapes under land abandonment.

2. Methods

2.1. Study area

The study was conducted in southern Portugal, within about 30,000 ha situated in Serra do Caldeirão (37°08′–37°22′N, 8°03′–7°49′W; 200–580 m a.s.l.). Climate is Mediterranean, with marked variation in annual rainfall (415–1903 mm), about 80% of which occurs in October–March and <5% in June–August. Mean monthly temperature ranges from 10.3 °C (January) to 24 °C (August). Cork oak forests dominate the landscape, ranging from almost pure stands to complex Mediterranean maquis with cork oaks surrounded by tall strawberry trees (*Arbutus unedo*) and tree heath (*Erica arborea*) (Acácio et al., 2009). There are also nearly monospecific *Cistus ladanifer* shrublands and more diverse Mediterranean heathland dominated by *Calluna vulgaris* and species of *Genista*, *Cistus*, *Erica*, *Lavandula* and *Ulex* (Acácio et al., 2009). Agriculture is nearly absent and pastoral activities are largely restricted to a very few and small herds of goat and sheep. Economic activity is dominated by cork production which is generally conducted on small private properties (<10 ha) by aged landowners (often >60 years old).

The landscape was far more agricultural during the first half of the 20th century, when national policies of food self-sufficiency (Wheat Campaign; 1929–1938) conducted to large-scale clearing of natural vegetation for cereal cultivation (Feio, 1949; Guerreiro, 1951). Since the 1950s, human population has declined along with the abandonment of agricultural and pastoral activities, and the concurrent shrubland encroachment (Krohmer and Deil, 2003; Acácio et al., 2009). Cover by cork oak forests has remained fairly stable, though management largely changed from a traditional agroforestry system, with cereal cultivation and livestock grazing under the tree canopy, to a purely forestry system, with understory clearing as the main silvicultural operation (Feio, 1949; Guerreiro, 1951; Acácio et al., 2009). The periodicity of understory management is variable and depends on the decisions of individual landowners, but it often occurs at about 9-year intervals in association with the cork extraction cycle, though it is either absent or very sporadic in many stands. As a consequence, the landscape is a mosaic of stands with understory vegetation at different successional stages, ranging from recently cleared stands (<5 years) with early-successional herbaceous understory and scattered shrubs, to stands unmanaged for long periods (>50 years) with a complex multi-layered understory occupied by tall shrubs, small trees and forest herbs (Santana et al. 2011; Porto et al., 2011).

2.2. Study design

The study was based on the space-for-time substitution method (Foster and Tilman 2000; Inoue, 2003), using a chronosequence of 45 cork oak stands ranging from zero to about 70 years since the last clearing of understory vegetation. This method was used to infer the sequence of butterfly assemblage variation since the last fuel management event, from contemporary spatial variation in assemblage attributes among forest stands with different management histories. Because it was not possible to fully meet the assumption that sites differed only in age of the understory vegetation and that each site traced exactly the same history in both its biotic and abiotic components, due for instance to differences in aspect, elevation slope and in historical land uses, this approach is unlikely to provide detailed information on temporal changes that occur in any given site (Johnson and Miyanishi, 2008). However, examination of this chronosequence was expected to reveal broad, regional-scale successional trends by averaging across site-to-site differences in assemblage structure that occur because of differences in environmental conditions and site history (Foster and Tilman, 2000; Inoue, 2003).

Forest stands were selected according to a stratified random procedure (for details see Santana et al., 2011). Briefly, random locations were distributed across the study area at >800 m from each other, within forest stands with >30% canopy cover by cork oaks. Forests affected by fire were excluded, to avoid confounding the effects of mechanical fuel management and burning. Each random location was classified into one of six structural strata, corresponding to categories of increasing structural complexity of understory woody vegetation, which were based on a putative sequence of successional vegetation development (Santana et al., 2011). Structural categories were used instead of actual understory ages, because management histories could only be assessed *a posteriori* from inquiries and aerial photographs (see below). At each random location, a homogeneous 1-ha plot representative of the dominant structural stratum was chosen, and demarcated in the field. The procedure was repeated until eight plots in each stratum were selected, though three of these had to be excluded because they were managed during the study period. Stratification based on structural vegetation features served solely to guarantee a wide range of variation of understory ages in the sampled stands, and was not used in any analysis.

2.3. Management history

Understory management history was inferred primarily from a sequence of orthorectified and georeferenced digital aerial

Download English Version:

https://daneshyari.com/en/article/4385461

Download Persian Version:

https://daneshyari.com/article/4385461

Daneshyari.com