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Impact of landscape improvement by agri-environment scheme options on densities of characteristic farmland bird species and brown hare (*Lepus europaeus*)

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ABSTRACT

Causes for farmland bird declines are well studied, but on landscape level agri-environment schemes (AES) often show limited gains for biodiversity. We analysed population trends of nine farmland bird species and the brown hare in a Swiss arable landscape. Further, we focused on the impact of the quantity and quality of different ecological compensation area (ECA) options on densities of the study species, as well as on the extent of ECAs required on arable farmland to stop population declines of typical farmland species. Densities of bird species and hare counts were positively correlated with the quantity of ECAs and semi-natural habitat. However, effects of ECA options on birds and hares are species specific. The quantities of wildflower areas and semi-natural habitat strongly enhanced bird and hare numbers. The quality of the ECA options was also important, as densities were positively related to the amount of meadows of high ecological quality, but not to the amount of meadows of low ecological quality. To attain target densities, the required proportion of high-quality AES options and semi-natural habitat has to be at least 14%. This study provides evidence that intensively managed arable farmland can be improved for bird diversity and hare density by the Swiss AES. The amount of AES options of high ecological quality is of major relevance for nature conservation. We estimate that the amount of high-quality options and semi-natural habitats in the Swiss arable lowland must be four times higher than today's area to halt and reverse population declines of farmland species.

1. Introduction

Over the last decades, agricultural intensification and increased pesticide and fertilizer inputs have resulted in landscape degradation and fragmentation as well as loss of species-rich traditional farmland. Negative consequences of agricultural intensification on farmland biodiversity are well studied (Billeter et al., 2008; Flohre et al., 2011; Henle et al., 2008; Tscharntke et al., 2005). In most European countries, agri-environment schemes (AES) were set up in the early 1990s to reduce or even reverse these detrimental effects. But so far, positive effects of AES options on biodiversity were mainly found at the plot and farm scale (e.g. Haaland et al., 2011; Perkins et al., 2011; Setchfield et al., 2012), while examples for benefits of AES at the landscape scale remain rare. Over the past years, the overall effect of AES on biodiversity was intensively studied and examples of limited positive impacts on biodiversity were given (Birrer et al., 2007b; Kleijn et al., 2011; Knop et al., 2006; Vickery et al., 2004; Whittingham, 2007). In Switzerland, ecological compensation areas (ECAs) were implemented as part of the Swiss AES, but the positive effects of ECAs on species richness and abundance on a landscape level have also been rather moderate (Birrer et al., 2007b; Herzog et al., 2005a; Walter et al., 2004). The Swiss AES and its ECA options were designed to promote broad species diversity, from plants and insects to birds and mammals. Thus, the seed mixtures for the options "wildflower area" and "ECA meadow" are composed to establish a broad diversity of indigenous plant species. Further, specific management criteria (such as the presence of a minimal number of indicator plant species, unmowed grass/vegetation areas, pile of stones or branches, shrubs, ditches etc. and late cutting dates) have to be met to create more structural diversity in the landscape, providing food, nesting habitat, shelter and protection against predators for many different species. Swiss farmers have to implement ECAs on at least 7% of their farmland if they aim for any subsidy payments (direct payments), and

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can select among 16 options of ECAs, including wildflower areas, ECA meadows, hedgerows and other traditional farmland habitat (Schweizerischer Bundesrat, 1992). Yet, instead of implementing the most appropriate options for species conservation, options are usually chosen according to the best cost-benefit ratio for the farmer. Further, ECAs are often placed on low-yield locations such as wet, steep or shady areas (Herzog et al., 2005a).

Habitat quality and quantity play a key role in the conservation of farmland species (Birrer et al., 2007b; Vickery et al., 2004). However, the question of thresholds for certain habitat types to benefit the populations of typical farmland species has rarely been focussed in the debates of AESs. This is very likely due to the fact that farmland habitat and landscape can be very heterogeneous and differ greatly among countries and among regions. Furthermore AES options vary widely between programs and countries, and habitat requirements differ between target species. Yet, plausible estimates of required habitat quantity and quality are needed to optimize the different AES options for species conservation (Vickery et al., 2004).

First, we were interested in the benefits of ECAs at the landscape scale. We compared population trends of farmland birds and brown hare between neighbouring regions with different levels of ECA options. We expected more species to show a stable or positive population trend in the study site with a high proportion of ECAs than in two control sites. Second, we investigated the effects of different ECA options and of semi-natural habitats on density of farmland bird species and on the counts of brown hares. We hypothesized that the various ECA options differed in their effects on bird densities and hare numbers, respectively. Wildflower areas and semi-natural habitats were expected to be more suitable than ECA meadows to promote all species except the skylark (*Alauda arvensis*). For skylarks, we anticipated a small but positive effect of vegetated paths and emmer fields (*Triticum dicoccum*, a cereal variety grown at low intensity). The effectiveness of ECA meadows was thought to depend on their ecological quality (i.e. botanical and structural richness). The third goal was to examine whether quantitative thresholds of ECAs could be derived from the counts of farmland birds and hares. For this, we developed habitat models which predict species densities from habitat quantities.

2. Methods

2.1. Study area

The study was conducted in the region of Klettgau (Switzerland, about 450 m asl), a west-east orientated valley in the north of the Swiss lowland plateau with a mild and rather dry climate for Switzerland (mean annual precipitation = 1072 mm, mean annual temperature = 8.5 °C). The Klettgau is an intensively cultivated landscape with mainly arable production. Crop variety is high but cereal crops dominate, followed by sugar beets, grassland, maize and oilseed rape. Crop yields are amongst the highest in Switzerland. The intensity of arable production is generally comparable to the neighbouring EU countries. Average field size is around 1 ha, which is smaller than in most of the EU, but typical of the Swiss lowland. The open landscape is sparsely interspersed with semi-natural habitats such as hedgerows and creeks.

We collected the data in three study sites named Widen (5.3 km^2, 47°42′N 8°31′E), Langfeld (2.1 km^2, 47°41′N 8°29′E) and Plomberg (4.6 km^2, 47°40′N 8°27′E). The proportion of settlement area within the study sites is small (Widen: 6.3%, Langfeld: 1.4%, Plomberg: 3.2%) and woodland only covers a small fraction in the study site Plomberg (0.5%). Other habitat structures are small gravel-pits in all study sites and the embankment along a railway line dissecting the study sites Langfeld and Plomberg.

Table 1
Description of explanatory variables. Variables are measured as proportion of the cell area (200 × 200 m for birds, 500 × 500 m for brown hare).

Variable	Description
Wildflower area	Perennial elements on arable land sown with indigenous herbs and forbs. They normally remain not longer than six years at the same place. Fertilization and chemical plant protection is not allowed. Exception: single-plant treatments of problematic weeds with herbicides
ECA meadow	Sown with a seed-mixture of grass species and herbs. Not cut before June 15, not fertilized, mulching not allowed. Chemical plant protection prohibited; exception: single-plant treatments of problematic weeds with herbicides High-quality meadow: occurrence of indicator species Low-quality meadow: absence of indicator species
Semi-natural habitat	Hedges and semi-natural habitats, i.e. creeks including embankments, gravel-pits, railway embankments, nature conservation area, wet grassland, ruderal areas, areas used for equestrian or dog sport, bushes, coppices, small woods
Path	Min. 50% of the path is vegetated with grass and forbs
Emmer	Emmer (*Triticum dicoccum*) and einkorn (*Triticum monococcum*) cereal fields. Compared to modern winter wheat varieties, these two ancient wheat species show sparse and heterogeneous growth, because of very low fertilizer input. The use of herbicide, insecticide or fungicide is not allowed.
Wheat/maize/sugar beets/oilseed rape	Fields of these crop types in the cell area
Tall structures	Buffer area around tall vertical structures: 50 m around power lines and 100 m around houses/buildings

Since the early 1990s, ecological compensation areas (ECAs) as part of the Swiss "standard AES" (Schweizerischer Bundesrat, 1992) were implemented, consisting mostly of the options 'wildflower area' and 'ECA meadow' (see Table 1). Sown with seed mixtures of native plant species, these options enhance species richness (Aviron et al., 2009; Herzog et al., 2005b). Owing to an adaptive habitat management (Whittingham, 2011) and advisory of farmers, appropriate ECA options were chosen. For example, wildflower areas make up 25–33% of the total ECAs (average proportion in the Swiss lowland is ca. 5%, BLW, 2012). Soils in the study site Widen are of lower fertility compared to the other two study sites. Payments by the AES overcompensated potential yield losses in this area. As a consequence a large part of the area was ecologically highly improved by the implementation of ECAs. In the study site Widen the proportion of the ECA options 'wildflower area' and 'ECA meadow' increased from 1.5% in 1991 to 14.2% in 2012, a level much higher than in other parts of Switzerland (BLW, 2012). In the other two study sites, these ECA options sum up to about 5% of the total area, as farmers hesitate to switch to low-input production and to implement more ECAs on high-yield soils.

2.2. Bird census

We surveyed nine species typical of Swiss arable landscapes which were of conservation concern: common quail (*Coturnix coturnix*), common kestrel (*Falco tinnunculus*), European stonechat (*Saxicola torquatus*), marsh warbler (*Acrocephalus palustris*), garden warbler (*Sylvia borin*), common whitethroat (*S. communis*), red-backed shrike (*Lanius collurio*), yellowhammer (*Emberiza citronella*) and corn bunting (*Miliaria calandra*). Other species typical of arable landscapes and of conservation concern (BAFU and BLW, 2008) were not present in the study area (e.g. white stork (*Ciconia ciconia*), western yellow wagtail (*Motacilla flava*)) or could not be