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A Large-Scale Survey of the Use of Winter Bird Crops by Foraging Birds on Farmland

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1. The following report is a preliminary analysis to assess the relative abundance and species richness of primarily gamebirds and seed-eating passerines (with reference to insectivorous passerines) associated with winter bird crops (i.e. game-cover crops and wildbird mixes within the set-aside scheme) through the winter period.

2. The survey comprised a sample of 121 farms selected from across England representing arable and mixed farming regions. On each of these farms, volunteer observers surveyed plots, comprising one winter birds crop and three or four adjacent conventional crops, for birds. Volunteers visited the farms on six occasions once a month between October and March.

3. To compare relative bird densities between crop-types, generalised linear models with a log-link function and Poisson error term were fitted to the summed bird count data from each individual field on each farm plot, for each of the six visits.

4. In general, bird densities on winter bird crops were higher than on conventional crops. Among winter bird crops, second year kale was the most consistent crop across species to support the highest or second highest densities of birds. Maize was prominent among the gamebird species but less so amongst the other species. Quinoa was utilised by Blackbird and Song Thrush but also by Linnet, Chaffinch and Reed Bunting, but did not support the highest densities of gamebird species.

5. Across species, second year kale was dominant and seasonal phases (October and November) mid (December and January) and late (February and March), although for several species (e.g. Red-legged Partridge, Goldfinch and Reed Bunting) too few birds were recorded on bird crops by late winter to register a difference in their usage.

6. Preliminary recommendations indicate that, among bird crops, kale would be the most effective addition to arable farmland to increase bird diversity and abundance around conventional fields. Quinoa also attracted high densities of thrushes, Greenfinches and Linnets, and mixed with kale would provide an effective bird crop mix.

7. Analysis over the forthcoming winter will concentrate on interactions between crop usage and season, as well as the influences of companion crops in attracting birds to bird crops

2. INTRODUCTION

In recent years there has been growing concern about widespread loss of biodiversity in arable landscapes, in particular in the UK, mainland western Europe and the USA (Flade & Steiof 1990; Barr *et al.* 1993; Saris *et al*. 1994; Millenbah *et al.* 1996). In the UK a number of long-term monitoring programmes have shown substantial declines in the status of many groups of plants and animals (Firbank *et al*. 1991). For example, the results of Countryside Survey 1990 (Barr *et al.* 1993) showed a marked reduction in hedgerow length and plant biodiversity in arable landscapes since 1978. Analysis of the British Trust for Ornithology's Common Birds Census, supported by two periodic atlas studies of breeding bird distribution, also revealed that many of Britain's farmland bird populations have suffered serious long-term declines (Gibbons *et al*. 1993; Marchant & Gregory 1994; Fuller *et al*. 1995; Siriwardena *et al.* 1998). Such declines are less evident in other habitats such as woodland (Fuller *et al*. 1995). The species in decline occupy a broad range of ecological niches and include birds like Grey Partridge *Perdix perdix* and Song Thrush *Turdus philomelos*, and seed-eating passerines such as Skylark *Alauda arvensis*, Tree Sparrow *Passer montanus*, Linnet *Carduelis cannabina* and Yellowhammer *Emberiza citrinella*. Similar declines in farmland birds are reported from elsewhere in Europe, for example, in Germany (Flade & Steiof 1990) and The Netherlands (Saris *et al*. 1994).

There is now growing evidence linking these bird declines with major changes in agriculture since the 1970s (e.g. Fuller *et al.* 1995; Siriwardena *et al*. 1998). These changes include increased use of pesticides, with possible indirect effects on the food resources of birds (Rands 1985, 1986; Potts 1986, 1991; Campbell *et al*. 1997), and a switch from spring to autumn sown cereals. The latter has resulted in a loss of winter stubble fields which provide important foraging habitats (Evans & Smith 1994; Aebischer 1997; Evans 1997a, Buckingham *et al*. 1999; Robinson & Sutherland 1999).

One of the problems facing attempts to reverse declines in bird population trends on farmland has been the difficulty of integrating intensive agricultural regimes with conservation measures. Sympathetically managed field margins (grass strips, beetle banks and conservation headlands) may go some way to achieving this since they attract foraging birds in both winter and summer. Many insectivorous and seed-eating species will use field margins at densities equal to or exceeding densities in open field areas (Henderson *et al*. in press). However, margins represent only a small proportion of farmland (usually less than 5%) and it is therefore vital to maximise their usage if they are to prove an effective conservation strategy for either maintaining or increasing bird populations on farmland.

In the UK, many farms and landowners grow “crops” to provide winter cover and food for game birds (Pheasant (i.e. Ring-necked Pheasants *Phasianus colchicus*), Grey Partridge and Red-legged Partridge *Alectoris rufa*). These crops include variable mixtures of maize, millet, cereals, kale, mustard, and other exotic seed producing plants which may also provide food and cover for indigenous seed-eating passerines (and possibly some insectivores too). In addition, wildbird mixtures are grown under the set-aside scheme (where land is removed from production, in order to reduce crop surpluses, and is replaced by a sown or naturally regenerated “green cover”) comprising a wildbird option of non-harvestable mixtures of cereals, brassicas or quinoa to provide winter food for birds. Recently, the Arable Stewardship Scheme, which aims to integrate wildlife prescriptions with conventional farming by introducing a variety of prescriptions designed to attract and support bird populations, has been introduced as a pilot scheme in two areas of the UK. Prescriptions include the establishment of field margins with seed mixes tailored to attract both foraging and breeding birds.

The following report is a preliminary analysis to assess the relative abundance and species richness of primarily gamebirds and seed-eating passerines (with reference to insectivorous passerines) associated with winter bird crops (i.e. game-cover crops and wildbird mixes within the set-aside scheme) through the winter period, October to March. The sampling of plots within the Arable Stewardship Scheme begins in the winter of 1999/2000. The analyses are, at this stage, intended to be exploratory but informative with further scrutiny of interactions between variables anticipated in future investigations on large data sets.

3. METHODS

3.1 Study Sites and Field Methods

The winter bird survey comprised a sample of 121 farms in the first winter, selected from across England representing arable and mixed farming regions. Volunteer observers surveyed plots on each of these farms for birds during the winter of 1998/1999 by locating a pre-selected winter bird crop (i.e. a margin, strip or whole field) plus two or three adjacent conventional fields. The bird crop is often part of one of the adjacent conventional fields but is considered here as a separate field or crop in its own right. The mean plot area (i.e. the bird crop plus conventional fields) was 24.9 ha and mean winter bird crop area = 1.25 ha (5% of total).

Observers made up to six visits to a farm plot between October and March (one visit per month with at least two weeks between visits). On each visit to the farm plot, the observer began by walking around the edge of the bird crop recording all birds seen or heard in both the crop and the adjacent boundary. Observers were asked to walk through the bird crop where this was feasible (i.e. where the cover was not too dense and where permission was granted) and especially so where the bird crop was over 20 m wide, to achieve greater coverage. Observers then walked both around the perimeter and two or three times across the centre of each adjacent conventional field, again recording all birds seen or heard on the field or in the boundary. Birds flying directly over a field were not recorded. Birds were recorded as using the first field or boundary that they were seen to occur in, with subsequent movements between fields ignored. Observers were asked to take care in distinguishing between independent records and probable duplicates (i.e. movements of individual birds). No visits were made in heavy rain or in wind greater than force four.

Several papers have emphasised the importance of the physical characteristics of hedgerows in determining bird abundance, in particular hedge height and tree frequency (Green *et al.* 1994; Parish *et al.* 1994, 1995). Observers therefore estimated the proportion of each field boundary that was woody (hedgerow or treeline), the average height of each hedged boundary and counted the number of trees (>5 m tall) in the boundary of each field. They also noted the presence or absence of a wood near to any of the survey fields. Farmers provided field areas (ha) and crop details. The variety of bird crops and conventional field types included in the survey is presented in the Appendix. Observers estimated average crop height at each visit, and were asked to indicate whether or not the winter bird crop contained weeds or was relatively weed free.

3.2 Analysis

In this report, each individual bird record is termed a count, and only counts which observers could definitely attribute to independent birds were used in the analyses. At each site and visit, the sum of the counts of each species on each field was used as the basic unit to compare relative bird densities and distributions between field-types.

For analytical purposes, conventional field types were classified into the following categories: (1) *Winter cereals*: autumn-sown wheat, barley or oats; (2) *Sugar Beet*: non-harvested sugar beet; (3) *Cereal stubbles*: harvest stubbles of wheat, barley or oats; (4) *Non-cereal stubbles*: harvest stubbles of linseed, sugar beet, oilseed rape or legumes; (5) *Grazed grassland*: combined ley grass or permanent pasture where livestock were present or had recently been present; (6) *Non-grazed grassland*: permanent pasture with no recent sign of grazing activity, and (7) *Bare soil*: ploughed or cultivated land possibly containing a sown crop.

The major winter bird crops included: (i) *Maize*: including maize or maize/millet mix; (ii) *Kale*: first-year and second-year or older kale used as a cover crop rather than for its food value for gamebirds but producing seed in the second winter; (iii) *Millet*: almost always admixed with maize; (iv) *Quinoa:* grown as a seed producing crop usually in conjunction with cover crops such as kale; (v) *Sunflowers*: also a seed producing crop but providing little cover, (vi) *Linseed/forage rape*: grown to provide seed (linseed) and cover (rape) for gamebirds and (vii) *Cereals*: strips or block varieties of wheat, triticale etc, grown for seed and cover. Mixtures of these bird crops were common. Custom commercially produced wildbird mixtures incorporating maize/millet/mustard/kale and other components such as buckwheat and sunflowers are also available. Bird mixes are included in the analysis below given their potential to provide food and cover for songbirds as well as gamebirds. However, the focus of the analysis was to identify important differences for birds, between individual component crops. Strictly, several crops, such as buckwheat, mustard, stubble turnips and linseed were too few in number for a meaningful analysis although a second winter's set of data may provided enough information to report on these crops in future reports.

The bird species analysed were gamebirds (Pheasant, Grey Partridge and Red-legged Partridge) and seed-eating passerines, Sparrows (Passeridae) Finches (Fringillidae), and Buntings (Emberizidae). The species analysed below include nine which were sufficiently numerous to examine statistically, while also representing each of the family groups above, plus Tree Sparrow, as a species of high conservation concern, and two insectivorous species that are also currently declining on farmland in England (Blackbird *Turdus merula* and Song Thrush).

The relationship between bird abundance and field type was analysed using a log-linear analysis (Brown & Rothery 1993), appropriate for data that are Poisson distributed; that is, for non-negative data where the variance increases and is equal to the mean. Log-linear models allowed a spatial and temporal analysis of field-type and sample month respectively on bird densities. Models control for farm (i.e. differences between observers, geographic location or the farm management regime) and boundary effects. To compare relative bird densities between field-types, generalised linear models with a log-link function and Poisson error term were fitted to the summed bird count data from each individual field on each farm site, for each of the six visits (Genmod procedure: SAS Institute Incorporated 1996). An example model fitted to each bird species is as follows:

$$N=\exp(I+c_i+s_j+t_k+(h*\text{height})+(f*\text{tree freq.})+a)+\varepsilon$$

where: N = number of individuals of each species on each field type

I = intercept term

c_i = factor representing field-type i (where i= one of field types defined above).

s_j = factor representing farm site j (j=1 to n farms); used to assess between-farm differences in bird abundance.

t_k = factor representing temporal change in field usage across the winter.

H = coefficient of boundary height explanatory variable (to assess the effects of boundary height - measured per field).

$F\ t$= coefficient of boundary tree frequency explanatory variable (to assess the effects of trees in boundaries - measured per field).

a = log (area) offset variable for each field type (to control for field area).

ε = Poisson error term

Other factors and variables such as the presence or absence of hedges, weeds or nearby woodlands were analysed within the same model structure. All models were fitted relative to winter cereal, with parameter significance tests calculated with respect to this crop type. Winter-cereal was selected since it occurred on more farms than any other crop. The square root of the scaled deviance/degrees of freedom was used as an over dispersion factor (controlling for birds' tendency to aggregate in winter) in parameter significance tests (SAS Institute Incorporated 1996). The models returned Type 3 likelihood-ratio (LR) significance values for each independent variable in turn, while controlling for all other factors in the equation.

4. RESULTS

4.1 Analytical Caveats

Due to the flocking nature of winter birds and their transient nature, and possibly due to observers being unable to access the internal areas of bird crops, the data were, as expected, dominated by zero counts (i.e. no birds seen of a particular species on a particular field type). Thus, zeros represented, for example, 47% of records for Pheasants on maize/millet or Chaffinches in kale, and on average across all species and field types, 80% of the records of birds on the ground. Binomial tests (using presence/absence data) generated poorly fitting models and failed to generate probability values. The analyses presented here use conventional and appropriate GLM processes as described above but with zero records removed so that the resulting data distribution (i.e. of "where birds were") was closer to Poisson. The effect of removing zero counts (i.e. "where birds were not") will if anything, bias slightly (increase) the relative densities of birds using conventional fields, where densities were lower, compared to winter bird crops. Bird counts on fields were combined with the counts of birds on the adjacent boundaries to increase sample size and greatly increase the power of the analysis to identify significant associations between birds and field types or other variables. Bird counts on fields and on boundaries were significantly correlated for all species (Table 4.1.1, with Linnet and Tree Sparrow the weakest associations), and so the likelihood that the relative distribution of birds between field types would be affected by combining these data was much reduced. In winter, combining field and boundary counts is also biologically meaningful since most bird species recorded in boundaries are not generally occupying territories but are present as a direct consequence of nearby foraging resources (and their being disturbed from the crop by the observer for example). Nevertheless, the effects of hedgerow height and nearby woodlands were analysed within the model structure below.

Relative bird densities (exponentials of parameter estimates) which compare all conventional crops and winter bird crops together for each bird species relative to winter cereals, are presented in Table 4.1.2. Typically, most species in winter are aggregated in distribution since they form flocks (Table 4.1.2; dev./df. >1). Consequently, the analysis assumes that each bird count is independent of any other, which, within flocks, may not be true even though flock sizes continually fluctuate in number. This point needs to be considered when interpreting the results.

4. 2 Species Densities

All of the models presented in Table 4.1.2 are significant with the exception of Tree Sparrow (with only 22 observations available) and Reed Bunting. In general, bird densities on winter bird crops were higher than on conventional crops. However, because of their greater area, the detectability of birds on conventional fields may have been lower than on bird crops. Among bird crops, the two crop types that supported the highest densities of birds are summarised in the penultimate two columns of Table 4.1.2 for each species, with the exception of wildbird mixes (MX). Relatively high densities of Grey Partridges, Greenfinches, Goldfinches, Linnets and Yellowhammers were found amongst wildbird mixes. However, these preferences were difficult to interpret since the exact content (by proportion) of mixes was usually unknown and the data therefore less informative than comparisons between the single-species crops.

Among winter bird crops, second year kale was the most consistent crop across species to support the highest or second highest densities of birds. Maize was prominent among the gamebird species but less so amongst the other species (though generally preferred to a maize/millet combination) with the exception of Reed Bunting for which the relationship was non-significant. Quinoa was utilised in particular by Blackbird and Song Thrush and by Linnet, Chaffinch and Reed Bunting, but did not support the highest densities of gamebird species. The rape/linseed mixed crop was scarce but one of the preferred crops of Goldfinches and also supporting relatively high densities of Red-Legged Partridges and Yellowhammers. Minority bird crops such as the rape/linseed combination tend to be more susceptible to single large flocks of birds dominating the analysis, and will benefit from more data from future fieldwork to provide a more representative assessment of their value to birds. Sunflowers were notable in being overwhelmingly preferred to other crops by Greenfinches (see Table 4.1.2), but otherwise emerged as one of the least utilised crops by all other species analysed.

Consistent trends amongst conventional crops are much less clear but may benefit from a temporal analysis, to see whether birds switch between field types depending on their availability or on farm management activities. Cereal stubbles supported higher densities than winter cereals of Pheasants, finches and buntings, a pattern which is consistent with previous studies of winter crops (e.g. Buckingham *et al.* 1999). Non-grazed grassland was preferred by more species than grazed grassland, and was especially important for Grey Partridge (a higher density than on winter bird crops) and Linnet. This is in contrast to Red-legged Partridge which showed much stronger association with bird crops, but a preference for bare ground, grazed grassland and especially non-cereal stubbles amongst conventional field types (Table 4.2.2 shows this species becoming scarcer in bird crops in late winter as it moved into conventional crops, including winter cereals). The thrush species were scarce on conventional fields (but preferred grass fields) which may reflect their tendency to avoid relatively open habitats compared to cover crops.

Further analysis of kale companion crops (Table 4.2.1) produced no significant differences between crop combinations for any species (due to low sample sizes, see Appendix), but possibly kale in combination with maize was consistent in supporting the highest mean densities of birds across the species analysed. Sunflowers (usually with kale) were undoubtedly the most important component crop for Greenfinches (see also Table 4.1.2) and quinoa was probably the main attraction for Linnets and Tree Sparrows as a companion crop (see also Table 4.1.2). Second-year kale itself however, was still the preferred crop across species.

4.3 Relationships With Boundary Variables

Other than field type, Pheasant and Chaffinch preferred taller hedges (Likelihood ratio (LR): χ^2_1=32.2, P<0.001, LR: χ^2_1 =4.2, P<0.05 respectively), while the presence of a hedge was significantly preferred by Grey Partridge (LR: χ^2_1 =5.1, P<0.05), Blackbird (LR: χ^2_1 =6.8, P<0.01), Song Thrush (LR: χ^2_1 =4.2, P<0.05), Greenfinch (LR: χ^2_1 =7.7, P<0.01) and Yellowhammer (LR: χ^2_1 =4.2, P<0.05). In this analysis, the presence/absence of an adjacent wood did not significantly effect the distribution of any of the species analysed. The presence of weeds within the bird crops was only significant for Blackbird (LR: χ^2_1= 22.5, p<0.001). Overall preferences for lower crop vegetation were significant for Red-legged Partridge (LR: χ^2_1= 15.8, p<0.001) and Tree Sparrow (LR: χ^2_1= 14.3, p<0.001) (all crops combined).

4.4 Temporal Changes

The analysis of temporal changes in the usage of winter bird crops relative to conventional crops requires further analysis which is planned for the forthcoming winter. This is because sample sizes broken down by sample month and crop are currently very small for most bird species and will benefit from a further year's data. Meanwhile the winter bird crops which supported the highest bird densities of each species during three phases of winter: early (October and November) mid (December and January) and late (February and March), are presented in Table 4.2.2. Here second year kale is dominant across species and seasonal phases, although for several species (e.g. Red-legged Partridge, Goldfinch and Reed Bunting) too few birds were recorded on bird crops by late winter to register a difference in their usage. For Greenfinches, sunflowers, which dominate the general analysis above, were utilised only in early winter, after which second-year kale was again an important crop. Linnets (and Yellowhammers too) also increased markedly on second year kale in late winter after occurring at lower densities on quinoa in the early season (or maize and millet in the case of Yellowhammers). Pheasants moved from kale, quinoa and maize crops in early and mid-winter into mainly kale crops in later winter presumably as the maize and quinoa crops become depleted or die. Red-legged Partridges were at highest densities in second year kale crops in early and late winter before moving out onto farmland, preferring grazed fields, winter cereals or cultivated bare earth (cf. vegetation height preferences above).

5. DISCUSSION AND CONCLUSIONS

For at least one species that occurs on farmland, the Song Thrush, post-fledging mortality, including winter mortality, has been shown to be capable of driving population declines (Thomson *et al*. 1997). Furthermore, Siriwardena *et al.* (in press) demonstrated that survival rates for a suite of farmland birds were lower in periods of population decline than at other times, and indicated that winter mortality was probably an important factor in these declines. Factors which are likely to affect bird populations on farmland include a shortage of preferred feeding habitat during winter as a result of the switch from spring to autumn sown crops (during the 1970s and early 1980s in the UK). This process led to a subsequent loss of winter stubbles that are recognised as one of the most important habitats for providing food to seed-eating passerines in particular (Evans 1997a & b). Preliminary analyses indicated key preferences by both gamebirds and seed-eating passerines for winter bird crops compared to all other conventional field types including cereal stubbles. In our present analysis, the previous crop content of winter stubbles was unknown and content (where barley stubble is preferred to other stubbles) is recognised as having a significant impact on the field's use by birds (Buckingham *et al*. 1999). Nevertheless the comparison with stubbles highlights the potential value of winter bird crops to provide food and cover for many bird species over the winter period.

Among winter bird crops, second-year kale, grown as a cover crop but also producing a seed crop in the second year, supported the highest densities of the greatest range of bird species analysed. Although general preferences for the winter as a whole may obscure seasonal switches in preference between crops, during three seasonal phases (early, mid and late winter), second-year kale was again the most dominant crop to support birds in variety as well as abundance. Clearly, more subtle changes in bird densities between both bird crops and conventional fields, have not yet been examined, and these may indicate key seasonal preferences for crops not yet recognised as being important over the whole winter.

Among seed producing crops maize and millet were probably the most consistently preferred crops across both gamebirds and passerines. However, bird crops containing complex mixtures of seed and cover plants supported very high densities of partridges and seed-eating passerines (but were not utilised by thrush species). These mixture crops are clearly important sources of food for birds and their impact especially compared to Arable Stewardship prescriptions, will be examined in greater detail on receipt of a second winter's data. Our results also indicate that the siting of preferred crops next to wooded boundaries and especially hedgerows would further increase the value of the bird crop to both gamebirds and passerines.

6. PRELIMINARY RECOMMENDATIONS

The ability of kale to attract both gamebirds and seed-eating passerines suggests that this crop, with its companion seed crops, have the potential to support bird species in both abundance and variety. Kale was also valuable to two insectivorous species, where it presumably provided both food and cover for foraging birds. Preliminary recommendations therefore indicate that, among bird crops, kale would be the most effective addition to arable farmland in increasing bird diversity around conventional fields. Quinoa also attracted high densities of thrushes, Greenfinches and Linnets, and mixed with kale would provide an effective crop mix. Maize held good numbers of gamebirds but fewer passerines, and its susceptibility towards colder and damper conditions in more northerly regions of England and the UK make it less desirable than kale and quinoa on a national basis. Positioning preferred bird crops near hedgerows would increase further their usage by both gamebirds and passerines.

7. FORTHCOMING ANALYSIS

For the winter of 1998/1999, volunteer observers returned data for 121, with several observers still expected to send back information to the BTO. The process of seeking more volunteers for the 1999/2000 season is underway with priorities being given to farms piloting the Arable Stewardship Scheme in East Anglia and the West Midlands. This will have the effect of increasing overall sample of farms, as new sites are introduced, as well as making a second winter's worth of data available. Additional farms for the 1999/2000 season (which were not surveyed in the preceding winter) will prove valuable in increasing the overall sample of farms available for analysis and help provide more detailed information regarding some of the more subtle interactions between birds and crop habitats. Analysis over the coming winter will concentrate on interactions between crop usage and season, as well as the influences of companion crops in attracting birds to bird crops. The influence of patch size on bird density will also be examined in the immediate months ahead.

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Species	Spearman's *rho*	P
Pheasant	0.79	**
G. Partridge	0.84	**
R-l Partridge	0.80	**
Blackbird	0.83	**
S. Thrush	0.84	**
T. Sparrow	0.41	**
Goldfinch	0.79	**
Greenfinch	0.79	**
Linnet	0.43	**
Chaffinch	0.70	**
Reed Bunting	0.60	**
Yellowhammer	0.89	**

Table 4.1.1 Spearman rank correlations between the total number of birds recorded on fields and the total number of birds recorded on the adjacent boundaries (n=213 fields); ** P<0.001

	Winter bird crops									Conventional crops or field types							Bird crop			
Species	**CL**	**K1**	**K2**	**MA**	**MM**	**RL**	**SU**	**QU**	**MX**	**BA**	**CS**	**GR**	**GZ**	**NS**	**SB**	**P**	**Highest**	**Lowest**	**Dev/df**	**n**
Pheasant	0.78	2.16	4.90	4.40	4.10	2.63	0	1.15	0.89	1.28	2.23	1.55	0.21	0.89	2.63	***	K2	MA	5.4	467
G. Partridge	1.02	0.45	4.38	4.61	2.71	4.1	0	1	17.34	1.58	0.64	18.86	0.18	0	0.49	***	MA	K2	5.2	101
R-l Partridge	2.12	1	20.90	11.36	5.74	10.95	0	1	1.74	3.03	0.80	0.89	2.97	28.19	1.33	***	K2	MA	7.8	186
Blackbird	1.09	5.22	4.97	4.03	2.39	1.55	0	5.85	0	1.09	1.01	0.85	0.61	1.67	0.70	***	QU	K1	1.4	636
S. Thrush	2.29	2.70	3.23	0	1.25	1.28	1.64	3.66	0	0.76	0.47	0.50	0.39	1.12	1.13	***	QU	K2	0.7	155
T. Sparrow	0	0	12.2	0	0	0	0	1.17	0	15.7	0.19	0	0	0	1	ns	K2	QU	4.5	22
Goldfinch	1.22	0.87	3.76	0.89	0.21	3.68	0	1.72	0	0.79	0.23	0.27	1.30	1	0	***	K2	RL	3.7	110
Greenfinch	1.93	14.02	44.90	12.0	16.78	19.21	177.7	33.1	57.3	2.68	3.91	3.6	3.03	6.04	5.92	***	SU	K2	10.2	195
Linnet	0.59	0	69.96	1	1	0.90	1	48.75	58.97	5.75	6.21	43.8	0	1	18.7	***	K2	QU	10.1	105
Chaffinch	1.78	14.51	23.58	13.20	6.61	1.77	1.41	14.57	15.72	2.90	2.13	1.26	0.90	3.64	1.03	***	K2	QU	8.7	601
Reed Bunting	3.29	0	2.27	8.85	3.29	2.90	0	51.9	1	2.15	1.46	1.46	0.36	0	0.78	ns	QU	MA	1.2	89
Yellowhammer	2.69	1.47	3.3	4.8	1.13	4.18	0	3.20	2.85	0.71	1.00	0.38	0.31	0.36	0	***	MA	RL	5.3	258

Table 4.1.2 Results from Generalised Linear Model, Poisson regressions: Relative densities of birds species occurring on winter bird crops and conventional crops. The densities are relative to winter cereals (=1). Field area is controlled for as an offset variable (log area). The dispersion factor given by "deviance/degrees of freedom" (dev./d.f.) for values >1 represents the degree of aggregation (flocking) for each species. N=the number of records of each species used in the modelling and *P* the significance probability indicates overall field type differences in bird density for each species (***P<0.001, ns= non significant). Abbreviations as follows: 1. Bird crops: cereals (CL), First-year kale (K1), Second year kale (K2), Maize (MA), Maize/millet (MM), Rape/linseed (RL), Sunflowers (SU), Quinoa (QU) and Mixed bird crop (MX); 2. Conventional crops: Bare earth (BA), Cereal stubbles (CS), Grassland non-grazed (GR) , Grassland grazed (GZ), Non-cereal stubbles (NS) and Sugar beet (SB).

	Kale crop combinations							
Species	**K1**	**K2**	**KC**	**KM**	**KQ**	**MK**	**KS**	**N**
Pheasant	0.5	4.1	0	0.3	1.3	22.9	0	55
G. Partridge	0.1	6.5	0	0	1.3	1.9	0	25
R-l Partridge	<0.1	1.9	0	0	1.3	5.0	0	31
Blackbird	1.9	1.8	1	2.5	1.0	2.5	0	60
S. Thrush	0.4	0.9	0	0	0.7	0.5	0	42
T. Sparrow	0	0.9	0	0	3.8	3.1	0	8
Goldfinch	<0.1	0.7	0	0.6	0	2.2	1.0	34
Greenfinch	0.2	3.4	0	0	1.7	0.6	17.3	41
Linnet	0	5.8	0	0	6.4	1.2	6.0	34
Chaffinch	1.1	14.0	0	2.0	7.1	6.3	8.3	61
Reed Bunting	0	1.2	0	0.3	1	0.9	0	26
Yellowhammer	0.1	1.7	0	0	0.1	0.4	0	47

Table 4.2.1 Mean densities of birds (per ha) on different combinations of kale crops. N=the total number of fields contributing to each species account. Abbreviation are: First-year kale (K1), Second year kale (K2), Kale and cereals (wheat, triticale etc) (KC), Kale and millet (KM), Kale and quinoa (KQ), Maize and kale (MK), Kale and sunflowers (KS). (Highest densities are presented on bold for clarity).

Species	Early winter	Mid winter	Late winter
Pheasant	K2/QU/MA	MM/MA	K2
G. Partridge	K2	K2/MM	MM (CS)
R-l Partridge	K2	K2/MA	GZ (WC)
Blackbird	K2/K1	K2	K2
S. Thrush	K2	K2/QU	K2
T. Sparrow	-	-	-
Goldfinch	K2	K2	0
Greenfinch	SU/MM	K2	K2
Linnet	QU	CS	K2
Chaffinch	K2	K2	K2
Reed Bunting	K2	MA	0
Yellowhammer	MM/MX	K2	K2

Table 4.2.2 GLM regression modelling: A summary of crop preferences (i.e. the highest relative densities) demonstrated by bird species foraging during early (October-November), mid (December-January) and late (February-March) winter. See Table 4.1.2 for abbreviations.

APPENDIX 1

Field type	No. of plots	No. of fields
Conventional field type:		
Bare earth	59	65
Cereal stubbles	45	51
Non cereal stubbles	6	6
Non cereals	21	25
Sugar beet	13	13
Winter cereals	98	114
Grassland non-grazed	40	52
Grassland grazed	20	24
Winter bird crop:		
Buckwheat	1	1
Cereals	36	39
Cereals and kale	1	1
1st-year kale	17	18
2nd-year kale	28	29
Kale and quinoa	5	5
Linseed	2	2
Maize	16	16
Maize and millet	17	17
Maize and kale	10	10
Millet and kale	2	2
Mixed crop	5	5
Quinoa	10	10
Quinoa and sunflowers	1	1
Fodder rape	2	2
Rape and linseed	1	1
Sunflowers and kale	4	4

Field type sample sizes for conventional crops and bird crops.