



Modelling distribution of habitats required for different uses by the same species: Implications for conservation at the regional scale



Mattia Brambilla^{a,b,*}, Fabio Saporetti^c

^a *Fondazione Lombardia per l'Ambiente, Settore Biodiversità e Aree protette, Largo 10 luglio 1976 1, I-20822 Seveso, MB, Italy*

^b *Museo delle Scienze, Sezione Zoologia dei Vertebrati, Corso del Lavoro e della Scienza 3, I-38123 Trento, Italy*

^c *Gruppo Insubrico di Ornitologia, Civico Museo Insubrico di Storia Naturale di Clivio e Induno Olona, Via Manzoni 21, 21050 Clivio, VA, Italy*

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ABSTRACT

Most modelling exercises use generic occurrence points of a species, but the distribution of habitats used for different purposes may differ. Modelling separately the availability of functionally different habitats may allow for the identification of the habitats mostly affecting/limiting distribution, with important implications for conservation. We analyzed the regional distribution of the black woodpecker in Northern Italy. We separately modelled the availability of feeding and nesting habitats at the fine scale (20 m × 20 m), and compared the outputs with a more conventional distribution modelling procedure, which included all records and was developed at the territory scale (1 km × 1 km). Both the conventional and feeding habitat models performed well (although they tended to under- and overestimate occurrence, respectively), whereas the nesting habitat model had a lower discriminatory ability. Nesting and feeding habitats show different relationships between woodpecker occurrence and habitat variables, this resulting in a weak overlap of the respective niches and in quite different distributions. The conventional model provided less information for management, being mainly affected by elevation and urbanized areas; the two specific models instead showed effects of habitat variables on occurrence of feeding and nesting sites. The availability of feeding habitat is likely the most important factor limiting distribution in the area and could be the focus of possible habitat management, which should include the preservation of grassland patches interspersed within woodlands, especially on South-facing, gently sloping mountainsides. Modelling separately the availability of functionally different habitats may provide useful information for conservation and management.

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1. Introduction

Modelling habitat suitability and species' distribution are increasingly important subjects in ecology and conservation biology, and have become one of the main tasks for those scientific disciplines (Rushton et al., 2004). The importance of knowing the spatial distribution of a species and the spatial configuration of its preferred habitats, coupled with the ever increasing availability of data layers with habitat information and of high-performance methods and programs, has resulted in a huge production of distribution models for plant and animal species (Elith et al., 2006). Such models have been used to predict the current distribution, but also to forecast the future and to estimate the past distribution of target species (Fouquet et al., 2010; Louzao et al., 2013). The commonest

of those models are correlative species distribution models (SDMs), which assess relationships between species distribution data and environmental features, to evaluate the suitability of a given area for a species of interest. Models provide a measure of the probability of presence or an estimate of the environmental suitability, which can be used to define species' spatial occurrence (Graham et al., 2004a; Brambilla et al., 2009; Báez et al., 2012), inform surveys (Raxworthy et al., 2003; Bourg et al., 2005), evaluate impacts of climate and habitat change (Thuiller et al., 2005a; Brambilla et al., 2010a; Fouquet et al., 2010; Elith et al., 2011; Chamberlain et al., 2013; Temunović et al., 2013; Brambilla and Gobbi, 2014), test evolutionary hypotheses (Peterson et al., 1999; Graham et al., 2004b), predict species invasions (Roura-Pascual et al., 2004; Thuiller et al., 2005b; Rödder and Lötters, 2009; Ficetola et al., 2010; Stiels et al., 2011; Barbet-Massin et al., 2013) and inform conservation planning (Araújo and Williams, 2000; Ferrier et al., 2002; Rödder et al., 2010). In recent years, SDMs have become one of the most frequent tasks in conservation, and

* Corresponding author at: Fondazione Lombardia per l'Ambiente, Settore Biodiversità e Aree protette, Largo 10 luglio 1976 1, I-20822 Seveso, MB, Italy. Tel.: +39 02 80616123.

E-mail address: brambilla.mattia@gmail.com (M. Brambilla).

presence-only and presence-background SDMs are becoming prevalent because they do not require absence data (Jiménez-Valverde et al., 2008). Their use has been progressively extended beyond the description of the crude species' distribution, and recently SDMs have been adopted also to estimate maximum abundance (VanDerWal et al., 2009), population density (Oliver et al., 2012) or reproductive parameters, such as productivity and territory size (Brambilla and Ficetola, 2012).

Until now, modelling exercises mostly used presence data collected in multiple ways, including all occurrence points in a unique dataset, without distinguishing among 'functionally different' records of the model species (e.g. breeding, foraging, etc.), or among records of individuals of different sexes or ages, which also can use different habitats and sites (e.g. Singh et al., 2010; Ficetola et al., 2013). However, such records tied to different type of individuals or animal activities are likely to occur in mobile animal species with complex habitat requirements (González-Solís et al., 2008; Ficetola et al., 2009). The overall distribution of an animal species may result from the combination of factors acting at different spatial scales (Brambilla et al., 2010b; Hortal et al., 2010), and may be affected by species interactions (e.g. Giannini et al., 2013). At the regional scale, species distribution may theoretically be driven by the combination of the relative distributions/availability of habitats used for different purposes or by different individuals. This is the reason why various types of habitats should be included within cells used as units for such species; some alternative approaches have been proposed to address this task (Guisan and Thuiller, 2005): (i) larger modelling cells accounting for larger portions of the landscape, to ensure that all habitat types can be included (Jaberg and Guisan, 2001); (ii) focal predictors that summarize information on the neighbouring landscape within the focal cell; or (iii) fitting a separate model for each type of habitat use or for various types of individuals. Due to several reasons including this neighbourhood influence (information in a given point relate also to the adjacent habitat patches), valid absences are hard to obtain for these species (Boyce et al., 2002), and in most cases specific presence-only models should be fitted (Guisan and Thuiller, 2005). The use of large modelling cells (including several habitat types) is likely to be the approach currently most used for wide-ranging, large species. Here, we explore the results of building a model with large cells, to ensure that all habitat types can be included (Jaberg and Guisan, 2001), and the results of fitting models separately for each type of habitat used (cfr. the third approach described above), considering focal predictors that summarize information on the neighbouring landscape within the focal cell (cfr. the second approach described above).

In this study, we analyze at the regional scale the breeding distribution of the largest Eurasian woodpecker species, the black woodpecker *Dryocopus martius*. We model the species distribution using all species records at a large scale, and the fine-scaled distribution of habitats used for different activities (feeding and nesting/resting, respectively) by the species, which uses nests also as resting sites (Cramp, 1985). Then, we compare the outputs of the different modelling procedures (cfr. Estrada and Arroyo, 2012) to evaluate the similarity of the predicted distributions and estimate niche overlap (Warren et al., 2008) between feeding and nesting habitat suitabilities.

We believe that such a kind of assessment is potentially relevant to both modelling ability and conservation planning. If modelling separately the availability of habitats with different functions provides more accurate models than traditional methods, when adequate data are available such an approach can be adopted for wide-ranging species with complex requirements to allow finer predictions of their distribution. On the other hand, and more importantly, pointing out what kind of functional habitat is currently lacking or under-represented for a species in a given

area could allow conservationists to implement the most suitable management for the target species, without unnecessary efforts. If functional habitats differ in their features, and just one or a few are affecting a species in a portion of its range, focussing on the relevant functional habitat(s) would promote species occurrence/abundance and avoid wasting resources to promote the availability of already existing habitats.

2. Materials and methods

2.1. Model species

The black woodpecker inhabits a wide variety of forest habitats, especially coniferous, mixed and beech *Fagus sylvatica* woodlands (Cramp, 1985). The home-ranges of the species are usually comprised between one and a few hundreds of hectares (Cramp, 1985), and a radio-tracking study in the Italian Alps suggested that home-ranges average 316 ha, whereas the area most exploited (core area) during breeding period averages 92.4 ± 10.9 ha (Bocca et al., 2007). This species generally prefers woodland with large trees, favouring tall trunks of climax and mature forest, preferably well spaced, to which it is tied for nesting; on the other hand, it often feeds on ants, thus relying also on more or less open ground for foraging (Cramp, 1985), or on young plantations (Rolstad et al., 1998).

We believe that black woodpecker in the study area could be a good model species to investigate the fine-scaled distribution of habitats required for different uses, because of the following reasons: (i) all the area we investigated is within the dispersal distance (cfr. Merow et al., 2013) shown by the species (Cramp, 1985), which actually had been observed outside the breeding season in all the geographical sectors of the area (Saporetti et al., unpublished data); (ii) interactions with other species are unlikely to affect the distribution of that species at that scale, as the black woodpecker has a very few predators and competitors in this part of its range (cfr. Cramp, 1985).

In the study area, the black woodpecker is still expanding its breeding range, from the mountain portion in the north, the first to be occupied, toward the lowland areas in the south-western areas (Saporetti, 2010).

2.2. Study area and fieldwork

Our work took place in the province of Varese, Lombardy, N Italy. The province of Varese encompasses c. 1200 km² of mainly hilly and low-mountain areas (elevation 140–1650 m a.s.l.), with a gradient of increasing elevation from south to north. The landscape is dominated by woodland in the north, whereas in the south urbanized areas alternate with intensive cultivations and woodlands especially along river valleys (C.C.I.A.A., 1988). The climate of the area (pre-Alpine wet climate, without arid seasons) is characterized by relatively abundant precipitation (1100–2300 mm/year over the study area) with two maxima (in spring and autumn) and relatively small temperature variability. Climate is rather uniform over the whole study area, with temperature variations mostly due to differences in elevation (C.C.I.A.A., 1988).

We searched for nests between 2008 and 2012, within all the territories identified in the province during previous surveys dedicated to the local atlas (Gagliardi et al., 2007) and during a work investigating woodpecker distribution (Saporetti, 2010). A total of 18 nests within 11 different territories were found. Feeding sites were searched for and mapped in the northern portion of the province (in the northernmost SCI – Site of Community Importance, Val Veddasca, about 50 km²; see Fig. 1). Feeding sites ($N = 140$) were identified on the basis of the typical traces left by foraging black woodpeckers, especially on snags, logs and stumps (Saporetti,

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