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Fodder crop management benefits Northern Lapwing (*Vanellus vanellus*) outside agri-environment schemes

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ABSTRACT

To date, agri-environment schemes (AES) have had limited success in reversing biodiversity loss over greater spatial extents than fields and farms, and vary widely in their cost-effectiveness. Here, over nine years, we make use of the management initiative of a farmer in an upland livestock farming landscape in Scotland, undertaken wholly outside AES, to examine its effect on breeding densities of Northern Lapwing *Vanellus vanellus*. Management designed by the farmer involved planting a *Brassica* fodder crop for two consecutive years followed by reseeding with grass, with eight out of 17 fields at the farm undergoing this management since 1997. After controlling for other habitat parameters of importance, the density of breeding Lapwings was 52% higher in fields that had undergone fodder crop management than those that had not. Densities were highest in the first year after the fodder crop was planted, prior to reseeding with grass, but remained above levels in control fields for approximately seven years after the fodder crop was last planted. Very high Lapwing densities (modelled density = 1 pair ha^{-1}) in the year after the fodder crop was planted likely result from the heterogeneous ground surface created by grazing of the crop providing an "attractive" nesting habitat. Continued high densities following reseeding with grass may partly be accounted for by philopatry, but the fact that they are field-specific also suggests that these fields continue to offer enhanced foraging conditions for several years. Fodder crop management was implemented at the study site to fatten lambs over winter and ultimately improve grass condition for grazing. This system is therefore based on active farming and benefits both the farmer and breeding Lapwings. As such, it may be possible to implement it more widely without the need for high agri-environment payments. More generally, it is an example of the land owner being actively involved in developing conservation solutions in partnership with environmental research, rather than being seen as a passive recipient of knowledge as has typically been the case with the design of AES. Such approaches need to be adopted more consistently in designing interventions for environmental outcomes on farmland, but may be of particular importance in the UK if the certainties of European Union AES are to come to an end.

1. Introduction

Agriculture is the principal land use across Europe and accounts for over 40% of the European Union (EU) land area (European Commission, 2017). The EU's Common Agricultural Policy (CAP) has been instrumental in directing public subsidy to production and thus driving agricultural intensification, with attendant widespread wildlife losses that have been particularly well documented for birds (Donald et al., 2006). Recognising the negative impacts of agricultural intensification on biodiversity, 'greening' of the CAP since the early 1990s has included agri-environment scheme (AES) funding designed to encourage the adoption of environmentally friendly management practices by compensating for lost income. To date, the success of AES in halting biodiversity loss has been mixed and more associated with the scale of implementation (farms) than the scale of policy ambition (national biodiversity loss) (Kleijn et al., 2011; Whittingham, 2011).

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Problems include implementation at too small a spatial scale (O'Brien and Wilson, 2011; Broyer et al., 2014), lack of appropriate measures for certain species, taxa or farming systems (Redpath et al., 2010; Fuentes-Monteymayor et al., 2011) or conversely a large range of prescriptions that vary in their effectiveness or fail to deliver all a species' requirements (Smart et al., 2013). However, when schemes are targeted effectively, are adaptable, and farmers are given site specific advice, they can provide the desired conservation benefits, at least locally or for species whose populations have been reduced to very small size and geographical range (Wilson et al., 2010; Schmidt et al., 2017).

Farmland breeding shorebirds (waders) have suffered large population declines as a result of agricultural change (Wilson et al., 2009) and are a good example of the problems in ensuring AES success described above. In the Netherlands and the UK, two of the most important countries in Europe for this bird assemblage (Birdlife International, 2004), there is good evidence of localised demographic or population benefit but little translation of these local successes to reversal of national population declines (Kleijn and Van Zuijlen, 2004; Verhulst et al., 2007; O'Brien and Wilson, 2011; Smart et al., 2014).

The need to deliver cost-effective conservation benefits for shorebirds on farmland is now urgent, and alternatives to AES which provide both conservation and economic benefits and could be promoted without the need for compensatory payments should be explored (e.g. Osgathorpe et al., 2011), especially given the planned exit of the UK from the EU and potential accompanying loss of CAP payments for agri-environment measures. Here, we evaluate an unusual and innovative fodder crop management system implemented on an upland grassland farm in Scotland that is associated with nationally exceptional breeding densities of waders, particularly Northern Lapwing *Vanellus vanellus,* (McCallum, 2012), but which is implemented primarily for husbandry and commercial reasons, and not for conservation purposes. The management system involves planting the forage brassica 'tyfon' (*Brassica campestris* x *B.rapa*) for two consecutive years in a field that was previously pasture, prior to reseeding the field with grass (see Table 1 for timeline). This process improves grass productivity after reseeding (EBLEX, 2008), as well as providing fodder (stubble turnips) for fattening of lambs over the winter (Koch et al., 1987). The ground is limed during fodder crop management in order that the optimum soil pH for fodder crops and grass growth is obtained prior to reseeding.

In this study we examine the utility of this management in supporting high densities of breeding Lapwings. Specifically, we test i) whether fields with a prior history of fodder crop management have higher Lapwing densities and ii) whether the density of breeding Lapwings is related to the number of years since fodder crop management. We also test whether vegetation height or percentage bare ground varies between grass fields that had previously undergone fodder crop management and those that had not.

2. Methods

2.1. Study site and fodder crop management

The study took place in 2003 and from 2006 to 2011 on 315 ha of commercially farmed grassland (56° 4′40.06″N 4° 0′45.00″W) in Scotland, at 140–320 m altitude. The farmland supports approximately 1200 black-faced sheep and 50 limousin cross cattle and comprises 120 ha of "in-bye" land (140–270 m altitude) and 195 ha of "out-bye" (175–320 m altitude). "In-bye" is the local term for agriculturally improved, enclosed fields below the moorland wall, and "out-bye" is the land beyond the moorland wall where vegetation is semi-natural in character (Gray, 2000) grading from acid grassland to moorland dominated by ling heather *Calluna vulgaris*.

Unusually for Scottish farmland, fodder crop management has been used in the study area to keep sheep on in-bye fields over winter. This management has been in place since 1997, and by 2011 eight fields had been placed in this management regime (Fig. 1), whereas the remaining nine had been subject to no cultivation or reseeding. Data collected on these 17 fields, making up the 120 ha of in-bye land, support the analyses presented here. Fodder crop management involves planting of tyfon in late June or early July for two consecutive years, after which the field is reseeded with grass (perennial rye-grass *Lolium perenne* and white clover *Trifolium repens* seed mix) in June or July of the third year (Table 1). All fields that have undergone tyfon cultivation have then remained as grass since reseeding.

Prior to sowing tyfon, soil pH was tested by the farmer. Lime (5 tonnes ha-1 annum-1) was applied for up to three consecutive years with the first application at the time that tyfon was first planted with the objective of raising soil pH to 5.8 to coincide with grass reseeding. The range of soil pH in the in-bye fields that had not undergone fodder crop management was between 4.7 and 5.5 and it is likely that pH prior to fodder crop management fell within this range across all in-bye fields. Fertiliser (NPK, 2:1:1, 250 kg ha^{-1}) was applied at the same time as tyfon or grass was planted. Fields that had not been subject to tyfon cultivation received this fertiliser less frequently, and were limed no more frequently than once every five years.

Lapwings arrive to nest from the beginning of March and leave at the end of June or early July. Planting of tyfon or reseeding with grass thus occurs at the end of the breeding season so that Lapwing use is only potentially affected in the year after management has occurred (Table 1).

2.2. Lapwing and habitat surveys

To test whether field use of breeding Lapwings was related to fodder crop management, the number of breeding Lapwing pairs in each in-bye field was counted in 2003 and from 2006 to 2011. In each year either one (2003 and 2006–2007) or two (2008–2011) survey visits were made. Where only one survey visit was made, this was between 1st and 21st May. When an additional visit was made, this was between 18th and 30th April with at least 18 days between surveys. Surveys were carried out on foot, walking to within 100 m of all points of each field and scanning ahead (up to 400 m) with binoculars from appropriate vantage points to record all Lapwings (O'Brien and Smith, 1992). Annual totals of Lapwing pairs were calculated for each field by halving the number of individuals recorded (Barrett and Barrett, 1984). Flocks of birds not exhibiting signs of breeding behaviour were excluded. Lapwings were counted on at least 12 in-bye fields in all years of the study, with all 17 fields counted in four years. Table 2 shows the number of fields in each treatment where Lapwings were counted in different years.

Data on field characteristics likely to influence the suitability of a field for breeding Lapwings were measured using ArcGIS 9.2 (ESRI Inc,

Table 1
Timings of fodder crop management process in comparison to Lapwing use at the study site.

Farm management	Late June / July	Autumn / winter	March
Year 1	Tyfon planted	Tyfon grazed	Most of crop has been grazed
Year 2	Tyfon planted	Tyfon grazed	Most of crop has been grazed
Year 3	Grass planted	Grazing excluded for grass growth	Grass grazed
Lapwing activity	Leave for wintering grounds	Absent	Arrival for breeding