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Do factors describing forest naturalness predict the occurrence and abundance of middle spotted woodpecker in different forest landscapes?

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ABSTRACT

Conservation biologists often use some specialized species as surrogates for communicating conservation needs, e.g. to signal states and changes in ecosystem. This requires a detailed knowledge of a species' habitat demands and relationship between its occurrence and abundance, and certain environmental conditions. This paper explores the relationship between the occurrence and abundance of middle spotted woodpecker (*Leiopicus medius*) and structural, compositional, and functional elements of forest naturalness in three different forest landscapes in Poland, which encompass a wide spectrum of species' habitats. Neither compositional nor functional elements of forest naturalness seemed to affect species' distribution. In all studied areas, environmental variables related to the structural elements of forest naturalness, e.g. the share of old and uneven-aged stands, number of large living trees, positively influenced the occurrence and abundance of middle spotted woodpecker. Mature, unevenly structured forests might occur as a result of sustainable forest management, aimed at preserving the continuity of old stands and the maintenance of diverse age and species' structure, providing suitable habitat condition for the species. Therefore, both presence and abundance of middle spotted woodpeckers can serve as indicators of wildlife-friendly forest management in deciduous forests.

1. Introduction

The ambiguous term "forest naturalness" is still one of the main problems in studying the relationship between forest-dependent species and their environment. According to Winter (2012), naturalness can be either the state of ecosystem undisturbed by humans or the difference (often referred to as the degree of naturalness) between the primeval and the current state. The main problem with the former approach is the lack of reference point—forest ecosystems truly undisturbed by human activities (Chiarucci et al., 2010; Parviainen, 2005; Winter, 2012). The latter is often used in forest conservation strategies to assess the ecological value of forest ecosystems (McRoberts et al., 2012).

The degree of forest naturalness can be analyzed at three levels: compositional, structural, and functional level of ecosystem (Roberge et al., 2008). Compositional level refers to the occurrence of elements that are characteristic of forests with a high degree of naturalness, e.g. high number of native tree species and dead wood diversity. Structural level relates to the spatial configuration of the elements and their quantities, e.g. diversification of the age and vertical structure of stands, and microhabitats such as hollows and giant trees. Functional level concerns the processes that are characteristic for natural dynamics, disturbances, and succession of the forest ecosystems, and to the anthropogenic change (Angelstam et al., 2004; Brumelis et al., 2011; Bütler et al., 2004; Korpilahti and Kuuluvainen, 2002; Kurlavicius et al., 2004). The above-described conditions might be interrelated, i.e. natural disturbances serve as a driving factor of uneven stand structure; the presence of trees of various age and size results in high diversity dead wood of different types, and so forth. Yet despite many studies on forest naturalness, these criteria are still not harmonized with forest inventory database and management plans (Korpilahti and Kuuluvainen, 2002; Winter, 2012). The possible solution to this problem is to use only selected criteria that can be translated into quantifiable indicators based on available datasets ready-to-use or field measurements designed for the specific purpose of study.

Conservation biologists often use some specialized species as surrogates for communicating conservation needs. Some species

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have particular attributes that may enable them to signal changes in ecosystems, e.g. extent of various types of anthropogenic influence, population trends in other organisms, or to locate areas of high biodiversity (Caro and O'Doherty, 1999). Among forest-dependent birds, several woodpecker species are assessed as indicator species due to their dependence on habitat components typical for natural forests. They require large home ranges and often depend on dead and large trees for nesting and foraging (Mikusiński and Angelstam, 2004). Most woodpeckers excavate holes, especially in dying or decayed trees (Kosiński and Kempa, 2007; Wesołowski, 2007). Mikusiński and Angelstam (1997) demonstrated that the history of forest use and the level of economic development have affected the occurrence of specialized woodpecker species throughout Europe. This relationship was confirmed by several studies (Angelstam et al., 2003; Roberge et al., 2008; Spitznagel, 1990). The occurrence of particular woodpecker species and woodpecker richness has been shown to be excellent indicators of species' richness and/or abundances of other forest birds (Drever et al., 2008; Mikusiński et al., 2001; Roberge and Angelstam, 2006).

The effective indicators assessing changes in habitat (e.g. forest naturalness), called "health indicators," are likely to be small, resident species, restricted to certain habitats, and with wide geographic range (Caro and O'Doherty, 1999). The middle-sized (20–22 cm; wing-span 33–34 cm), non-migratory middle spotted woodpecker (*Leiopicus medius*), distributed over large parts of Europe from NW Spain to western Russia and from the coasts of the Mediterranean to the North and Baltic Sea (Pasinelli, 2003), is considered as one of the best indicators of forest naturalness (Roberge et al., 2008). This species is associated with mature, rough-barked deciduous stands (Hertel, 2003; Kosiński, 2006; Pasinelli, 2003). Moreover, middle spotted woodpecker often uses polyphore-infested trees for excavating holes (Kosiński and Winiecki, 2004; Pasinelli, 2007). These studies suggest that some habitat components associated with forest naturalness might have an impact on the presence of middle spotted woodpecker. However, Landres et al. (1988) noticed that although geographically separated habitats appear similar, in fact, they might vary, e.g. in vegetation structure, habitat, and resource patchiness, and natural disturbance regimes. Such discrepancies in habitat features might affect indicator species' responses. Several studies found that middle spotted woodpecker exhibited a certain degree of flexibility in habitat use, utilizing other habitats than mature oak stands, i.e. beech and alder stands, commonly associated with its occurrence (Hertel, 2003; Pasinelli, 2003; Stachura-Skierczyńska and Kosiński, 2014; Weiß, 2003; Winter et al., 2005). However, it might be speculated that its occurrence and abundance in geographically separated areas depend on similar structural characteristics of forest stands. Early research that assessed the relationship between the presence of the middle spotted woodpecker and the degree of naturalness of the forests was restricted to two regions in the European hemiboreal zone (Roberge et al., 2008). However, to achieve knowledge that could be widely applicable to solve conservation problems, e.g. use the middle spotted woodpecker as an effective indicator of forest naturalness with wide geographic range, studies of habitat selection should be replicated across the geographically separated habitats within the species' range (Roberge et al., 2008). In this study, we analyzed the relationship between the occurrence and abundance of middle spotted woodpecker and forest naturalness within the species' continuous range in different types of forest landscapes. All studies areas were located in the zone of temperate deciduous forests encompassing a wide spectrum of woodpecker habitats, mostly in productive forests characterized by long history of use and different degree of human alteration.

In this article, we focus on the following questions: (1) Which factors related to forest naturalness affect the presence and abundance of middle spotted woodpeckers? (2) Do geographically separated habitats show the same pattern of species' response to factors describing forest naturalness? Finally, we discuss the usefulness of middle spotted woodpecker as an indicator of forest naturalness according to the knowledge about species' habitat requirements.

2. Material and methods

2.1. Study area

Studies were performed in Poland, in three NATURA 2000 Special Protection Area sites (Fig. 1), differing with regard to dominant forest types, history, and intensity of management use: Krotoszyn Oak Forest (KOF), Forest at the Drawa River (FDR), and Knyszyn Forest (KF). All studied areas were located in the deciduous forest zone, which encompass a wide spectrum of potential woodpecker habitats: oak-dominated old growths, oak-beech nemoral forests, deciduous forests with maple and lime and alder bogs. KOF (17°32′17″E, 51°38′36″N) consists of several small isolated forest patches of about 15,600 ha in total, surrounded by agricultural areas. Stands dominated by pedunculate oak (*Quercus robur*) cover about 7400 ha (47% of total forest cover). Almost 66% of oak-dominated stands are over 100 years old, which signifies that KOF has the largest concentration of old oak forests in Central Europe (Kasprowicz, 2010). Most of oak stands are intensively managed with clear-cutting (about 51% of all cutting area), except for few reserves covering less than 1% of total forest area. FDR (15°53′37″E, 53°02′32″N) covers about 115,000 ha of forest land. Scots pine (*Pinus sylvestris*) is a dominant species, mainly on sandy soils, abandoned fields and grasslands, and sites primarily covered by broadleaved and mixed forests that were destroyed during wars. Deciduous stands, mainly with oak and beech (*Fagus sylvatica*) or ash (*Fraxinus excelsior*) and alder (*Alnus glutinosa*), along water courses are located mostly in the southern part of the area covering about 11,200 ha (9.7% of forest land); however, stands with oak as a dominant species constitute less than 5000 ha (4.3% of total forest cover). Beech and oak stands are usually managed with shelterwood. In total, clear-cutting constitutes about 29% of all cutting area. Protected forests, including the Drawieński National Park, cover about 9% of the total forest area. KF (23°24′18″E, 53°03′23″N) encompasses about 92,000 ha of forests. Pine is the dominant species, followed by spruce (*Picea abies*), birch (*Birch* sp.), and alder. KF has been an important timber growing area since the 16th century, with several episodes of wanton exploitation during wars (Czerwiński, 1995). Deciduous stands cover approximately 12,000 ha (13% of forest land), but stands with dominating oak make only 3400 ha. The most common management practices in deciduous forests are clear-cutting (alder bogs) and selective cutting with long rotation period (species-rich deciduous stands). In total, clear-cutting constitutes about 24% of the total cutting area. Protected reserves cover approximately 4% of the total forest area. More detailed characteristics of forest stands are given elsewhere (Stachura-Skierczyńska and Kosiński, 2014).

2.2. Woodpecker occurrence data

Woodpeckers were counted on 1 km^2 sample plots, selected at random, during pre-breeding periods (from the second half of March until the end of April) in 2010 (KOF), 2010–2011 (FDR), and 2011–2012 (KF) (Stachura-Skierczyńska and Kosiński, 2014). Two regions (FDR and KF) were surveyed in two years due to the large number of sample plots. During the long-term monitoring of middle spotted woodpeckers (15 years) on two large study plots in western Poland, we found that the number of territories varied slightly between years (coefficient of variation CV = 7.4 and