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Research Paper

Coupling a landscape-based approach and graph theory to maximize multispecific connectivity in bird communities

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ABSTRACT

Environmental policies have highlighted the importance of preserving ecological networks to limit the fragmentation of natural habitats and biodiversity loss. A crucial issue for landscape managers is how to reconcile conservation measures that benefit all species and the maintenance of human activities. This study aimed to promote landscape multifunctionality, i.e., improving connectivity for several species without significantly modifying human activities. The objectives were to identify the most strategic natural landscape types to prioritize for preservation and to propose landscape management actions in highly anthropized areas that would benefit a majority of species. The analysis combined landscape types and bird species observation data to model landscape suitability for six species profiles defined by their affinity for wetlands, agricultural areas, urban areas and three types of forested landscapes. By graph modelling, we analysed the functional connectivity of the ecological networks of these species profiles. The results revealed that only ten landscape types out of 72 were core habitats for three species profiles simultaneously. These were primarily forested landscape types — either strict or associated with open areas (wasteland, forest clearing). Conversely, some anthropogenic landscapes dominated by built areas and sometimes shared with agriculture were completely unfavourable for all species profiles. The graph modelling analysis showed that the transformation of some landscape types could potentially improve connectivity for four species profiles presenting different ecological requirements. This coupling approach thus provided guidance to propose some landscape management actions that benefit the majority of species while preserving land uses.

1. Introduction

The expansion of human activities causes significant environmental impacts to both landscapes and species. The conversion of land cover types and the intensification of land use practices lead to a reduction in the quality and quantity of habitat and increased isolation of habitat patches (e.g., Benton, Vickery, & Wilson, 2003; Saunders, Hobbs, & Margules, 1991). Landscape modification and habitat fragmentation affect the behaviour, biology and interactions of species in different ways, such as by disrupting dispersal, changing movement patterns, altering home ranges or increasing predation risk (Fahrig, 2010; Fischer & Lindenmayer, 2007). These impacts are particularly strong on specialist species, an ecological consequence especially well documented for birds (Devictor et al., 2008). The abundances of specialist bird species tend to decline more strongly than those of generalists with increasing fragmentation, which has been observed in the case of specialization to the main habitats, i.e., forests (Gregory et al., 2007), farmlands (Chamberlain, Fuller, Bunce, Duckworth, & Shrubb, 2000; Jeliazkov et al., 2016) and urban lands (Pellissier, Cohen, Boulay, & Clergeau, 2011; Pellissier, Mimet, Fontaine, Svenning, & Couvet, 2017).

Environmental policies (e.g., Grenelle in II, 2010) have highlighted the importance of preserving ecological networks to reduce habitat fragmentation and biodiversity loss. These networks include both core habitat areas and corridors between habitat patches (Boitani, Falcucci, Maiorano, & Rondinini, 2007). As they encompass the entire area in which a species can complete its life cycle (e.g., feeding, breeding, dispersing), networks are key to maintaining and restoring landscape connectivity and to ensuring the persistence of species populations. Defined as "the degree to which the landscape facilitates or impedes movement among resource patches" (Taylor, Fahrig, Henein, & Merriam, 1993), landscape connectivity is highly dependent on the species considered. Among the various methods to analyse

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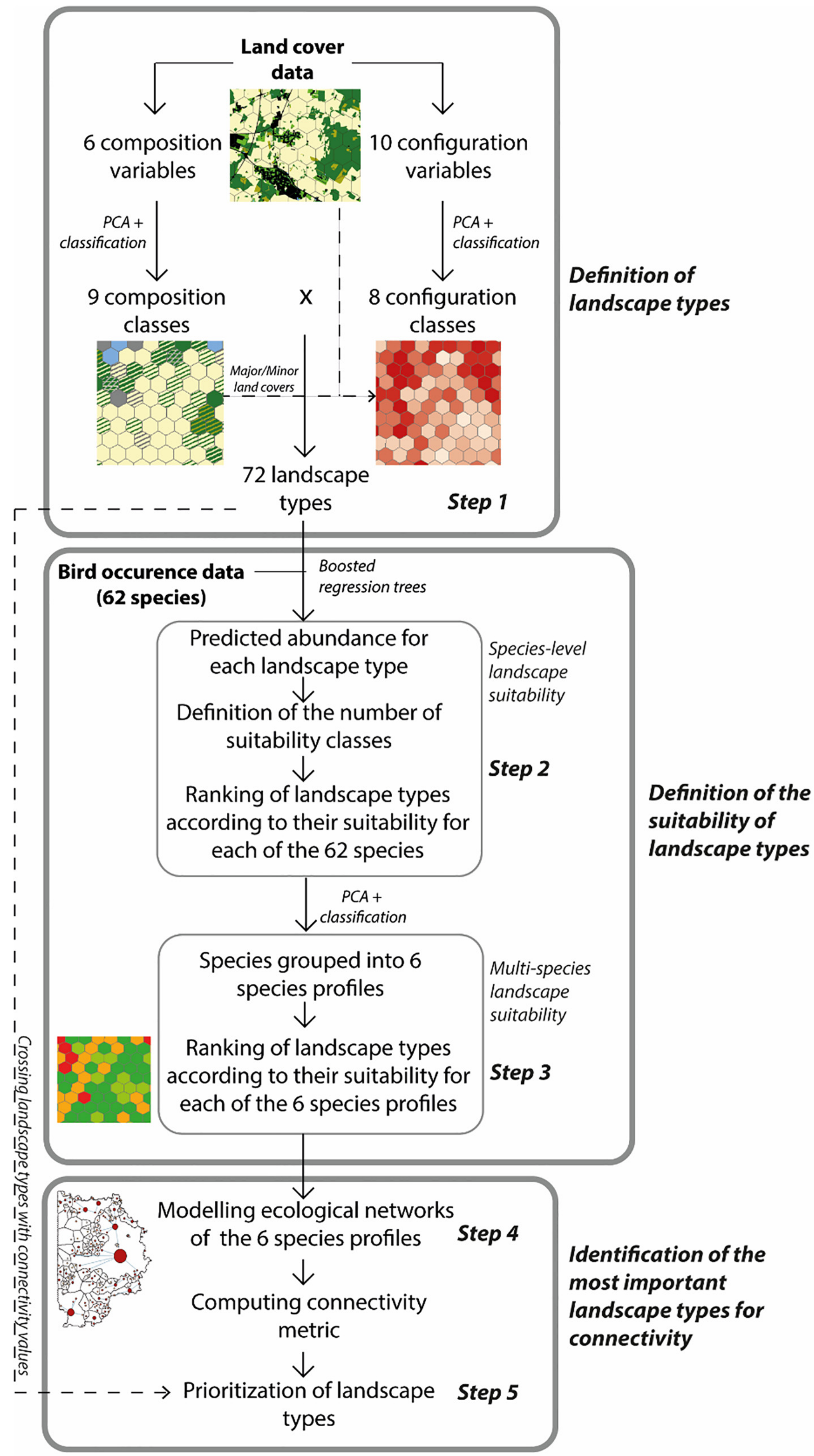

Fig. 1. Schematic representation of the workflow for modelling and maximizing the connectivity of multispecific ecological networks. For further details on the composition and configuration variables, see the Methods section.

connectivity, graph modelling is recognized as a powerful tool for representing potential movements of species (Urban, Minor, Treml, & Schick, 2009). This tool is increasingly used in land-use planning for habitat prioritization, environmental impact assessment and connectivity improvement (Foltête, Girardet, & Clauzel, 2014; Zetterberg, Mörtberg, & Balfors, 2010). Nevertheless, the use of graph modelling