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Poor effectiveness of Natura 2000 beech forests in protecting forest-dwelling bats

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ABSTRACT

With the establishment of the Natura 2000 (N2000) network, the European Union intends to develop strategies to conserve Europe's threatened habitats and species, including bats. Forest-dwelling bats are highly reliant on forest structures, such as snags and hollow trees, which the bats need as roosts. The decrease in such forest microhabitats significantly affects the habitat use and, therefore, the activity in forests. To determine whether N2000 beech forests under active timber production offer better habitats for bats compared to commercially used non-N2000 forests, we measured the bat activity and assessed the potential roosts in trees and snags in eleven pairs of stands. All survey stands represented mesotrophic beech forests (*Fagus sylvatica* L.) of the N2000 habitat type 9130 (*Asperulo-Fagetum*) in three European Biogeographic Regions. The activity of all bat species, the activity of priority N2000 species, the species number, the number of trees with roosts and the snag volume did not differ significantly between the N2000 and non-N2000 stands. We conclude that the current management of the N2000 beech forests is almost identical to that of non-N2000 commercial forests, and thus, the N2000 status has not led to an increase of bat-relevant habitat variables yet. Consequently, additional efforts beyond the administrative assignment of N2000 areas are required to build and ensure an ecologically effective and sustainable network of beech forests in Europe, including increasing important forest requirements for bats, such as roosts and snags.

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Introduction

Biodiversity is largely threatened by anthropogenic activities, a fact that is well-recognised by international policy. At least 20 regional or global conservation agreements have been established in recent decades (Boere & Rubec 2002), with the intention of measurably improving nature (Male & Bean 2005). In addition to the formulation and implementation of political interventions, it is essential to evaluate their effects on biodiversity (Donald et al. 2007), but the efforts towards monitoring these effects are mostly not considered in political discussions and often lag greatly behind other policy fields (Ferraro & Pattanayak 2006). At the European scale, the coherent Natura 2000 (N2000) network is a highly promising approach to safeguard Europe's biodiversity (Maiorano et al. 2007). The legislation is based on the Birds Directive (European Council 1979) and the Habitats Directive (European Council 1992). Regarding habitats (Annex I) and species (Annex II), 27 Member States of the European Union (EU) established Special Areas of Conservation (SAC) where specifically designed management plans should be developed (Article 6(1), European Commission 2007). In addition to protected areas where utilisation is normally prohibited or restricted, such as National Parks or nature reserves, the major part of the network consists of still commercially used sites. This centrepiece of the EU nature conservation strategy covers

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more than 20% of the terrestrial and marine EU territory (European Commission 2012a), currently with 26,406 sites (Tsiafouli et al. 2013), underlining the idea of thinking and acting on an international scale, according to the demand for effective nature protection (Opermanis et al. 2012).

The overall objective of N2000 is to maintain and restore a "Favourable Conservation Status" (FCS) (Articles 1e, 1i) for all habitats and species that are listed in Annexes I and II (European Council 1992). The maintenance of FCS mostly targets the previously protected areas that already provide good habitat quality. In contrast, restoring FCS is a challenge for the commercially managed sites where habitat quality is often lower and therefore needs to be improved. FCS means that the habitats and the species populations are in good condition with regards to both the quality and the extent and have a positive future perspective (Evans & Arvela, 2011). The conservation status must be evaluated and reported every six years by all of the Member States (Article 17, Habitats Directive). In the first report, covering 2001–2006, only 17% of both the habitats and species were classified as having a "favourable" conservation status, whereas for the main proportion, an "unfavourable/bad" or even "unknown" conservation status was reported (European Commission 2009).

Forests are an indispensable key for biodiversity. They cover more than 50% of the terrestrial N2000 surface area and represent the most important habitat type for many endangered species (European Communities 2003). Many of these species are depending directly or indirectly on particular tree species, such as the European beech (*Fagus sylvatica* L.), which is the main deciduous tree species in Europe (Bolte et al. 2007; Packham et al. 2012). The limitation of beech distribution to Europe bestows great responsibility on the EU for the protection and conservation of the species itself and all habitat types characterised by beech. Forest structural composition plays a decisive role in biodiversity (Cale et al. 2013; Ishii et al. 2004; Remm & Lohmus 2011; Tews et al. 2004) and greatly affects the habitat quality for forest-dwelling animals such as birds (Pinotti et al. 2012), arthropods (Gossner et al. 2013; Russo et al. 2011) and bats (Lacki et al. 2007). With the N2000 network, the EU and their Member States have vowed to designate SACs for the 13 bat species that are listed in Annex II. Bats strongly depend on the quality of their habitats, especially on the availability of foraging and breeding structures (Perry et al. 2007; Ruczynski et al. 2010). Therefore, forest-dwelling bats can be used as good indicators of forest habitat quality (Jones et al. 2009), but also to examine the habitat – suitability of forest stands under different management conditions and intensities (Russo et al. 2010). Thus they are suitable for evaluating the implementations of conservation measures in N2000 forests. In general, the populations of European bat species have declined because of habitat degradation, fragmentation and land-use changes (Frey-Ehrenbold et al. 2013; Vié et al. 2008), but little is currently known about bats and their activity within forests under active timber production (Miller et al. 2003; Russo et al. 2010), even though the large majority (97%) of European forests are commercially used (FAO 2011). Thus, managed forests play a key role in supporting bats in Europe, including most N2000 forests where active timber production is still common practice (Tsiafouli et al. 2013). With this study, we aimed to estimate how bats are affected by N2000 in commercially used beech forests at the moment. Therefore, we compared the bat activity and the bat diversity in pairs of beech stands used for timber production inside and outside the N2000 network. We expected higher values inside stands protected by N2000 caused by a better management here. Because bats are very dependent on foraging and breeding structures (Perry et al. 2007; Ruczynski et al. 2010) the positive influence of N2000 on bats would thus be reflected by more diverse bat-relevant forest microhabitats, which were estimated in all stands, too. Thus, it would be possible to evaluate the current state of the implementation of the N2000 network and the N2000 management plans. Studying *Asperulo-Fagetum* beech stands, we focused on one of the major temperate forest types in Europe that covers more than 13,000 km^2 (European Topic Centre on Biological Diversity, 2009) and therefore represents one of the most important habitats for forest-dwelling bats in Europe.

Methods

Study areas

The survey was conducted in eleven pairs of utilised forest stands in Europe (Fig. 1) representing *Asperulo-Fagetum* beech forests (N2000 habitat type code 9130) in three Biogeographic Regions (Atlantic: 2 pairs, Continental: 7 pairs, Mediterranean: 2 pairs; Fig. 1). Each pair consisted of one stand located within a N2000 site and of one stand within a reference site outside N2000 (Table 1). All stands were selected using the following criteria: (i) dominated by European beech (>70%), (ii) managed by a high forest management strategy, (iii) the trees are 80–120 years old and (iv) each stand has a size of at least 10 hectare (ha). Within each stand, eight study plots without conifers in the overstorey (0.1 ha each, $n_{\text{total}} = 176$) were randomly selected within the created grids (edge length = 50 m × 50 m).

Bat survey

The bat surveys were performed in 2011 (seven pairs of stands) and 2012 (four pairs of stands). Bat calls were recorded simultaneously for four of our eight survey plots each stand on one night in end of May and for the other four plots in the beginning of July from 6.00 pm to 6.00 am the next day; this period of time was chosen to minimise the confounding factors of seasonal migration (Ford et al. 2005); we standardised the night surveys with regard to the temperature and wind speed; nights with very high relative humidity and rainfall were avoided. Thus, we generated eight recording data sets, respectively eight survey nights in each of the 22 stands. In sum, we performed 176 all-night surveys (22 stands × 8 plots) with 96 h recorded in each stand (8 plots × 12 h). Each night, we used eight Batcorder 2.0 instruments (ecoObs GmbH 2010) simultaneously on the plots, where they were installed in the centre on a metal pole approximately 2.5 m above the forest ground (see Fig. S1). The omnidirectional microphones were orientated upwards at a 10° angle and were not directed into dense vegetation to minimise the effect of the forest structures on the ultrasonic sound transmission in the understorey (Marten & Marler 1977; Patriquin et al. 2003). After recalibration before each survey season, we used the same batcorder-settings (quality: 20, threshold: −27 dB, post-trigger: 60 ms, critical frequency: 16 kHz) and "Auto + Timer" mode (18.00–06.00) for each survey.

Bat-relevant habitat variables

We assessed all trees with roosting resources (cavities, bark-pockets) according to the microhabitat types M12–M15 and M18 in Winter and Möller (2008) in each study plot. The identification and evaluation were performed by visual inspection. The volume of the standing deadwood [m^3] was calculated from the height [m] and the diameter [cm] at breast height (1.3 m; dbh), including all snags with at least 7 cm (dbh) with bark and 6 cm (dbh) without bark (for details, see also Winter & Möller 2008). For the statistical calculations, all data on plot level (1000 m^2) were standardised to values per ha, from which the mean + sd per ha of each stand was calculated (for details see Table S2). To estimate the characteristics of the habitat variables, we furthermore compared [a] trees with

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