



Bird community response in mountain pine forests of the Pyrenees managed under a shelterwood system



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ABSTRACT

Understanding the effects of forest management on biodiversity is a vital challenge given the current regime of large-scale socio-ecological drivers affecting forest ecosystems and their multifunctionality. Here we assessed how forest management affects abundances of common breeding birds in mountain pine (*Pinus uncinata* Ram. ex DC) stands in the Pyrenees. We assessed, at guild level, avian response to changes in stand structure across different management stages in forests managed under a shelterwood system, as well as in unmanaged forests. Bird guilds were based on habitat breadth, nesting habitat, and foraging habitat. Bird abundance was modelled separately for each guild as a function of stand variables known to be good surrogates of stand density (stand density, quadratic mean diameter, shrub cover) and maturity (dominant height, cavities). For this purpose, we used likelihood methods, which provided flexibility in the shape of the expected responses. For most bird guilds, unmanaged forests showed similar bird abundance to managed forests. Total bird abundance was maximum after regeneration cuts, due to the positive response of canopy nesters and canopy foragers. The typical open stand structure after removal cuts negatively impacted forest specialists, cavity nesters and trunk foragers, but the impact was offset by the higher number of generalists, ubiquitous, ground nesters and ground foragers. General stand descriptors such as stand density, quadratic mean diameter and dominant height were the most influential variables, whereas the association of bird abundance with shrub cover and cavities was less influential and guild-specific. We show that a shelterwood system can be a suitable management tool to promote the abundance of most common bird guilds in dense, homogeneous stands, given that some key structural legacies are retained throughout the rotation and stand structure heterogeneity is promoted. By obtaining quantitative relationships between the main structural features affected by harvests and the abundance of birds, we formulate management recommendations that are valid for forests managed not only under shelterwood systems but also under other silvicultural methods.

1. Introduction

The forests of the Pyrenees, like those of most mountains in the Mediterranean basin and Western Europe, have a long history of overexploitation dating back millennia. This trend has drastically reversed since the second half of the 20th century, as depopulation and other socio-economic changes have brought abandonment of farmland, decline in livestock, and widespread desertion of logging and forest

management (García-Ruiz et al., 1996; Cervera et al., 2015), all leading to forest expansion (Roura-Pascual et al., 2005; Ameztegui et al., 2010).

Despite a lack of management for decades, most forests in the region are relatively young and still more conditioned by land-use legacies than by natural disturbance dynamics (Ameztegui et al., 2016). Therefore, they do not present the complex structural features that can be found in natural or old-growth forests in other parts of the world (Wirth et al., 2009; Barbati et al., 2012; Mansourian et al., 2013).

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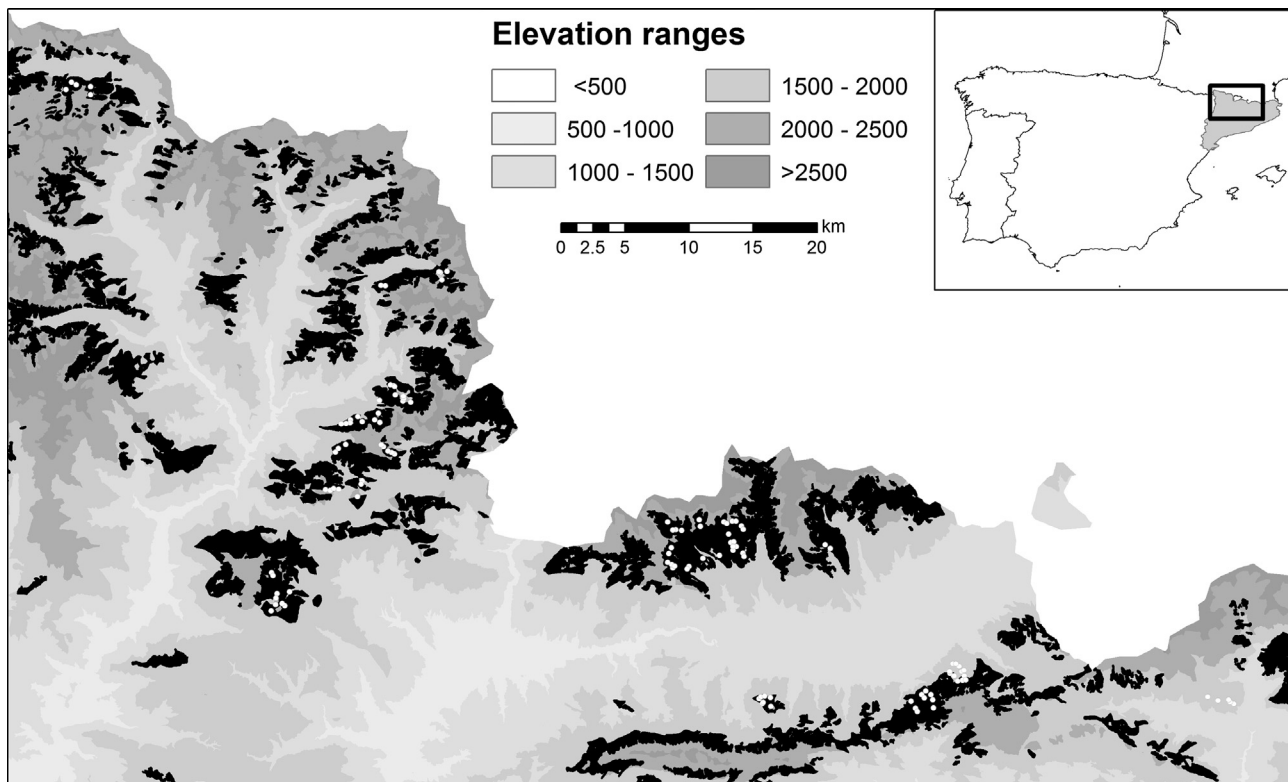


Fig. 1. Study area (upper right) and plot location (white dots) within the mountain pine distribution (in black).

Consequently, current landscape is characterized by large areas of continuous, even-aged forest cover, often with high stem densities (Coll et al., 2012). These homogeneous landscapes are highly vulnerable to natural disturbances (Martín-Alcón et al., 2010) and can compromise the provision of goods and services supplied by forests, including their ability to host biodiversity (Gil-Tena et al., 2007; Moreira and Russo, 2007). For instance, several bird species require heterogeneous stand structures—with vertical stratification—to meet their requirements for foraging and nesting substrates (Bergner et al., 2015; Mag and Ódor, 2015), whereas several other bird species need a mosaic of open areas and forests to thrive, and are currently endangered due to forest expansion (Vallecillo et al., 2008).

In this context, forest management can help break the landscape homogenization process by modifying forest structure and diversifying habitats (Perry and Thill, 2013; Duguid et al., 2016). Of the many silvicultural systems available, most managers of pine forests in the Pyrenees use a shelterwood system. The shelterwood system is applied through a series of partial cuts that progressively remove the entire stand over a fraction of the rotation, usually 20–40 years (Smith et al., 1997), promoting the establishment of a new generation of seedlings before the mature trees are fully removed. Cuts are usually applied on relatively small surfaces (a few hectares), and the method also avoids the period completely devoid of trees that characterizes other silvicultural systems. For all this, the shelterwood system is suggested to favour avian diversity (Goodale et al., 2009; King and DeGraaf, 2000), particularly when applied on small groups (Balestrieri et al., 2015) and if the rotation period and/or proportion of shelter trees are increased (Mag and Ódor, 2015).

Some of the key structural features of forests—such as tree density, basal area, dominant height or understory development—vary significantly throughout the rotation of a forest managed under shelterwood systems. Birds are a taxon particularly responsive to changes in forest structure (Camprodon and Brotons, 2006; Gil-Tena et al., 2007; Nikolov, 2009), but the structure resulting from each management stage affects avian diversity in a guild-specific way depending on the

functional requirements of its organisms (e.g. Balestrieri et al., 2015; Mag and Ódor, 2015). However, the direct relationship between the main forest structural features and avian diversity over time is not yet well known.

Here we analyzed bird communities across a geographical gradient of mountain pine (*Pinus uncinata* Ram. ex DC) forests in the Pyrenees. We sampled bird abundance at three different stages in the rotation of forests managed as a shelterwood system, as well as in unmanaged stands. This approach captured the full range of forest structural variability throughout rotation. Our aim was (i) to assess abundance variability in several bird guilds—based on habitat specialization and nesting and foraging substrates—across successive management stages, and (ii) to quantify and model the relationship between the main structural features that are modified by management and the abundance of different bird guilds. Given that shelterwood cuts gradually modify several key features of forest structure at relatively small spatial scales and relatively long timespans of decades, our hypothesis is that the progressive reduction in stand density will not substantially affect bird abundance provided that key nesting and foraging resources are maintained. However, the drastic changes in forest structure after the removal cuts are likely to induce sharp changes in the avian community.

2. Materials and methods

2.1. Study area and surveyed stands

Our study area was the subalpine mountain pine forests of the Catalan Pyrenees. Mountain pine (*Pinus uncinata* Ram. ex DC) is a shade-intolerant, soil-indifferent conifer dominating the subalpine belt of the southern Pyrenees between 1700 and 2400 m a.s.l., where it covers over 60,000 ha (Coll et al., 2012). Mountain pine forests constitute favourable habitats for a large community of plant and animal species, and have been classified as Habitat of Community Interest (92/43/EEC) when distributed on siliceous substrates (habitat code 9430)

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