Forest Ecology and Management 325 (2014) 1–7

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Cavity-nesting birds show threshold responses to stand structure in native oak forests of northwestern Tunisia

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ARTICLE INFO

Article history:
Received 2 January 2014
Received in revised form 17 March 2014
Accepted 21 March 2014
Available online 22 April 2014

Keywords:
Conservation targets
Ecological thresholds
Mediterranean forest
Woodpeckers
Dead wood
Forest harvesting

ABSTRACT

The detection of thresholds in forest bird response to gradients in forest alteration is a powerful approach to quantify their ecological requirements and to develop evidence-based targets for conservation. For this purpose, we analyzed the response of 31 forest bird species to a gradient in forest alteration by human activities (e.g. fire; grazing; firewood collection) in the Kroumirie region of northwestern Tunisia. We surveyed forest birds using point counts at 48 stations located throughout Feija National Park. From a data set of 12 vegetation variables, we obtained a gradient in forest alteration using a principal component analysis. Then, we modeled the probability of detection of bird species along this gradient using logistic regression. We selected the five most sensitive species as target species as indicated by the area under the receiver-operating characteristic curve (AUC). Then, we quantified thresholds in their probability of detection as a function of four habitat structure variables: density of large-diameter trees (dbh > 30 cm), canopy closure, density of snags, and downed woody material.

Nineteen of 31 species exhibited a significant response to forest alteration (PCA1), including 7 positive and 12 negative responses. Among these, the five best models (AUC > 0.8) corresponded to Levaillant's Woodpecker (*Picus vaillantii*), Great Spotted Woodpecker (*Dendrocopos major*), Lesser Spotted Woodpecker (*Dendrocops minor*), Short-toed Treecreeper (*Certhia brachydactyla*), and Atlas Flycatcher (*Ficedula speculgera*). On the basis of their threshold values, we recommend to protect stands with densities of large-diameter trees of at least 650 stems ha^{-1}, and 207 stems ha^{-1} of snags, to meet the structural requirements (90% probability of detection) of the most demanding species, respectively Levaillant's Woodpecker and Atlas Flycatcher.

1. Introduction

Habitat degradation is considered as one of the main threats to biodiversity worldwide (Pimm and Raven, 2000). Millennia of anthropogenic activity in native Mediterranean forests have caused a decline in critical habitat components such as large-diameter trees and dead wood (Clavero et al., 2011), along with an alteration of ecosystem processes such as natural regeneration, mainly through overgrazing (Blondel and Aronson, 1999; Plieninger, 2007) and the use of agricultural land depends on the native forests (Plieninger et al., 2011). Hence, landscapes are composed of a mosaic of native woodland, maquis and grassland (Pereira and Da Fonseca, 2003). Several studies have documented the environmental degradation in the Mediterranean basin and the resulting landscape structure (Atauri and de Lucio, 2001; Pereira and Da Fonseca, 2003; Blondel, 2006; Geri et al., 2010; Pereira et al., 2014a). Others have documented relationships between avian assemblages and habitat structure using bird occurrence and abundance data (Camprodon and Brotons, 2006; Diaz, 2006; Kati and Sekercioglu, 2006; Gil-Tena et al., 2007; Pereira et al., 2014a). A few more studies have identified potential threats to native Mediterranean oak forests and proposed management actions (Godinho and Rabaca, 2011; Robles et al., 2011; Pereira et al., 2014b).

In the Mediterranean region, Santos and Tellería (1992) and Diaz (2006) have shown that pine plantations host fewer species and a lower abundance than the primary forests they are intended to replace. Barrientos (2010) found that a habitat generalist, the Great Spotted Woodpecker (*Dendrocopos major*), mainly used native oak trees to nest in a landscape dominated by pine plantations. However, the breeding habitat requirements of other forest bird species in managed landscapes remain poorly documented,

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http://dx.doi.org/10.1016/j.foreco.2014.03.050
0378-1127/

especially in the southern portion of the Mediterranean basin, even though this information is critical to conservation planning.

In Tunisia, native Mediterranean oak forests persist in the mountains of the Kroumirie region, where clear felling for small scale agriculture, firewood collection, sheep and goat grazing, and anthropogenic fires threaten their persistence. In this context, it is very important to quantify the habitat requirements of species sensitive to human activities to prevent further ecological degradation and promote sustainable land use practices. To protect remnants of native vegetation and to guide their management, conservation strategies should ideally be based on empirically-derived quantitative targets (Villard and Jonsson, 2009). This approach has been applied in hemiboreal and boreal forests through the estimation of critical amounts of habitat, or habitat components, required to reach high probabilities of presence of target species (Bütler et al., 2004a; Homan et al., 2004; Guénette and Villard, 2005; Roberge et al., 2008a). Thresholds have originally been sought at the landscape level (Jansson and Angelstam, 1999; Betts et al., 2007) but some researchers have also documented threshold responses to habitat components at the local scale (Bütler et al., 2004a; Roberge et al., 2008a). We must ensure that threshold ranges are consistent through time and space before using them to develop conservation targets (Betts and Villard, 2009; Müller and Bütler, 2010).

Here, we wanted (1) to determine whether forest birds of the Mediterranean basin exhibit threshold responses to local habitat structure, which might be used as targets for conservation, and (2) to fill the gap of knowledge on the quantitative habitat requirements of Mediterranean forest birds, particularly in north Africa. For this purpose, we modeled forest bird occurrence along gradients in forest alteration; we identified target species exhibiting high requirements for specific habitat parameters; and we quantified those requirements.

2. Methods

2.1. Study area

The study was conducted in Feija National Park (hereafter Feija NP), a Mediterranean ecosystem located in the Kroumirie ecoregion of northwestern of Tunisia (Fig. 1). Altitude ranges from 500 to 1200 m (Statir Peak). The climate is Mediterranean, with hot and dry summers and moist, cool winters. The annual average rainfall ranges from 800 to 1500 mm (Feija National Park weather station).

Feija NP covers 2632 ha, half (1362 ha) of which is represented by Zen oak forest. In the study area, Zen oak is found at high altitudes (800–1000 m). It is a dense forest with tall trees forming a closed canopy and, thus, an open understory. Shrubs are sparse and the herbaceous layer is practically absent. Sporadic livestock grazing contributed to prevent the development of a herbaceous stratum. Natural tree regeneration is also practically absent. Seedlings are grazed within a few years, either by livestock or by wild boars or deer. The ground is covered by a thick layer of leaf litter. Its decomposition gives a mull-humus. Cork oak forest covers 234 ha and is located at lower altitudes (600–800 m). Trees are sparsely distributed, allowing the development of a dense and varied shrub stratum dominated by *Erica arborea*, *Arbustus unedo*, *Calycotume villosa*, and *Pistacia lentiscus*. Mixed forest (zen and cork oak) covers 655 ha, shrubland covers 203 ha, and grassland covers 78 ha.

The status of National Park was attributed to El Feija forests in 1991. Since then, it is officially forbidden to log for cork, dead wood, etc.. It is also prohibited to hunt or to introduce animals. However, 40 families live within the park limits and these families depend on livestock and collect firewood. Hence, there is a significant pressure on the park's forests.

2.2. Bird surveys

We surveyed forest songbirds and woodpeckers using a modified point count method at 48 stations systematically located along wildlife trails and foot paths, at least 150 m away from the nearest road and either 450 m (in zen oak and cork oak forests) or 350 m apart (in shrubland and grassland). We chose those distances in the field using a hand-held GPS unit to reduce the risk of double-counting individuals of species, such as Levaillant's Woodpecker (*Picus vaillantii*).

We conducted surveys during the 2009 breeding season, from 13 to 20 May; 25 May to 3 June and 9 to 17 June. We performed

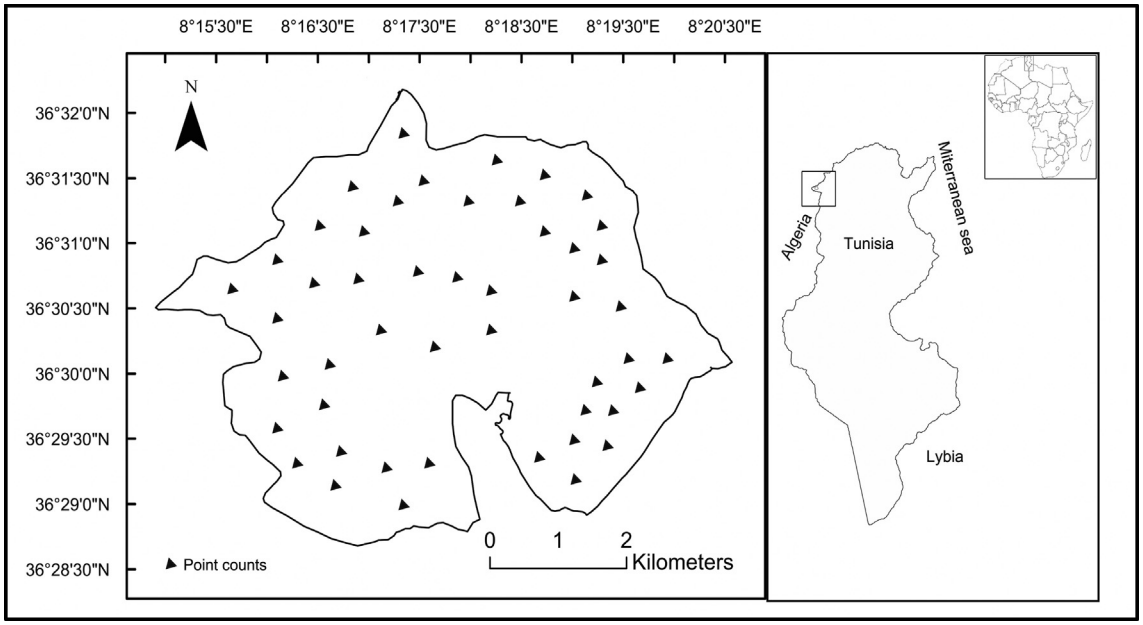

Fig. 1. Study area showing Feija National Park and the location of individual point count stations (black triangles).