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The effect of land type diversity and spatial heterogeneity on farmland birds in Norway

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ABSTRACT

The decline in farmland birds observed throughout Europe during recent decades has attracted much attention. Agricultural intensification or land abandonment are commonly forwarded as key drivers. Several countries have established agri-environmental schemes (AES) to counter these negative trends among farmland birds. This paper reports a study of the relationship between land use and bird species in the agricultural landscape of Norway. The main objective was to investigate the effect of spatial heterogeneity and diversity of land use on total richness and abundance of farmland birds at a national level.

Monitoring the distribution and abundance of birds is part of the Norwegian monitoring programme for agricultural landscapes. The monitoring programme is based on mapping of 1 × 1 km squares distributed across the entire agricultural landscape. Within these squares permanent observation points are established for bird monitoring. Detailed interpretation of aerial photographs provides the land classification. We tested the relationship between landscape metrics at different levels of land type detail and species richness and abundance of farmland and non-farmland birds.

There was a positive relationship between species richness and abundance of farmland birds and agricultural area. For non-farmland birds the relationship was negative. Spatial heterogeneity of land use was a significant positive factor for both farmland and non-farmland species. High land type diversity was positive for farmland bird richness, but negative for abundance. Non-farmland bird richness was not affected by land type diversity, but abundance had a negative response.

The results presented in this paper highlight the importance of a spatial heterogeneous landscape. However, we also found that land type diversity could negatively affect the abundance of both farmland and non-farmland birds. Our findings suggest a need for different management approaches depending on whether the aim is increased species richness or abundance. Achieving both aims with the same means might be difficult. We thus suggest a need for land use analyses before proper management strategies can be implemented.

1. Introduction

European bird populations and farmland birds in particular have shown a marked decline in distribution, abundance and biomass since the 1980s (Inger et al., 2015). Several factors have either alone or in concert been found to influence bird populations negatively, across countries with differing agricultural practices. Most of this decline is ascribed to the intensification of agricultural production throughout most of Western Europe (Donald et al., 2001; Donald et al., 2006), but also to land abandonment (Wretenberg et al., 2007) and reduced landscape heterogeneity (Heikkinen et al., 2004; Wretenberg et al., 2010; Pickett and Siriwardena, 2011).

These observed negative population trends might be further amplified in response to climate change. Synchrony of environmental variables over large spatial scales as a consequence of climate change seems to induce spatial synchrony of populations and is suggested to increase extinction risk (Walther et al., 2002; Root et al., 2003; Post and Forchhammer, 2004). Therefore, climate change has the potential to worsen the situation for already declining farmland bird populations, and is suggested to increase extinction risk (Root et al., 2003; Post and Forchhammer, 2004). Such negative prospects increase the need to identify the key factors causing declines in bird populations (Bennett et al., 2014), especially since these declines may cause cascading effects on other ecosystem functions and ser-

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vices (Sekercioglu et al., 2004). For instance, birds provide several important ecosystem services, such as seed dispersal, pest and parasite control as well as aesthetic value (Whelan et al., 2008; Geiger et al., 2010; Anderson et al., 2011; Wenny et al., 2011; Winqvist et al., 2011). The observed negative population trends could lead to population extinctions and hence cause collapse in important ecosystem services. Finding and addressing the major drivers of bird declines is therefore essential.

Land use and land use change have been suggested as key drivers affecting the distribution and abundance of farmland birds. However, several studies have shown that the effects of intensification or abandonment are to a large extent dependent on the landscape context. Fox (2004) found stable and increasing populations, in spite of intensification. Studies also show that in areas dominated by intensive agricultural production, farmland birds seem to benefit from more extensively managed areas, while in areas where the landscape is mainly extensively managed many farmland bird species benefit from intensification (Robinson et al., 2001; Wretenberg et al., 2010). Reduction in heterogeneity of the landscape could also explain the negative trends in populations. Set-aside areas (Gillings et al., 2010; Henderson et al., 2012), hedgerows or field margins (Bradbury et al., 2000; Batary et al., 2010) and even land abandonment in some cases (Woodhouse et al., 2005) have all been found to have positive effects. This is explained by the fact that many farmland birds require multiple habitat types to fulfill their niche requirement throughout the breeding season (Dallimer et al., 2012).

Compared to most European countries, Norway is relatively extensively managed with high levels of landscape heterogeneity. However, many of the bird species breeding in Norway overwinter in continental Europe on shared winter ranges with migrating birds from other countries. That several bird populations share common wintering grounds could cause similar population trends between different countries (Wretenberg et al., 2006). But if the conditions on the breeding grounds differ markedly between countries it could complicate finding the driving forces behind populations trends, since population processes are affected both by conditions on the wintering grounds as well as on breeding grounds. Here, there is a knowledge gap about these populations because few if any studies have been published on farmland birds and land use in Norway. Wretenberg et al. (2006) emphasize the need to study more populations of farmland birds outside of continental Europe, especially in countries dominated by more extensive agricultural practices and where the migrating birds share common winter grounds.

To be able to uncover the mechanisms that cause population change at a national level, it is necessary to complement all the local and regional studies that have been conducted, with national monitoring programs that also provide detailed land use data. The objective of this paper was to consider the effect of landscape composition expressed as landscape metrics on species richness and abundance of farmland birds in Norway. In addition to the amount of agricultural land and other aspects of land use that have been documented to have effect on farmland birds, we consider the effect of i) spatial heterogeneity of land use and ii) diversity of land use categories. By the use of land use data classified at different levels of detail, in combination with bird observations, we have investigated the characteristics and components of the landscape that can sustain the highest number of species and abundance.

2. Materials and methods

2.1. Monitoring programme

The objective of the Norwegian monitoring programme for agricultural landscapes is to document status and change of land use and spatial structure, as well as assess possible consequences of changes on different landscape components, biodiversity, cultural heritage and accessibility (Dramstad et al., 2002). The monitoring programme is based on interpretation of aerial photographs and designed to report developmental trends at national and regional levels. Approximately 1000 1 × 1 km monitoring squares are randomly distributed across the agricultural landscape using a stratified sample technique. Of these squares, 119 were included at random in the bird monitoring scheme (Fig. 1). The aerial photography is a Norwegian national programme with a 5-year inventory cycle (for further details see Dramstad et al., 2002).

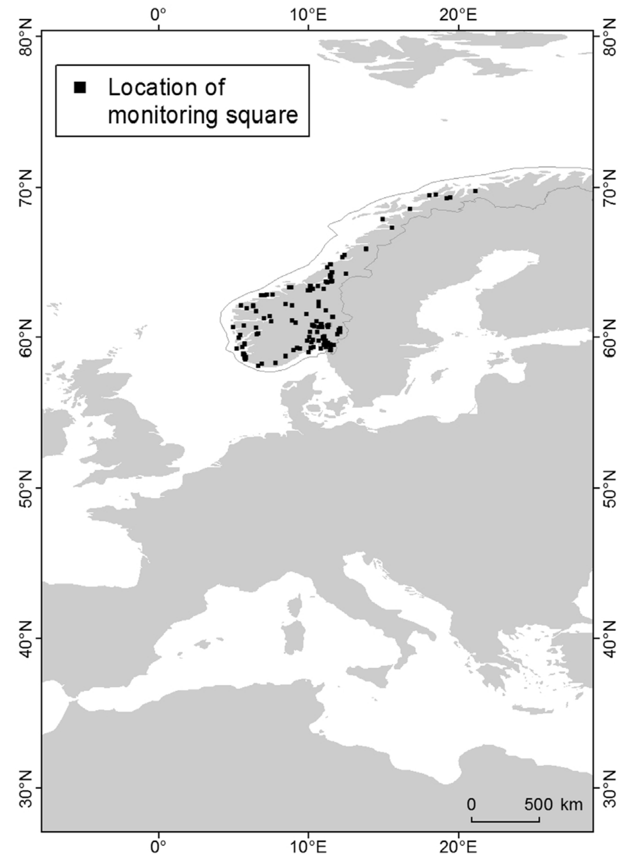

Fig. 1. Distribution of the 119 monitoring squares (1 × 1 km) in Norway, set in an European context.

2.2. Land types

The monitoring squares are mapped and different land types are identified and digitized (scale 1:12,500) through a detailed manual interpretation of true color aerial photographs. Highly anthropogenic areas are mapped according to land use, whilst more natural areas are mapped according to land cover, hence the use of the generic term "land types". A hierarchical classification system of three levels is used. The most detailed level identifies 102 land types (DET_{102}). These are further generalized into 24 types (DET_{24}). Finally, at the third level, these are generalized into seven classes of land types (DET_7): agricultural land, natural bare ground, permanent and unforested dry-land vegetation, natural un-forested wetland vegetation, forest and tree-covered land, built-up areas and water/snow/ice. In addition to areal features, both line and point elements are registered. Based on the digitized maps a wide array of landscape metrics may be calculated and these constitute the basis for reported indicators (Dramstad et al., 2002). By combining these landscape metrics with bird observations conducted