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A guild-based approach to assessing the influence of beech forest structure on bird communities

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ABSTRACT

The advantages of using birds as indicators of biodiversity and/or habitat quality in forest habitats rely principally (1) on their relative ease of detection and (2) on their strong association with many forest features. Here we investigate how forest structure can shape a bird community at the stand level (ca. 30 hectares), using an expeditious sampling protocol and a simple but reasoned guild approach. We focused on three beech (*Fagus sylvatica*) forests in Italy with different structures resulting from different management histories: Cansiglio, Chiarano-Sparvera and Marchesale. We hypothesise that the abundance of the selected guilds varies in relation to forest structure as a result of forest management; to test this hypothesis we modelled guild abundance along a latitudinal transect in a similar habitat (*i.e.* beech forest) in order to offset the geographical and environmental sources of variability. Birds were surveyed through replicated aural/visual point counts. Thus we identified four guilds: generalist cavity nesters (TIT), generalist canopy nesters (WAR), insectivorous cavity nesters (INS) and granivorous canopy nesters (FIN). Forest structure and deadwood were estimated for each of the 27 sampling points. Guild abundance was estimated using the N-mixture models approach, which allows the mean abundance at each sampling location and the detectability to be estimated. Both the mean abundance and detectability were constrained to forest structure and time variables. Guild-estimated abundance was tested for differences among sites using ANOVA. Mean guild abundance proved different only for two guilds. INS was more abundant in Cansiglio than in Chiarano and Marchesale while between Chiarano and Marchesale there was no significant difference. Also WAR abundance was greater in Chiarano, followed by Marchesale and Cansiglio. Shelterwood management may result in a higher abundance of specialist guilds (*i.e.* insectivorous cavity nesters), compared to other management options. Our results highlight this pattern in the Cansiglio forest, where the age and the applied treatments resulted in a lower tree density and in a larger mean diameter. Such features are often correlated with a larger amount of dead wood which, in turn, promotes the presence of cavity nesters, otherwise rare-to-absent in the bird community. Forest structure is largely influenced by forest management that can be guided to benefit specific bird assemblages by applying specific treatments focused at increasing structural diversity and at multi-functionality.

1. Introduction

In the last few decades traditional forestry has begun to be replaced in many western European countries by a more sustainable approach to harmonising forest harvesting with biological conservation, carbon sequestration and long-term timber production. A pan-European strategy has been set up and developed to meet these goals (Rametsteiner and Mayer, 2004) and, regarding biological conservation, great efforts have been placed on the use and development of biodiversity indexes as well as indicator species to provide guidance for forest management (Lindenmayer et al., 2006, 2000; Noss, 1999).

Although the Forest Principles, drawn up during the United Nations Conference on Environment and Development in 1992, declared that the conservation of biological diversity was one of the main goals in sustainable forest management, this purpose is often difficult to pursue due to the uncertain response of the animal community to forestry, which can be largely dependent upon: (1) local conditions; (2) the *taxa* involved, and on (3) the

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time scale and spatial extent involved. For example, habitat loss is widely recognised as one of the major causes of biodiversity decline (Brooks et al., 2002; Pimm and Raven, 2000), but habitat fragmentation could cause positive, negative or null effects on biodiversity (Fahrig, 2003; Jansson and Andre, 2003; Villard et al., 1999). Furthermore, the onset of edge effects after forest cutting and their misinterpretation can lead to poor understanding of the ecological system and of its reaction to disturbance (Craig, 2007; McCollin, 1998; Murcia, 1995; Ries et al., 2004). Hence, biodiversity indexes which have, like all indices, a high synthesis capability but limited power of analysis, should be used with great caution and results carefully interpreted and transferred to other forest contexts.

Another approach concerns the use of biological indicators, defined as indicators of biodiversity and/or of abiotic conditions as well as of changes in ecological processes (Spellerberg, 1994). The fundamental principle of this approach is founded on the assumption that the occurrence, or abundance, of an indicator species could be informative about co-occurring species. Although this is not necessarily true (Morrison, 1986), an indicator may provide reliable information about species with similar characteristics, like nesting sites or feeding habits (Severinghaus, 1981). This approach is based upon the guild concept, which has been defined as a 'group of species that exploit the same class of environmental resources in a similar way' (Root, 1967), and it may be a very powerful tool in detecting changes in natural systems. The guild approach, given the possibility to aggregate data, has proved useful in data analyses and results interpretation, given that inventories of forest birds may result in a large number of species and individuals (Canterbury et al., 2000; Nikolov, 2009; Verner, 1984).

Birds have been widely studied as biological indicators in many habitats such as wetlands (Croonquist and Brooks, 1991), streams (Bryce et al., 2002), rangelands (Bradford et al., 1998) and forests (Canterbury et al., 2000). The advantages of using birds as indicators of biodiversity and/or habitat quality in forests rely principally (1) on the relative ease of detection and (2) on their strong association with many forest features. Abundance and compositions of bird communities are affected by many forest features. These include the dominance of coniferous or broadleaved trees (Donald et al., 1998), the presence of plantation forests of non-local species (Deconchat et al., 2009), the abundance of old and dead trees, which usually provide plenty of nest sites (Newton, 1994; Robles et al., 2011), silvicultural techniques (King and DeGraaf, 2000), the spatial scale at which disturbances take place (Drapeau et al., 2000), and the presence of primary cavity nesters, *i.e.* woodpeckers, building microhabitats and nest cavities (Martin and Eadie, 1999; Newton, 1994).

Most of the above studies focused on a medium/large spatial extent and therefore refer to changes in the overall forest environment. Conversely, fewer studies have focused upon smaller extents, investigating the influence of changes in forest structure on the bird community at the level of a single forest stand (or smaller) (Carrillo-Rubio et al., 2014; Nikolov, 2009; Spiering and Knight, 2005), which is the most common extent at which forest harvesting takes place in Italy.

Here we investigate how forest structure can influence bird community at the stand level (ca. 30 hectares), using an expeditious sampling protocol and a simple but reasoned guild approach. We hypothesise that the abundance of the selected guilds could vary in relation to forest structure. To test this hypothesis we modelled guild abundance along a latitudinal transect within three beech forests (*Fagus sylvatica*) in order to offset the geographical and environmental sources of variability. Furthermore, as forest structure is strongly influenced by management, our study wanted also to test how different forest management options may influence bird communities.

2. Materials and methods

2.1. Study area

This research was developed within the sub-action Forest Biodiversity (ForBD) of the Life+ project ManFor C.BD. (*Managing forests for multiple purposes: carbon, biodiversity and socio-economic wellbeing*). Among the seven study sites in Italy we selected three beech stands of 30–35 ha located within (1) Cansiglio Forest (Veneto Pre-Alps) in the Campo di Mezzo-Pian Parrocchia State Reserve, (2) Chiarano-Sparvera Regional Forest (Abruzzo, central Apennines) and (3) Marchesale State Reserve (Calabria, southern Italy). Although all the study sites lie within the *Fagetum* phytoclimatic band, they have a different structure due to different management histories. The surface that was interested by the study is between 30 and 35 ha. The Cansiglio and Marchesale stands are embedded within an extensive forested area of mainly beech interspersed with a few scattered secondary pastures, while the Chiarano-Sparvera stand represents the southernmost portion of a large beech forest and is mostly surrounded by pastures.

The northernmost site is located within the Cansiglio Forest (CA) (Veneto Region, 46°03′N, 12°23′E) lying on a limestone-marl bedrock; it has a gently sloping morphology with small ridges and valleys. Its elevation ranges from 1280 to ca. 1380 m a.s.l.; mean yearly temperature is 5.6 °C and mean annual rainfall is 1660 mm. The stand is a mainly even-aged beech high-forest with sporadic silver fir (*Abies alba*) and spruce (*Picea abies*) though mature and ultra-mature high-forest and regeneration stages also occur. The applied treatment is shelterwood, harvesting usually occurring in small groups.

The Chiarano-Sparvera (CS) site is located in the middle of the latitudinal transect within the central Apennines in Abruzzo (41°51′N, 13°57′E). The stand has an elongated shape and is separated into two contiguous parts by a very narrow strip of meadows and rocks. Elevation ranges from ca. 1700 to 1800 m a.s.l. and the landscape morphology comprises an almost uniform (22–28.5°) north-east facing slope on Cretaceous limestone. The mean yearly temperature is 8.5 °C while average annual rainfall is 1100 mm. The management type was coppicing with standards until the early 1970s, when conversion to high-forest started with a first thinning of sprouts from the stumps, leaving 1 or 2 stems per stump maximum; the stand is currently a relatively young even-aged high-forest.

The southernmost stand is located within the Marchesale State Reserve (MA) in Calabria (38°30′N, 16°14′E). Its elevation ranges from 1100 to 1200 m a.s.l. The landscape morphology consists of an alternation of small hills (slope ~40%), valleys and plateaux, with a north-facing aspect. The bedrock is granite of the Serra and Sila formation. Yearly mean temperature is 10.1 °C and mean annual rainfall is 1880 mm. A small portion (5%) of mixed beech-silver fir high-forest can be found at the border of the area. It is an even-aged beech forest with both young and adult stages. Treatment type is single tree selection.

2.2. Bird sampling protocol

Each stand was divided into nine equal sized (2.5–3 ha) patches, in which centroid, birds were counted by means of unlimited radius point counts (Blondel et al., 1981). The minimum distance between sampling points was 130 m (mean ± sd = 164.8 ± 30.2). Each of the 27 sampling points was surveyed 2–5 times (mean = 3.5) in 2012, from mid-May to late-June. Within this period, sampling was replicated at intervals spanning from 1 day to 43 days (average = 8.5 days). We assume that surveys conducted