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Impact of recent changes in agricultural land use on farmland bird trends

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ABSTRACT

Agriculture has been, and still is, strongly shaping landscapes across Europe. In recent decades, agricultural land use has changed considerably, mainly driven by reforms of agricultural and bioenergy policies. Here, we related temporal and spatial changes in agricultural land use at both the landscape and regional scale to population trends of farmland birds. Monitoring data of the Common Breeding Bird Survey of Lower Saxony, Germany, and high-resolution data on agricultural land use from 2005 to 2012 were used to calculate the temporal trend slopes of farmland birds and agricultural variables at the landscape scale ($1\,km^2$). Agricultural variables comprised the area covered by maize, set-aside, permanent grassland as well as crop diversity. The number of territories were analysed for all farmland birds together as well as for two subgroups (‘field nesters’ and ‘non-field nesters’). Further, we tested whether population trends of farmland birds differed between agricultural regions, characterised by different land-use change dynamics.

Trends of farmland birds and non-field nesters were negatively related to increasing maize cultivation at the landscape scale. We further found that population trends of field nesters reacted region-specifically and performed worst in an agricultural region that was characterised by the strongest increase of maize and decrease of crop diversity, indicating a negative effect of broad-scale landscape homogenisation. To counteract the process of spatial and temporal land-use homogenisation and to inform policy-makers on options for mitigation, we conclude that conservation actions should be tailored at a regional scale to halt or even reverse negative farmland bird population trends.

1. Introduction

Globally, increasing demands for food and bioenergy are driving forces of land-use changes (Tilman et al., 2002; Dale et al., 2011). Across Europe, recent evidence suggests that agricultural intensification and land-use change have been the main causes of population declines in common farmland birds over the last decades (Chamberlain et al., 2000; Donald et al., 2001; Berg et al., 2015).

In Europe, the Common Agricultural Policy (CAP) is one of the major public policies driving agricultural change (Mattison and Norris, 2005; Wretenberg et al., 2007; Pe’er et al., 2014). It has been and still is strongly shaping the farmed landscape by inducing changes in crop and grassland management, spatial distribution of different crop types, crop specialisation at farm and landscape level and removal of non-crop habitats such as field margins and hedgerows, thereby affecting farmland bird populations (Chamberlain et al., 2000; Donald et al., 2001; Wretenberg et al., 2007). Since its introduction in the early 1960s, the CAP has undergone major changes. One of these changes was the introduction of compulsory arable set-aside as part of the CAP reform in 1998. Even though not targeted at enhancing farmland biodiversity, this measure was shown to benefit farmland birds, though effects differed between species and type of set-aside considered (Henderson and Evans, 2000; Herzon et al., 2011). For many farmland birds, the abolishment of the set-aside scheme in 2008

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diminished food sources and resulted in a loss of suitable nesting habitat (Gillings et al., 2010).

Another important policy that induced recent changes in agricultural land use can be attributed to the support of renewable energy. In this regard, the European Union has committed to increase the proportion of renewable energy from 9% in 2010 to 20% of total energy consumption by 2020 to gain independence from fossil fuel and to contribute to climate change mitigation (EU, 2009). In Germany, the National Sustainability Strategy envisaged a doubling of biomass for energy production by 2050 (Bundesregierung, 2002). To fulfil this goal, a bonus payment for the production of electricity from renewable raw materials was introduced within the amendment of the Renewable Energy Act (EEG) in 2004, resulting in an increased cultivation of maize (*Zea mays*). Using major food crops for bioenergy production, such as maize and rapeseed, results in competition for limited agricultural land and impacts agricultural land rental prices, thereby triggering land-use change and agricultural intensification (Wright and Wimberly, 2013). There is further evidence that much of the change to bioenergy production came at the expense of permanent grasslands, a process that has been observed in Germany (Nitsch et al., 2012) and in the US Corn Belt (Wright and Wimberly, 2013). The expansion of maize cultivation and the loss of permanent grasslands have both been suggested as possible causes of population declines of farmland bird species (Laiolo, 2005; Brandt and Glemnitz, 2014; Sauerbrei et al., 2014; Teillard et al., 2014). There is, however, considerable spatial variation in land-use change in response to policy interventions due to regional differences in farming conditions (Mattison and Norris, 2005; Wretenberg et al., 2007). Understanding the impact of changes in agricultural land use on farmland birds is of great importance to provide recommendations for future improvements in bird conservation, as well as informing decision-makers of possible positive or negative effects of policy interventions and providing information on options for mitigation.

In order to study the effect of agricultural land use on farmland birds, relationships are often investigated within one year along a spatial gradient displaying differences in crop management and cover (e.g., Bas et al., 2009; Guerrero et al., 2012). This approach assumes that relationships over space can be used to predict changes over time, even though bird communities might respond differently to temporal changes in habitat availability and distribution than to spatial gradients (La Sorte et al., 2009; Bonthoux et al., 2013). Accordingly, studies using such space-for-time substitutions were shown to sometimes overestimate effects (La Sorte et al., 2009; Bonthoux et al., 2013). To investigate potential impacts of agricultural land-use change on farmland birds, other studies have drawn conclusions based on the rate of change between two census years (Wretenberg et al., 2010; Bonthoux et al., 2013; Berg et al., 2015). Such comparisons are, however, likely to mask considerable differences in the temporal patterns of farmland birds and agricultural land use taking place within a short time period. Hence, for more reliable insights into how population trends of farmland birds relate to changes in agricultural land use, long-term data are needed (e.g. Baker et al., 2012). Yet, assessing the impact of changes in agricultural land use on farmland birds hinges on adequate high-resolution, spatially explicit data on agricultural land use for large areas.

Here, we used bird data of the Common Breeding Bird Survey of Lower Saxony, Germany, collected between 2005 and 2012 that we linked to agricultural data of high spatial (parcel specific) and temporal (yearly) resolution deduced from the IACS (Integrated Administration and Control System) database. Amongst the species covered by the bird monitoring scheme, we focused on those farmland birds included in the European Farmland Bird Indicator (FBI, introduced by Gregory et al., 2005). Because specialist bird species have been shown to react more strongly to changes in agricultural land use than generalist species (Wretenberg et al., 2007; Hiron et al., 2015), we further defined a subset of farmland bird species that nest within agricultural fields ('field nesters'). The remaining species ('non-field nesters') that use agricultural fields predominantly as foraging habitat were analysed separately. We expected population trends of farmland birds to be linked to policy related changes in agricultural land use within Lower Saxony, Germany. Therefore we focused on highly dynamic agricultural variables that were assumed to influence farmland bird communities, namely the area covered by maize (Laiolo, 2005; Hötker et al., 2009; Chiron et al., 2013), by set-aside (Henderson and Evans, 2000; Herzon et al., 2011), and by permanent grassland (Laiolo, 2005; Teillard et al., 2014) as well as crop diversity (Benton et al., 2003; Guerrero et al., 2012). Moreover, farmland birds have been shown to react region-specifically, indicating the need for spatially tailored conservation actions (Whittingham et al., 2007; Wretenberg et al., 2007). Hence, to test whether population trends of farmland birds differ between agricultural regions, we divided the case study area into regions based on different land-use change dynamics of the aforementioned agricultural variables.

Specifically, we addressed the following questions: (i) Are population trends of farmland birds related to changes in agricultural land use driven by recent reforms of agricultural and bioenergy policies? (ii) Do population trends of farmland birds differ between regions characterised by different land-use change dynamics? (iii) Are field nesters more strongly affected by land-use changes than non-field nesters?

2. Material and methods

2.1. Bird data

To explore population trends of widespread farmland birds, we used data collected by the Common Breeding Bird Survey of Lower Saxony. Annual surveys were conducted on monitoring plots of 1 km^2 in size and birds were inventoried by qualified, but volunteer ornithologists. Monitoring plots were visited four times (between March and June) during the breeding season each year between 2005 and 2012. Line transects were used as a field method to survey birds (Gregory et al., 2004). Observers walked a predefined transect of 3–4 km length covering all main habitats within the monitoring plot and mapped all bird territories that were encountered along the transect line. Transect routes did not change over the years. All birds seen or heard from the transect line were documented regardless of their distance to the observer. Birds flying over and birds recorded outside their characteristic breeding season were excluded. Further details of the monitoring scheme can be found in Mitschke et al. (2005).

For our analysis, we focused on those monitoring plots that contained at least 10 % farmland in 2005. Further, we restricted our dataset to those plots that were visited at least in five years. These constraints led to a total number of 97 plots, homogenously distributed across Lower Saxony (see Appendix A, Fig. A.1).

The classification of farmland birds is based on those breeding bird species listed in the EU-Farmland Bird Indicator (FBI), covering a total of 39 species (EBCC, 2015). For our analysis we excluded species with less than ten territories and those that were recorded on less than four monitoring plots in the data set. We analysed all remaining 19 FBI-species ('farmland birds') as well as two subsets that were classified according to their nesting preference. The first group, referred to as 'field nesters', contained eight species that depend and are highly specialised on arable land and grassland as nesting habitat. The second subset, the 'non-field nesters', covered