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Research Paper

Effects of agri-environmental habitat provision on winter and breeding season abundance of farmland birds

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ABSTRACT

Farmland bird populations continue to show declines in spite of over 20 years of research and implementation of agri-environmental schemes (AES) intended to reverse this. Although it is well known that provision of winter food resources can attract farmland birds, there is continuing uncertainty over the ability of AES to provide tangible benefits for target species in terms of increased abundance. Answering these questions is hampered by interannual fluctuations in bird populations and the mobility and territoriality of farmland birds, which have complicated the interpretation of previous studies.

We monitored birds for five years on a large arable estate in central England managed under varying levels of AES uptake (low level uptake of simple and widely applicable AES options, more extensive uptake of more complex AES options), and two control treatments (on-site and off-site). Bird abundance in winter and both total abundance and number of territories in the breeding season were calculated from monthly visits to 16 transects.

Several species showed significantly higher winter abundance on AES treatments, particularly granivorous species (*e.g.* reed bunting, yellowhammer, linnet). Many other species (*e.g.* blackbird, chaffinch, robin) also showed significant differences in winter abundance between treatments on the estate and off-site controls. In the breeding season, linnet, reed bunting, goldfinch and combined granivorous birds showed higher abundance or number of territories on AES treatments compared to on-site controls. For most other species the differences were only significant between treatments on the estate and off-site controls. Independently of AES treatment, a lower coverage of cereals or greater Shannon diversity of crops in the local landscape also had a positive effect on the abundance of many species.

Our results suggest that well-implemented AES can significantly enhance local populations of both farmland specialists of conservation concern and generalist species. Our results also show that, in many cases, these effects were only demonstrable at the farm scale, in comparison with off-site controls. This is probably due to high levels of movement and dispersal of birds resulting in a farm-scale spill-over of beneficial effects of agri-environment measures. Our results therefore highlight the importance of thinking beyond the single-farm scale when designing schemes or studies for monitoring the effectiveness of AES, and the importance of selecting appropriately located controls.

1. Introduction

Agricultural intensification has led to widespread declines in farmland biodiversity over the last century (Donald et al., 2001; Newton, 2004; Kleijn et al., 2011). Changes in farm management, including removal of semi-natural habitats, increased pesticide and fertilizer input and more efficient harvesting have all had deleterious impacts on farmland wildlife, including birds. Farmland birds have undergone severe declines across the EU (Donald et al., 2001, 2006; EBCC, 2016), and particularly in the UK (DEFRA, 2015). Whilst the exact mechanisms of negative impacts of agriculture on populations vary between species, many share the loss of breeding and foraging habitat due to removal of semi-natural features and increased management intensity, and the loss of food resources in terms of invertebrates and seeds (Fuller, 2000). For many granivorous birds, declines have been driven by the loss of overwinter food resources caused by increased herbicide use and the dominance of autumn-sown cereals (Wilson et al., 2009). For insectivorous species, loss of foraging habitat and reduced invertebrate food resources in the breeding season have been identified as important drivers of declines (Potts, 1986; Campbell et al., 1997; Schaub et al., 2010).

One of the key mechanisms for promoting population recovery of

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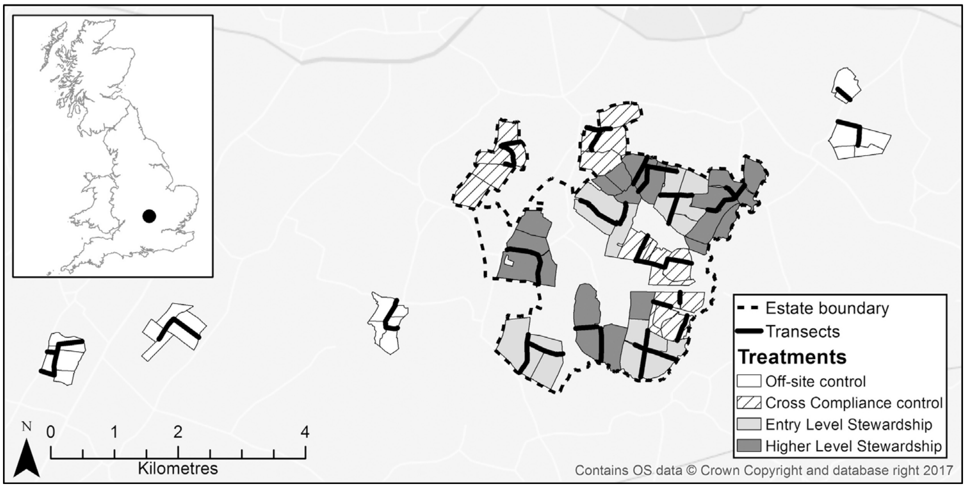

Fig. 1. Map of the study area showing experimental treatments on the Hillesden Estate and the locations of off-site controls in surrounding farmland. Inset map shows location of Hillesden within central England.

farmland birds are agri-environment schemes (AES). The major AES intervention directly aimed at farmland birds has been the provision of winter food resources by sowing areas of seed-bearing plants as an option for participating farmers. Such resources are well known to be utilised by a wide range of farmland birds, although the quality and quantity of the food provided can vary greatly with plant type and subsequent management (Vickery et al., 2009; Hinsley et al., 2010; Field et al., 2011) and across space and time (Vickery et al., 2009; Davey et al., 2010a). There is also evidence that many sown winter bird-food patches are largely depleted of seed by late winter, leaving birds with insufficient resources (Perkins et al., 2008; Siriwardena et al., 2008; Hinsley et al., 2010). Whilst some agri-environmental management options have been introduced to address this issue (*e.g.* extended overwinter stubbles, supplementary seed feeding), their efficacy is relatively unexplored (but see Siriwardena et al., 2007).

In addition to overwinter food, AES can also provide habitat for foraging and nesting in the breeding season *via* creation, restoration or maintenance of hedgerows (Hinsley and Bellamy, 2000; Maudsley et al., 2000; Staley et al., 2012), in-hedge trees (Redhead et al., 2013), field margins (Vickery et al., 2009; Pywell et al., 2011) and other semi-natural habitat features. This can both increase local populations of invertebrates (Vickery et al., 2009; Woodcock et al., 2010) and make them more accessible to foraging birds (Perkins et al., 2000; Benton et al., 2003), as well as providing suitable nesting habitat.

Many studies have demonstrated local and farm-scale successes of AES (Hinsley et al., 2010; Baker et al., 2012; Aebischer et al., 2016) and, recently, Bright et al. (2015) demonstrated that higher level schemes enhanced breeding densities of some priority farmland bird species even in the absence of ongoing advisory support. However, in spite of over 20 years of AES provision, and accompanying research, declines in farmland birds have continued, both in terms of individual species (Eaton et al., 2015; Harris et al., 2016) and aggregate farmland bird indicators (DEFRA, 2015). The extent to which AES have mitigated these declines remains largely unknown (Kleijn and Sutherland, 2003; Kleijn et al., 2006, 2011). Because farmland birds are mobile, with many species being partially or wholly migratory, the potential for movements of birds between winter feeding sites and breeding areas even within the same study landscape has complicated the interpretation of several studies (Hinsley et al., 2010; Aebischer et al., 2016). Therefore the overall effectiveness of AES remains unclear, with the general consensus that the current level of uptake of beneficial options is insufficient to promote a reversal of national-scale population declines (Davey et al., 2010a,b; Baker et al., 2012). If new AES aim to be better equipped to achieve population increases, it is important to improve the understanding of how AES management affects farmland birds at the local scale, both in the immediate vicinity of AES interventions and the wider context of the farm or holding. It is also important to understand whether the response to AES is consistent between winter and breeding seasons, accounting for the year-round mobility of birds over farmland landscapes (Siriwardena et al., 2006; Siriwardena, 2010).

The present study seeks to understand the impact of the provision of winter food and summer breeding habitat on the local populations of a range of farmland bird species, over a long-term experiment (5 years) within a single, large-scale farmland landscape. We monitored bird numbers in both winter and the spring/summer breeding season, and utilised two levels of AES (low level uptake of simple and widely applicable AES options, more extensive uptake of more complex AES options tailored to local circumstances), a control, and a spatially separated control to allow investigation of 'spill-over' of birds from AES to non-AES treatments. The aims were to:

1. Determine the impact of AES management on winter bird numbers.
2. Investigate whether increased winter bird abundance due to AES seed provision resulted in increased numbers of breeding birds or territories.
3. Examine whether such increases were detectable at the treatment scale and/or farm scale.

2. Methods

2.1. Study site

The study took place on the Hillesden Estate, which comprises approximately 1000 ha of predominantly arable farmland close to Buckingham, central England (51°57′N, 1°00′W, Fig. 1). The estate lies on seasonally wet clay soils with crop rotations dominated by winter wheat *Triticum aestivum*, winter oilseed rape *Brassica napus*, field beans *Vicia faba* and spring barley *Hordeum vulgare*.

The experimental layout of the Hillesden Estate was initially established in 2005/2006 in order to monitor the effects of Environmental Stewardship (ES, the then recently introduced UK AES) on farmland biodiversity, including farmland birds, and productivity (*e.g.* Hinsley et al., 2010; Woodcock et al., 2010; Redhead et al., 2013; Broughton et al., 2014; Pywell et al., 2015). In 2011 the experimental design was altered to improve the ability to compare the effects of management under i) Entry Level (ELS) and ii) Higher Level Stewardship (HLS) schemes, which involved the relocation of treatments and AES options to the current experimental design (Fig. 1). A high level of spill-over effects between adjacent treatments (*i.e.* effects resulting from movement or dispersal of organisms between different treatments) had been detected after the first five years of the study (Hinsley et al., 2010;