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The provision of winter bird food by the English Environmental Stewardship scheme

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Environmental Stewardship (ES) is the main mechanism for reversing the decline in farmland birds in England, and includes a range of options designed to provide winter foraging for seed-eating species. We estimated granivorous songbird densities on ES options designed to provide winter food, on farms within the Entry Level (ELS) or Higher Level (HLS) strata of ES. ES Wild Bird Mixtures (WBMs) hosted higher densities and a wider range of granivores than non-ES game covers, although in East Anglia the enhanced HLS WBM was used no more than the basic ELS WBM. In the West Midlands there were low densities of granivores on all WBMs and game covers. The widespread ELS WBM appeared to provide little food for buntings but supported finches, partially through greater weed burdens. There was a weak, non-significant trend for Skylarks *Alauda arvensis* to make greater use of ELS cereal stubbles than non-ES stubbles, possibly because of post-harvest herbicide restrictions allowing overwinter weed growth. At the field scale, this work demonstrates that although some ES options provide winter food resources for birds, there is limited evidence for additional benefits of Higher Level vs. Entry Level Stewardship to wintering farmland songbirds.

Keywords: agriculture, agri-environment scheme, conservation, granivore, Skylark, stubble, wild bird cover.

Many farmland bird species have undergone well-documented population declines and range contractions in the UK since the mid-1970s (Gibbons *et al.* 1993, Fuller *et al.* 1995, Siriwardena *et al.* 1998, Gregory *et al.* 2004). Various facets of agricultural intensification have been major causes of these declines (Chamberlain *et al.* 2000, Newton 2004), although the precise mechanisms differ spatially and by species due to regional differences in farming systems and ecological differences between species. Reduced availability and abundance of winter seed food has been identified as a key limiting factor of the populations of a suite of declining, resident granivorous farmland species in the UK (Peach *et al.* 1999, Hole *et al.* 2002, Gillings *et al.* 2005, Siriwardena *et al.* 2007). The switch from spring to autumn sowing of the majority of cereal and oil-seed crops in lowland UK and the increased use and effectiveness of herbicides have led to reductions in both weed seeds and spilt grain, the loss of large areas of weedy, post-harvest stubbles, and a decrease in the abundance and diversity of within-crop and marginal arable weed species (Wilson *et al.* 2009).

To conserve a range of widespread, formerly common farmland bird species, a variety of habitats is needed to provide nesting and food requirements throughout the farmed landscape. Agri-environment schemes (AESs) are the key delivery mechanism for these (Vickery *et al.* 2004). AESs across Europe have been criticized for a dearth of clear targets and accompanying monitoring/evaluation (Kleijn & Sutherland 2003), and for delivering limited biodiversity benefits (Kleijn *et al.* 2001, 2006, Kleijn & Sutherland 2003). However, there is evidence that targeted, well-monitored schemes, backed up by advice to landowners, can produce measurable benefits (Evans *et al.* 2002, Evans & Green 2007). For example,

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there is evidence from the Arable Stewardship Pilot Scheme that certain options, some of which have been incorporated into the successor Environmental Stewardship (ES), can provide resources for a range of widespread but declining species (Critchley *et al.* 2004, Pywell *et al.* 2004a, 2004b), including birds (Bradbury *et al.* 2004, Stevens & Bradbury 2006). At a population level, provision of weedy cereal stubbles and invertebrate-rich grassland, via the Countryside Stewardship Scheme (CSS), led to an increase in the population of the Cirl Bunting *Emberiza cirlus* of 83% in 6 years on CSS land, while numbers on surrounding non-CSS land remained stable (Peach *et al.* 2001).

ES was launched in England in 2005 by Natural England (the UK government conservation agency for England) and is a multi-objective AES comprising two elements: Entry Level Stewardship (ELS), in which land managers are paid for simple conservation landscape improvement measures, is open to all English farmers in receipt of Single Farm Payment subsidy; Higher Level Stewardship (HLS) involves more complex land management targeted at farm-specific environmental features (e.g. habitats and species) and entry is competitive. The success of ES in delivering its targets and its future development is informed by an evaluation programme, following a clearly defined model, as outlined by Kleijn and Sutherland (2003). As part of the evaluation, studies are being conducted to assess the efficacy of both ELS and HLS in providing habitats that are used by feeding and nesting birds (including this study) and in increasing farmland bird populations (e.g. Davey *et al.* 2010).

ES has a number of options that allow farmers to provide winter food resources for birds. The most popular are sown plots of so-called 'Wild Bird Mixtures' (WBMs – mixes of seed-bearing crops) and the leaving of cereal stubbles through the winter (covering 2784 agreements on 3459 ha and 3237 agreements on 43 791 ha in England in July 2006, around 0.76% of all land under ES: Natural England unpubl. data). Various versions of these options are available to agreement holders (Natural England 2008a, 2008b). ELS options tend to require less management, cost less to implement and therefore attract less remuneration than those available to HLS farmers (the ethos behind ES is that farmers are recompensed for income foregone by taking land out of production and into conservation measures). ELS options may also be included as part of an HLS agreement (Natural England 2008b). HLS options generally require additional management and are targeted at priority species.

This paper reports on a study to measure the comparative efficacy of measures that aim to provide winter seed resources for widespread granivorous bird species. We compare granivore densities on basic ELS WBM and stubble options (EF2/3 and EF6), with their more complex, targeted HLS counterparts (HF12 and HF15), and their non-ES equivalents (game cover, comprising dense stands of cover crops provided over the winter to provide shelter and food to gamebirds; and rotational cereal stubbles, post-harvest stubbles retained until conditions are suitable for establishing the next crop, usually in mid-winter and usually subject to post-harvest herbicide treatments).

METHODS

Site selection

Three range-restricted, declining (Eaton *et al.* 2008), resident granivorous species are specifically targeted by HLS in winter: Grey Partridge *Perdix perdix*, Tree Sparrow *Passer montanus* and Corn Bunting *Emberiza calandra*. Farms entering HLS within these species' ranges adopt measures specifically aimed at their conservation, including ES WBM and stubble options. As the primary focus of this study was on HLS sites and options in comparison with their ELS equivalents, we aimed to survey a minimum of 20 HLS farms for each target species. The selection of non-HLS sites reflected the occurrence of ELS and non-ES farms in the local landscape. We attempted to recruit as many non-ES farms as possible to match sample sizes with HLS farms, but logistics made this impossible. This may have limited the explanatory power of the study. Site selection was based on the presence of any of the target species on the farm, as revealed by the Farm Environment Plan (FEP – a specific audit of the environmental features present produced as part of the farmer's HLS application), or coincidence of sites with current knowledge of species' distributions (taken from the Bird Conservation Targeting Project (BCTP) http://www.rspb.org.uk/targeting). Twenty-seven HLS farms were thus identified using maps from the GENESIS database (the database and mapping tool used by Natural England to administer ES), and surveyed in two regions. In East Anglia (EA), farms were selected within the ‘East Anglian Chalk’, ‘North West Norfolk’, ‘Bedfordshire & Cambridgeshire Claylands’, ‘The Fens’ and ‘Breckland’ Joint Character Areas (JCAs), and in the West Midlands (WM) within the ‘Shropshire, Cheshire & Staffordshire Plain’ and ‘Cheshire Sandstone Ridge’ JCAs (Table 1). This selection allows comparison between different geographical locations and farming systems (arable EA vs. mixed WM), similar to the Arable Stewardship Pilot Scheme (Bradbury *et al.* 2004). Thirteen ELS farms and 14 farms with no ES agreement within 2–10 km of the selected HLS sites were surveyed during the same period (Table 1). HLS, ELS or non-ES farms were assigned to one of 10 geographical clusters (five in each region) with similar soil type, topography and prevalent farming systems. The close geographical proximity and characteristics (Cluster membership) of sites chosen were an attempt to maximize the chance of target and other granivorous species occurring at any site if the right feeding habitats were present. A minimum separation distance of 2 km was employed to minimize the likelihood of management practices on one farm influencing bird distribution on adjacent land. We attempted to match farms within and across clusters as closely as possible in terms of holding size (and surveyed area – see below) and farming system. Holdings (or survey areas, if the farm was disaggregated) of < 20 ha were excluded. In addition to being coincident with current knowledge of target species’ distributions, the selection of sites was dependent upon their containing one or more options to provide winter seed.

Field methods

Two survey visits were made to each site between 1 November 2007 and 29 February 2008. Each survey visit was completed within a single day. On each visit, field-scale counts were made of all bird species feeding in survey units (fields or sub-field plots of uniform land-use), comprising either habitat providing winter seed (including ES options) or crops. On each site, an area of up to 1 km^2 of farmland was surveyed (mean survey areas shown in Table 1). On ES sites that had a range of winter food options, fields were selected from farm maps to maximize the range and number of plots of options surveyed (but regardless of apparent quality). On non-ES sites, the survey area was a block that included plots or fields of game cover or stubble as for ES farms (Table 2). Observers walked transect routes to flush birds in each survey unit. In survey units with short vegetation, transect walks were based on 50 m separation. As some bird species tend to use only the field edge for foraging, transects were also walked within 5 m of all field edges. This method effectively achieves complete counts of birds (Perkins *et al.* 2000, Bradbury & Allen 2003, Bradbury *et al.* 2004). The location of all birds present (using boundary features or open fields of each survey unit) were distinguished. Double-counting of birds was minimized by ignoring flushed birds on subsequent encounters (Bradbury & Allen 2003, Bradbury *et al.* 2004). Surveys started at least 1 h after sunrise to avoid missing birds travelling from roosts, and were not conducted in periods of heavy rain, strong wind or poor visibility. Routes were reversed between visits to minimize any effects of time of day on the presence or detectability of birds. The order of visiting sites was randomized and varied for the second survey.

On all sites, details of survey units were mapped and categorized, along with details of associated margins and boundary features. Field

Table 1. Areas (ha) of ES and non-ES farms surveyed with region and number of HLS sites targeted at each of three species by either: [a]Farm Environment Plan (FEP) only (i.e. known to occur on that site at the time of application to HLS); or [b]FEP in combination with recent distribution data from the Bird Conservation Targeting Project.

	West Midlands						East Anglia					
	No. of sites	Total area	Mean area	P.	TS	CB	No. of sites	Total area	Mean area	P.	TS	CB
HLS	14	708.7	50.6	6[a]/11[b]	9/14	1/8	13	788.7	60.7	13/13	4/4	5/11
ELS	7	356.0	50.8				6	286.2	47.7			
Non-ES	7	294.1	42.0				7	334.5	47.8			

P., Grey Partridge; TS, Tree Sparrow; CB, Corn Bunting.

Table 2. ES options and non-ES crops providing winter seed food for birds, and their ES codes.

	ES				
	HLS		ELS		Non-ES
Stubbles	HF15	Reduced herbicide, cereal crop management preceding overwintered stubble and a spring crop, no post-harvest herbicide or cultivation until mid-February	EF6	Overwintered stubbles, no post-harvest herbicide or cultivation until mid-February	Rotational stubbles, no restrictions on herbicide or cultivation after harvest
Seed cover crops	HF12	Enhanced Wild Bird seed Mix	EF2	Wild Bird seed Mix	Game cover
			EF3	Wild Bird seed Mix on set-aside land	

maps were digitized and survey unit areas and boundary lengths were determined using MAPINFO PROFESSIONAL v9.0 GIS software (Troy, NY, USA). Basic vegetation measures were collected on each visit within a 0.5×0.5 m quadrat at 10 sampling locations (evenly distributed along the longest axis, a minimum of 10 m apart) in each cover crop or cereal stubble on a site. We recorded percentage cover of weeds (broadleaved and grasses), of each sown component and also the percentage of plants in seed for each of these vegetation categories.

Statistical analyses

All statistical analyses were conducted in SAS v9.1 (SAS Institute 2003). Model effects and levels are defined in Table 3.

Landscape

Several landscape characteristics of survey sites were analysed in generalized linear models (GLMs) using PROC GENMOD. The arable/grassland ratio, habitat diversity (calculated from all in-field land-use types present in the 1-km^2 survey area, including adjacent un-surveyed land if present – Simpson's index (D); Equation 1), and mean field enclosure per farm (calculated from the individual Boundary indices (BI) of each field, after Wilson *et al.* (1997); Equation 2) were specified as dependent variables, with normal error structure and an identity link function. Region, ES status and the interaction term between these effects were included as categorical fixed effects. The arable/grassland ratio values were arcsine transformed to normalize the data.

Table 3. Definitions of independent effects included in GLMS and GLMMS and the constituent levels of categorical effects. Also included are definitions of dependent 'seed provision' indices for cover crops and WBMs.

Effect	Levels
Region	2; West Midlands, East Anglia
ES status	3; HLS, ELS, Non-ES
Cluster	Random; 10; 5 in each Region
Cover crop type	3; HLS enhanced WBM, ELS WBM, Game Cover
Stubble type	3; HLS, ELS, Non-ES stubble
Habitat diversity	Continuous
Boundary Index	Continuous
Seed provision Index	Continuous; mean seed provision per survey unit of brassicas (kale, radish, mustard), cereals, seed-crops (quinoa, canary grass, millet, sunflower, linseed), weeds (broadleaved, grass), maize
Site	Random

$$D = 1/(\Sigma P_{\mathrm{i}}^2) \quad (1)$$

where P_i is the proportion of habitat i in the 1 km^2 relative to the total area of known habitat.

$$\mathrm{BI}_a = \Sigma(s_j \times l_j)/L_a \quad (2)$$

where s_j is the height classification of boundary j of field a (according to Wilson *et al.* 1997), l_j is the length of boundary j of field a and L_a is the total length of boundaries surrounding field a.

Bird use of stubbles and seed-crops

Bird counts for all ES and non-ES seed-crop types (WBMs and game covers) and stubble types were compared separately within a generalized linear mixed modelling (GLMM) framework. Data were analysed with maximum total counts (across two winter survey visits) per survey unit for each seed-crop or stubble as the dependent variable, a Poisson error structure and log link function. These models were constructed using PROC GLIMMIX with over-dispersion accounted for using the random _RESIDUAL_ statement. Each model included fixed categorical Stubble or Seed-crop Type (each a three-level factor comparing densities in HLS, ELS WBMs and game cover or HLS, ELS and non-ES cereal stubbles), random Cluster and Site identifiers, and continuous arable/grassland ratio, habitat diversity and boundary index effects (included as these co-variates were shown to vary significantly with Region or ES Status, see Results section below). The natural log of survey unit area (ha) was specified as an offset variable. This base model assessed the significance of differences in bird density between food-providing habitats.

Many HLS agreements also contain ELS options, including WBM options EF2/3 and stubble option EF6. With this in mind, the base models for WBMs and stubbles were re-applied to a reduced dataset, including only these options, and a fixed two-level ES Status effect (HLS or ELS) replaced Seed-crop Type and Stubble Type in each model, to test whether usage of these options differed between ELS & HLS agreements.

Individual analyses were attempted for the three HLS target species. A broader suite of farmland granivorous passerine species, the intended beneficiaries of the focal options in ELS and HLS, was analysed together as a guild. This group analysis was undertaken in response to low counts of individual species in an attempt to detect broad responses to seed provision by a group of species with similar ecology. However, individual species' local abundances and responses to differences in seed type provided are likely to reduce the power to detect such responses when they are considered as a guild. This grouping ('Granivores') comprised Tree Sparrow, Corn Bunting, Reed Bunting *Emberiza schoeniclus*, Yellowhammer *Emberiza citrinella*, Chaffinch *Fringilla coelebs*, Brambling *Fringilla montifringilla*, Goldfinch *Carduelis carduelis*, Linnet *Carduelis cannabina* and Greenfinch *Carduelis chloris*. Skylark *Alauda arvensis* densities on stubbles were also analysed.

Significance testing was conducted on full models using Type III Wald chi-squared test comparisons and a significance level of $P < 0.05$. Significance of differences between effect levels were derived from *post hoc* pair-wise comparisons of 95% confidence limits of least squared mean parameter estimates. Separate base models were constructed for each region because agricultural management may have differing effects according to landscape type (Robinson *et al.* 2001). Models were also constructed across regions to maximize sample sizes, but included Region as a fixed effect.

Seed provision on WBMs and game cover

Mean 'seed provision' indices for each Seed-crop survey unit (proportion of cover of each vegetation species × proportion of plants of that species which carried seed) were calculated for all vegetation present, all weeds and the various WBM components (Table 3). The maximum value for each category across both visits was used for analysis. These proportions were normalized by arc-sine transformation prior to analysis. We tested for differences in mean seed provision by each component of survey unit vegetation between Seed-crop Types in PROC GLIMMIX with a random Site effect and normal error structure/identity link function.

RESULTS

Eighteen HLS sites harboured at least one of the three target species, although for all three, occupancy of WM sites fell some way below the numbers expected based on FEP and distribution figures used for site selection (Table 4). In EA a high proportion of HLS sites expected to harbour Corn Bunting and Grey Partridge did so (Table 4). Corn Buntings were not found in the WM, nor on non-ES sites in EA. Tree Sparrows were not found in EA. Grey Partridge were more common in EA. Skylarks were ubiquitous in EA, and on ES sites in the WM, but were largely absent from non-ES farms in this region. Numbers of all three target species were insufficient to allow formal analyses, and therefore results are presented for the larger group of granivorous passerines (including Tree Sparrow and Corn Bunting) and separately for Skylark.

Table 4. Site occupancy of species and groups by ES status and Region. Site occupancy for target species is based on the number of sites where that species was observed compared with the number of sites where it was expected as determined by: [a]Farm Environment Plan (FEP) only (i.e. known to occur on that site at the time of application to HLS); or [b]FEP in combination with recent distribution data from the Bird Conservation Targeting Project.

	West Midlands					East Anglia					
	Non-ES	ELS	HLS	FEP[a]	FEP + Dist[b]	Non-ES	ELS	HLS	FEP	FEP + Dist	Total HLS
Granivores	7	7	14			6	6	13			
Grey Partridge	1	1		1/6	3/11	3	5		11/13	11/13	14
Tree Sparrow	3	2		3/9	4/14	0	0		0/4	0/4	4
Corn Bunting	0	0		0/1	0/8	0	2		4/5	5/11	5
Skylark	1	6	12			7	6	13			

Landscape

The arable/grassland ratio was significantly higher in East Anglia than in the West Midlands ($P < 0.0001$). WM ES sites tended to be less grassland-dominated than non-ES sites (29.2% on ELS and 43.6% on HLS farms compared with 88.5% on non-ES farms), probably explaining the absence of Skylarks on non-ES farms in this region. EA HLS farms were less dominated by cereals (90.8%) than non-ES (94.7%) and ELS sites (96.4%). There was no regional difference in habitat diversity within farms, although HLS farms were significantly more heterogeneous (3.33) than non-ES farms (1.97). The degree of field enclosure (BI) differed significantly, both regionally (EA greater than WM) and with ES status (ELS < HLS < non-ES). Thus, these three measures of landscape were included in all bird density models, to control for site-specific influences on bird numbers.

Bird use of stubbles and seed-crops

A total of 1507 granivorous passerines was recorded on 26 (20.9 ha) seed-crop plots in EA and 778 on 18 (28.4 ha) in WM. Significantly higher densities of granivores were recorded on WBMs in EA and both regions combined (although a non-significant relationship in the case of the latter ($P = 0.097$)) than on non-ES game covers (Table 5a). No differences in densities were found between WBMs and game cover in WM. Granivore densities on ELS WBM were similar in both regions in the context of whether they were located on ELS or HLS agreements (Table 6). The composition of granivore flocks on Seed-crops varied with crop type (Fig. 1). Most Yellowhammers, Corn and Reed Buntings, and Tree Sparrows were observed on HLS WBMs, whereas ELS WBMs had most Bramblings and Goldfinches. Game covers hosted mainly Chaffinches. Game covers provided a higher proportion of maize seed, whereas ELS WBMs provided significantly more weed seed and HLS WBMs more cereal seeds (Fig. 2). Maize was present in one HLS WBM as a result of partial failure of establishment of the original seed mix, where maize was sown later to provide game cover in bare patches, despite this crop being explicitly excluded from the allowable seed mix.

A total of 552 granivorous passerines was recorded on 34 (324.3 ha) stubble fields in EA and 701 on 41 (243.5 ha) in WM. Densities of granivores on ES stubbles were not statistically higher than on non-ES stubbles in WM (Table 5a) and were no higher on ELS stubbles on HLS farms compared with those on ELS farms ($P = 0.270$) (Table 6).

Skylarks were more abundant on ELS stubbles on HLS farms (Table 6). Comparison of their use of stubbles showed no significant differences with type in EA and WM, although when data from the two regions were combined, another weak relationship ($P = 0.074$) suggested that Skylarks may have been more abundant on ES than non-ES stubbles (Table 5b). Small sample sizes of stubble fields and low densities of birds are likely to have reduced the power of this analysis.

DISCUSSION

In the context of a subsidy-based AES, maximizing the efficacy of conservation measures is vital to achieve the best and the most cost-effective conservation outcomes. Therefore, basic ELS options should perform better than habitats already commonly present on farmland, and meet

Table 5. Results of GLMM analyses of: (a) granivore density in cover crops and stubbles; and (b) Skylark density in stubbles on non-ES, ELS and HLS farms.

(a)	Cover crops	*n*	Birds/ha	se	Significance	Stubbles	*n*	Birds/ha	se	Significance
EA	Game cover	4	2.10 b	4.35	$P < 0.05$	Non-ES	10	1.33	4.86	NS
	EF2/3	14	25.53 a	15.83		EF6	21	14.62	37.91	
	HF12	8	49.31 a	42.05		HF15	3	2.05	32.14	
WM	Game cover	5	9.98	11.86	NS	Non-ES	22	8.04	3.87	NS
	EF2/3	13	12.28	9.06		EF6	17	19.94	6.72	
	HF12	8	17.67	10.65		HF15	2	1.99	27.00	
Both	Game cover	9	4.73 b	4.75	NS ($P = 0.097$)	Non-ES	32	7.96	5.38	NS
	EF2/3	27	17.71 a	7.62		EF6	38	17.27	9.48	
	HF12	16	27.97 a	12.98		HF15	5	1.97	9.47	

(b)	Stubbles	*n*	Birds/ha	se	Significance
EA	Non-ES	10	3.03	2.89	NS
	EF6	21	6.43	4.17	
	HF15	3	10.73	16.99	
WM	Non-ES	22	0.96	0.84	NS
	EF6	17	4.46	2.68	
	HF15	2	2.09	7.86	
Both	Non-ES	32	2.07 b	1.12	NS ($P = 0.074$)
	EF6	38	6.29 a	2.36	
	HF15	5	5.94 a	7.75	

n, number of survey units; Birds/ha values are least-squares mean estimates from models; letters refer to significant differences between levels at $P < 0.05$, determined by *post hoc* pair-wise comparisons of 95% confidence limits; se, standard error of parameter estimates; NS, not significant at $P = 0.05$ level.

Table 6. Results of GLMM comparison of granivore and Skylark densities on WBMs and stubbles on farms in ELS and HLS management.

	WBMs		Stubbles	
	ELS	HLS	ELS	HLS
Granivores	43.15 (31.38)	16.05 (9.19)	8.46 (7.14)	17.99 (7.19)
	NS		NS	
Skylarks			1.21 (1.41)	9.30 (3.63)
			$P = 0.025$	

Values are least-squares mean estimates from models; standard errors of parameter estimates are given in parentheses; NS, not significant at $P = 0.05$ level.

the expectations laid out in the management guidelines. Those options for which additional premiums are paid should perform proportionately better again. Although it has proved difficult to draw conclusions about the use of cover crops and stubbles at various levels of ES intervention by the three target species of HLS (because their numbers, even on targeted farms, were too low), this study has demonstrated some positive outcomes of ES options for a broader suite of granivorous species, including two of the three target species and other species of similar conservation concern (Eaton *et al.* 2008). The fact that target species were not found on HLS farms to the extent that the FEPs indicated suggests that the targeting process on Higher Level farms has not been successful, and management aimed at species will not be benefitting them if they are not finding these resources. In this case, revision and strengthening of the FEP process may be needed for more successful targeting. The FEP and advisory resources available to farms entering the scheme have increased in availability and quality in more recent years since this study was carried out (pers. obs.). Alternatively, the frequency of winter visits in this study may not have been sufficient to detect mobile species at low densities. This may be true for Tree Sparrow, which is known to range widely in winter (Calladine *et al.* 2006).

In the autumn-sown cereal-dominated East Anglian region, where agricultural intensification has resulted in winter food shortages for granivores (Shrubb 2003, Wilson *et al.* 2009), WBM options

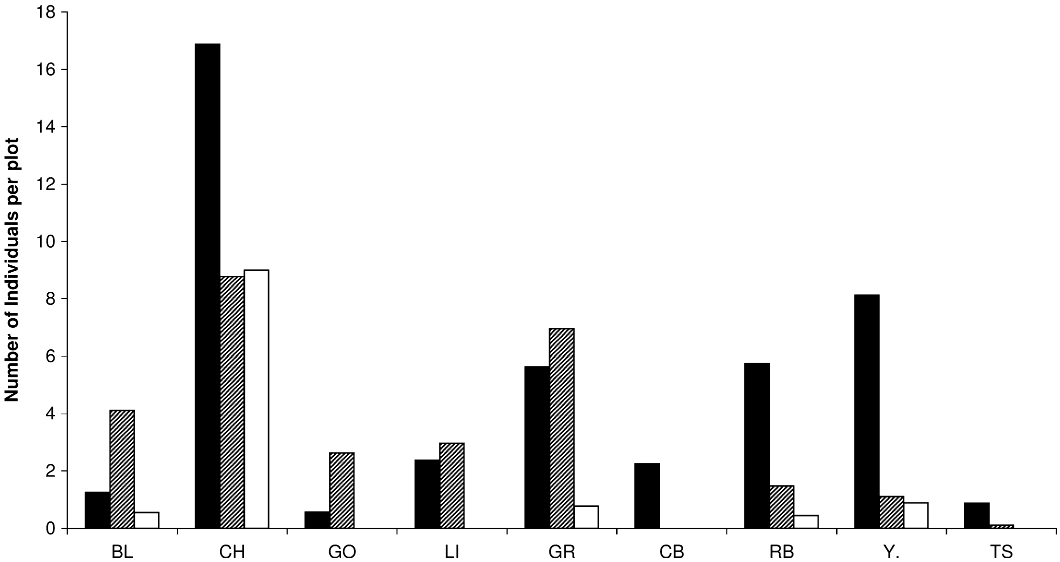

Figure 1. Variation of granivorous passerine flock composition on game cover and WBMs in EA and WM combined. Solid bars, HLS WBM (HF12); hatched bars, ELS WBM (EF2/3); open bars, game cover. BL, Brambling; CH, Chaffinch; GO, Goldfinch; LI, Linnet; GR, Greenfinch; CB, Corn Bunting; RB, Reed Bunting; Y., Yellowhammer; TS, Tree Sparrow.

held significantly higher densities of granivores compared with non-ES game covers. Granivore densities in ELS and HLS WBM did not differ significantly, although there was a trend for higher densities in HLS. Shortage of overwinter seed resources are equally important in the pastoral-dominated agriculture in the WM, with the loss of arable components of mixed farming and the switch from hay making to silage production (Shrubb 2003, Wilson *et al.* 2009). Clearly WBMs should be important in this context (Parish & Sotherton 2008), but the use of ES and game

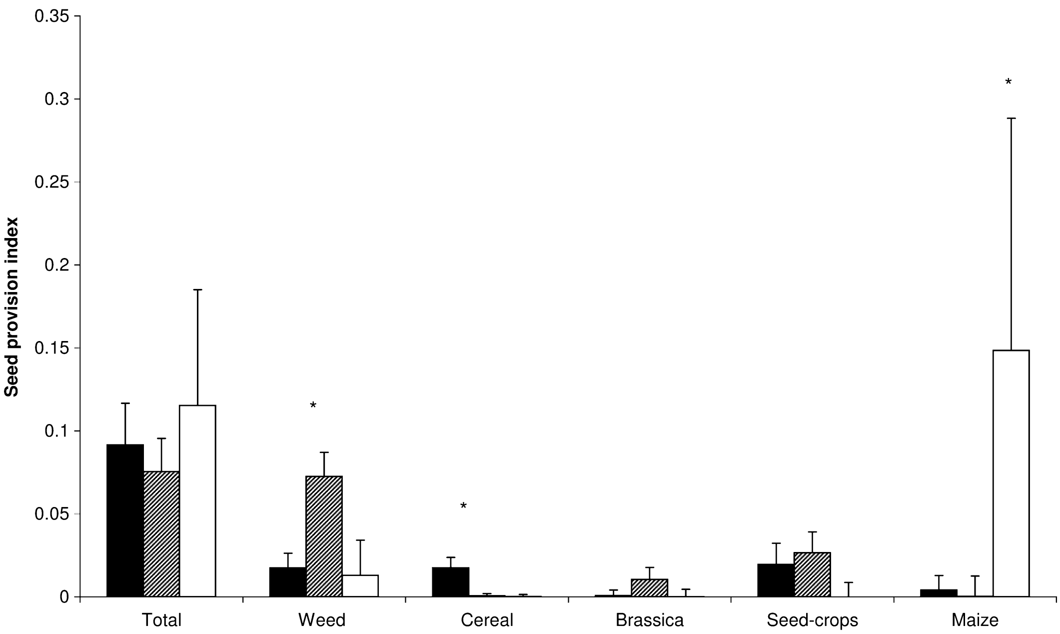

Figure 2. Variation of seed provision by different components of cover cop vegetation on game cover and WBMs in EA and WM combined (*significant differences between crop types at the $P < 0.05$ level). Values are back-transformed arc-sine least-square mean estimates from GLMs. Error bars are +1 se. Solid bars, HLS WBM (HF12); hatched bars, ELS WBM (EF2/3); open bars, game cover.

covers were all at an equally low level. Far fewer granivores were encountered on WM sites, and WBMs and game cover were less common, suggesting that WBMs are not providing a better food resource than game covers in this region. It should be a priority of future ES recruitment in this area to increase the uptake of these options as well as to develop methods of increasing the food potential of the prevalent pastoral methods (e.g. Buckingham & Peach 2006).

Variation in bird density and the composition of bird flocks between seed-crop type probably reflect observed differences in the composition and abundance of seed between ELS and HLS WBMs and game covers. Whilst ELS WBMs were catering for small seed-eating *Carduelis* finches (mostly of low conservation concern) and Reed Buntings, HLS WBM was providing food for the red- and amber-listed Tree Sparrow, Yellowhammer and Corn Bunting. Therefore, there may be a resource provision gap between ELS and HLS WBMs. More and better advice to ELS farmers about the composition of their WBM plots to meet local needs may redress this and make bunting food more widely available (there is no compulsion to include cereals in the ELS WBM mixes (EF2/3 – Natural England 2008a), and buntings are known to favour this food source; Perkins *et al.* 2008). It is possible that in amalgamating individual granivorous species' counts into a larger functional 'Granivores' grouping for analyses, variation in species composition across farms, clusters or regions on the basis of local landscape factors may have been masked. However, our comparison of flock composition with cover crop type seems to indicate some systematic variation in this respect, although it cannot be taken as definitive.

Weed cover of ELS WBM plots is an indicator not just of increased availability of small-seed food (likely to benefit Linnets and Goldfinches particularly, Campbell *et al.* 1997), but also of a sparser crop. Our vegetation data suggest that total vegetation cover is less on HLS than ELS WBMs, but this was very variable (our unpubl. data). This may be because there is no yield measure as part of WBM prescriptions, and therefore no incentive to the farmer to ensure good seed yield or crop establishment (Perkins *et al.* 2008). However, as access to the crop is particularly important for buntings and sparrows, which prefer to feed on the ground (Campbell *et al.* 1997), and food detectability is improved in shorter or sparser vegetation (Whittingham & Markland 2002, Butler & Gillings 2004), the density of WBM swards should be controlled (by sowing rates or row widths) if the resources provided are to be utilized effectively by their target species, particularly in the cereal components of 1-year mixes targeted at buntings (Perkins *et al.* 2008). However, this may also facilitate ease of access for other, non-target species (such as Wood Pigeons *Columba palumbus*), which may deplete resources rapidly, or encourage rapid resource depletion by target species, affecting the persistence of the resource. Solutions to these issues are likely to be found at a local scale, and thus highlight the provision of sound local advice to land managers.

Overall, the WBM results suggest that while there were trends for higher densities and more species of conservation concern to occur in HLS than ELS, they were not necessarily significant differences. On the strength of our results, it is unclear whether the extra management, and targeting, of HLS-enhanced WBMs is worthy of the increased administration costs to the scheme in providing consistent extra benefit. However, the relatively low sampling intensity of this study has not definitively tested this.

Skylarks were found at higher densities in ELS stubbles than non-ES stubbles. This was a weak statistical relationship, and may be the result of low sampling intensity. It is well established that post-harvest stubbles, without broad-spectrum herbicide, can allow substantial weed growth, and some seed setting through the winter (Buckingham *et al.* 1999). This can provide seed food for granivores (Bradbury *et al.* 2008, Wilson *et al.* 2009), and also 'green' food for species such as Skylarks, whose diet is known to contain non-seed plant material (Green 1978). Additionally, substantial weed growth may provide extra crypsis benefits for Skylarks, which prefer some cover for roosting and feeding (Butler *et al.* 2005). Non-ES stubbles tend to be shorter lived, as they are often ploughed in before the end of the year to allow frost action on the soil and to suppress grass weeds. Even if they persist long into the winter, standard practice tends to lead to early application of herbicide post-harvest to suppress weeds. Our sample of HLS reduced herbicide stubbles (HF15) was very small, as this option currently has low uptake. Our results suggest that bird use of this option may be low. One explanation is that because of the reduced herbicide input of this option, farmers tend to place it in fields with known low weed burdens, therefore reducing the amount of food available to birds. However, the cause remains unclear and further work is necessary to make any definitive assessment of this option.

There appears to be some difference in the efficacy of the ELS stubble option (EF6) dependent on whether it is managed under an ELS or HLS agreement. HLS EF6 stubbles attract more granivores and Skylarks compared with the same management on ELS farms. This may be the result of different rotations or other farm-wide practices or a difference in the execution of the same prescription by different farmers. HLS farmers are afforded specific management advice as part of scheme entry, and we cannot exclude the possibility that they may also spend more time on ES prescriptions than their ELS counterparts. Different, pre-agreement cropping patterns or management on farms entering HLS compared with those in ELS may have resulted in either greater weed seed banks in the soil or less effective or reduced weed control in the preceding crop. Alternatively, HLS farms may, by the nature of the scheme, be in areas where the habitat is better suited to target (and non-target) species, and this may explain the greater usage of ELS stubbles on HLS farms. However, the ELS stubble option appears to attract more Skylarks and granivores than non-ES stubbles. This will be increasingly important after the loss of compulsory set-aside (Vickery *et al.* 2008) and help in improving the quality of arable pockets in the grass-dominated West Midlands (Robinson *et al.* 2001). These results reiterate the low level of food provision of non-ES stubbles, particularly critical in the current situation of the loss of arable land-use (Robinson *et al.* 2001) and of rotational set-aside in the west of England (Vickery *et al.* 2008).

These results only examine bird densities using crops, and allow no inferences about the effect of these on bird populations through time. The aim of ES is to increase and sustain wild bird populations (and particularly those which have undergone recent declines) through the deployment of such options in the agricultural landscape. Therefore, ongoing work is needed to reveal if usage and spatial distribution of such seed-rich habitats is sufficient to influence birds at a population level (Siriwardena *et al.* 2006).

Furthermore, the longevity of food resources supplied by such seed-rich habitats is of crucial importance and there is already much evidence that a 'hungry gap' exists in much English farmland towards the end of the winter (Siriwardena *et al.* 2008). Certainly, most of the overwinter stubbles surveyed in this study are unlikely to fill this gap; even if they maintain seed resources throughout their life, they will not survive much past the middle of February (the earliest permissible ES stubble cultivation date is 15 February, Natural England 2008a, 2008b, 2010) to allow establishment of spring-sown crops. A new ES extended stubble option (EF22) has become available in 2010, which will remain largely unsprayed (apart from localized treatment of injurious weed species) and uncultivated until at least mid-August (Natural England 2010), and will contribute towards bridging this gap. Although WBMs within ES, particularly 2-year plots, are much more likely to remain into the spring, seed loss is likely to be almost complete by this time for most sown species (Siriwardena *et al.* 2008) and our observations tend to confirm this. Some cereal components (most notably *Triticale*) have been developed for, and are promoted on, their ability to retain seed through the winter, and have been observed to do so in WBMs in Scotland (Perkins *et al.* 2008). This reinforces the conclusion that to benefit declining species, and particularly buntings, ELS WBMs should contain a cereal component, and enhanced WBMs should be encouraged more within HLS agreements.

Davey *et al.* (2010) found few indications of success of ELS in influencing farmland bird numbers positively at landscape scale, which they attributed to factors operating at various scales. Option quality at an individual farm scale and resource density within the landscape were cited as potential reasons for lack of success. Our results tend to echo this, and although ELS winter food options do show some improvement over the non-ES food sources available, it is uncertain whether they exist at either great enough density, or are of sufficient quality, to affect a change in the fortunes of declining farmland granivores. In this context, it is concerning that HLS options were generally no more effective than the more widespread ELS ones. It seems likely that their quality is similarly inconsistent. Moreover, the question of their effectiveness at improving the conservation status of the scarcer target species remains unanswered. Clearly, the provision of resources at the farm scale is important to these species, but the availability of the resources at a wider landscape scale may well be important, and not influenced by HLS. Thus even for target species, the effectiveness of HLS will be tempered by that of ES in total, especially for wide-ranging species such as Tree Sparrow. Because these species have become so localized in some regions, their scarcity makes their use of particular habitats in relation to fixed features (ES plots) harder to quantify. It is to be hoped that the examination, currently underway, of target species' trends on farms of different ES levels will inform this question more.

In the current economic climate, the resources available for AESs are likely to become ever more tightly squeezed between the demands of food-security based agricultural policy and competing state and European-wide demands for funding. Therefore, it is imperative that ES can demonstrate fitness for purpose and value for money. To that end, the feedback from monitoring will be vital in addressing shortcomings in resource provision and improving option implementation (Kleijn & Sutherland 2003). It is also important to acknowledge that the impact of ES measures will take time to be realized, with the attendant lag in population responses to environmental change. ES should be viewed through this prism, and both individual options and the schemes should be afforded time to 'mature' and for ecological responses to become evident (Davey *et al.* 2010). The farms studied here had only been subject to ES management for 2 years before monitoring began. Therefore, the continued monitoring currently forming part of the same programme is more likely to detect songbird responses to management as the scheme progresses. It is therefore imperative that monitoring and scheme evolution remain a continuous iterative process, and that ES is given adequate continued support to prove its financial and biodiversity worth (Kleijn *et al.* 2001, 2006, Kleijn & Sutherland 2003).

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