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Research article

Bioenergy and biodiversity: Intensified biomass extraction from hedges impairs habitat conditions for birds

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ABSTRACT

Biomass is increasingly used as an alternative source for energy in Europe. Woody material cut from hedges is considered to provide a suitable complement to maize and oilseed rape, which are currently the dominant biomass sources. Since shrubs and trees are also important habitats for birds, however, coppicing of hedges at the landscape scale may adversely affect the diversity of the avifauna. To evaluate this risk, we estimated the response of hedge birds to three management scenarios differing in cutting intensity and hedge selection. The analysis was done using hedge data of the Lautertal municipality (n = 339 hedges; Vogelsberg area, Hesse, Germany). It focused on 25 bird species, which are all listed in the hedge programme of the German Ornithological Stations. Information on the preferences of these birds for certain hedge features such as height or width was gathered by an extensive literature review. A cluster analysis on the consolidated literature data allowed us to identify three groups of birds according to their preference for certain hedge attributes. Two groups, which included Yellowhammer (*Emberiza citrinella* L.) (i) and Blackbird (*Turdus merula* L.) (ii), favoured trees located in hedges, but differed in their preference for hedge shape, with (i) being attracted by long and broad hedges and (ii) by high hedges. The third group, which included the Whitethroat (*Sylvia communis* L.), preferred small hedges with gaps and medium vegetation density. Spatially explicit suitability models based on these data allowed us to predict the status quo of hedge suitability for these species groups. Field surveys proved the accuracy of the predictions to be sufficient, since the hedge suitability predicted was significantly and positively correlated to the occurrence of 9 out of the 12 testable focal species. Our models predicted biomass extraction to almost always reduce hedge suitability for the three bird groups. Concerning the Yellowhammer and the Blackbird group, a high level of biomass extraction reduced hedge suitability by approximately 20%. We thus conclude that intensively extracting biomass can significantly reduce hedge suitability for birds, despite considerable differences in habitat requirements. Considering the variable response of the bird groups to our scenarios as well as the variation in habitat occupancy by birds, however, cutting woody material from hedges nevertheless provides an option to reduce adverse effects of bioenergy production on biodiversity at the landscape scale, as long as hedge management is based on the best knowledge available.

1. Introduction

Fostering sustainable energy production from renewable resources is crucial to counteract worldwide climate change (IPCC, 2012). Over the last decades, renewable energy obtained from biomass has become increasingly relevant (Wahlund et al., 2004). German policy, for example, aims at almost doubling the share of today's bioenergy production to 10–15% of total energy production (BMU, 2013; BMU and BMELV, 2012). Woody material cut from hedges may offer a suitable alternative to maize and oilseed rape, which currently are the dominant biomass sources (Oreszczyn and Lane, 2000). The cultivation of maize and oilseed rape has been shown to reduce habitat quality for many taxa, mainly through intensive management (pesticides, fertilization, etc.) and landscape homogenization (monocultures; Dauber et al., 2010; Gevers et al., 2011; Louette et al., 2010; Pedroli et al., 2013; Sauerbrei et al.,

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2014). Wood extracted from hedges has been used for household energy production for many years (Baudry et al., 2000), with rotational trimming regimes or complete coppicing of smaller hedge areas already being established management methods (Forman and Baudry, 1984). Recently, the production of wood chips or pellets from hedge cuttings has increasingly moved into the focus of bioenergy concerns (Neupane et al., 2011; Picchio et al., 2012).

Hedges play a key role in maintaining bird diversity in agricultural landscapes (EENRD/EC, 2009; Morelli, 2013). They provide important needs such as food, shelter and nesting sites for a broad variety of bird species (Batáry et al., 2010; Fuller et al., 2001, 2004; Hinsley and Bellamy, 2000). Furthermore, hedges harbour a wide range of functionally important arthropod groups such as pollinators or predators, which support agricultural production (Marshall and Moonen, 2002). Hedge management has already become an important tool of nature conservation to foster specific species (French and Cummins, 2001; Hinsley and Bellamy, 2000; Maudsley et al., 2000; Sotherton et al., 1981; Staley et al., 2012, 2013). An unregulated intensification of biomass extraction may critically reduce the significant contribution of hedges to the resilience of agricultural landscapes (Bas et al., 2009; Gillings and Fuller, 1998).

The avifauna is a widespread indicator for evaluating changes of environmental quality and ecosystem health as well as associated changes of biodiversity (Gottschalk, 2008; Gregory et al., 2003; Harrison et al., 2014; Padoa-Schioppa et al., 2006). Birds inhabiting hedges require specific habitat characteristics, which are mainly related to vegetation structure (e.g. Arnold, 1983; Green et al., 1994; Macdonald and Johnson, 1995; Sparks et al., 1996). For example, certain hedge bird species such as Blackbird or Chaffinch benefit from mature hedge vegetation such as trees, which store a high biomass, while other species such as Red-backed Shrike or Whitethroat prefer low biomass hedges with light vegetation density (Barkow, 2001; Morelli, 2012; Morelli et al., 2012; Stoate and Szczur, 2001; Whittingham et al., 2001). Thus, the mode and amount of biomass extraction as well as the hedge type affected will differentially impact bird species (Hinsley and Bellamy, 2000).

Habitat suitability models are frequently used to develop scenarios that allow for analysing the effect of land-use changes on species distribution or habitat quality (Blanchard et al., 2015; Gottschalk et al., 2010; Guisan and Zimmermann, 2000; Reino et al., 2006; Sauerbrei et al., 2014). Knowledge-based habitat modelling is an established method to estimate potential habitat suitability (Humphries et al., 2010; Petit et al., 2003; Salski, 1992; Store and Kangas, 2001), which nicely complements regression models that compute habitat suitability based on occurrence data (Brotons et al., 2004; Eggers et al., 2009). It is known that the statistical quality of these two approaches may diverge, but the applicability of knowledge-based models for conservation research is increasingly appreciated (Krueger et al., 2012; Murray et al., 2009; Polfus et al., 2014).

In the study reported here, we used knowledge-based models on the demand of birds for certain hedge parameters to assess the impact of different cutting regimes on habitat suitability. For doing so, we related information extracted from peer-reviewed papers on habitat requirements of hedge birds (e.g. vegetation height or density) to corresponding hedge parameters surveyed in our study area in order to make spatially explicit predictions on habitat suitability of hedges. Calculations were conducted for status quo and three hedge management scenarios focusing on low, medium and high yield of biomass. Hence, the scenarios differed in both cutting intensity and hedge selection, but the number of hedges cut remained identical. Model quality was evaluated by species distribution data, which were gained by conducting bird surveys in the study region. We investigated whether groups of birds with similar requirements on hedge characteristics could be identified. First, we hypothesized that the quality of our knowledge-based models can be confirmed with a field validation. In a second hypothesis we assumed that biomass extraction that only focuses on increasing biomass yield critically reduces suitability of hedges as habitats for birds.

2. Material and methods

2.1. Study area and hedge data

All hedges included in this study were located in an approx. 10 km^2 area of the Lautertal commune (Vogelsberg region, Hesse, Germany: ~50° 34′ N, 9° 16′ E). The region is of volcanic origin and is dominated by managed grasslands and - to a lesser degree - by crops growing on comparatively nutrient-poor soils developed from basalt. The study area is characterized by a large number of semi-natural hedges and encompasses a “NATURA 2000” Special Protected Area for birds.

Data on parameters of 339 different hedges recorded in 2012 and 2013 was provided by the “Naturschutzgroßprojekt Vogelsberg” (funded by German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the German Federal Agency for Nature Conservation) and by “Bioenergie-Region Mittelhessen” (funded by German Federal Ministry for Food and Agriculture). This information was used for compiling a “hedge matrix” derived from presence/absence data for the different parameters. Furthermore, we categorized hedge parameters according to Arnold (1983), Macdonald and Johnson (1995) and Hinsley and Bellamy (2000) or based on the categories used for the hedge survey (Table 1). Mean height and width of all hedges varied around 4 m. A “gap” is defined as a hedge segment free of woody vegetation (minimum length 0.5 m) that does not split one hedge into two adjacent hedges. All parameters were surveyed in a standardized format to make them comparable.

As a prerequisite for scenario building, we also calculated the potential yield for each hedge by assigning biomass scores to selected parameters (vegetation density, height, width, length, age,

Table 1
Extrapolated biomass scores for the different hedge parameters used in the analysis (see section on Methods for details).

Hedge parameter	Abbreviation	Category	Biomass score
Vegetation density	DE1	<50%	1
	DE2	50–75%	2
	DE3	75–100%	3
Height	HE1	<4 m	1
	HE2	>4 m	2
Width	WI1	<4 m	1
	WI2	>4 m	2
Length	LE1	<150 m	1
	LE2	>150 m	2
Age	AG1	<25 a	1
	AG2	>25 a	2
Woody plant species	WS1	<10	1
	WS2	>10	2
Trees in hedges	TRE	Present	3
Gaps	GAP	Present	–
Ditch	DIT	Present	–
Deadwood	DWO	Present	–
Ground vegetation layer	GVL	Present	–
Adjacent land-use	LU1	Crop	–
	LU2	Stream	–
	LU3	Fallow	–
	LU4	Grassland	–
	LU5	Settlement	–
	LU6	Forest	–
	LU7	Track/Road	–