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Linking occurrence and changes in local abundance of farmland bird species to landscape composition and land-use changes

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ABSTRACT

Changes in agricultural policies have caused dramatic changes in land-use in agricultural landscapes. To investigate whether such changes in land-use relate to temporal changes in bird communities a repeated inventory (1994 and 2004) of farmland birds was made in 212 point-count sites in south-central Sweden.

Distinct changes in abundance of several species over the study period were recorded, abundance of the 16 studied species decreased by 23%. The decline was significant for eight species, while two species increased significantly. Persistence and colonisation models suggested similar species–habitat relationships as the snapshot models, i.e. eight of the 12 associations were in line with what could be expected from the snapshot models. Occurrence of nine species was linked to land-use whereas six species displayed links between changes in occurrence and changes in land-use. In line with previous studies positive effects of short rotation coppice and negative effects of autumn-sown crops were found, while set-asides showed fewer effects than expected. In the snapshot models several species showed links to landscape characteristics such as amount of forest (negative for five species) and landscape heterogeneity (positive for six species). The evidence for effects of the landscape variables on persistence/colonisation was more restricted.

The results suggest that both land-use changes and the landscape setting may cause local changes in abundance of farmland birds, even for species displaying a general decline in numbers between years, the effects of land-use changes being, however, strongly species specific.

1. Introduction

The polarisation of agriculture, i.e. intensification of agriculture in productive areas and abandonment of farmland in less productive areas, is widespread in Europe and is causing farmland biodiversity to decline (Robinson and Sutherland, 2002). Farmland butterflies, birds and many other taxa associated with traditional low intensity farming have suffered from this polarisation of agriculture (Chamberlain et al., 2000; Stoate et al., 2001; Wretenberg et al., 2006; Baldi et al., 2013; Loos et al., 2014). Most studies of farmland biodiversity declines and its relationships to landscape structure and farming practices are "snap-shot" studies, i.e. organisms are inventoried at different sites in one year to establish species–habitat relationships. While, this approach often has been used to evaluate the impact of landscape changes on communities (Pickett, 1989; Sanderson et al., 2009; Chiron et al., 2010; Flick et al., 2012), it assumes that variation in spatial patterns will reflect variation in temporal patterns, e.g. when land-use changes due to changed agricultural policies. However, such space-for-time substitutions may fail, e.g. due to density-dependent bird habitat relationships (Riffell and Gutzwiller, 2009; Barnagaud et al., 2011; Wells et al., 2011) or complex community dynamics (Fukami and Wardle, 2005). Furthermore, several studies have shown that space-for-time substitutions might overestimate the effects of habitat changes on the dynamics of bird communities (Johnson and Miyanishi, 2008; Sorte et al., 2009; Bonthoux et al., 2013).

Bearing in mind the potential problems with the space-to-time substitutions mentioned above temporal dynamics in communities in response to changing environment should preferably be investigated by temporally repeated data (Adler and Lauenroth, 2003). This is especially so concerning studies in agricultural landscapes because (i) farmland habitats change drastically between years due to rotational schemes of land-uses and large-scale changes in agricultural policies (e.g. Wretenberg et al., 2007) and (ii) land-use changes are assumed to be the main drivers of

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population changes of several farmland birds due to their strong effects on abundance of individual species (e.g. negative effects of winter wheat (Chamberlain et al., 2001; Eggers et al., 2011), and positive effects of set-asides (van Buskirk and Willi, 2004) and short-rotation coppice (Berg, 2002b)).

Here, we report on a repeated inventory (1994 and 2004) of farmland birds at 212 sites in a farmland-forest landscape gradient in south-central Sweden. We make use of the fact that the agricultural policy shifted dramatically between these years; 1994 was the last year of an eight year period promoting low-intensity farming because of overproduction (i.e. the set-aside period), whereas farming practices and land-use in 2004 reflected a nine year period of increased production according to the Common Agricultural Policy in the European Union (Wretenberg et al., 2007). In order to investigate the effects of land-use changes on birds, two types of analyses were conducted. First, we investigated occurrence – land-use relationships and their interactions to landscape composition and landscape heterogeneity in a “snap-shot model”. Second, we tested whether changes in local land-use were linked with changes in local occurrence of species, in terms of probability of (i) persistence (i.e. occurrence in both years in previously occupied patches) and (ii) colonisation (i.e. occurrence in the second year only of previously empty patches). Third, we investigated whether land-use-driven changes in local occurrence were related to surrounding landscape composition (cf. Wretenberg et al., 2010) and landscape heterogeneity and compared the results to our snap-shot models.

We hypothesized that changes in species occurrence should be related to changes in land-use and especially land-uses earlier shown to have strong positive (set-aside, short rotation coppice) or negative (autumn sown cereals) effects on bird species-richness. Furthermore, we expected these land-use relationships to be dependent on the composition of the surrounding landscape as suggested by previous studies (Wretenberg et al., 2010) and that high landscape heterogeneity should affect population changes of most species positively.

2. Methods

We used 212 census points (i.e. sites) located in the counties of Uppland and Västmanland (approximately 59°40′N–60°07′N and 16°30′E–18°10′E) in south-central Sweden (total study area c. 1800 km^2). The sites were located in landscapes with different amounts of forest (e.g. median 28%, range 0–92% as measured within a 600 m radius from the census point). However, all sites were located in farmland habitats and the proportion of farmland within 100 m (i.e. the radius used for bird censuses) was high; 82% of the sites had more than 80% farmland within 100 m. The sites were mainly located in arable fields and the proportion of semi-natural pastures was low (1.4% within 100 m radius). All census points were located at least 600 m apart (median 900 m, range 600–4000 m). In 1994, the census points were selected in a stratified design with respect to different land-use types (i.e. spring-sown crops, autumn-sown crops, leys, cultivated pasture, set-aside fields and short rotation coppice), semi-natural pastures, occurrence of residual habitats (e.g. ditches, within-field habitat islands and field roads) and landscape composition (forest-dominated and farmland-dominated). Initially, several hundred potential census points were investigated to cover variation in land-use. Almost all sites with short rotation coppice were chosen (i.e. the rarest land-use) whereas the selection of the census points in other land-use types was random within these strata.

A detailed habitat mapping (including field types and different types of non-crop habitats) was done within 100 m (only used in site descriptions not in analyses) and within 300 m of the point centres (used in analyses) with the help of field visits, land-use maps (1:10,000) and aerial photographs. Proportions of different habitats and land-use types (see Table 1) were estimated from these detailed maps using the software ArcView, version 3.3 (Anonymous, 1992–2002) with the XTool extension (DeLaune, 2001). At the landscape level (600 m radius) only the proportion of forest and the proportion of arable fields (all field types combined) was mapped.

The proportion of the landscape covered by forests within 600 m radius from the census point was used as the descriptor of landscape composition. This descriptor was strongly correlated with the proportion of arable fields (therefore, not included in the analyses) at the same spatial scale ($r = -0.89$, $P < 0.001$) and with the proportion of forest at smaller spatial scale (e.g. radius of 300 m; $r = 0.92$, $P < 0.001$). Landscape heterogeneity was estimated by the number of transitions between crop and a group of 10 non-crop habitats (usually with trees and shrubs, e.g. farmsteads, woodlots, semi-natural pastures). The number of transitions was counted along each arm of an eight-armed ruler in a standardized manner, and the mean number of transitions per site was used as estimate of landscape heterogeneity (see Berg, 2002a). The environmental variables used in the analyses are listed in Table 1.

2.1. Bird censuses

Birds were inventoried with point counts (Bibby et al., 1992). All sites were visited five times in 1994 and 2004 during early morning (mainly from sunrise, i.e. from 4:45 during first period to 3:27 in last period, to 10 am), once in each of the periods 1–10 May, 11–20 May, 21–31 May, 1–10 June and 11–20 June. Each person (all highly experienced bird watchers) visited 11–23 sites per morning and each observer visited the same sites across the whole study period. We carefully selected the survey points such that each observer inventoried points covering same landscape types and land-uses to avoid observer biases. Sites were inventoried in a different order at each occasion to avoid bias due to variation in diurnal activity of birds.

Table 1
Description of landscape and land-use variables included in the analyses.

Variables	Description
Forest coverage	Area (ha) of forest (coniferous, deciduous and young forest) within 600 m.
Landscape heterogeneity	Number of transitions along an eight-armed ruler between arable land and a group of 10 other habitats (farmsteads, within-field habitat islands, semi-natural pastures, coniferous forest, deciduous forest, young forest, gardens, rivers, lakes and a class including other rare habitats) within 300 m.
Short rotation coppice	Proportion of short rotation coppice (*Salix*) among all open habitats within 300 m.
Non-rotational set-aside	Proportion of fields under long-term set-aside (at least two years) among all open habitats within 300 m. Usually with dense tall vegetation.
Ley	Proportion of cultivated grassland-used for hay and silage production among all open habitats within 300 m.
Cultivated pasture	Proportion of arable land under pasture among all open habitats within 300 m.
Rotational set-aside	Proportion of set-aside with stubble from the previous year among all open habitats within 300 m. Usually with short and sparse vegetation.
Autumn-sown crops	Proportion of autumn-sown crops among all open habitats within 300 m. Consisted mainly of wheat.