BTO Research Report No. 494

Winter Farmland Bird Survey

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Report of work carried out by The British Trust for Ornithology

February 2008

British Trust for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU
Registered Charity No. 216652

British Trust for Ornithology

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Published in April 2008 by the British Trust for Ornithology
The Nunnery, Thetford, Norfolk, IP24 2PU, UK

ISBN 978-1-906204-31-0

CONTENTS

Page No.

Page No.

LIST OF TABLES

Page No.

Page No.

CHAPTER 7

CHAPTER 8

CHAPTER 9

LIST OF FIGURES

Page No.

CHAPTER 2

CHAPTER 3

CHAPTER 4

Page No.

LIST OF APPENDICES

Page No.

1. INTRODUCTION

This report presents the results from a large-scale survey of wintering birds on a representative sample of lowland farmland in Britain – the Winter Farmland Bird Survey. The aims of the Winter Farmland Bird Survey were three-fold: first, to provide information on the distribution and abundance of a suite of farmland bird species across the whole of lowland Britain; second to describe the distribution and abundance of agricultural habitats in winter; and, third to identify the habitat preferences of farmland birds in winter across a wide geographic area and to investigate the importance of regional and seasonal differences.

This report draws together much of the work undertaken on the Winter Farmland Bird Survey project, including published and unpublished work. It includes preliminary analyses that aimed to assess the strengths and weaknesses of the dataset (Supplementary Analysis, Chapter 9), and considers broad habitat associations (Chapters 2, 3), the importance of stubble fields (Chapter 4), landscape-level habitat associations (Chapter 5), regional similarities in drivers of distribution (Chapter 6), possible population-level responses of birds to winter habitat availability (Chapter 7) and investigating possible linkages between farmland and gardens (Chapter 8).

At the time of writing, chapters 2, 3 and 7 are in press or already published; chapter 8 is in review; and chapter 4 is in preparation for publication in association with investigation of set aside loss.

2. DISTRIBUTION AND ABUNDANCE OF BIRDS AND THEIR HABITATS WITHIN THE LOWLAND FARMLAND OF BRITAIN IN WINTER

Published as: Gillings *et al*. (in press) Distribution and abundance of birds and their habitats within the lowland farmland of Britain in winter. *Bird Study*.

2.1 Introduction

British farmland in winter is an essential habitat for many resident species and also for many northern and eastern winter immigrants from Iceland, Scandinavia and the Low Countries. Marked declines and range contractions in breeding populations of many farmland birds (Marchant *et al*. 1990; Gibbons *et al*. 1993; Fuller *et al*. 1995) have prompted intensive studies of many species. Such changes evident in the breeding season would lead us to expect similar patterns of winter declines and range contractions but large scale information on distribution and abundance are lacking. Furthermore, there are a range of species such as Fieldfare (see Table 2.1 for scientific names) and Redwing that are present on British farmland predominantly only in the winter months and are not monitored. Several intensive studies of bird communities or individual species have provided important insights into densities and habitat selection at the local (Wilson *et al*. 1996; Buckingham *et al.* 1999; Perkins *et al.* 2000, Donald *et al*. 2001) or regional level (e.g. Hancock & Wilson 2003). This paper provides the first overview of winter farmland bird communities at the scale of the whole country using data from an extensive volunteer survey conducted over three winters: 1999/2000, 2000/01 and 2002/03.

The Winter Farmland Bird Survey (WFBS) project had three main aims. First, to provide information on the distribution and abundance of a suite of farmland bird species across the whole of lowland Britain. Second, to quantify the distribution and abundance of agricultural habitats in winter. Third, to identify the habitat preferences of farmland birds in winter across a wide geographic area and to provide scope for investigating the nature of regional, seasonal and annual differences in these preferences. Results from non-random and casual record components of the survey are summarised in Gillings and Beaven (2004; see also www.bto.org/goto/wfbs.htm). This paper uses data on birds and their habitats collected from a stratified random sample of 1-km squares and aims to give a national overview of the general patterns of abundance, distribution and broad habitat preferences. We also report information on the distribution of agricultural habitats in winter since this information is not currently available through standard agricultural statistics.

2.2 Methods

2.2.1 Target species

The survey initially targeted 30 species of farmland bird (Table 2.1). These included: i) species for which winter ecology has been identified as a key research need (e.g. Tree Sparrow); ii) species whose main wintering habitat is farmland and iii) species that use farmland in large numbers in winter but for which it is not necessarily their main habitat (e.g. Chaffinch). In subsequent winters additional species were also recorded but this paper concentrates on the target species. These differed widely in ecology and distribution, so methods were integrated to provide adequate coverage and detection of all 30 species. Since detection and identification of these species in winter was likely to rely heavily on calls other than songs, an audio tape including calls of the target species and potentially confusing species was provided free to all participants.

2.2.2 Selection of survey squares

Volunteer surveyors did all the fieldwork for the survey. Fieldwork to survey farmland species in winter is very time consuming, so, to best focus the volunteers’ effort in lowland farmland areas we used a two-stage procedure to select 1-km sample squares: a coarse 10-km resolution filter followed by a finer 1-km resolution filter. Data on the extent of cropped land (the ‘crops and fallow’ category) and agricultural grassland ('pasture' category) within 10-km squares (Department for Environment, Food and Rural Affairs (Defra) and Scottish Office June census statistics) were combined and expressed as the percentage of the land area in each 10-km square. An analysis of relative abundance bird data from Lack (1986) showed that setting this figure at a threshold of 30% or more gave coverage of more than 70% of both range and numbers for most target species (Appendix 1). The selected set of 10-km squares with more than 30% cropped land and agricultural grassland was largely in the lowlands, outside urban areas. Next, individual 1-km squares classified as Marginal upland or Upland by the Institute of Terrestrial Ecology (ITE) Land Classification System (Bunce *et al*. 1996) were excluded and the ITE Landcover Map of Great Britain (Fuller & Parsell 1990) was further used to exclude any squares with 25% of more woodland cover (landcover types 15+16) or urban/industrial cover (landcover type 21).

Finally, squares were stratified by region and by Arable or Pastoral ITE Landscape Types to ensure good geographic coverage. In England, three regions were based on amalgamated government administrative regions (www.statistics.gov.uk/geography/gor.asp). Wales and Scotland were treated as regions in their entirety (Fig. 2.1). It was our aim to assess farmland bird ecology on a regional basis and in order to do so we needed to ensure sufficient numbers of sample squares were surveyed in all regions and landscape types. In some regions certain strata were rare (for example only 7% of 1-km squares fell in Wales, of which only 8% were Arable) so the stratification was adjusted to achieve reasonable samples sizes in each region and landscape type (Appendix 2).

2.2.3 Field methods

Bird and habitat recording were undertaken on a patch-by-patch basis within each 1-km square. A patch was defined as any area (>0.3 ha) of a single habitat. All non-farmland habitats were excluded from the survey so in the majority of cases a patch equated to a field, a game cover strip, an orchard or a farmyard. Species smaller than thrushes may be difficult to detect in fields (Tucker 1992). This difficulty can be reduced using the complete area search method (e.g. Hancock & Wilson 2003) but this time consuming method is not suitable for volunteer observers. Instead we adopted a hybrid of methods involving whole patch counts conducted from the patch edge and across-patch transects (winter 1 only). The latter plus pilot work showed that edge counts were an appropriate means of surveying most of the target species, underestimating the abundance of only four (Atkinson *et al*. 2006).

Observers made three visits to their square from the beginning of November to the end of February and on each visit surveyed as many patches as possible within a 4 hr time limit, ideally surveying the same patches on each visit and in each year. Fieldwork was conducted in 1999/2000, 2000/2001 and 2002/2003; 2001/2002 was omitted due to access restrictions arising over Foot and Mouth Disease.

Visits were made on calm dry days with good visibility, avoiding the first and last hours of daylight. Observers walked around the edge of each habitat patch and recorded birds in three zones: boundary = hedges and other boundary structures including any 'verge' vegetation adjacent to the crop/margin; margin = outer 20 m of the crop or uncropped margin; interior = the field beyond the margin zone. Birds were assigned to the zone in which they were first detected, except where, for instance, a flock was continuously moving between the margin and the boundary, in which case they were assigned to the margin as the most likely foraging habitat. In 1999/2000 this edge count was followed by a single straight transect across the field, ideally diagonally through the field centre. Transects were only 20 m wide (10 m either side) to ensure that all birds in the strip would be detected (=flushed) irrespective of vegetation height (Hancock & Wilson 2003). Flying birds were ignored unless clearly associated with a patch (e.g. just flushed or about to land).

Each patch was assigned a habitat code based on Crick (1992) and Gillings and Fuller (2001) with new codes specific to winter habitats. Habitats were coded on each visit to account for the high rate of change due to agricultural operations in winter. Illustrated notes were provided to all observers to aid the identification of crops and stubbles. Set-aside was recorded as a stubble or grassland depending upon what it most resembled.

2.2.4 Analysis

With three visits in each of three winters there were multiple ways of summarising the data. Since visit number (1, 2 or 3) was not biologically meaningful[a], visits were reassigned to one of three periods: early = November-December, mid = January, late = February. Visits falling outside these periods were excluded from analysis and if more than one visit fell in a period, one was selected at random for analysis. Hereafter, independent data points are referred to as 'winter×period' combinations.

Survey maps were digitised and field area and perimeter length determined using a geographic information system (GIS). The timed 4 hr search often precluded coverage of the entirety of the farmland within the square. On average, observers surveyed 57.0 ± 0.3 ha of farmland per 1-km square, which is equivalent to 72.1 ± 0.3% of the farmland actually present in each square.[b] Therefore, for mapping, which required square-scale total bird counts that were unbiased by effort, bird counts had to be standardised by scaling-up for each square based on the area of farmland surveyed and the area of farmland actually present in that square.[b]

At least one survey for birds and habitats was undertaken on 18 025 patches and most received multiple visits across seasons and winters. The frequency distributions of bird counts were extremely skewed: for many species 90% or more patches were apparently unoccupied leading to zero-inflated distributions which could not be transformed. This presented problems for summary statistics and significance testing so we adopted a three level approach, considering the levels of occupancy of sample squares, the occupancy of patches within occupied squares, and the density of individuals within occupied patches. The percentage of squares occupied by a species was calculated separately for each winter×period and then averaged across the nine winter×periods. Weightings were used to account for the original stratification of squares and any bias in coverage within each winter×period. For species present in 1% of squares or less patch occupancy or density figures were not calculated. For the rest, the percentage of patches occupied was calculated separately for each winter×period by calculating the percentage of patches occupied within each occupied square and then averaging across those squares. For each winter×period densities were calculated for each occupied patch and a median taken within squares and then across squares. For summary purposes, patch occupancy and density figures are presented for mid winter 2. One-way differences in densities between winters or periods were assessed using Kruskal-Wallis tests.

We wished to produce maps that summarised the distribution and abundance of the target species and opted for smoothed contour maps to indicate patterns of relative abundance because these could effectively provide summary information when reproduced at a small scale whilst not placing too much emphasis on the actual densities, which for some species are likely to be under-estimates. Maps were produced by Inverse-distance weighting over the 10-15 nearest neighbours in ArcMap (version 9.0). This method was selected because it makes no assumptions about the underlying data and in trials it yielded the maps that best reflected the geographic variation in counts. For each species the bird data used were the total number of individuals recorded on a visit to a square (i.e. summed across all patches) and standardised for total area surveyed and averaged across all visits. Contour levels were selected to reflect 10 quantiles thus producing relative abundance maps comparable across species.

Habitat availability was mapped, using inverse distance weighting, in early, mid and late winter using the percentage of farmland in the square that was under each cover type (and taking a mean across winters).

2.2.5 Evaluating habitat use and use relative to availability

For a general description of habitat use we present simple occupancy rates based on the proportion of individuals and the proportion of records (approximating to flocks) of each species in each of 10 broad habitat types: GU = unimproved grass, GI = improved grass, GO = other grass, CC = cereal crop, CO = other crop, SC = cereal stubble, SO = other stubble, FY = farmyard, BS = bare soil, OH = other agricultural habitats. For subsequent analyses the ‘other’ categories were broken down into constituent parts.

Given large variation in availability between habitats analyses were conducted to determine the strength of associations between individual species and habitats. Due to the nature of the survey data, where many squares did not hold individual species or habitat types, we were unable to use either compositional analysis or log-linear models and instead assessed habitat use in relation to availability at two hierarchical scales. Firstly we ask what are the habitat characteristics of occupied 1-km squares. Secondly we consider which habitat types are used at the patch level within occupied squares. The square-scale analysis aimed to determine whether occupied squares differed in habitat composition from unoccupied squares and was performed as follows. For each of the nine winter×period combinations we identified the n squares a species occupied and calculated the mean percentage availability of each broad habitat across those n squares. We then used randomisation to determine whether this observed composition differed significantly from chance as follows. From the total of N squares surveyed in that winter×period we resampled with replacement n squares from which the mean percentage availability of each broad habitat was calculated. This was repeated 1000 times and the 25th and 975th ranked values of habitat availability were taken as the lower and upper confidence limits of expected habitat composition below and above which a habitat was deemed to be present in significantly lesser or greater quantity in occupied 1-km squares. Tallying the frequency of winter×periods in which each habitat was significantly different from expectation gave a measure of the consistency with which habitats were positively or negatively associated with species at the square-scale.

The patch-scale analysis aimed to determine whether use of habitats in occupied squares exceeded availability in those squares and was performed as follows. Taking only those n squares occupied by a species in a winter×period, and only those squares in which habitat h was present we determine the percentage of all individuals recorded in habitat h and the percentage of the surveyed area classified as habitat h (the ’area method’). Since individuals in flocks cannot necessarily be treated independently we also calculated the percentage of patches of habitat h occupied by the species and the percentage of all patches surveyed classified as habitat h (the ‘frequency method’). For both methods we then determined the number of squares in which use exceeded availability (+), availability exceeded use (-) or use equalled availability (0) and summed these values across the nine winter×period combinations to report the percentage of all square-visits in which a habitat was present and used proportionately greater than its availability.

2.3. Results

2.3.1 Coverage

Across the three winters of the survey 1090 sample squares were surveyed, providing at least one visit to 18 025 habitat patches and yielding counts of over 1 million individual birds (Table 2.1). Geographic coverage was good (Fig. 2.1) though there was a slight deviation from the original stratification in winters 1 and 2 ($\chi^2_4 = 13.3$, $P < 0.01$; $\chi^2_4 = 13.9$, $P < 0.01$) (Appendix 2). In each winter over 95% of squares were visited at least twice and in winters 1 and 3 over 85% of squares were visited three times (65% in winter 2).

2.3.2 Apparent occupancy, densities and distributions

Species varied widely in the percentage of squares and patches that were apparently occupied (Table 2.1). Chaffinch was the most widespread species at both scales, being recorded from 82% of squares and 19% of patches. The next most widespread were Fieldfare, Song Thrush and Starling, all reported from 52-3% of squares on average. The scarcest species were Woodlark, Twite and Snow Bunting which were reported from less than 1% (Table 2.1). Occupancy at patch and square scale were positively correlated across species (n = 30, r_s = 0.70, P < 0.0001), although most species were only reported from a low percentage of patches (Table 2.1). There was no significant correlation between square occupancy and density in occupied patches (n = 26, r_s = 0.16, P > 0.4), or between patch occupancy and density (n = 26, r_s = 0.22, P > 0.2). For most species densities were similar across winters and periods and example figures from mid winter 2 showed that median densities were less than 1 bird/ha for 16 species and only exceeded 2 birds/ha for six species. Densities differed significantly (P < 0.01) between winters for five species: Pied Wagtail occurred at lower density in winter 3; Fieldfare densities declined across the three winters; Starling densities were low in winter 2 and Chaffinch densities were high in winter 1. Densities differed significantly (P < 0.01) between period for five species: Grey Partridge and Skylark densities dropped in late winter; Fieldfare and Redwing densities increased through the winter; and Chaffinch densities peaked in mid winter. Exact densities should be interpreted with caution due to under-recording of certain species and it is possible that some of the density variations noted could have been due to habitat effects.

For the 26 species with sufficient records, relative abundance maps are given (Fig. 2.2). These maps provide a visual summary of underlying records for the whole of the lowland agricultural area of Britain. The distribution patterns fall into several groups: widespread/ubiquitous species (e.g. Starling, Chaffinch); widespread species with higher abundance in certain regions (e.g. Lapwing, Fieldfare, Redwing); species localised in one region (e.g. Stonechat, Tree Sparrow); and species localised but patchy (e.g. Curlew, Corn Bunting).

2.3.3 Habitat availability

Grass represented the main agricultural land cover, accounting for 43% of the surveyed land and 47% of the patches (Table 2.2). Cereal crops accounted for 24% of area and 14% of patches (Table 2.2). The difference between percent of area and of patches illustrates the difference in field size: grass fields tend to be small whereas cereal fields tend to be large. Twenty percent of the land was stubble, of which half was cereal stubble (Table 2.2).

The distribution of grass and cereal crops were polarised into the west and east respectively and remained relatively constant over the winter (Fig. 2.3). In contrast the distribution of cereal stubble was patchy and showed a slight decrease and gradual fragmentation through the winter and bare tillage showed a clear increase in its prevalence (Fig. 2.3).

2.3.4 Habitat use and use in relation to availability

The greatest proportion of most species was found in either unimproved or improved grass though this is unsurprising given the relatively high availability of pasture (Table 2.2). Notable exceptions were Grey Partridge, Stock Dove and Skylark (all present in cereal crops and stubbles) and Golden Plovers (cereal crops and bare soil). Furthermore, a high proportion of Pied Wagtails and House Sparrows was reported from farmyards and a high proportion of Greenfinch, Goldfinch, Linnet and Twite in other crops. Similarly, a high proportion of all four buntings was found in cereal stubbles (Table 2.2).

Individual species responses to habitat at the square and patch scale are shown in Table 2.3. Unimproved grass was rarely selected at the square-scale though was positively associated with Snipe presence at the patch scale. Improved grass was positively selected by several invertebrate feeders at both square and patch scales. Only Golden Plover and Lapwing were associated strongly with cereal crops at the patch scale. Several granivorous passerines were associated with other crops, specifically often game cover crops. Only Skylark, Linnet and Yellowhammer showed strong association with cereal stubbles at the square scale, though a wider range of species did at the patch scale. The pattern of association for other stubbles was similar to other crops. The two sparrows and Starling were associated with squares containing farmyards and pied wagtails were also associated with farmyard patches. The same species as were associated with cereal stubble (Skylark, Linnet and Yellowhammer) were also associated with squares containing bare soil, as was Grey Partridge.

2.4 Discussion

This study presents the first national picture of the winter distribution of farmland birds in relation to their habitats. The survey covered over 400km^2 of farmland and recorded approximately 300 000 birds per winter. The results provide a useful national comparison for local intensive studies. We also provide new information on the spatial abundance of cereal stubble fields – a key resource that is not monitored by standard agricultural statistics.

2.4.1 Aggregated distributions

Levels of apparent occupancy of squares and patches, and densities within apparently occupied patches point to most species being highly aggregated in a small number of the available patches. We might expect this pattern for species such as Corn Bunting that are known to have undergone substantial breeding population declines and breeding range contractions (Fuller *et al*. 1995), but similar patterns for widespread and ubiquitous species such as Chaffinch and Greenfinch are less expected.

There are few historic or contemporary surveys at the appropriate scale with which to compare these apparent occupancy and density figures. Stoate *et al*. (2003), Henderson *et al*. (2004) and Atkinson *et al*. (2005) report low densities and/or occupancy rates (though with differing methods). Hancock and Wilson (2003) present occupancy figures in Scottish 1-km squares for 13 species. Their occupancy rates were positively correlated with occupancy rates from WFBS in the Scotland region (n = 13 species, r_s = 0.89, P < 0.0001) but were generally higher, perhaps because methods used by Hancock and Wilson (2003) were more intensive than those employed by this survey. However, pilot work suggested that the methods used here were only likely to underestimate certain species, namely Grey Partridge, Snipe, Meadow Pipit and Skylark (Atkinson *et al*. 2006). More likely is that the design of some intensive studies may have focussed attention on geographic hotspots (as was the case for Hancock & Wilson 2003) or known favoured habitats (e.g. set-aside or game cover crops).

Therefore, the low occupancy rates and densities of both common and scarce species may be more representative of the broad suite of habitats present across the British lowlands. Two non-exclusive explanations of this observation are predation pressure and food abundance. Under high predation pressure individual birds may join flocks to reduce their predation risk. Thus, even if all fields contain sufficient food, scarcer passerines may be present in a small number of flocks in a fraction of fields rather than distributed equally over all fields. It would be interesting to know if individual flock sizes have changed over recent decades and whether aggregations change through a winter as food resources become depleted through predation and habitat modification (e.g. ploughing). An alternative explanation is that the distribution of birds reflects the aggregated distribution of seed resources. In an intensive field study, Vickery *et al*. (2002) showed that most stubble fields contained very low densities of weed seeds, and only a small proportion of fields held high densities of seeds. Exactly the same pattern was evident in the frequency distribution of granivorous passerine densities in individual stubble fields and, crucially, the density of weed seeds was a strong predictor of the abundance of granivorous passerines at the field scale. Similarly in Scotland the density of granivorous passerines was correlated with weediness of fodder crops (Hancock & Wilson 2003). If these results are widely applicable then the highly aggregated nature of the bird distributions described in this paper may reflect a more general tendency for seed resources to be spatially aggregated.

2.4.2 Preferred habitats

Patterns of habitat association confirm on a larger scale those shown by local and intensive studies (e.g. Wilson *et al*. 1996; Buckingham *et al.* 1999; Hancock & Wilson 2003; Atkinson *et al*. 2005): avoidance of cereal crops and bare tillage by most species and positive association of pasture by invertebrate feeders and of stubbles by granivorous species though differences between square and patch scale results are informative.

A high proportion of species showed a square-scale association with cereal crops which at first may seem contrary to published results but probably is indicative of the general association of many granivorous species with arable landscapes. In support of this, only the two plover species were associated with cereal crops at the patch scale. Similarly, the association of Skylarks at the square scale with bare soil may indicate squares in which stubbles are or were available. Farmyards may provide spilt grain or food associated with livestock that may attract granivorous species (Lack 1992) and we found strong positive associations with farmyards by many species at both square and patch scales. This could potentially arise from a calculation artefact due to the small area that farmyards comprise, however these results were apparent when the patch measures were calculated in terms of number of patches and number of records as well as area and individuals. Hancock and Wilson (2003) also demonstrated selection of farmyards by certain farmland species (especially House Sparrow and Chaffinch), but noted that the high priority declining species preferred more open habitats.

No species showed a strong patch-scale association with bare soil which is significant given the large proportion of arable land taken up by this habitat, albeit temporarily. Several species showed weak association with one of the general ‘other’ categories. Even for a national survey of this extent the sample sizes for crop-specific analyses were often too small, hence the use of the ‘other’ categories. At the square scale many species showed associations with other crops and other stubbles which is probably indicative of selection for arable landscapes with a high diversity of crop types. Few species showed a high association with other crops or other stubbles at the patch scale. Skylark, Chaffinch, Brambling and Linnet all showed moderate associations with other stubbles, a category mostly comprising maize stubble. These fields arise from harvested maize crops as opposed to the remains of game cover crops which are not ‘harvested’ until late February at the end of the sampling season.

It is noteworthy that pasture accounted for the highest proportion of individuals or flocks for 23 of the 30 species. Though the large area of grass in lowland Britain means that this does not constitute a calculable preference for all species, it does mean that beneficial management of pasture could benefit a large proportion of the populations of many species, both invertebrate feeders and granivores. Previous studies have shown that sward structure is the greatest factor limiting pasture use by invertebrate feeders due to access (Atkinson *et al*. 2005) or detectability issues (Butler & Gillings 2004; Devereux *et al*. 2004). Therefore, better sward management to increase access to invertebrate prey may benefit invertebrate feeders, and allowing grasses to bear seeds may benefit granivores at the field scale (Atkinson *et al*. 2005). As with many such recommendations, whether this can be achievable on a sufficient scale to impact upon population trends is unknown.

These results, like those concerning apparent occupancy, relate to those birds detected by the combination of methods used. Every effort was made to design methods that could be used by volunteers without causing biases due to detectability differences between species and habitats. Preliminary work suggested that for most species these methods were acceptable for the majority of species because they tended to be distributed around the outsides of fields where they could be seen from field margins (Atkinson *et al*. 2006). In these cases it is unlikely that habitat had a major influence on detectability. However, for Grey Partridge, Snipe, Skylark and Meadow Pipit these results could be affected by low detectability but our results are reassuringly consistent with those of studies that have employed more intensive field methods. In this respect the decreased densities of Grey Partridge and Skylark in late winter may be due to decreased detectability in taller crops.

2.4.3 Bird and habitat distributions

The bird distribution maps shown here are the first for wintering bird species since the *Winter Atlas* of the early 1980s (Lack 1986) and are useful for assessing changes since then, as well as being informative in helping to target agri-environment schemes. Patterns of relative abundance appear broadly similar to the 1980s for Grey Partridge – small populations still exist in the south-west though there now appears to be gaps in the range in much of Kent/Sussex/Surrey and Dorset/Somerset (Fig 2.2a). Golden Plovers have shown a pronounced shift to the east (Fig 2.2b), Lapwings less so (Fig 2.2c), since the 1980s probably in response to milder winters (Gillings *et al*. 2006). The distribution of Snipe (Fig 2.2d) contrasts markedly with that from Lack (1986), now showing low relative abundance in all but the south-west peninsula and south-west Wales. Whilst this could be associated with changes in water-level management it is worth noting that the maps (Fig. 2.2) are based only on farmland habitats whereas those in Lack (1986) cover all habitats so some differences may be expected for species like Snipe that are not absolutely tied to farmland. In this respect the apparent absence of Stonechat from all but the south-west and Wales (Fig. 2.2j) may reflect a habitat bias in its distribution, with those in the north and east having been missed due to associations with non-farmland habitats. Likewise, the Brambling map (Fig. 2.2s) indicates the absence of woodlands from the WFBS coverage. Fieldfare, Redwing and Mistle Thrush maps (Figs 2.2k, m & n) are suggestive of increased wintering in East Anglia. Tree Sparrows have been lost from many southern and eastern areas (Fig. 2.2q) since the 1980s and the House Sparrow map shows more spatial variation in relative abundance in eastern England and less contrast with the south-west (Fig. 2.2p) than was apparent in the 1980s. Of the buntings, Yellowhammer and Reed Buntings look similar but Corn Buntings have contracted further in to hotspots. All other species do not appear to have changed markedly, though these relative abundance maps could conceal general increases or decreases in density throughout ranges. These results are suggestive of major changes among winter farmland populations, some of which are consistent with the declines and range contractions observed in the breeding season (Gibbons *et al*. 1993; Fuller *et al*. 1995) and others which may be part of larger scale redistributions, perhaps related to winter weather patterns.

Government departments produce maps of summer cropping patterns based on June census information (e.g. Defra in England[c]) but none are available of crops and stubbles in winter. This study provides new maps of the distribution of some key agricultural habitats across the British lowlands in winter. These have purposefully been represented with broad contour categories and coarse resolution so as not to over-interpret the underlying data. However, those for grass and cereal crops reassuringly mirror those produced by Defra for English summer cropping, giving confidence that these first maps of stubble and bare tillage may also be reliable. These maps are an average across years and hide some annual variation. For instance, the autumn and winter of 2000/2001 was particularly wet and delayed ploughing of many stubbles meant that 32% less cereals had been planted in England and Wales by 1 December 2000 compared to the same time in 1999 (Defra). Abundance maps from WFBS also show higher densities of cereal stubble throughout winter 2000/2001.

The maps are informative in relation to known habitat requirements. Most of the granivore species of conservation concern show positive associations with stubble fields. Moreover, breeding population declines in Skylark and Yellowhammer are less severe in areas with 10-20ha of cereal stubble compared to areas with less than 10ha of stubble (Gillings *et al*. 2005). The habitat maps presented here suggest that there are currently few areas with sufficiently high densities of stubble to reverse population declines. Increasing the density of stubble within areas that currently have little could help stem declines in these areas. The scale at which the habitat is available is not apparent from these data. We currently know little of the within and between season dispersal abilities of these declining species. Siriwardena *et al*. (2006) show that several farmland passerines are highly sedentary within a winter, suggesting that food resources may need to be made available in a fine-grain mosaic to be effectively used in order to bring about population recoveries.

2.5 Conclusions

In general our conclusions are broadly in agreement with previously published intensive studies but the strength of a large scale survey such as this is that the randomised design of the study has highlighted just how scarce and aggregated many farmland species have become in the wider countryside. These results, and the underlying data, will be invaluable in helping to target future agri-environment schemes.

Endnotes

a. Visit dates varied widely from October 23rd to into April. Visits falling outside the requested observation period (November-February) were rejected. In each winter dates for visits 1, 2 and 3 overlapped considerably because, for instance, some observers made only two visits, started in January but still numbered them 1 and 2. For this reason visit number could not be used as a surrogate for time. Instead individual visits were reassigned to a period of the winter. Ideally three periods each of 40 days would have been used, but this led to markedly differing sample sizes in each period (twice as many in period 3 as in period 1). Instead the three periods were defined as *Early* = November/December, *Mid* = January and *Late* = February to yield approximately equal sample sizes.

b. The actual area of farmland in the sample 1-km square was estimated as the sum of arable and grassland cover types from the *Land Cover Map 2000* (*LCM2000*, Fuller *et al.* 2002) and this was compared with what was actually surveyed. Across all the visits to all the squares the mean ± SE area of land surveyed was 57.0 ± 0.3ha. The mean percentage of farmland surveyed out of that actually present in the square was 72.1 ± 0.3%. The percentage of the square's farmland covered differed significantly between regions (χ^2_4 = 571.9, P < 0.0001): E. England = 78%, N. England = 71%, Scotland = 79%, W. England = 65% and Wales = 59%. Thus bird counts and habitat areas had to be scaled upwards to standardise all to the area of farmland actually present in each square to prevent geographic biases in densities arising solely from differing effort. The ratio of area surveyed to area of farmland present was used to extrapolate all counts and areas.

c. farmstats.defra.gov.uk/cs/farmstats_data/MAPS/agricultural_atlas/map_select.asp

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Appendix 1 The percentage of the winter range (number of 10-km squares) and total population (in parentheses; based on summed relative abundance measures) of different species contained within subsets of British 10-km squares identified on the basis of minimum percentage cover of cropped land and agricultural grassland. Bird data from Lack (1986).

Species	**Subsets of 10-km squares with differing minimum thresholds of farmland cover**									
	10%+		**20%+**		**30%+**		**40%+**		**50%+**	
Grey Partridge	95.1	(96.7)	90.4	(93.4)	85.7	(88.3)	77.7	(80.1)	67.4	(71.0)
Golden Plover	89.5	(97.0)	84.5	(94.4)	79.1	(89.9)	72.2	(82.7)	62.8	(72.1)
Lapwing	85.7	(97.2)	79.6	(95.0)	74.3	(91.3)	66.5	(85.6)	56.8	(78.0)
Snipe	84.5	(95.6)	78.6	(90.4)	73.2	(84.5)	65.7	(76.1)	55.6	(65.6)
Curlew	74.3	(87.8)	68.2	(80.1)	62.6	(68.9)	54.8	(55.8)	45.3	(40.3)
Stock Dove	95.7	(98.3)	90.8	(96.0)	85.7	(93.0)	78.0	(86.6)	67.9	(79.7)
Skylark	87.1	(93.9)	80.9	(90.5)	75.7	(82.1)	68.3	(72.7)	58.3	(63.5)
Meadow Pipit	79.7	(89.8)	73.3	(81.8)	67.9	(74.0)	60.7	(63.3)	51.5	(53.4)
Pied Wagtail	89.9	(95.4)	83.8	(89.5)	78.1	(79.3)	70.4	(67.5)	60.4	(54.7)
Stonechat	72.8	(74.6)	64.2	(64.7)	57.9	(57.4)	50.0	(47.9)	39.6	(36.6)
Fieldfare	81.3	(95.3)	74.6	(90.0)	69.1	(84.3)	61.8	(77.7)	52.7	(68.6)
Song Thrush	82.6	(90.9)	76.4	(85.7)	70.9	(80.3)	63.8	(72.1)	54.5	(61.4)
Redwing	81.8	(95.7)	75.5	(90.1)	70.2	(83.8)	63.0	(77.1)	53.7	(69.5)
Mistle Thrush	84.2	(90.8)	77.8	(84.2)	72.3	(78.1)	65.0	(69.4)	55.8	(58.6)
Starling	81.5	(96.9)	74.6	(94.4)	68.9	(91.7)	61.6	(79.5)	52.4	(71.2)
House Sparrow	83.3	(94.2)	76.8	(91.2)	71.1	(87.0)	63.6	(81.2)	54.2	(73.3)
Tree Sparrow	95.9	(98.7)	92.6	(96.1)	88.3	(93.7)	80.8	(86.4)	70.6	(77.5)
Chaffinch	79.3	(85.5)	72.8	(77.7)	67.2	(72.5)	60.2	(63.3)	51.4	(50.2)
Brambling	89.6	(90.9)	83.1	(83.7)	77.3	(75.1)	69.6	(65.3)	58.9	(49.4)
Greenfinch	88.3	(96.0)	82.4	(90.2)	76.8	(84.8)	69.1	(76.4)	58.9	(66.6)
Goldfinch	89.1	(93.2)	83.3	(88.0)	77.7	(81.4)	69.4	(72.1)	59.7	(59.4)
Linnet	93.5	(95.8)	88.1	(89.3)	82.6	(82.0)	74.6	(73.1)	63.6	(60.6)
Bullfinch	87.0	(88.6)	81.3	(83.3)	76.2	(78.9)	68.7	(71.8)	59.2	(62.7)
Yellowhammer	90.9	(96.6)	85.1	(93.9)	79.7	(90.9)	72.0	(83.5)	61.9	(73.0)
Reed Bunting	88.5	(93.0)	82.6	(87.6)	77.0	(80.2)	69.4	(69.0)	58.7	(57.2)
Corn Bunting	96.1	(96.8)	93.6	(95.3)	90.4	(87.8)	82.9	(79.4)	73.4	(71.2)

Appendix 2 Summary by region and landscape stratum of the number (and %) of 1-km squares present in reality and selected for coverage (see Methods) and surveyed in each winter. The number of squares surveyed in each winter and their percentage distribution across survey strata is shown. A = Arable squares, P = Pastoral squares (see Methods).

	E. England		**N. England**		**Scotland**		**W. England**		**Wales**	
	A	**P**	**A**	**P**	**A**	**P**	**A**	**P**	**A**	**P**
Squares available										
% (n = 126,059)	33.0	4.5	5.6	12.3	8.7	4.6	7.2	17.2	0.6	6.3
Stratified sample										
% (n = 3000)	30.8	4.2	5.3	11.7	9.0	6.0	6.7	16.3	3.5	6.5
Coverage										
%W1 (n = 870)	34.2	3.7	5.3	12.0	7.3	4.7	6.8	16.6	2.3	7.1
%W2 (n = 801)	30.8	3.4	6.4	12.7	9.7	4.6	6.5	16.5	2.6	6.7
%W3 (n = 745)	31.7	3.1	6.8	12.6	9.8	3.8	6.4	16.1	3.0	6.7

Table 2.1 A list of the target species surveyed, giving a summary of abundance and apparent occupancy. *Total* is the number of birds counted summed across the three winters. *Square* gives the percentage of squares occupied, averaged across winter×periods (range in brackets). *Patch* gives the median within-square percentage of patches occupied (quartiles in brackets) within occupied squares for winter 2, period 2. *Density* gives the median (quartiles in brackets) density (birds/ha) within occupied patches for winter 2, period 2. *W* and *P* indicate significant differences in density in occupied patches between winters and periods. * P < 0.05, ** P < 0.01, *** P < 0.001.

Species	Scientific name	Total	Square	Patch	Density	W	P
Grey Partridge	*Perdix perdix*	5853	14 (11 - 18)	8 (6 - 15)	0.8 (0.5 - 1.5)		***
European Golden Plover	*Pluvialis apricaria*	17,445	4 (1 - 6)	9.5 (6 - 15)	1.2 (0.5 - 2.4)		
Northern Lapwing	*Vanellus vanellus*	50,942	14 (10 - 22)	9 (6 - 17)	2.4 (0.6 - 7.2)		
Common Snipe	*Gallinago gallinago*	5249	16 (11 - 20)	8 (6 - 14)	0.5 (0.2 - 1.2)		
Eurasian Curlew	*Numenius arquata*	6031	5 (4 - 7)	10 (7 - 17)	0.9 (0.2 - 5.5)		
Stock Pigeon	*Columba oenas*	6810	16 (13 - 19)	8 (6 - 13)	0.5 (0.2 - 1.5)		
Wood Lark	*Lullula arborea*	93	<1 (0 - 1)	.	.		
Sky Lark	*Alauda arvensis*	45,225	44 (36 - 57)	13 (8 - 20)	0.7 (0.3 - 1.8)		***
Meadow Pipit	*Anthus pratensis*	26,453	37 (31 - 44)	10 (6 - 18)	1 (0.5 - 2.4)		*
White Wagtail	*Motacilla alba*	10,397	38 (30 - 47)	10 (6 - 15)	0.6 (0.3 - 1.4)	**	
Stonechat	*Saxicola torquata*	686	5 (3 - 7)	9 (7 - 11)	0.5 (0.3 - 0.8)		
Fieldfare	*Turdus pilaris*	159,438	52 (38 - 60)	12 (7 - 20)	2.8 (0.8 - 8)	***	***
Song Thrush	*Turdus philomelos*	12,903	53 (48 - 60)	14 (8 - 22)	0.4 (0.2 - 0.8)		
Redwing	*Turdus iliacus*	83,734	45 (28 - 56)	12.5 (8 - 19)	2.2 (0.9 - 5.6)		***
Mistle Thrush	*Turdus viscivorus*	6781	40 (37 - 44)	9 (6 - 15)	0.4 (0.2 - 0.7)		
Common Starling	*Sturnus vulgaris*	280,732	52 (48 - 56)	12 (7 - 18)	3.7 (1.3 - 10)	**	
House Sparrow	*Passer domesticus*	31,004	40 (38 - 42)	10 (7 - 15)	2.8 (1 - 8.7)		
Eurasian Tree Sparrow	*Passer montanus*	4751	8 (6 - 11)	8 (6 - 11)	1.7 (0.5 - 3.8)		
Chaffinch	*Fringilla coelebs*	111,368	82 (79 - 86)	19 (11 - 31)	1 (0.4 - 2)	***	***
Brambling	*Fringilla montifringilla*	1122	2 (0 - 4)	8 (6 - 9)	.		
European Greenfinch	*Carduelis chloris*	22,807	42 (37 - 47)	10 (6 - 16.5)	0.8 (0.3 - 2.1)		
European Goldfinch	*Carduelis carduelis*	18,882	27 (20 - 36)	9 (6 - 13)	0.9 (0.4 - 2.3)		
Common Linnet	*Carduelis cannabina*	42,408	19 (16 - 23)	8 (6 - 11)	3 (0.6 - 10.4)		
Twite	*Carduelis flavirostris*	1398	<1 (0 - 1)	.	.		
Redpoll spp.	*Carduelis cabaret/flammea*	1029	2 (1 - 3)	7 (5 - 11)	0.7 (0.4 - 2.7)		
Common Bullfinch	*Pyrrhula pyrrhula*	3250	19 (13 - 27)	9 (6 - 13)	0.4 (0.2 - 0.9)		*
Snow Bunting	*Plectrophenax nivalis*	258	<1 (0 - <1)	.	.		
Yellowhammer	*Emberiza citrinella*	27,097	38 (33 - 43)	11 (6 - 17)	0.8 (0.3 - 2)		
Reed Bunting	*Emberiza schoeniclus*	5521	14 (12 - 16)	9 (6 - 14)	0.5 (0.2 - 1.4)		
Corn Bunting	*Emberiza calandra*	2552	3 (2 - 4)	10 (7 - 14)	0.7 (0.3 - 2.1)		

Table 2.2 Availability and bird use of 10 broad agricultural habitat types within the British lowlands. Availability is expressed as the percentage of the total surveyed area and in brackets as the percentage of all surveyed patches (i.e. approximating to the number of fields). Use is expressed as the percentage of the total count and in brackets as the percentage of the total number of records (i.e. approximating to the number of flocks). For clarity the two habitats accounting for the highest percentage of birds (or flocks) are highlighted in bold. GU = unimproved grass, GI = improved grass, GO = other grass, CC = cereal crop, CO = other crop, SC = cereal stubble, SO = other stubble, FY = farmyard, BS = bare soil, OH = other agricultural habitats.

Species	**GU**		**GI**		**GO**		**CC**		**CO**		**SC**		**SO**		**FY**		**BS**		**OH**	
Availability	**12**	**(16)**	**28**	**(38)**	**3**	**(3)**	**24**	**(14)**	**7**	**(5)**	**10**	**(7)**	**3**	**(3)**	**1**	**(3)**	**9**	**(6)**	**3**	**(4)**
Grey Partridge	7	(8)	16	(17)	2	(2)	**22**	**(23)**	12	(13)	**23**	**(19)**	4	(4)	0	(0)	8	(9)	6	(5)
Golden Plover	9	(8)	7	(12)	1	(2)	**58**	**(46)**	3	(6)	1	(5)	1	(3)	0	(0)	**18**	**(14)**	3	(4)
Lapwing	**22**	(16)	19	**(22)**	1	(4)	**30**	**(23)**	3	(4)	3	(9)	5	(8)	1	(0)	14	(12)	2	(3)
Snipe	**41**	**(32)**	**34**	**(37)**	1	(2)	4	(6)	3	(3)	6	(7)	6	(4)	0	(0)	2	(4)	3	(4)
Curlew	**33**	**(30)**	**47**	**(40)**	2	(3)	6	(10)	2	(3)	6	(8)	2	(2)	0	(0)	2	(2)	1	(2)
Stock Dove	9	(10)	**19**	**(25)**	3	(3)	19	**(19)**	9	(6)	**19**	(13)	6	(5)	3	(5)	10	(9)	4	(5)
Woodlark	**31**	**(41)**	4	(9)	0	(0)	17	(7)	0	(0)	**34**	**(29)**	0	(0)	0	(0)	8	(7)	5	(7)
Skylark	5	(8)	7	(11)	2	(2)	**13**	**(22)**	10	(11)	**43**	**(27)**	8	(6)	0	(0)	7	(9)	5	(4)
Meadow Pipit	**16**	**(19)**	**35**	**(33)**	3	(2)	4	(7)	13	(8)	15	(15)	6	(6)	1	(1)	3	(4)	5	(5)
Pied Wagtail	9	(13)	**24**	**(30)**	2	(3)	9	(9)	11	(5)	9	(7)	**11**	(6)	9	**(15)**	10	(7)	5	(4)
Stonechat	**34**	**(29)**	**29**	**(32)**	3	(3)	8	(8)	6	(7)	8	(8)	3	(4)	2	(1)	4	(4)	4	(4)
Fieldfare	12	(14)	**39**	**(39)**	4	(4)	**17**	**(15)**	5	(5)	8	(8)	4	(4)	0	(1)	5	(4)	6	(6)
Song Thrush	**14**	**(15)**	**35**	**(38)**	3	(3)	12	(13)	9	(7)	11	(9)	4	(4)	3	(2)	4	(4)	6	(6)
Redwing	**17**	**(19)**	**51**	**(47)**	3	(4)	7	(8)	3	(4)	6	(7)	5	(4)	1	(1)	2	(2)	4	(5)
Mistle Thrush	**15**	**(16)**	**39**	**(39)**	4	(3)	14	(14)	4	(4)	9	(8)	3	(3)	1	(2)	5	(5)	5	(5)
Starling	**15**	**(19)**	**55**	**(45)**	3	(3)	7	(7)	1	(3)	4	(7)	3	(3)	3	(7)	4	(3)	4	(5)
House Sparrow	11	(14)	**25**	**(30)**	2	(3)	7	(8)	2	(2)	6	(5)	3	(2)	**37**	**(27)**	3	(4)	4	(5)
Tree Sparrow	6	(10)	**14**	**(19)**	1	(2)	10	(10)	11	(9)	**27**	**(18)**	9	(6)	8	(12)	8	(8)	5	(6)
Chaffinch	10	**(14)**	**20**	**(32)**	2	(3)	10	(13)	12	(7)	**19**	(10)	7	(4)	9	(6)	6	(5)	5	(6)
Brambling	**17**	(13)	7	(13)	1	(1)	13	(7)	12	**(14)**	11	**(16)**	**22**	(12)	8	(6)	2	(8)	7	(11)
Greenfinch	13	**(19)**	**17**	**(28)**	2	(3)	13	(13)	**18**	(8)	13	(10)	7	(4)	5	(5)	5	(4)	7	(6)
Goldfinch	13	**(17)**	**15**	**(24)**	3	(3)	7	(11)	**22**	(9)	11	(11)	9	(6)	4	(5)	6	(6)	9	(8)
Linnet	4	(9)	9	**(15)**	2	(3)	9	(11)	**18**	(14)	**32**	**(26)**	11	(8)	1	(1)	6	(7)	7	(7)
Twite	0	(11)	**36**	(12)	0	(0)	14	(12)	**37**	**(21)**	11	**(35)**	0	(0)	0	(0)	1	(6)	1	(3)
Redpoll	**15**	**(21)**	**23**	**(26)**	6	(4)	9	(10)	11	(8)	5	(10)	6	(7)	0	(2)	12	(4)	13	(9)
Bullfinch	**20**	**(19)**	**34**	**(36)**	3	(3)	14	(14)	7	(6)	8	(8)	3	(3)	1	(2)	3	(4)	7	(7)
Snow Bunting	0	(0)	0	(10)	0	(0)	0	(12)	0	(0)	**99**	**(66)**	**1**	**(12)**	0	(0)	0	(0)	0	(0)
Yellowhammer	8	(10)	**14**	**(19)**	2	(2)	13	(17)	8	(9)	**37**	**(24)**	4	(3)	3	(3)	6	(7)	5	(5)
Reed Bunting	13	(17)	9	**(15)**	1	(2)	6	(10)	**18**	(13)	**25**	**(24)**	6	(5)	0	(1)	5	(6)	17	(9)
Corn Bunting	5	(8)	3	(7)	3	(2)	15	**(22)**	**18**	(13)	**26**	**(29)**	5	(4)	1	(2)	**19**	(8)	6	(6)

Table 2.3 Results of square-scale and patch-scale analyses of habitat use in relation to availability. For each broad habitat two pairs of numbers are given. The first pair indicates the number of winter×periods in which the habitat was present in significantly lesser or greater quantity in occupied squares. Habitat present in greater quantity in occupied squares on five or more visits are underlined. The second pair of numbers indicate the percentage of square visits in which the broad habitat was used more than it was available (within occupied squares in which the habitat type was present) . The first number is calculated using the Area method, the second using the Frequency method. Habitats for which use exceeded availability in 40% of squares or more are highlighted.

Species	**GU**	**GI**	**GO**	**CC**	**CO**	**SC**	**SO**	**FY**	**BS**	**OH**
	-/+ A/F	**-/+ A/F**	**-/+ A/F**	**-/+ A/F**	**-/+ A/F**	**-/+ A/F**	**-/+ A/F**	**-/+ A/F**	**-/+ A/F**	**-/+ A/F**
Grey Partridge	8/0 17/17	8/0 28/27	2/1 13/14	0/9 33/37	0/9 31/32	0/3 34/36	0/6 19/21	1/0 1/1	0/5 19/20	0/4 17/17
Golden Plover	2/0 14/14	8/0 24/24	1/0 25/25	0/9 **59/60**	0/7 14/14	7/0 11/11	0/3 15/15	5/0 0/0	0/3 25/26	0/2 11/11
Lapwing	3/0 19/20	5/0 32/33	0/0 24/25	0/9 **41/42**	0/5 13/14	6/0 17/18	0/9 29/34	2/1 2/2	0/1 32/33	0/5 6/8
Snipe	0/2 **47/47**	0/8 39/39	0/0 10/13	0/0 20/22	3/1 14/15	7/0 22/23	0/6 19/23	1/1 0/0	6/0 21/21	0/1 16/16
Curlew	0/3 30/29	0/4 **53/53**	0/4 15/15	0/4 31/31	0/3 13/13	9/0 26/28	0/4 18/18	2/0 0/0	5/0 9/11	0/2 5/5
Stock Dove	9/0 23/23	4/0 33/32	0/2 15/17	0/9 30/31	0/7 14/15	4/0 25/27	0/6 24/24	0/3 16/15	0/1 25/26	0/5 14/14
Skylark	9/0 16/17	9/0 17/18	4/0 15/18	0/9 30/37	0/9 30/34	0/9 **59/63**	0/6 33/38	3/0 0/0	0/9 21/26	0/5 12/14
Meadow Pipit	2/1 33/35	3/0 **42/40**	0/1 16/17	0/0 15/17	0/5 28/32	0/2 38/**42**	0/7 24/28	2/0 7/7	1/0 13/14	0/2 17/19
Pied Wagtail	3/0 24/24	0/2 33/33	0/2 14/14	2/3 18/19	1/2 18/20	2/0 20/22	0/6 28/31	0/4 **50/50**	3/0 24/26	0/3 15/16
Stonechat	1/1 35/35	0/3 38/37	0/3 20/20	1/3 22/23	0/3 26/27	8/0 22/21	0/5 15/16	3/0 2/4	4/0 18/18	1/3 18/18
Fieldfare	5/0 29/31	0/3 **49/48**	0/0 22/25	0/1 27/33	0/2 16/19	2/0 22/28	0/4 26/29	0/0 4/4	6/0 16/19	0/2 19/22
Song Thrush	6/0 35/34	0/6 **42/41**	0/2 23/24	1/0 26/30	0/1 29/32	1/0 30/34	0/3 23/25	1/1 11/10	8/0 21/23	0/2 24/24
Redwing	0/0 35/35	0/9 **51/50**	0/1 23/25	8/0 20/24	6/0 18/20	8/0 23/27	0/5 23/26	0/0 4/4	9/0 13/15	0/1 19/21
Mistle Thrush	2/0 32/30	2/1 **48/47**	1/0 20/20	0/5 28/30	1/3 15/15	3/0 23/25	0/2 18/19	0/4 8/7	0/0 18/20	0/5 18/18
Starling	0/4 34/35	0/9 **52/50**	0/1 20/23	9/0 15/18	6/0 12/14	7/0 21/25	0/3 17/20	0/5 31/33	9/0 13/15	0/2 15/17
House Sparrow	7/0 26/25	0/1 32/31	0/1 16/17	0/1 14/17	1/0 11/12	1/0 13/15	0/1 13/15	0/9 **76/76**	2/1 14/15	0/3 15/15
Tree Sparrow	9/0 22/21	3/0 25/26	1/0 10/11	0/8 16/17	0/9 23/23	0/1 30/33	0/7 28/29	0/6 33/33	1/1 18/18	0/5 19/19
Chaffinch	2/0 35/36	1/2 34/34	0/0 22/28	0/5 23/33	0/1 31/37	0/0 35/**41**	0/1 36/**44**	0/0 **51/50**	1/0 25/32	0/1 34/35
Brambling	4/2 27/27	1/0 16/16	0/0 17/17	0/8 15/15	0/3 37/35	4/0 24/24	0/2 39/39	1/0 18/17	1/4 20/20	0/5 25/25
Greenfinch	3/0 36/36	7/0 37/37	0/1 18/18	0/7 22/26	0/4 24/26	0/4 27/29	0/5 24/26	0/2 23/24	0/2 14/15	0/4 22/23
Goldfinch	2/0 32/31	7/0 32/31	0/0 17/17	0/7 19/22	0/6 26/27	0/2 24/27	0/8 28/30	1/1 18/17	0/1 17/18	0/4 26/25
Linnet	7/0 17/17	8/0 18/19	1/0 12/14	0/8 16/19	0/6 33/33	0/5 **44/45**	0/9 35/36	1/0 5/5	0/6 17/19	0/4 20/20
Bullfinch	3/1 37/36	0/4 **40**/39	1/1 14/14	0/4 26/29	1/3 21/22	9/0 22/23	1/6 15/16	3/0 6/7	7/0 17/18	0/5 20/21
Yellowhammer	9/0 27/26	9/0 27/26	3/0 16/17	0/9 22/29	0/9 23/25	0/9 **51/54**	0/3 22/26	2/3 13/13	0/8 20/25	0/2 21/23
Reed Bunting	5/0 28/29	6/0 20/20	3/0 11/11	1/6 16/18	0/5 35/37	0/1 **49/51**	0/8 22/24	1/1 4/4	1/2 14/15	0/5 23/25
Corn Bunting	4/0 15/16	8/0 21/20	0/0 10/10	0/9 28/32	0/9 23/26	1/0 **42/45**	1/2 30/28	3/0 8/8	0/2 20/17	0/3 25/27

Figure 2.1 Map showing the WFBS regions used for stratification and the distribution of 10-km squares containing surveyed 1-km sample squares. Upland areas that were excluded from coverage (see Methods) are highlighted in grey. Regions are named, along with their constituent English Government Office Regions (GOR) where relevant.

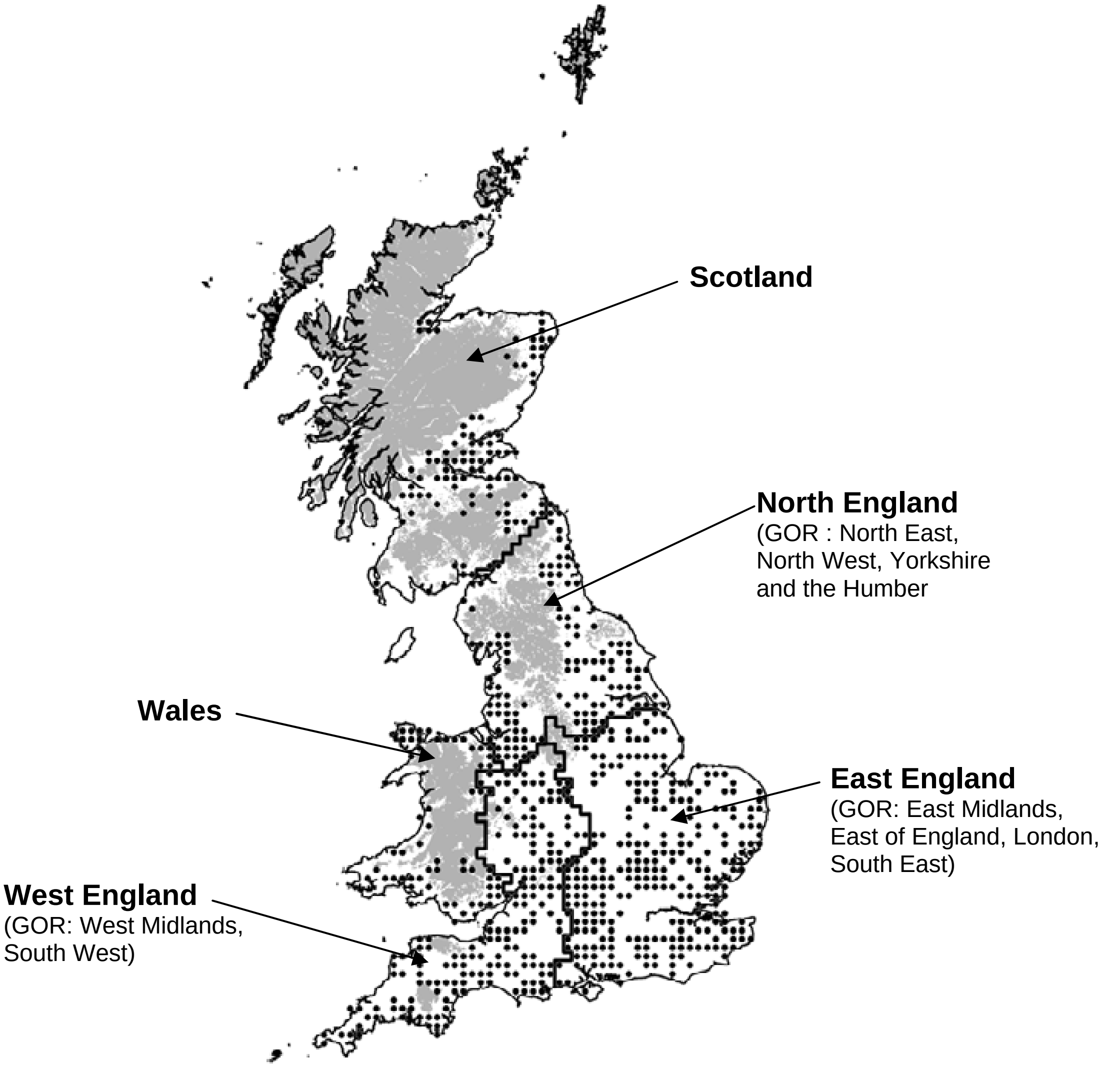
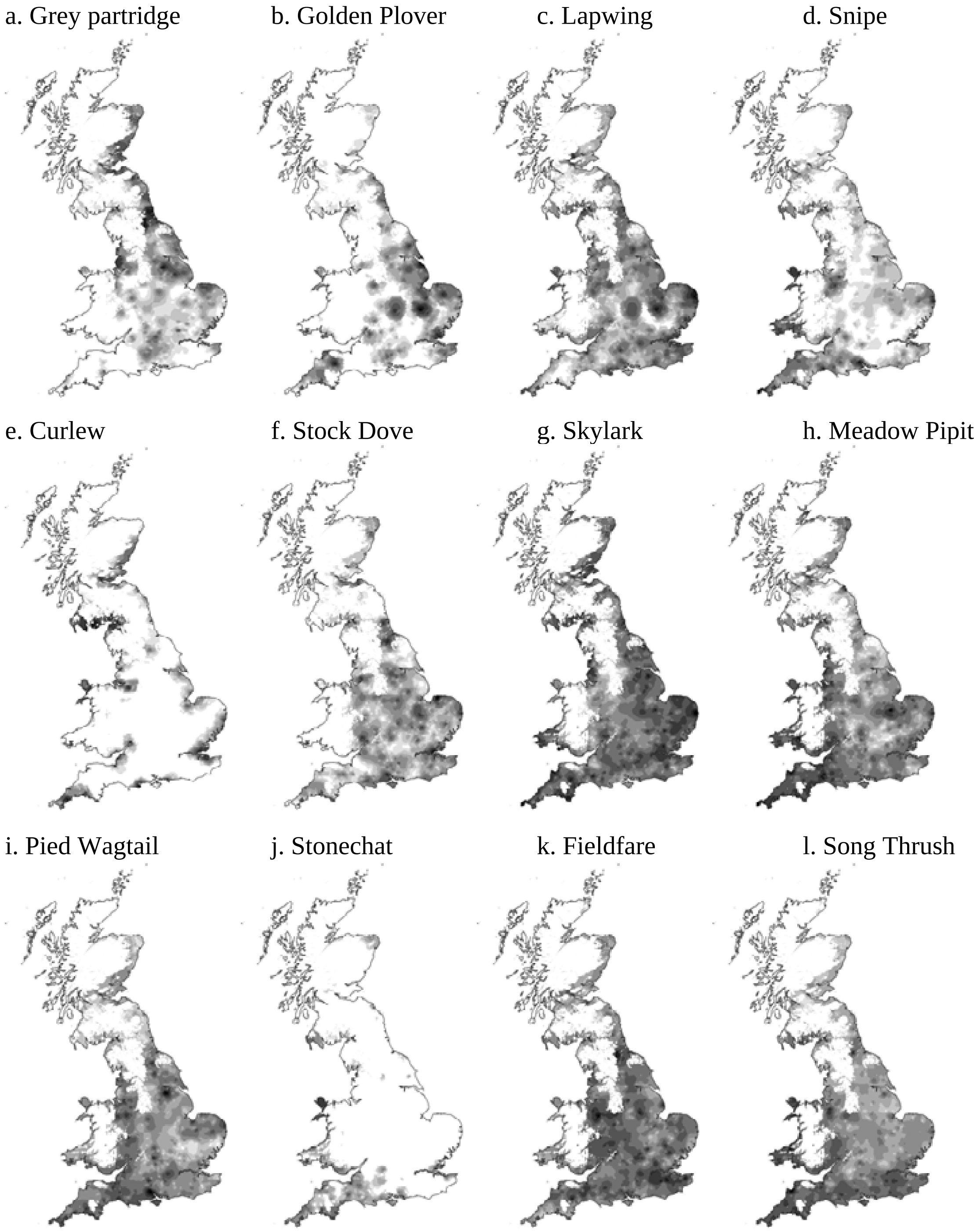


Figure 2.2 Bird species relative abundance maps based on inverse-distance weighting of mean counts across all visits to each square. Upland areas that were not included in the survey are blanked out in white (and see Fig. 2.1). Shading relates to contours based on ten quantiles to indicate relative abundance.



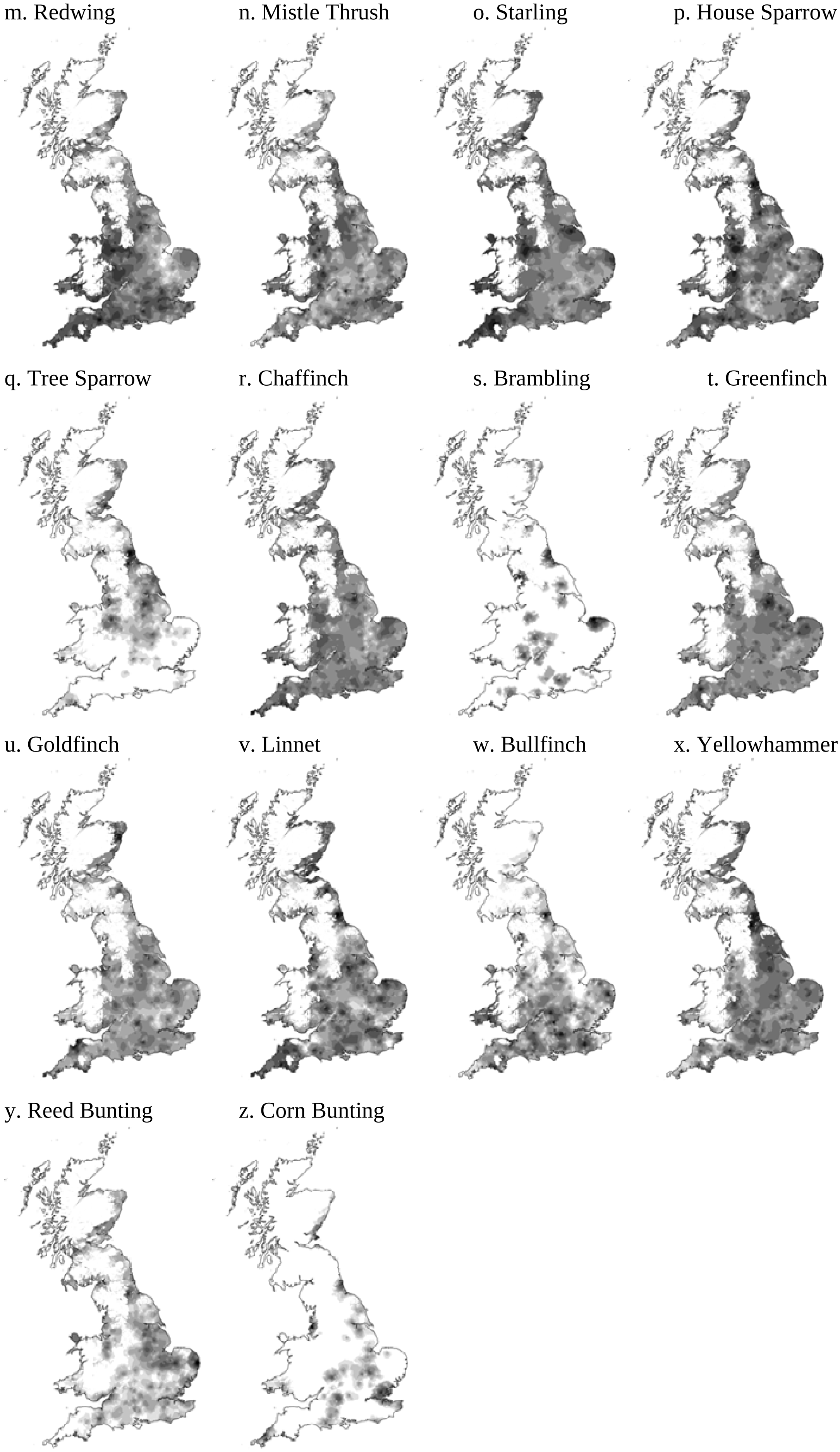

m. Redwing
n. Mistle Thrush
o. Starling
p. House Sparrow
q. Tree Sparrow
r. Chaffinch
s. Brambling
t. Greenfinch
u. Goldfinch
v. Linnet
w. Bullfinch
x. Yellowhammer
y. Reed Bunting
z. Corn Bunting

Figure 2.3 Maps showing the percentage of farmed land under each of four agricultural habitat types in early, mid and late winter. Upland areas that were not included in the survey are blanked out in white (and see Fig. 2.1). All maps have the same intervals of 0%, <2%, 2-5%, 5-10%, 10-25%, 25-50% >50%.

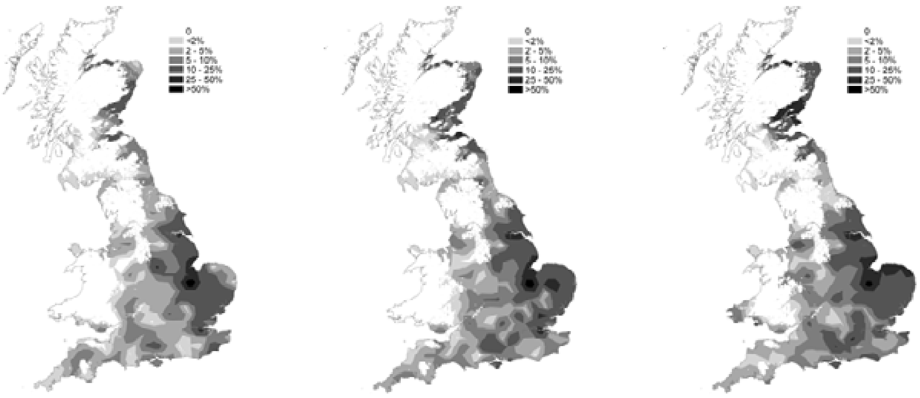
Early winter | Mid winter | Late winter

a. Grass

b. Cereal crop

c. Cereal Stubble

d. Bare Soil



3. WINTERING FARMLAND BIRDS FROM OUR HIGHWAYS AND BYWAYS

Published as: Gillings, S. & Beaven, P. (2004). Wintering farmland birds - results from mass-participation surveys. *Brit. Birds* **97**: 118-129

3.1 Summary

Farmland in winter is an important habitat for a wide suite of resident and migratory species. Many farmland species have declined and knowing their winter ecology and distribution are important precursors to providing recommendations for management practices that may help reverse these declines. Two surveys by the British Trust for Ornithology and *British Birds* - *Casual Records* and *Winter Walks* - aimed to draw on the local knowledge and enthusiasm of birdwatchers to assess the abundance, distribution and habitat use of farmland birds in winter. This paper reports some of the early findings from these surveys.

3.2 Introduction

Farmland birds have been headline news in popular and scientific press as a result of marked population declines especially since the mid-1970s. Concerted scientific work and lobbying have resulted in several species being designated 'Species of Conservation Concern (Gregory *et al.* 2002) and the inclusion of wild bird population trends as one of the 15 headline indicators in the governments 'Indicators of Sustainable Development' (DETR 1998). In order for the government to achieve their pledge of reversing farmland bird declines by 2020, we require continually updated knowledge of the status and ecology of farmland birds and monitoring of management schemes (Chamberlain & Vickery 2002). This is particularly true in winter since poor winter survival may be implicated in the declines of many species (Siriwardena *et al*. 2000). Furthermore, wintering in poor quality habitat may affect subsequent breeding success (e.g. Marra *et al*. 1998).

The last time wintering birds were surveyed across a wide geographic area was for the British Trust for Ornithology/Irish Wildbird Conservancy *Winter Atlas* in the early 1980s (Lack 1986). Since then, changes in farming (Chamberlain *et al*. 2000, Vickery *et al*. 2001; Robinson & Sutherland 2002), continuing population declines (Fuller 2000) and changing winter weather (Hulme 1999) may have changed the geographic range and abundance of farmland birds, whilst altering patterns of habitat use. Against this background, the BTO, in partnership with the Joint Nature Conservation Committee, began the *Winter Farmland Bird Survey* (WFBS), a three-year (1999/00 – 2001/02) volunteer survey of a suite of common, declining or scarce farmland bird species. The aims of WFBS were to assess national, regional and seasonal patterns of distribution, abundance and habitat selection, across a large geographic area and a number of consecutive winters.

The core of WFBS was a detailed survey of 1-km squares randomly located throughout lowland agricultural areas of Britain. However, some species are likely to be so scarce that random squares will provide few records. For example, Eurasian Tree Sparrow (see Table 3.2 for scientific names) and Corn Bunting are now so scarce that they regularly feature on local birdlines. Yet this also implies that birdwatchers know where these species still persist. The random square survey was supplemented by two mass participation volunteer surveys aiming at taping the enthusiasm and knowledge of amateur birdwatchers: *Casual Records* aimed to amass a large quantity of information on the numbers and distribution of 'significant' flocks of farmland birds and *Winter Walks* involved visiting a standard area regularly and recording the presence and absence of species. This paper reports results of the *Casual Records* and *Winter Walks* surveys, concentrating on five of the 30 target species. These included a game bird (Grey Partridge), a wader (Northern Lapwing), a migratory thrush (Fieldfare) and two granivorous passerines, one still relatively widespread (Sky Lark) and the other scarce (Eurasian Tree Sparrow). Full results for all 30 species can be found online via www.bto.org/surveys/special/wfbs/introduction.htm

3.3 Methods

Forms for *Winter Walks* and *Casual Record* were circulated to BTO members and *British Birds* subscribers in the autumns of 1999, 2000 and 2001. The field methods were simple. For *Winter Walks* observers chose a route at least 1 km length through farmland and visited it regularly between November and February. On each visit they noted the date and the number, activity and habitats used by 30 target species (Table 3.1). *Casual Record* forms were used to record 'significant flocks' of the target species from anywhere in the country, with guidance as to what constituted a significant flock – e.g. 100 or more thrushes etc.

Data from the two surveys were used to derive distribution maps, flock sizes, reporting rates and measures of habitat use. Reporting rates were simply the percentage of *Winter Walks* routes on which a species was reported in each week. These were produced to determine seasonal patterns of occurrence on farmland. These could then be related to the occurrence of farmland species in gardens (see below). Habitat descriptions provided by observers were used to classify every flock into different categories such as crop types, stubbles, hedgerow, farmyards etc. Note that since no measures of habitat availability were taken, we cannot consider *habitat preference*, only *habitat use*. For some analyses data were amalgamated into regions (see Fig. 3.1). These were Wales and Scotland plus three English regions based on those used by the Department for Environment, Food and Rural Affairs (DEFRA).

Throughout this article, reference is made to the BTO/CJ *Garden BirdWatch.* This survey provides the only other means of assessing seasonal occurrence of birds in winter. It involves weekly records of bird species occurrences in approximately 15,000 gardens nationwide. For more information visit www.bto.org/gbw/index.htm

3.4 Results

3.4.1 Coverage

Table 3.1 summarises the staggering number of forms received, routes visited, flocks recorded and birds counted in each of the three winters of the survey. In total, *Casual Records* and *Winter Walks* supplied 69,000 records of 4.3 million birds. Across the three winters, a total of 651 *Winter Walks* routes were visited, which involved volunteers walking in excess of 22,000km - that's equivalent to walking from Land's End to John O'Groats and back more than seven times!

The distribution of *Winter Walks* routes and *Casual Records* (Figures 1B and 1C) approximately matched that of the BTO membership (Fig. 3.1A) except that the areas of highest membership density (large urbanised areas) had few routes, presumably due to lack of nearby farmland. Coverage also included most of the geographic range of farmland (Fig. 3.1D), although there were striking gaps in *Winter Walks* coverage in fenland and the West Midlands and the density of routes was poor in Scotland.

Observer effort in the *Winter Walks* could vary in two ways - first by the length of the route and secondly by the number of visits made per winter. Mean route length was 3.7 km. Most routes (60%) were 1-3 km in length and only 15% exceeded 5 km in length. In all three winters 75-77% of routes were visited up to 10 times between November and February and 6-7% of routes were visited more than 20 times. There was no significant difference in the number of visits between winters (square root transformed counts, ANOVA, $F_{2,1019} = -0.55$, $P = 0.58$) and data were combined across winters.

3.4.2 Species prevalence and abundance

The most widespread species on farmland were Chaffinch, Fieldfare and Common Starling, all reported from over 75% of *Winter Walks* routes (Table 3.2). Of the declining farmland bird species, Sky Lark, Song Thrush and Yellowhammer were reported from over 50% of sites but Eurasian Tree

Sparrow and Corn Bunting were only reported from 14% and 7% of routes respectively (Table 3.2). By dividing all visits into weeks from 1 November to 28/29 February, it was possible to derive weekly reporting rates - the weekly percentage of *Winter Walks* routes on which a species was seen. The majority of species showed no clear trends in reporting through the winter. Some however showed consistent trends across the three winters and Fig. 3.2 shows examples for three common small passerines of farmland. The Sky Lark reporting rate decreased through November and December but then in the New Year began to increase, probably because mild weather in late winter may have enticed some birds to begin taking up territories, making them more apparent to the casual observer. In marked contrast, both Meadow Pipits and Pied Wagtails showed consistent declines in reporting rate from November to February (Fig. 3.2). Why this should be is not entirely clear. Perhaps flocks are easy to find in early winter when they feed on recently tilled fields but become progressively harder to see, as crops grow taller. In other species the trends indicated differing abundance from one year to the next. In two winters, Bramblings were present on approximately 5% of routes every week, but in winter 2000/01 they were virtually absent - a pattern mirrored in gardens (BTO/CJ Garden BirdWatch). This was probably because autumn 2000 had one of the best beech mast crops for decades meaning that these attractive finches remained in woodlands and did not need to foray into gardens and farmland.

The total number of each species reported is also given in Table 3.2. Whilst there is undoubtedly some duplication, it shows some interesting patterns. Common Starling, Northern Lapwing, Eurasian Golden Plover and Fieldfare were amongst the most reported and most abundant species. Far fewer Eurasian Tree Sparrows and Corn Buntings were reported than their relatives. Note striking differences in the reporting of some species between the two surveys. Bullfinches for instance were abundant on *Winter Walks* but scarce on *Casual Records* forms, probably because they rarely formed large flocks or joined other species and hence failed to exceed the 20 individual threshold required to be reported via *Casual Records*.

3.4.3 Selected species accounts

For each of the five species we provide a map showing all records from the two surveys. For each in turn we then consider abundance, seasonal trends in reporting and measures of habitat association. It should be reiterated that these habitat associations indicate only which habitats were *used* not which were *preferred* since surveys did not measures habitat availability. For instance, regional differences in habitat use may merely reflect regional differences in which habitats are available.

3.4.3.1 Grey Partridge

Grey Partridges were reported from scattered localities throughout central and eastern England with very few in Wales and Scotland (Fig. 3.3). Over 600 coveys were reported via *Winter Walks* compared to only 86 from *Casual Records*. *Winter Walks* coveys ranged in size from 1 to 57 individuals with 75% numbering 10 or fewer individuals and only 6% numbered 20 or more. Twenty was the threshold for reporting coveys to *Casual Records* and this explains why so few were reported via that survey.

There was no seasonal trend in the percentage of *Winter Walks* routes that reported Grey Partridges through the winter but there was a shallow decline in the average number from November to February. This was mirrored in *Casual Records* with around 30-35% of all birds being reported in November dropping to only 15% in February - perhaps birds were increasingly missed as crops grew taller or they become harder to see when supplementary feeding is withdrawn at the end of the shooting season.

On *Winter Walks*, 14% of birds were associated with pastures and a further 25% with crops (of which 84% cereal, 7% oilseed rape), 23% with stubbles (83% cereal) and 11% with bare till. Eight percent were associated with boundary habitats such as the hedge bases and rough vegetation around the edges of fields.

3.4.3.2 Northern Lapwing

This species was reported from all areas, although in Wales only small numbers were located in coastal districts and in Scotland, most birds were in the southern lowlands (Fig. 3.3). Eastern England was particularly densely inhabited whereas central and western areas had more patchy occupancy. Some regional bias is expected since most records were likely to have come from areas with most people (Fig. 3.2) - i.e. the south and east. However, many *Winter Walks* routes in the west were visited without plovers being found, suggesting that there really is an easterly biased distribution. There was little evidence of seasonal shifts in distribution nor seasonal trends in reporting rate and abundance between November and February.

Maximum flock sizes were 7000 from *Casual Records* and 5650 from *Winter Walks*. Large flocks were not the norm, and only 25% of flocks exceeded 120 birds. Nationally, approximately 25% of Northern Lapwings were reported from cereal crops, 25% from grass, and 15% from plough and harrow. Less than 10% of birds were associated with stubbles, mostly on cereal (56-80%), maize (0-27%) and sugar beet stubbles (7-8%). There were marked regional differences in habitat use, with more use of crops and bare till in east and west England, and greater use of pasture elsewhere. In Wales, 25% were on bare till. Use of stubbles was rare except in east England.

3.4.3.3 Sky Lark

Sky Larks were distributed similarly to Northern Lapwings, with birds being widespread in England and only present in Wales and the south-west near the coast. Flocks peaked at 500-700 birds but at least half of the reported *Winter Walks* flocks numbered 4 or fewer birds. Larger flocks were reported from *Casual Records,* partly due to the cut-off at 20 individuals, but probably also due to the difficulty of recording this skulking species when just out for a walk. Reporting rates increased in late winter as shown earlier (Fig. 3.2). Approximately half of all Sky Larks were associated with stubble fields. Seventy-eighty percent of these were on cereal stubbles (the commonest stubble type) with fewer on stubbles of bean, linseed, oilseed rape, maize, sugar beet or turnips. Crops accounted for up to 18%, of which three-quarters were on cereal crops and 10-15% on oilseed rape crops. Only about 10% of birds were on grass fields. Minor regional differences were evident: the percentage of birds in stubbles varied from 32% in East England to 73% in Scotland, use of grass peaked in Scotland and use of bare till peaked in Wales.

3.4.3.4 Fieldfare

Fieldfares were widespread, with perhaps more records in central and western England than in the east (Fig. 3). Some very large flocks of Fieldfares were reported, with maxima being 1950 from *Casual Records* and 5000 from *Winter Walks* but 50% of flocks numbered less than 15 birds. Reporting Rates indicated a decline in reporting through the winter. If birds were moving out of farmland, one place they could have gone was gardens. However, trends in gardens matched those on farmland, even across winters: in 2000/2001 Fieldfares were scarce in both *Winter Walks* routes and gardens up until mid winter before they increased.

Nationally, boundary habitats, mostly hedges and trees, were most important, accounting for 34% of birds. Grass accounted for 13-26% of birds, crops 15-25% and stubbles 7%. Of those on crops, 80-96% were on cereals (remainder being oilseed rape and bean crops). Cereals, maize and sugar beet were the most frequently used stubbles. Interestingly, the percentage of Fieldfares on boundary habitats during *Winter Walks* declined from 37% in November, 27% in December to 16% in January before increasing slightly to 21% in February. Was this indicative of birds depleting the hedgerows of berries, or a more profitable habitat becoming available elsewhere?

3.4.3.5 Eurasian Tree Sparrow

Eurasian Tree Sparrows had a very patchy distribution which extended from Scotland south to the Thames-Severn and largely excluding Wales, the south-west, south-coast and much of East Anglia (Fig. 3.3). Flocks numbered up to 100-200 birds but 75% of flocks numbered 10 or fewer individuals and there were no significant seasonal trends in either reporting rate or abundance. True to their name, 25-50% of Tree Sparrows were associated with hedges and trees. Only 4-7% were associated with crops. The type of crop differed between the two surveys. *Casual Records* found 43% associated with linseed crops and 22% with cereals, whilst *Winter Walks* found 58% associated with cereals and 24% with maize. Seventeen percent of Tree Sparrows were associated with stubbles, mostly cereals (86% from *Casual Records*) and sugar beet stubbles (54% from *Winter Walks*). Compared to House Sparrows, far fewer were associated with farm yards (3-5%, compared to 25% for House Sparrow).

3.5 Discussion

During the three winters of 1999/2000 to 2001/2002 hundreds of *British Birds* subscribers and BTO members spent a huge amount of time collating valuable sightings of farmland birds throughout virtually the whole range of Britain's lowland farmland. Collectively they walked huge distances and counted several million birds to provide a wealth of distribution, abundance and habitat use data. In combination with the more structured counts and habitat availability measures taken as part of the random square component of the survey, these three surveys provide a great deal of invaluable information.

In their own right, *Winter Walks* and *Casual Records* have given interesting insights into the ecology of farmland birds in winter. They show that despite agricultural changes, Britain's farmland is still used by significant numbers of birds in winter, but that there are causes for concern. Some of our granivorous species are becoming very scarce in winter and mirroring the trends seen in the breeding season. Species such as Eurasian Tree Sparrow, Corn Bunting, even House Sparrow, were reported from far fewer *Winter Walks* routes than one might have expected two decades earlier. Some species are becoming so scarce that gaining insights into their ecology from rigorously controlled surveys is difficult because so few are likely to be found in randomised squares. For such species, broad participation surveys such as *Casual Records* and *Winter Walks*, may be the only way of amassing information at a large scale.

Within the limitations of coverage achieved by *Winter Walks* it is possible to compare the distribution maps presented here with those from the *Winter Atlas* (Lack 1986). For Grey Partridge, Sky Lark, Fieldfare and Eurasian Tree Sparrow the extent of the distributions derived from *Winter Walks* and *Casual Records* were broadly similar to those in the Winter Atlas. Yet there were perhaps more gaps in the Grey Partridge and Tree Sparrow distributions. These ‘gaps’ in range could be due to incomplete coverage of these areas compared to the more thorough fieldwork of the *Winter Atlas*. However, such losses are reported by country bird reports and also match well-documented losses in the breeding season (Gibbons *et al*. 1993). There were also suggestions of more Northern Lapwings and Fieldfares wintering in the east. This is perhaps because recent winters have tended to be mild and lacking prolonged periods with frozen ground that might normally force these species to seek refuge and milder conditions further south and west.

One drawback of simply surveys such as *Winter Walks* and *Casual Records* is that it is difficult to collect detailed information about the habitats used in relation to their availability. Also, differences in the detectability, both between species and between habitats, confuse apparent patterns of habitat use. However some comparisons can be made. For instance, though 14% of Sky Larks were associated with cereal crops, cereal crops account for 24% of farmland in winter (Gillings & Fuller 2001). Moreover, over 50% of Sky Larks were associated with stubbles, despite accounting for less than 6% of farmland (Gillings & Fuller 2001). These patterns are in agreement with other extensive (Gillings

& Fuller 2001) and intensive studies (Wilson *et al*. 1996; Buckingham *et al*. 1999; Donald & Vickery 2001).

Here Grey Partridges made wide use of crops, stubbles and grass though Wilson *et al*. (1996) and Buckingham *et al*. (1999) both demonstrated preference for stubbles and set-aside over pasture and avoidance of arable crops and bare tillage. Potts (1986) described their diet in winter as consisting of weed seeds and spilt grain but that they would switch to grazing pasture vegetation if seeds were lacking which explains their catholic choices.

Northern Lapwings showed equal use of crops and grass rather than being concentrated in grass as might be expected (Lister 1964). This is perhaps an indirect consequence of their easterly distribution. Regional specialisation of agriculture has meant that less pasture exists in eastern Britain and then usually as short-rotation improved grass which has low earthworm abundance (Edwards & Bohlen 1996; Vickery *et al.* 2001) and probably presents poor feeding opportunities. Many birds were associated with lying water on agricultural fields and this is probably because field flooding can produce a temporary resource of drowned earthworms.

Not surprisingly, most Fieldfares were associated with hedges. Within fields, more were associated with grass than with crops reflecting the species' distribution bias towards pastoral and mixed farming landscapes (Fig. 3.3). Wilson *et al*. (1996) and Perkins *et al.* (2000) showed that Fieldfares were more likely to occur on grazed than ungrazed pastures. This might be because sheep produce a tightly cropped sward which may facilitate detection of earthworm and tipulid prey. Detailed questions such as these relating use and availability of habitats and their management will be addressed by the random square survey and other BTO studies.

For some species (e.g. Sky Lark), the results of *Casual Records* and *Winter Walks* supported results from local and intensive studies of abundance and habitat use, suggesting they may reflect more general patterns. For some species regional results differed from previous studies (e.g. Northern Lapwing). These surveys have also provided new information on distribution and abundance which, alongside the random square survey, should enable us to consider shifts in range and local losses of farmland bird populations in relation to agricultural land management. *British Birds* subscribers and BTO members have shown how amateur birdwatchers can provide an invaluable resource with which we can investigate the ecology of farmland birds and use the results to inform conservationists and decision makers.

3.6 References

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Table 3.1 Summary of uptake and reporting of farmland birds from i) *Casual Records* and ii) *Winter Walks* in the three winters of coverage.

i) *Casual Record*

	1999/2000	**2000/2001**	**2001/2002**
Forms received	440	302	280
Flocks recorded	7301	4860	5353
Total birds counted	1,238,477	852,530	893,045

ii) *Winter Walks*

	1999/2000	**2000/2001**	**2001/2002**
Routes visited	447	275	303
Flocks recorded	21,810	13,688	15,990
Total birds counted	554,861	351,240	395,686

Table 3.2 List of the 30 target species of the *Winter Walks* and *Casual Records* components of the Winter Farmland Bird Survey. %R is the percentage of *Winter Walks* routes (n = 651 totalled across three winters) that reported each species. WW and CR are the total number of individuals of each species reported by the two surveys.

Scientific Name	**English Name**	**%R**	**WW**	**CR**
Grey Partridge	*Perdix perdix*	23%	4606	1856
European Golden Plover	*Pluvialis apricaria*	19%	164,772	671,573
Northern Lapwing	*Vanellus vanellus*	57%	233,118	864,648
Common Snipe	*Gallinago gallinago*	20%	1905	45,524
Eurasian Curlew	*Numenius arquata*	12%	14,593	2594
Stock Pigeon	*Columba oenas*	33%	12,596	9669
Wood Lark	*Lullula arborea*	1%	51	138
Sky Lark	*Alauda arvensis*	60%	38,308	39,055
Meadow Pipit	*Anthus pratensis*	53%	18,171	12,534
Pied Wagtail	*Motacilla alba*	63%	11,793	8460
Stonechat	*Saxicola torquata*	16%	844	1161
Fieldfare	*Turdus pilaris*	79%	169,035	248,572
Song Thrush	*Turdus philomelos*	67%	5432	2057
Redwing	*Turdus iliacus*	71%	68,723	57,162
Mistle Thrush	*Turdus viscivorus*	64%	5936	269
Common Starling	*Sturnus vulgaris*	78%	308,018	744,120
House Sparrow	*Passer domesticus*	54%	19,419	4615
Eurasian Tree Sparrow	*Passer montanus*	14%	3431	5377
Chaffinch	*Fringilla coelebs*	84%	86,818	71,106
Brambling	*Fringilla montifringilla*	8%	1007	9553
European Greenfinch	*Carduelis chloris*	67%	18,526	21,988
European Goldfinch	*Carduelis carduelis*	59%	15,365	22,886
Common Linnet	*Carduelis cannabina*	35%	29,704	50,341
Twite	*Carduelis flavirostris*	3%	909	12,648
Common Redpoll	*Carduelis flammea*	9%	941	1341
Common Bullfinch	*Pyrrhula pyrrhula*	40%	2354	122
Snow Bunting	*Plectrophenax nivalis*	1%	542	4667
Yellowhammer	*Emberiza citrinella*	58%	27,229	19,775
Reed Bunting	*Emberiza schoeniclus*	29%	5091	4538
Corn Bunting	*Miliaria calandra*	8%	3186	7415

Figure 3.1 Maps showing the distribution of (A) relative density of BTO members, (B) 10-km squares containing *Winter Walks* routes visited in at least one of the three winters; (C) 10-km squares from which *Casual Records* were received from at least one of the three winters; (D) the distribution of arable and grass from MAFF June agricultural census returns. On (B) and (D), increasing dot size indicates greater BTO member density or farmland area respectively.

A

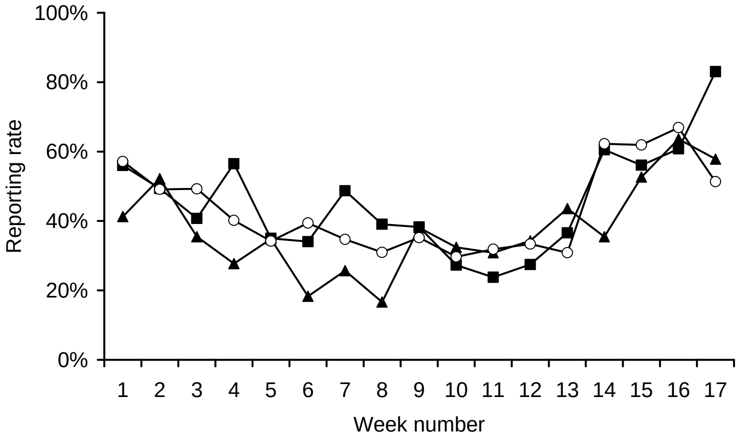
B

C

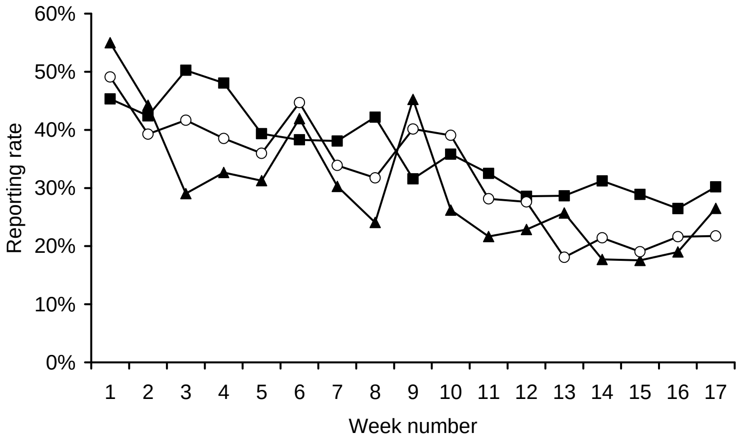
D

Figure 3.2 Weekly reporting rates of (A) Sky Lark, (B) Meadow Pipit and (C) Pied Wagtail on *Winter Walks* routes. Different symbols indicate different winters: squares = 1999/00, triangles = 2000/01 and circles = 2001/02. Week 1 = 1st – 7th November.

A Sky Lark



B Meadow Pipit



C Pied Wagtail

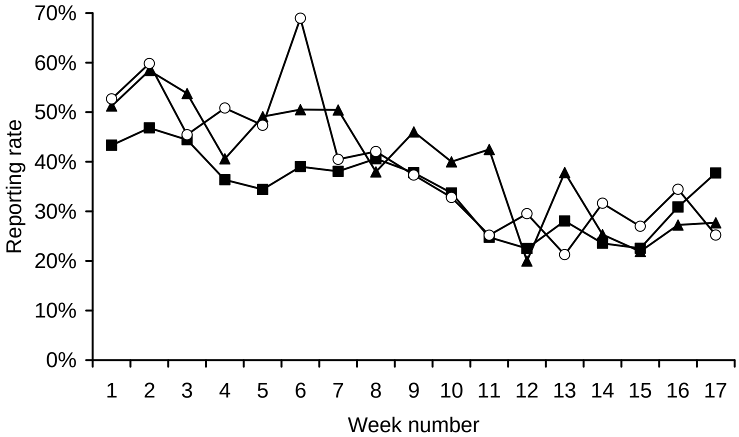
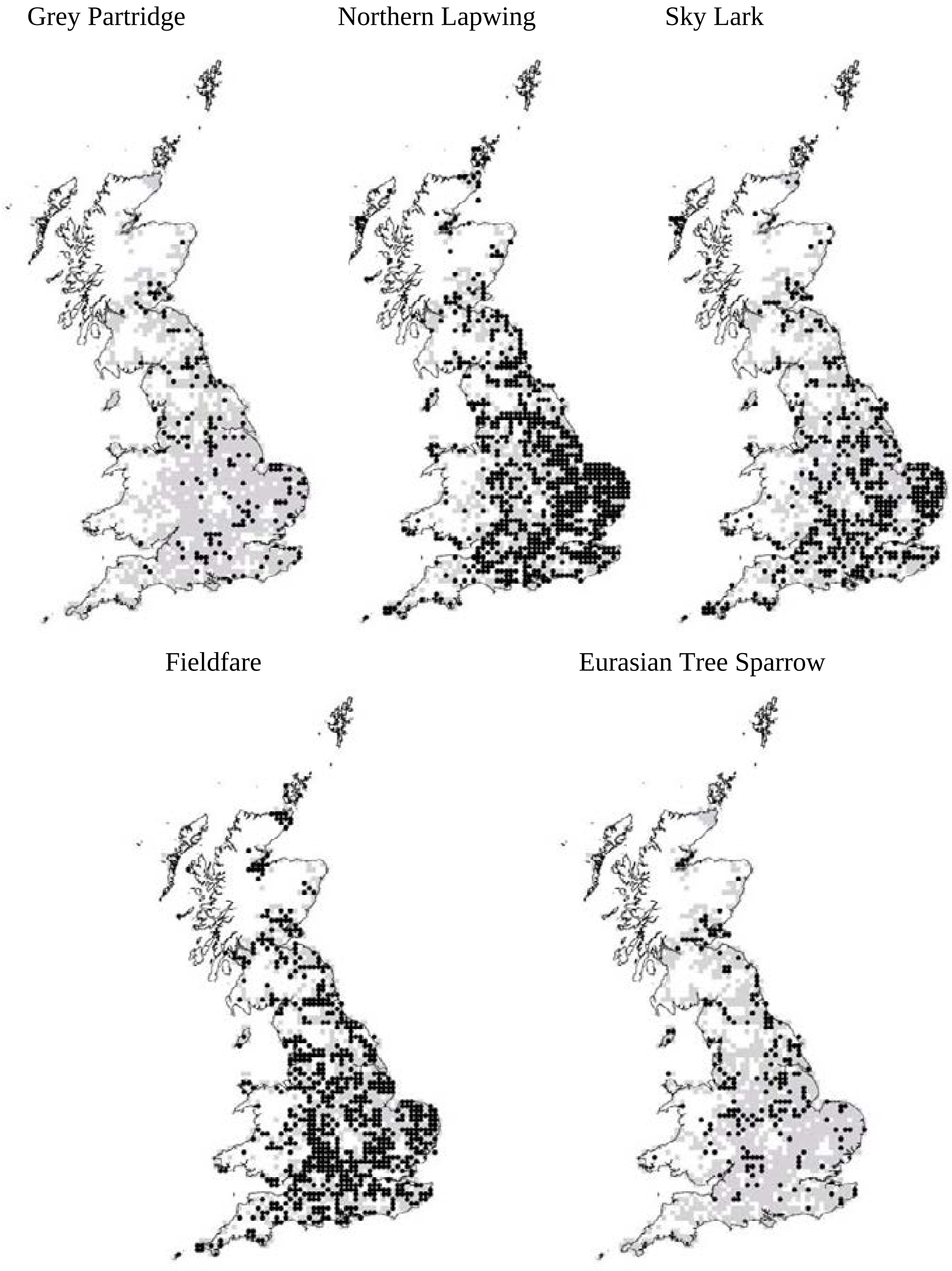


Figure 3.3 Maps showing the distribution within Britain of five farmland bird species, based on records from both *Casual Records* and *Winter Walks*. 10-km squares receiving at least some coverage from one or other survey are shown in grey.



4. THE IMPORTANCE OF STUBBLE FOR FARMLAND BIRDS

In preparation for publication in response to reduction of set aside.

4.1 Analyses

4.1.1 Habitat area estimates

I determined what proportion of the surveyed land in each 1-km square was of a given habitat type (e.g. cereal stubble). Since surveyors were limited to four hours in the square they were unable to survey the whole 100ha of the square. From the Centre for Ecology and Hydrology's Land Cover Map 2000 I derived the area of farmland as the sum of the following subclasses: improved grassland (subclass 14), neutral grassland (15), set-aside grass (16), calcareous grass (18), acid grass (19), arable cereals (21), arable horticulture (22) and arable non-rotational (23). The total area of habitat in a 1-km square was estimated by the product of the proportion of the surveyed area and the area of farmland in the square. For each stratum (region and landscape type) I estimated the area of habitat by multiplying the mean estimated area of habitat in squares from a stratum by the number of squares present nationally in that stratum. Ninety-five percent confidence limits were determined for each stratum by drawing, with replacement, a square at random from those in a stratum until the same number of resampled estimates were present as there were squares. As before, a mean was taken across these estimates and multiplied by the number of squares in the stratum. This procedure was repeated 1000 times to yield 1000 independent estimates of the area of habitat in the stratum. The 25th and 975th ranked values were taken as the lower and upper confidence limits respectively.

4.1.2 Bird densities

For the analysis some species were combined into functional groups: 1) Skylark, 2) Fieldfare, Song Thrush, Redwing, Mistle Thrush & Starling, 3) House Sparrow, Tree Sparrow, Chaffinch, Brambling, Greenfinch, Goldfinch, Linnet, Twite, Redpoll & Bullfinch, and 4) Yellowhammer, Reed Bunting & Corn Bunting. Within each field the total number of each functional group was determined and densities were calculated. This was performed for each visit separately then habitat specific means were calculated across all density estimates from the three visits in each year. Densities were calculated for the number of birds seen in the field interior, and for the total number of birds in the field including those in the boundary habitat (e.g. hedgerows). Note that all densities are based on counts made from the edge of the field so for skulking species such as Skylark these densities will be underestimates and may be biased by detectability differences.

At the field scale, differences in bird density between stubble types were tested using a repeated measures generalised linear model (GLM). Counts on the same field in a winter were treated as repeated measures, but counts across winters were treated as independent. Individual birds within flocks cannot be considered as fully independent but we adopt the pragmatic approach of using a GLM with a log link function and Poisson errors, with the square root of the deviance divided by degrees of freedom used as a correction for over-dispersion. The log of the field area was entered as an offset, allowing comparison of bird densities. Likelihood ratios (tested against the chi-square distribution) were used to test for differences in bird density between stubble types.

4.2 Results

4.2.1 Coverage of Winter Farmland Bird Survey squares

Across the first two winters of the survey 1017 1-km squares were surveyed, 871 in winter 1 and 779 in winter 2; 633 were surveyed in both winters (Figure 4.1).

The number of squares surveyed in each WFBS region in each winter is shown in Table 4.1 along with the number initially selected. There was no significant difference in the regional spread of surveyed squares between winters 1 and 2 (χ^2_4 = 4.1, P > 0.3), nor between the initial stratification and those actually surveyed (winter 1 χ^2_4 = 8.6, P > 0.05; winter 2 χ^2_4 = 4.3, P > 0.3). However, when landscape strata were considered (Table 4.2) there was a significant deviation from expected coverage in both winters (winter 1 χ^2_4 = 14.5, P < 0.01; winter 2 χ^2_4 = 10.3, P < 0.05). The weightings given in Table 4.2 correct for bias in coverage and the built-in bias in the stratification and are needed for some analyses where regional information was combined at larger scales.

Coverage on all three visits was attained on 85% of squares in winter 1 but only 65% of squares in winter 2, probably largely as a result of access restrictions imposed in early 2001 due to the Foot and Mouth disease outbreak. As a result, the number receiving two visits increased from 12% to 31%. Less than 5% of squares received only one visit in each winter.

4.2.2 Habitat area estimates

Figures 4.2-4.8 present estimates of the area of cereal crop and five stubble types present on lowland farmland. Following the survey design, areas are summarised for three geographic regions and two ITE landscape types. Note that for some stubbles their incidence on WFBS squares was so rare that estimates are highly variable. In some such cases error bars could not be computed due to frequent zero estimates.

Many figures show a marked change in habitat area estimates between the two winters. There are two likely causes of this. First, autumn and early winter 2000/2001 were particularly wet and this precluded the ploughing of many stubbles and the sowing of cereal crops. DEFRA highlight this in the December Census results stating “for 2000, areas sown by 1 December were affected by poor drilling conditions caused by wet weather”. The total area (in thousand hectares) of wheat, barley and oats sown by 1 December in 1999, 2000 and 2001 were 2788, 1893 and 2651. The change from 1999 to 2000 represents a drop of 32%. By 2001 plantings were back up to 95% of 1999 levels. By pairing visits across years (i.e. early 1999 with early 2000) and calculating the percentage change yields a drop in cereal planting from 1999/2000 to 2000/2001 of 34%, 34% and 31% for early, middle and late visits, exactly in line with expectation from the DEFRA December survey.

Second, some biases may have arisen whereby volunteers only resurveyed habitats that yielded birds in the first winter. As such the area of bird rich habitats may be inflated and the area of bird poor habitats underestimated. Further, if this occurred within a winter, depletion of stubbles may be underestimated. Further analysis and a third winter of data will help to confirm the scale of this potential bias, however, the close matching in the drop in cereal planting is encouraging.

The area of farmland estimated in this way was consistent between visits and years (Figure 4.2) which is reassuring.

4.2.3 Densities of birds on stubble types

The granivorous species; skylark, sparrows, finches and buntings occurred in higher densities on almost all stubble types than cereal or grass crops or bare tilled fields. In contrast, insectivorous thrushes and starlings were most abundant on grass fields (Fig. 4.9-4.12). All species/functional groups showed significant differences in density between stubble types: skylark χ^2_9=189.5, P < 0.0001; thrushes χ^2_9=51.6, P < 0.0001; finches χ^2_9=171.3, P < 0.0001, buntings χ^2_9=96.7, P < 0.0001. Sample sizes of number of field visits by stubble type are given in Table 4.3.

No single stubble type consistently supported the highest densities of birds, although small sample sizes for some stubble types make statistical comparisons difficult. Thus, high densities of skylarks and sparrows and finches on linseed stubble (winter one only) and buntings and thrushes and starling on oilseed rape stubble (winter one only) were based on a very small number of fields occupied by very large flocks. In general, consistently highest densities of skylark were found on barley stubble with lower but very similar densities on wheat, rape and sugar beet and lowest densities on maize stubbles (densities on linseed stubble varied between winters).

Among granivores, sparrows and finches occurred in high (but variable) densities on rape, linseed and sugar beet stubbles, lower densities on barley and maize stubbles, and lowest densities on wheat stubble. Buntings occurred in the highest densities on barley stubble, followed by wheat stubble with lowest densities on linseed and maize stubble (densities on sugar beet and oilseed rape stubble varied between winters).

The figures for bird density (granivores only) on different crop types and the extent of these stubble and crop types (Table 4.4) were used to assess the percent of the birds counted supported on these different habitats in winter (Figure 4.13). This suggests over 50% of skylarks, finches, sparrows and buntings are supported on cereal stubbles, 20% on bare till and 20% on cereal crop and the remaining 10% on other crop stubbles.

4.3 Discussion

Some caution is required in interpreting these national results. Relatively few 1-km squares received complete coverage and it is possible that observers preferentially selected stubble fields, resulting in an over-estimate of stubble areas. It is also possible that observers biased field selection towards stubble when revisiting in winter two. However, although there was an increase in stubble area in winter two, with a corresponding decrease in newly sown cereal, this was almost certainly due to very wet conditions in early winter 2000/2001 preventing ploughing (http://www.defra.gov.uk/esg/Work_htm/Notices/dec_uk.pdf). The total area (1000s of ha) of wheat and barley sown by 1 December in 1999 and 2000 were 2788 and 1893 respectively, a difference of 32%, corresponding well with the 34% difference recorded under WFBS and suggesting little bias.

With respect to the importance of stubbles for birds, the pattern of stubble use, at the national and regional scale, showed no single stubble type consistently supported the highest bird densities. At both scales, barley stubble generally supported relatively high densities of most species, high but more variable densities occurred on rape, linseed and sugar beet stubble and generally lower densities on wheat and maize stubble. Within the dominant stubbles of wheat and barley, the latter consistently supported higher densities of the four species/groups of birds, particularly buntings and skylarks, in both winters and at both national and regional scale. This apparent preference for barley over wheat stubble has been recorded elsewhere (e.g. Buckingham *et al.* 1999; Moorcroft *et al.* 2002) and may be related to earlier harvesting date (allowing more time for weeds to germinate), more diverse weed community (Robinson 2002) or less dense stubble (allowing easier access to food; Moorcroft *et al.* 2002).

Table 4.1 The number of 1-km squares surveyed in winter 1 and winter 2 within each WFBS region. Stratification is the number of squares initially selected in each region. Figures in parentheses are the percentage of the row total found in each region.

	E. England	N. England	W. England	Scotland	Wales
Winter 1	329 (38%)	152 (17%)	203 (23%)	104 (12%)	83 (10%)
Winter 2	261 (34%)	151 (19%)	184 (24%)	108 (14%)	75 (10%)
Stratification	1051 (35%)	511 (17%)	694 (23%)	300 (10%)	459 (15%)

Table 4.2 The number and percentage of 1-km squares surveyed in winter 1 and winter 2 within each WFBS region and each landscape stratum. Strat is the number of squares initially selected in each stratum. Weighting is a weight value for each stratum for each year to correct stratum specific totals so that they may be combined for national indices without causing regional bias.

	E. England		N. England		W. England		Scotland		Wales	
	A	P	A	P	A	P	A	P	A	P
Number of squares:										
W1	297	32	47	105	59	144	63	41	20	63
W2	234	27	51	100	53	131	74	34	21	54
Strat	925	126	158	353	202	492	274	185	105	195
Percentage of total:										
W1	34%	4%	5%	12%	7%	17%	7%	5%	2%	7%
W2	30%	3%	7%	13%	7%	17%	9%	4%	3%	7%
Strat	31%	4%	5%	12%	7%	16%	9%	6%	3%	6%
Weightings:										
W1	0.968	1.216	1.041	1.023	1.058	1.043	1.198	0.975	0.254	0.875
W2	1.229	1.441	0.960	1.074	1.178	1.146	1.020	1.176	0.242	1.021

Table 4.3 The number of fields surveyed, summed across visits, summarised by stubble type. Also the number of fields of bare tillage, cereal crop and grass surveyed.

Habitat Type	Number of fields	
	1999/2000	2000/2001
Barley Stubble	568	776
Wheat Stubble	874	1189
?Cereal Stubble	835	860
Fallow Stubble	319	400
O. Rape Stubble	108	93
Linseed Stubble	145	106
Maize Stubble	342	293
S. Beet Stubble	143	85
Bare Tillage	2305	2231
Cereal Crop	6431	3367
Grass	21690	16495

Table 4.4 Percentage cover of farmland by cereal crop (CC) and different stubble types: B = Sugar beet, C = Cereal, M = Maize, L = Linseed, R = Oilseed Rape. Farmland is the area (ha) of lowland farmland within each stratum (regions and ITE landscape types). Calculated from Winter Farmland Bird Survey data from two winters 1999/2000 and 2000/2001. E, M, L indicate Early, Middle and Late winter visits in each winter respectively.

Stratum	Visit	Farmland	Percentage cover of farmland					
			CC	B	C	M	L	R
E. England-A	E	3421533	39.4	1.0	9.1	0.9	0.5	0.8
	M	3420528	41.3	0.9	7.0	0.7	0.5	0.7
	L	3407762	41.2	0.4	5.4	0.6	0.2	0.6
	E	3443352	25.7	0.7	16.7	0.9	0.5	1.0
	M	3433508	27.4	0.6	13.8	0.8	0.5	1.0
	L	3414814	28.4	0.3	11.7	0.6	0.4	0.9
E. England-P	E	443678	25.3	0.0	6.8	1.6	1.5	0.8
	M	443678	27.1	0.0	6.3	1.2	1.3	0.8
	L	448267	29.3	0.0	6.6	0.4	0.7	0.9
	E	434624	22.3	0.3	11.5	4.8	1.2	0.0
	M	434624	22.1	0.3	11.2	3.5	0.8	0.0
	L	431733	18.4	0.0	11.2	4.8	1.1	0.0
N. England-A	E	601293	29.9	0.2	7.2	1.5	0.2	0.1
	M	601293	29.1	0.5	5.1	1.6	0.2	0.1
	L	591418	30.3	0.4	4.0	1.8	0.3	0.2
	E	589222	18.8	0.0	16.1	1.1	0.9	0.2
	M	593147	20.6	0.0	13.6	1.2	0.1	0.1
	L	575081	18.8	0.0	11.7	1.8	0.2	0.0
N. England-P	E	1207294	20.1	0.4	7.9	1.2	0.0	0.3
	M	1204550	20.0	0.3	7.2	1.2	0.1	0.2
	L	1215516	20.0	0.4	5.0	1.3	0.0	0.3
	E	1162413	10.5	0.3	13.7	1.3	0.1	0.9
	M	1160668	10.4	0.2	12.8	1.2	0.2	0.9
	L	1178866	11.5	0.1	10.7	1.4	0.0	0.4
W. England-A	E	752592	23.0	0.0	10.1	2.0	0.3	0.1
	M	754578	24.4	0.0	9.5	2.1	0.2	0.1
	L	746941	24.1	0.0	6.5	2.3	0.2	0.1
	E	727635	21.1	0.1	8.9	2.3	0.1	0.0
	M	725386	22.2	0.2	8.0	2.1	0.1	0.0
	L	776627	27.5	0.0	7.1	2.8	0.0	0.0
W. England-P	E	1715095	13.4	0.7	5.2	1.7	1.1	0.0
	M	1717320	14.7	0.9	4.8	1.6	0.9	0.0
	L	1716407	14.6	0.9	4.2	1.6	0.9	0.0
	E	1718876	10.2	0.3	7.0	2.8	1.0	0.1
	M	1705350	10.6	0.3	6.6	2.1	0.9	0.1
	L	1737885	11.7	0.1	6.1	1.4	1.3	0.1

Figure 4.1 The distribution of 1-km squares surveyed in Winter 1, Winter 2 and both winters. Note that each dot may represent more than one 1-km square.

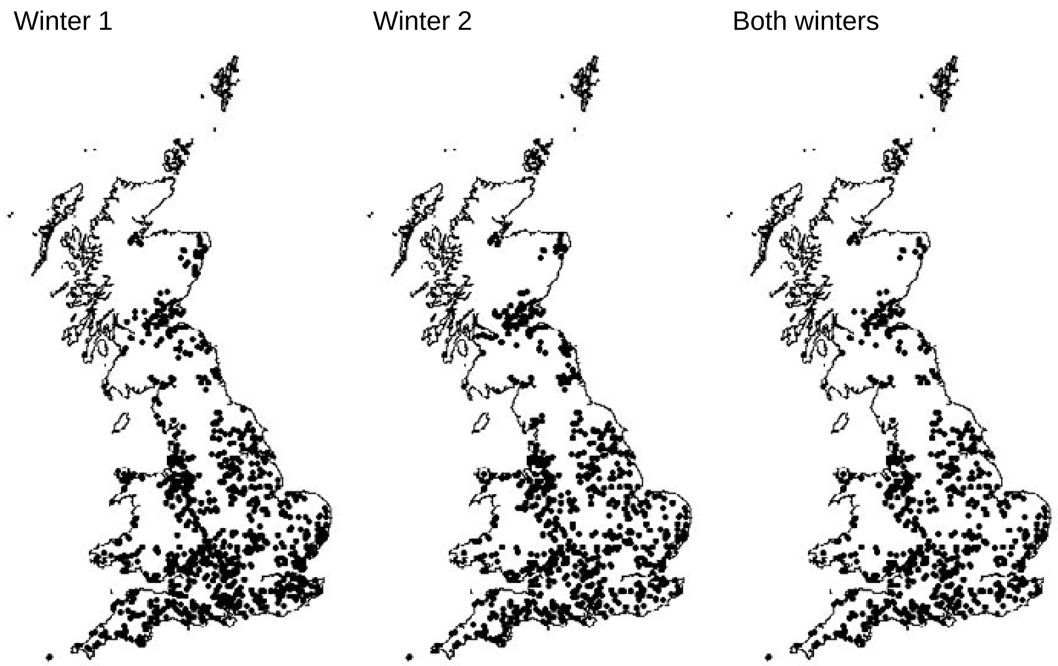
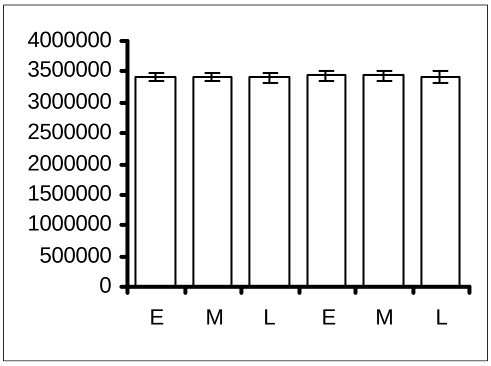


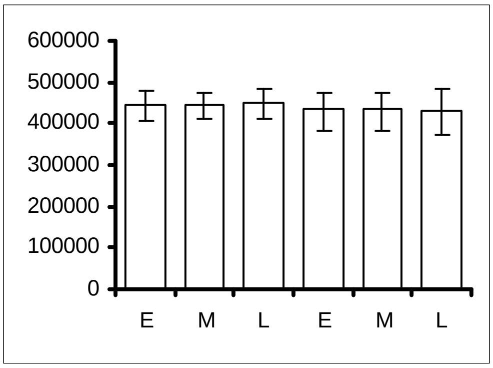
Figure 4.2 Estimates of the area (ha, mean and 95% confidence limits) of lowland farmland in three regions and two ITE landscape types calculated from Winter Farmland Bird Survey data from two winters 1999/2000 and 2000/2001. E, M, L indicate Early, Middle and Late winter visits in each winter respectively. Note the differing axis scales between charts.

East England

Arable

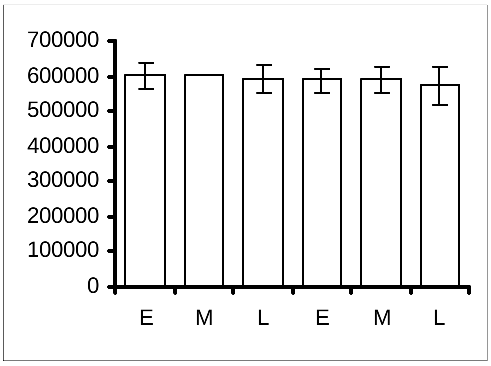


Pastoral

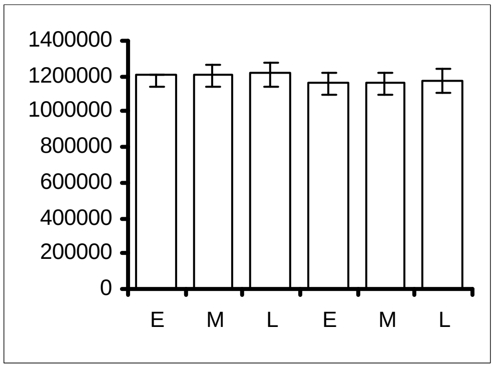


North England

Arable

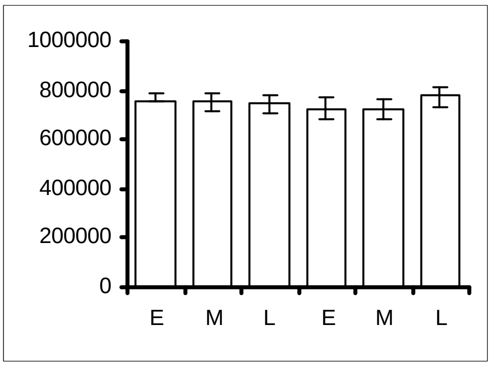


Pastoral



West England

Arable



Pastoral

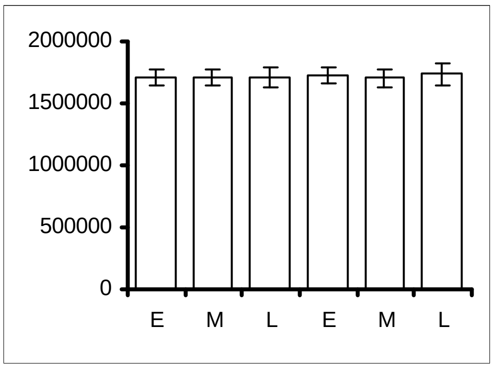
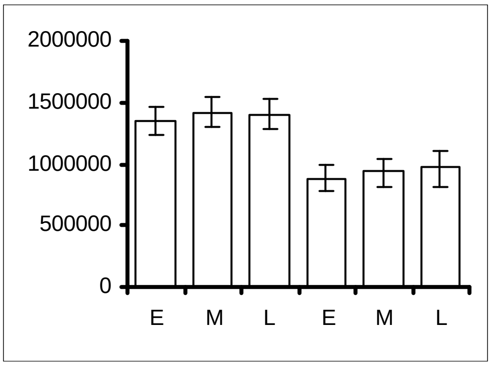
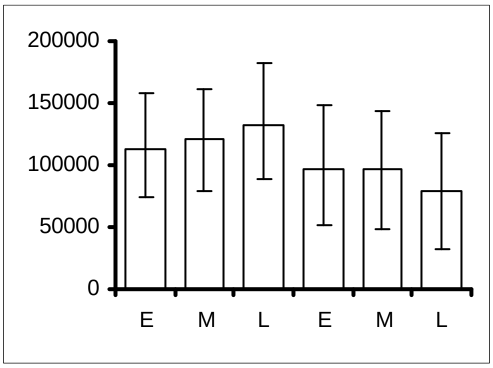


Figure 4.3 Estimates of the area (ha, mean and 95% confidence limits) of Cereal Crop on lowland farmland in three regions and two ITE landscape types calculated from Winter Farmland Bird Survey data from two winters 1999/2000 and 2000/2001. E, M, L indicate Early, Middle and Late winter visits in each winter respectively.

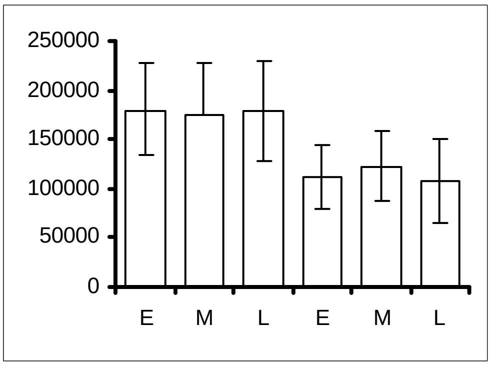
East England
Arable



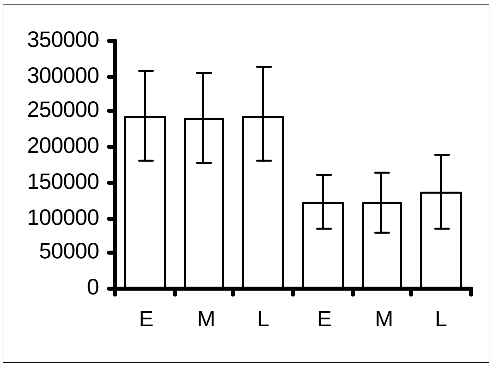
Pastoral



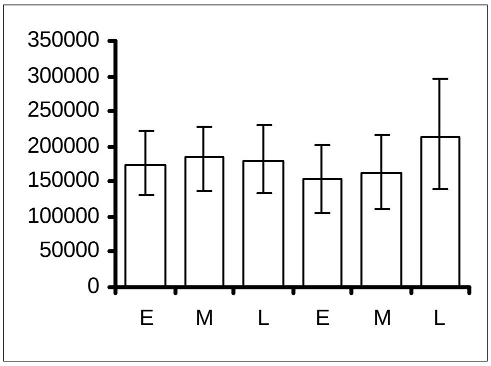
North England
Arable



Pastoral



West England
Arable



Pastoral

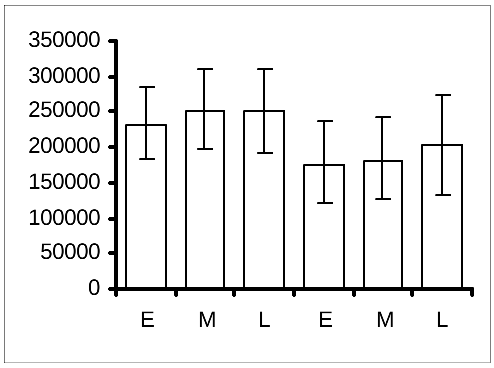
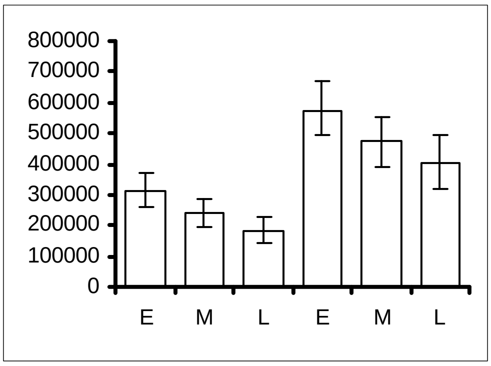
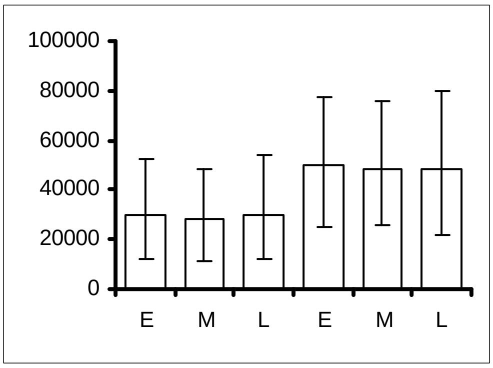


Figure 4.4 Estimates of the area (ha, mean and 95% confidence limits) of Cereal Stubble on lowland farmland in three regions and two ITE landscape types calculated from Winter Farmland Bird Survey data from two winters 1999/2000 and 2000/2001. E, M, L indicate Early, Middle and Late winter visits in each winter respectively.

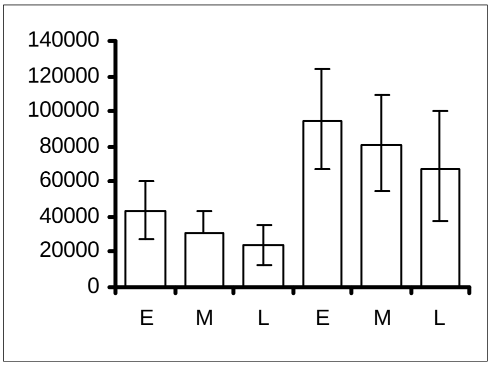
East England
Arable



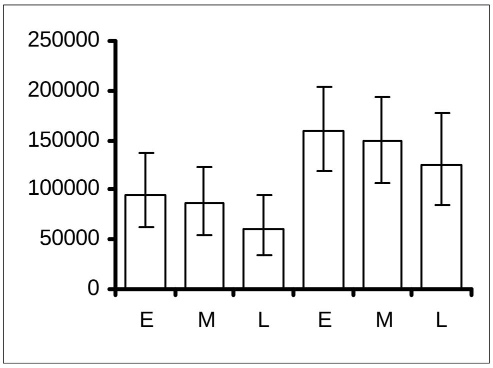
Pastoral



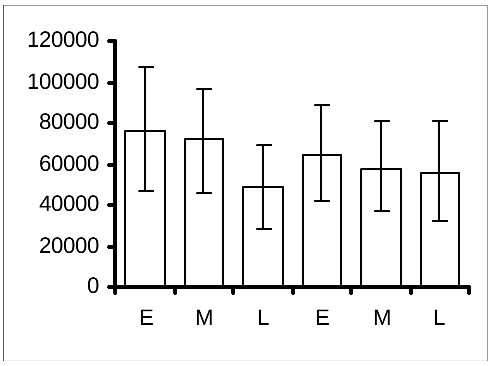
North England
Arable



Pastoral



West England
Arable



Pastoral

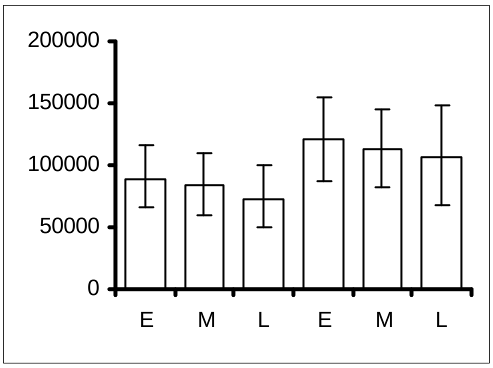
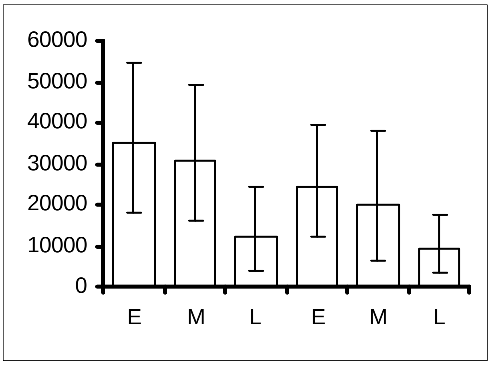


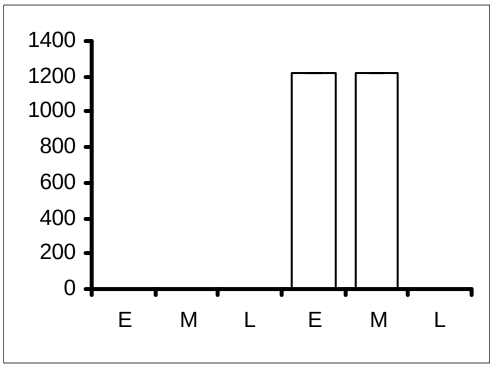
Figure 4.5 Estimates of the area (ha, mean and 95% confidence limits) of Sugar Beet Stubble on lowland farmland in three regions and two ITE landscape types calculated from Winter Farmland Bird Survey data from two winters 1999/2000 and 2000/2001. E, M, L indicate Early, Middle and Late winter visits in each winter respectively.

East England

Arable

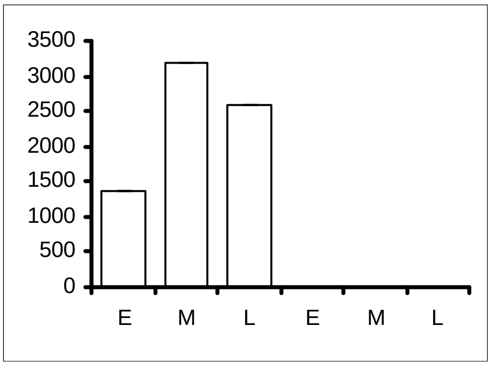


Pastoral

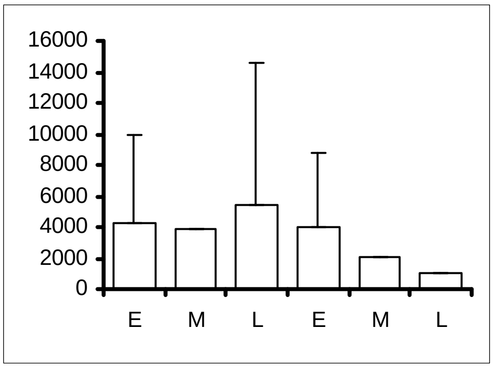


North England

Arable

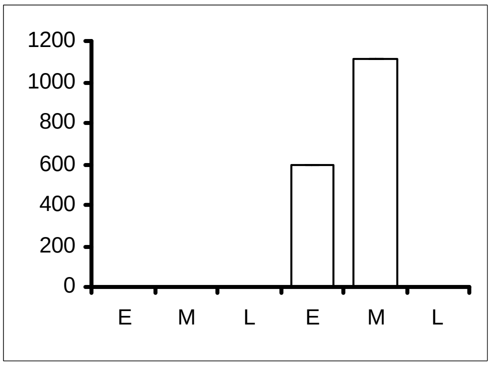


Pastoral



West England

Arable



Pastoral

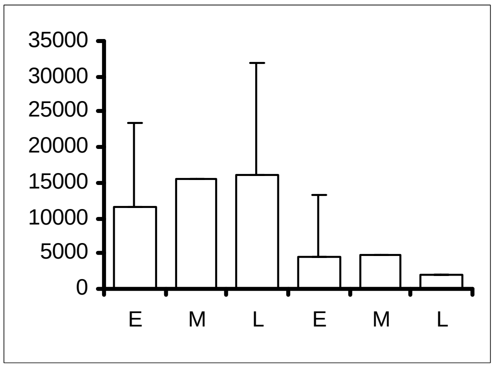
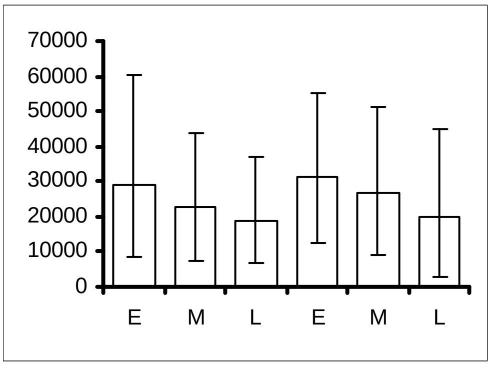
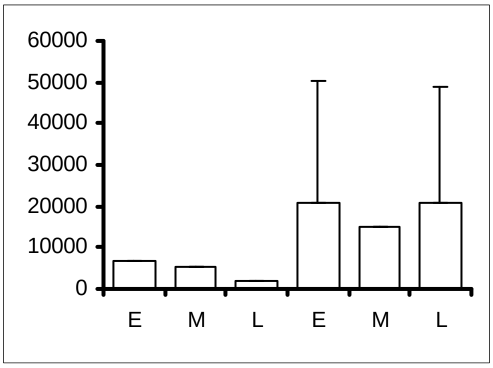


Figure 4.6 Estimates of the area (ha, mean and 95% confidence limits) of Maize Stubble on lowland farmland in three regions and two ITE landscape types calculated from Winter Farmland Bird Survey data from two winters 1999/2000 and 2000/2001. E, M, L indicate Early, Middle and Late winter visits in each winter respectively.

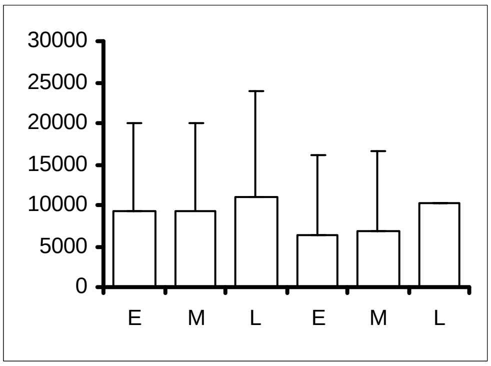
East England
Arable



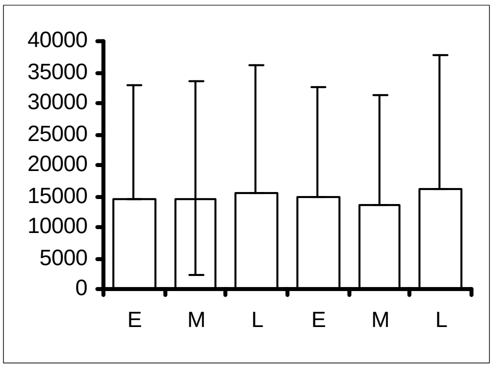
Pastoral



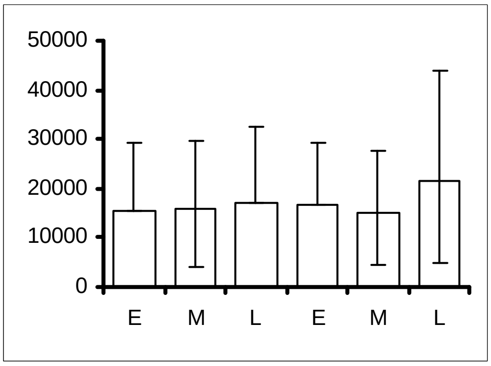
North England
Arable



Pastoral



West England
Arable



Pastoral

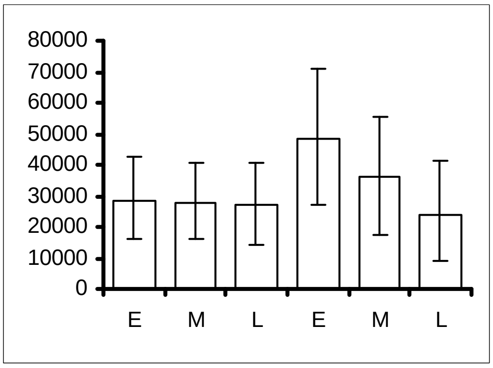
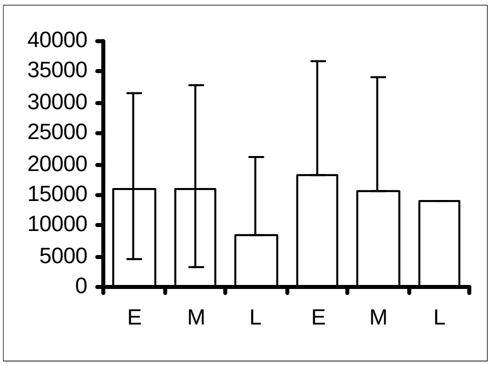


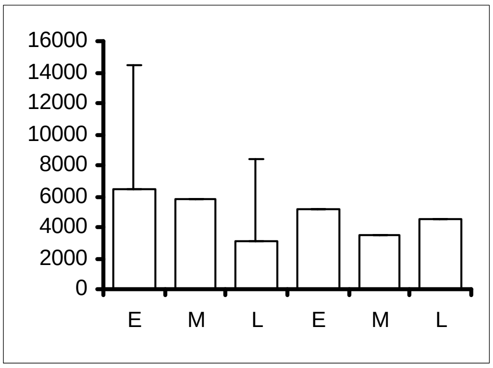
Figure 4.7 Estimates of the area (ha, mean and 95% confidence limits) of Linseed Stubble on lowland farmland in three regions and two ITE landscape types calculated from Winter Farmland Bird Survey data from two winters 1999/2000 and 2000/2001. E, M, L indicate Early, Middle and Late winter visits in each winter respectively.

East England

Arable

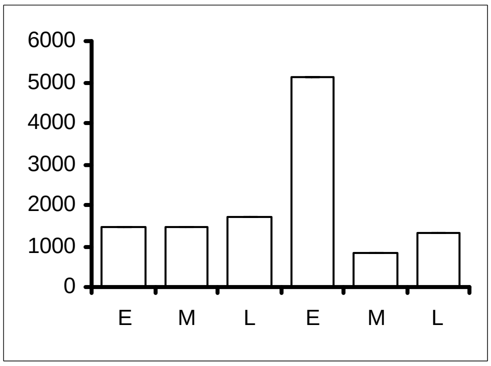


Pastoral

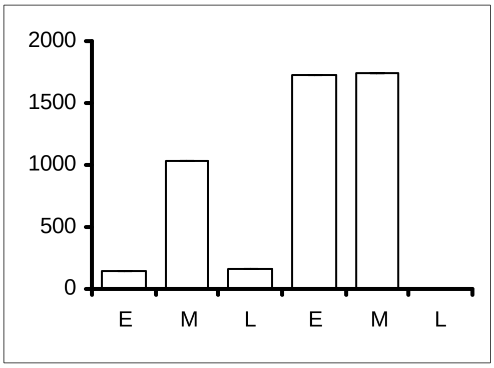


North England

Arable

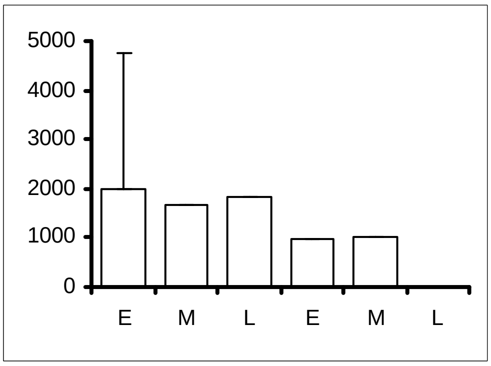


Pastoral



West England

Arable



Pastoral

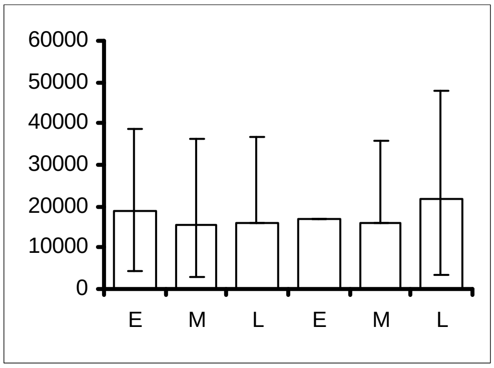
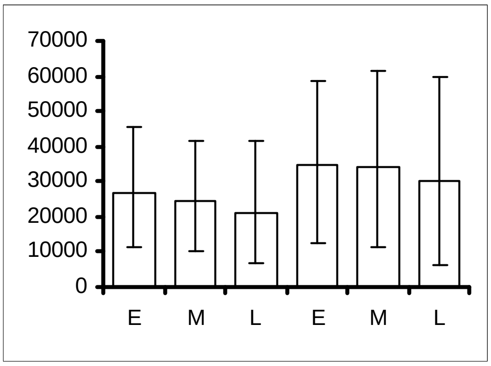


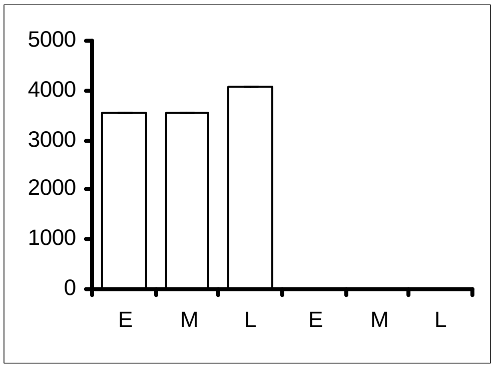
Figure 4.8 Estimates of the area (ha, mean and 95% confidence limits) of Oilseed Rape Stubble on lowland farmland in three regions and two ITE landscape types calculated from Winter Farmland Bird Survey data from two winters 1999/2000 and 2000/2001. E, M, L indicate Early, Middle and Late winter visits in each winter respectively.

East England

Arable

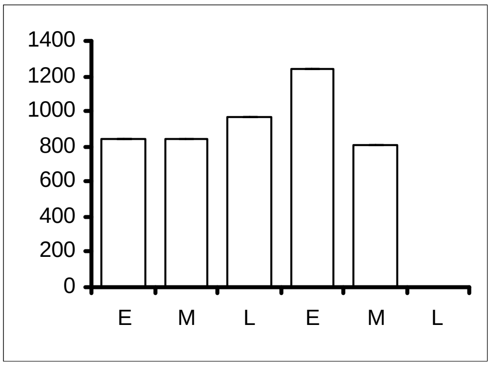


Pastoral

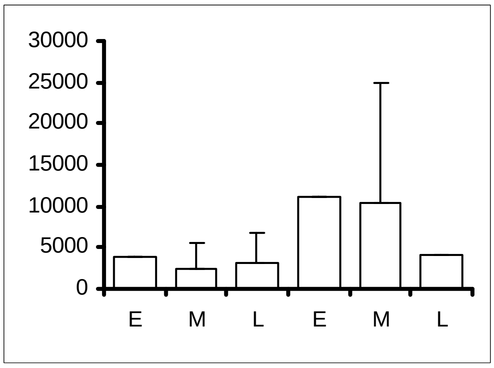


North England

Arable

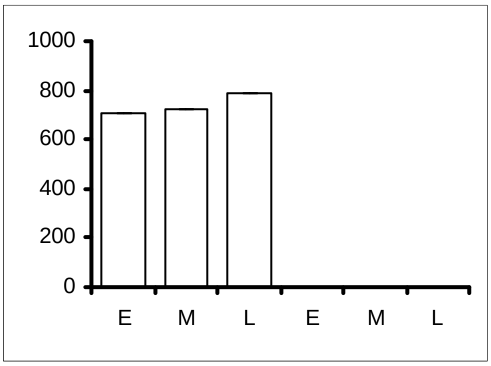


Pastoral



West England

Arable



Pastoral

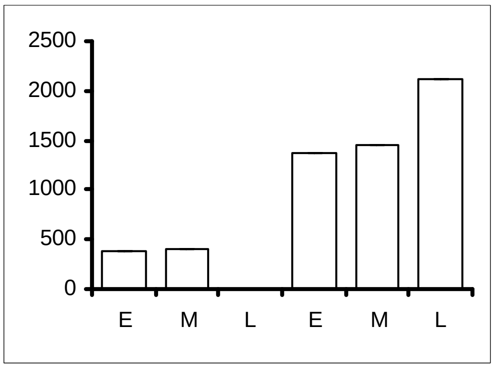


Figure 4.9 Mean densities (± SE) of farmland birds across all visits in winter 1999/2000 based on field edge counts. Solid part of bar indicates density attributable to birds within the field, the open part of the bar being birds in boundary habitats (hedges etc). With the exception of Skylark, species were aggregated into functional groups

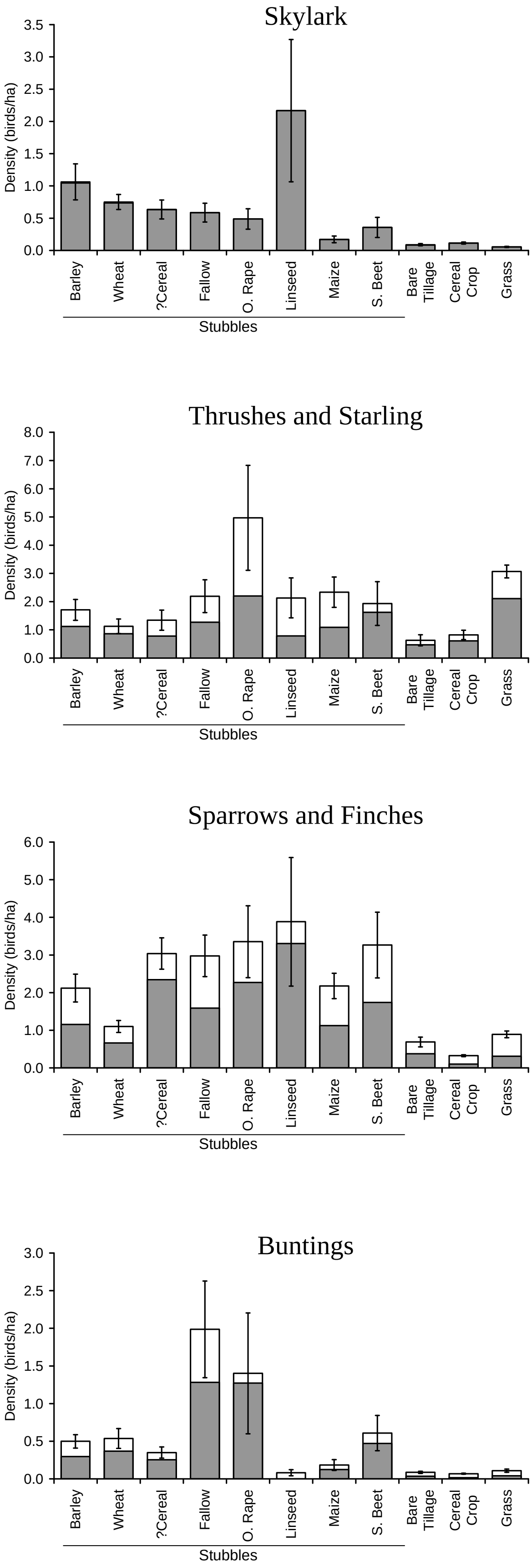


Figure 4.10 Mean densities (± SE) of farmland birds across all visits in winter 2000/2001 based on field edge counts. Solid part of bar indicates density attributable to birds within the field, the open part of the bar being birds in boundary habitats (hedges etc). With the exception of Skylark, species were aggregated into functional groups

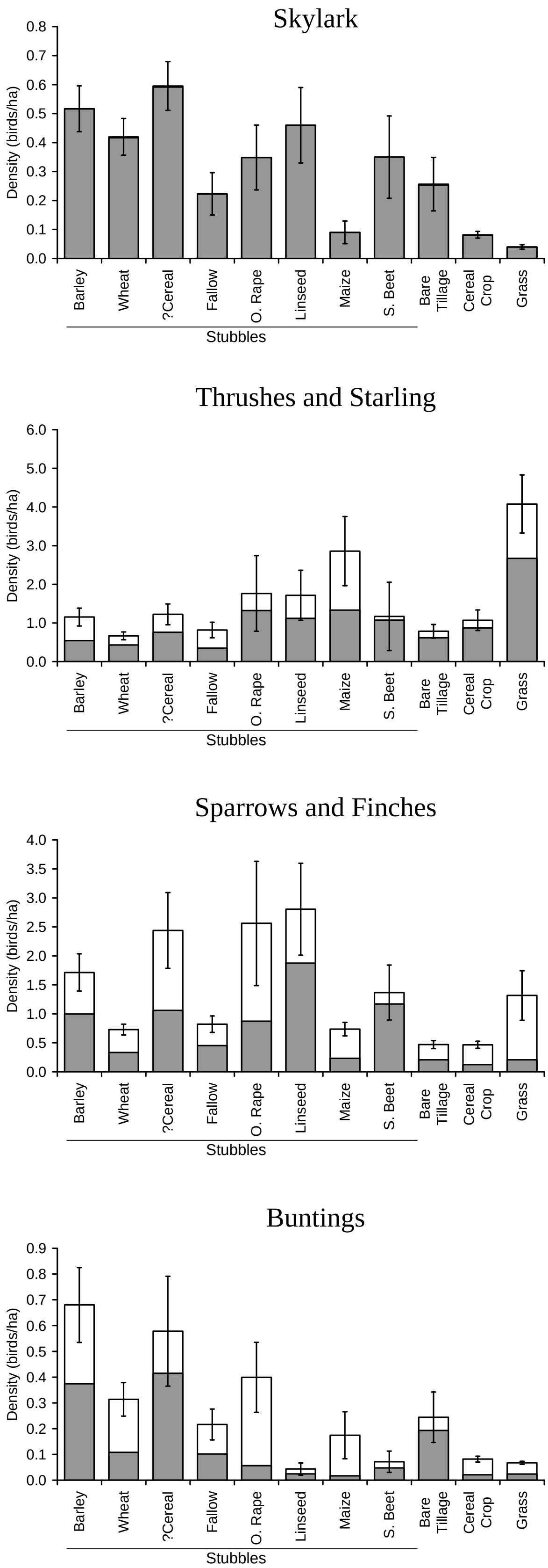


Figure 4.11 Mean densities (± SE) of farmland birds across all visits in winter 1999/2000 (open bars) and winter 2000/2001 (grey bars) based on field edge counts. With the exception of Skylark, species were aggregated into functional groups

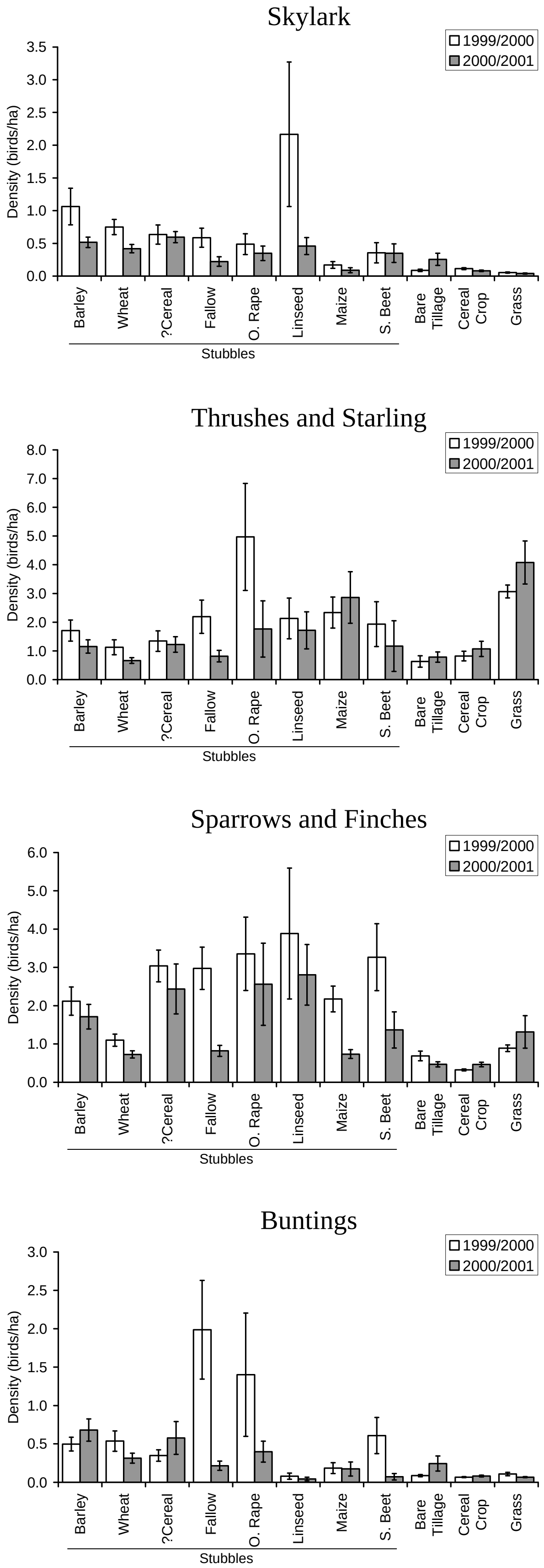
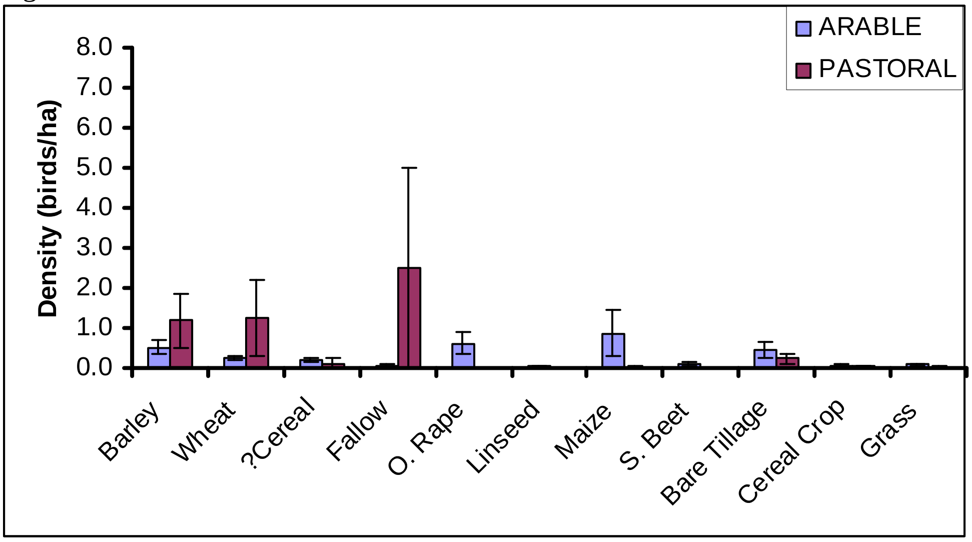


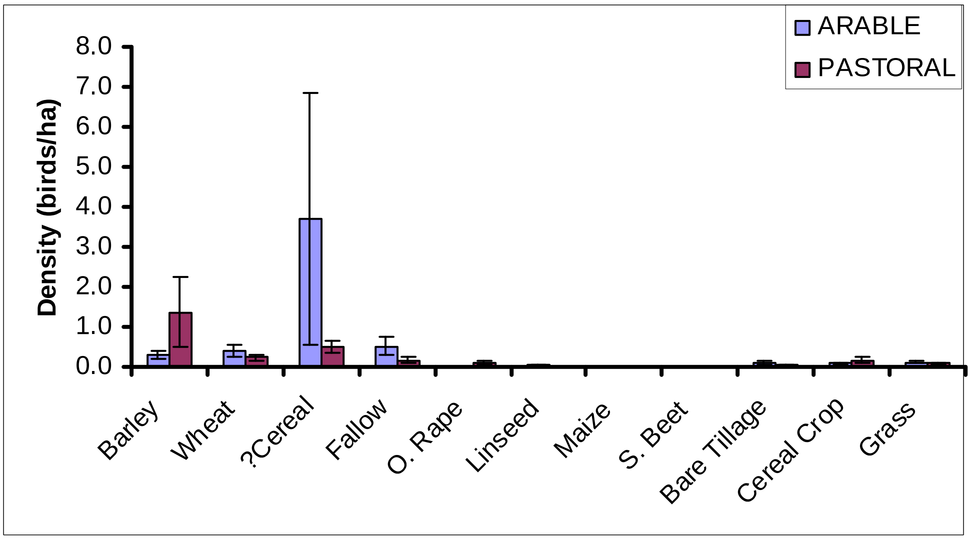
Figure 4.12 Mean densities (±SE) of functional groups on stubbles split by geographic region and ITE landscape type. Results for winter 2.

Buntings

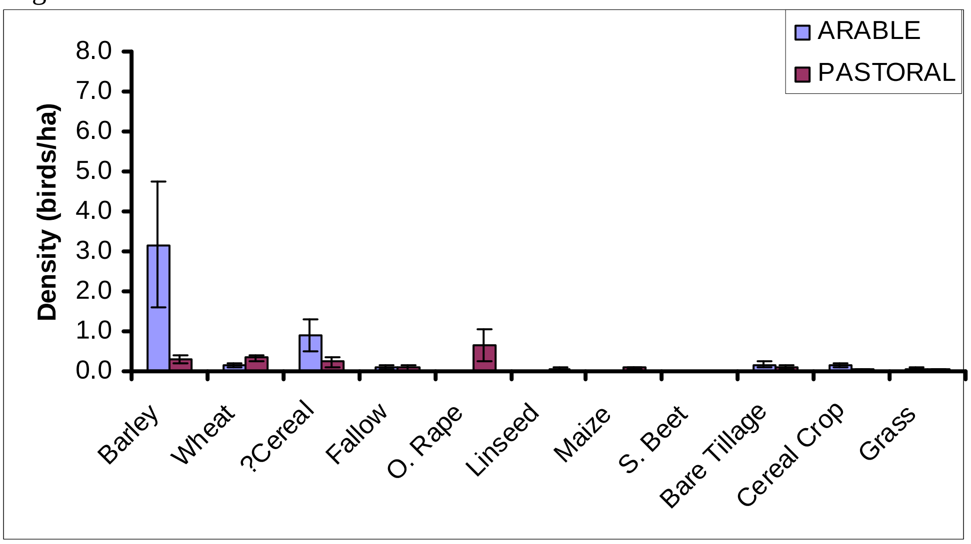
East England



North England

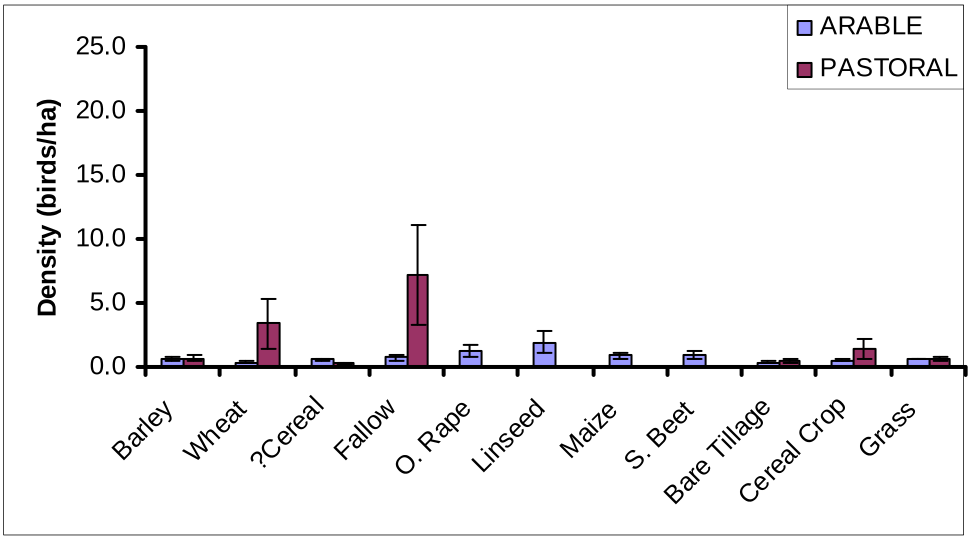


West England

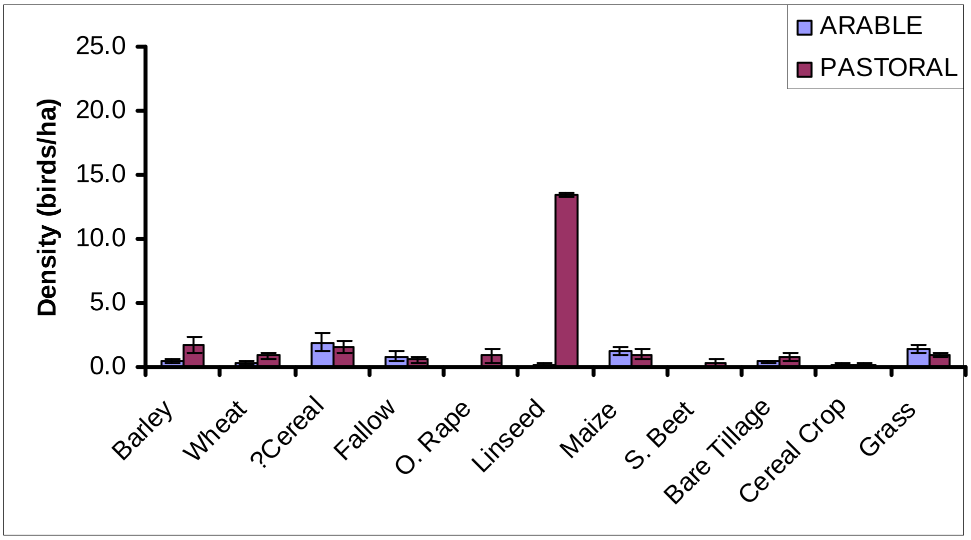


Finches

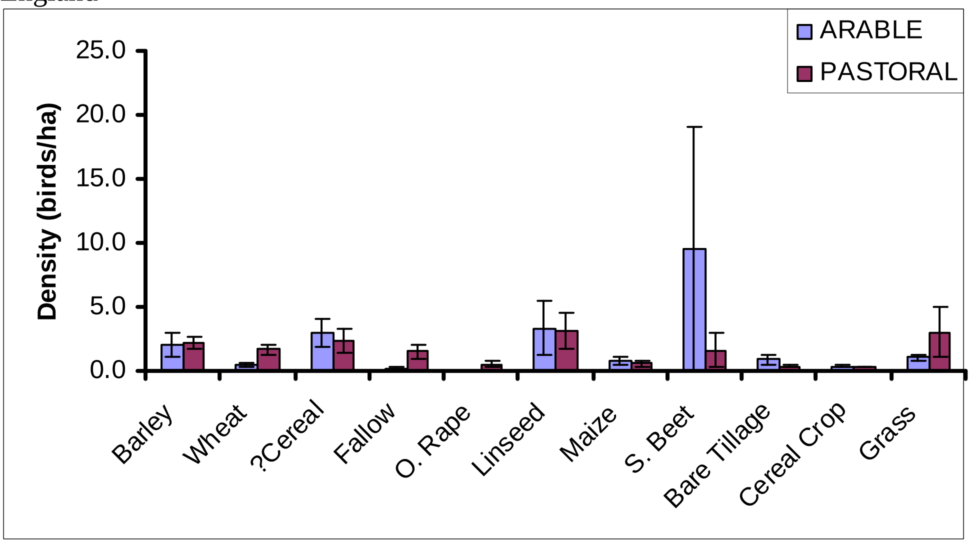
East England



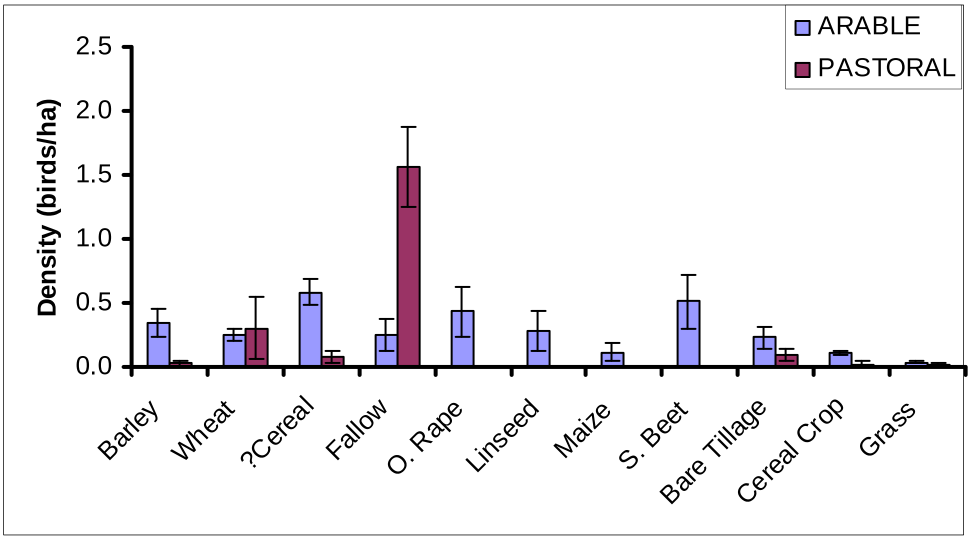
North England



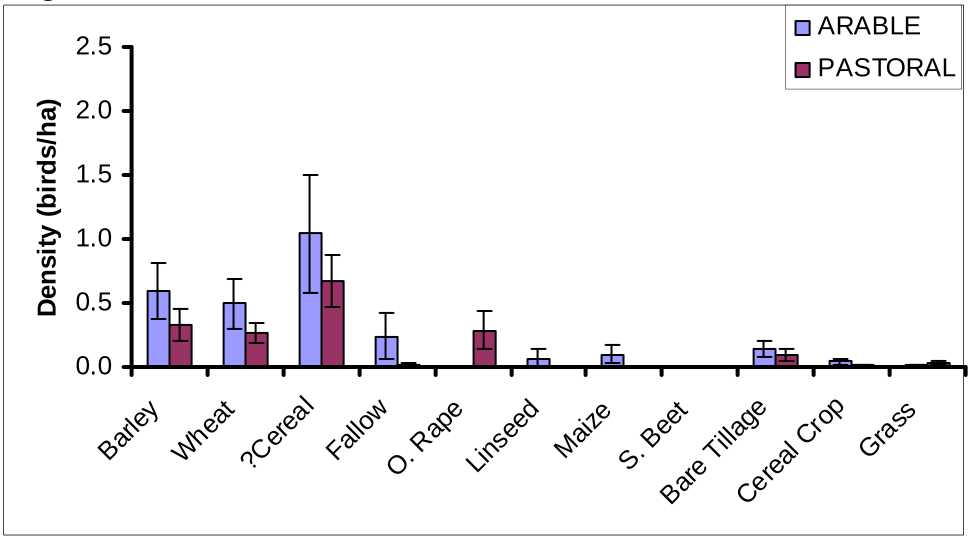
West England



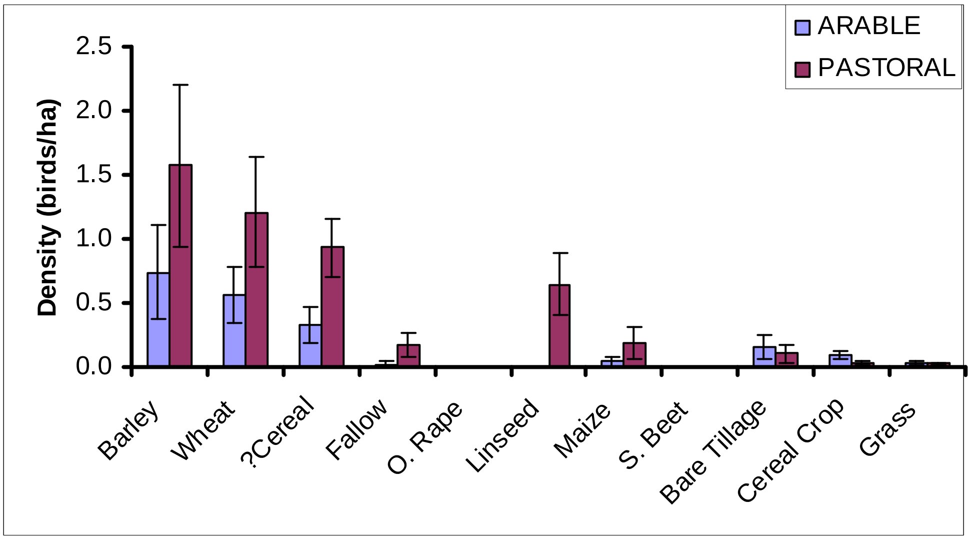
Skylark
East England



North England

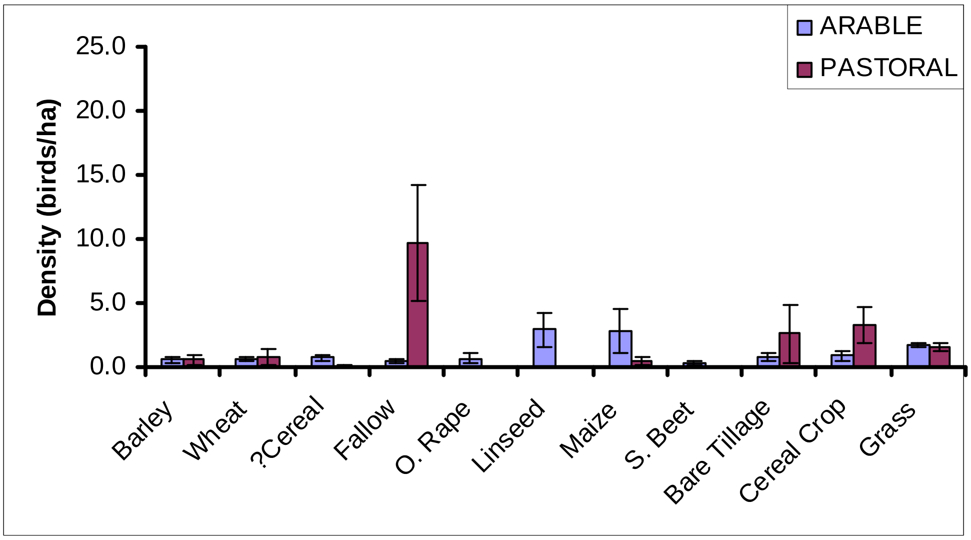


West England

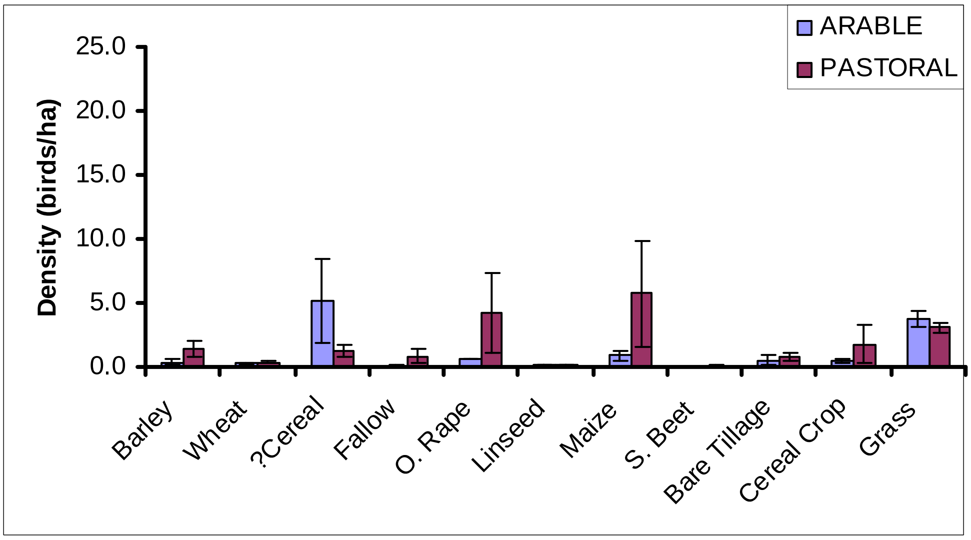


Thrushes

East England



North England



West England

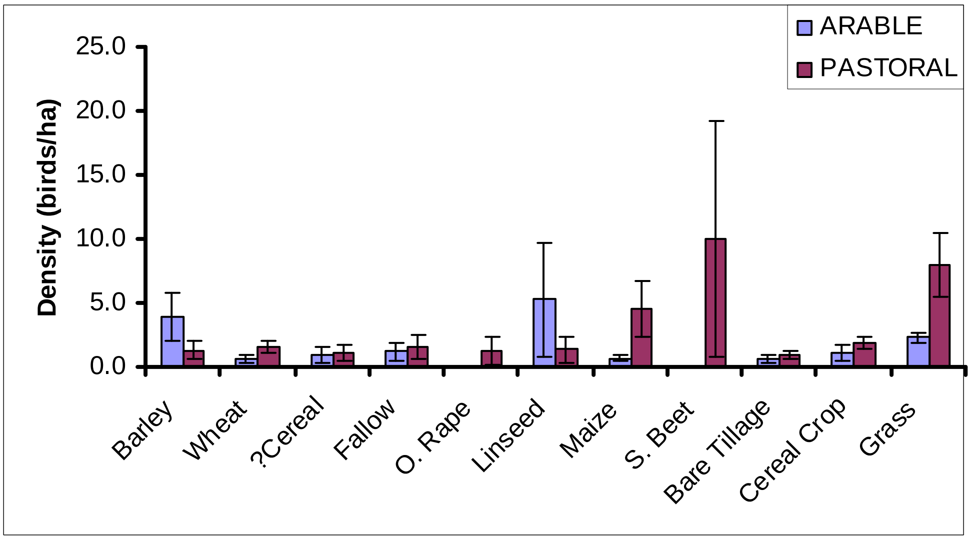
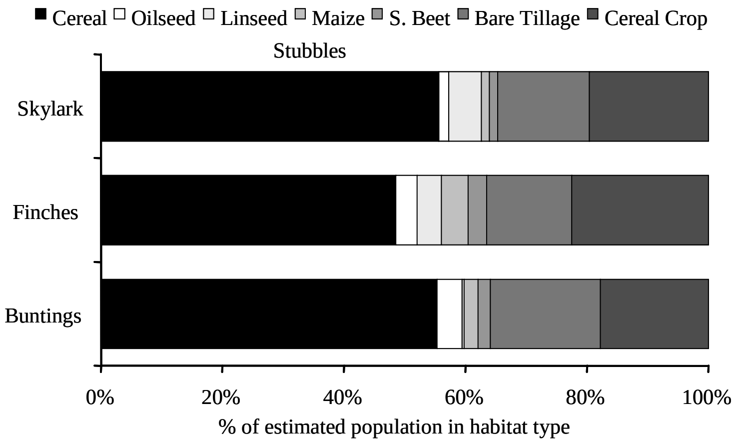


Figure 4.13 Estimates of population size of granivorous birds in different farmland habitat types in lowland England. Data are from the Winter Farmland Bird Survey and derived from the product of habitat specific density (birds/ha)



5. WINTER BIRD POPULATIONS ON BRITISH LOWLAND FARMLAND: VARIATION WITH REGION AND FARMLAND TYPE

5.1 Introduction

This paper describes general patterns in winter bird distribution and species richness on farmland across regions and major gradients in farmland types in Britain. These are derived from data gathered by volunteer observers through the Winter Farmland Bird Survey (WFBS). Over 1000 1-km squares were surveyed in the three winters 1999/2000, 2000/2001 and 2002/2003. This comprised around 18,000 fields and generated counts of over 300,000 birds each winter of 30 key species. Data on distribution of the winter habitats are summarised and show regional differences in the availability of key habitats for farmland birds in winter, such as stubbles and farmyards. Most granivorous species were more prevalent and attained higher abundance in arable or mixed farmland whereas most invertebrate feeders were associated more with pastoral farmland. There was a suggestion that several species associated with either arable or pastoral habitats at the landscape scale were more closely associated with mixed habitats at the local scale. The majority of species occurred at low densities throughout their range. Though species richness differed regionally and with farmland type, the magnitude of differences was small. Those species comprising the government's Farmland Bird Indicator were present at low density throughout, suggesting that this indicator has the potential to reflect the state of farmland across wide geographic areas in winter as well as summer.

The decline of biodiversity, particularly birds, associated with agricultural land in Britain and elsewhere in north-west Europe is one of the major issues in conservation science today (Krebs *et al.* 1999, Donald *et al.* 2001). That farmland birds have declined due to agricultural intensification within arable and pastoral systems is widely accepted. In the UK, many farmland bird species have Biodiversity Action Plans (BAPs: Anon 1995, 1998) and the Department for Environment, Food and Rural Affairs (Defra) uses a smoothed composite trend of numbers of a subset of 18 wild bird species[1] as a 'headline indicator' of the sustainability of its policies and 'quality of life' in England and Wales (Anon 1999). This 'Farmland Bird Indicator' (FaBI) declined by 46% between the mid-1970s and 2000 (Gregory *et al.* 2002). Defra has adopted a Public Service Agreement (PSA) target to reverse farmland bird declines in England and Wales by 2020 (Vickery *et al.* 2004).

Management practices within agri-environment schemes (AESs) will be key tools in meeting this ambitious target (Anon 1995, 1998; Swash *et al.*, 2000; Evans *et al.*, 2002). In England and Wales there are two complementary categories of management options within AESs: 'broad and shallow' and 'narrow and deep'. These form the Entry Level Scheme and Higher Tier respectively of the Environmental Stewardship Scheme to be launched in 2005. The former advocates every farmer doing a little and encompasses a wide range of 'low maintenance and low cost' options for managing agricultural land. The latter comprises higher maintenance and higher cost options that may be targeted towards key species or regions and are likely to be adopted by rather fewer farmers. Effective targeting for 'narrow deep options' for birds requires detailed understanding of their distribution and although this is well known in summer it is relatively poorly understood in winter.

Reduced over-winter survival is implicated in the population declines of several farmland species (Siriwardena *et al.* 2000) and there is a plausible link for many species between changes in cropping and the availability of winter food resources (e.g. Robinson & Sutherland 2002, Moorcroft *et al.* 2002). The winter habitat associations at the local scale are increasingly well understood for several farmland species, especially granivores. However, there is less information on the regional generalities of these studies. Furthermore, there is a range of species that use farmland in winter for which little is known about broad geographical distribution and habitat use. This includes partial migrants and residents such as Meadow Pipit and Pied Wagtail (see Table 5.1 for scientific names),

[1] Originally 20 species but two, Barn Owl *Tyto alba* and Rook *Corvus frugilegus*, no longer included due to insufficient monitoring data (Gregory *et al.* 2004)

plus several immigrants such as Fieldfare and Redwing that originate from breeding populations in Fennoscandia and Europe.

Against this background, the British Trust for Ornithology in association with the Joint Nature Conservation Committee coordinated a study of farmland birds in lowland Britain over three winters (BTO/JNCC Winter Farmland Bird Survey [WFBS]) with three main aims. First, to provide information on the distribution and abundance of a suite of farmland bird species across the whole of lowland Britain. Second, to quantify the distribution and abundance of agricultural habitats in winter. Third, to identify the habitat preferences of farmland birds in winter across a wide geographic area and to investigate the nature of regional and seasonal differences in these preferences. Results from non-random and casual record components of the survey are summarised in Gillings and Beaven (2004). This paper uses data on birds and their habitats collected from a stratified random sample of 1-km squares and aims to quantify broad patterns of abundance and the nature differences between regions and farmland systems. This includes the main gradient in farming systems – from predominantly grass in the north and west to predominantly arable in the east. We present information on the availability of broad agricultural habitat types by region and farmland system in order to understand regional differences in bird data. Finally we consider the implications of these findings for birds of conservation concern, particularly with respect to the sensitive management of farmland for more species.

5.2 Methods

5.2.1 Winter Farmland Bird Survey data

Bird data for this analysis came from the Winter Farmland Bird Survey, full details of which are given in Gillings *et al*. (in review), but relevant details are summarised here. Over the three winters of 1999/2000, 2000/2001 and 2002/2003 1090 1-km squares were surveyed for a suite of 30 farmland bird species (Table 5.1, includes scientific names). The 1-km squares were selected by a stratified random sampling approach that ensured good geographic coverage within the British lowlands. Volunteer surveyors visited each square on up to three occasions in up to three winters and spent 4 hours surveying agricultural habitat ‘patches’ (fields, orchards, farm yards) and in each patch recorded the abundance of each of the target bird species and the habitat type. Due to the timed nature of the visits it was not always possible to survey all of the agricultural habitats within the square, and on average volunteers surveyed 57.0 ± 0.3 ha of farmland, which on average amounted to 72.1 ± 0.3% of the farmland actually present in the square (Gillings *et al*. in review). For all analyses the For the analyses of habitat and scale presented in this paper we summarised the data in three forms, patch scale, 1-km scale and 10-km scale.

For patch scale we simply record the number of each species observed in each patch

5.2.2 Analysis

5.2.2.1 Data preparation

Survey maps were digitised and field area perimeter length determined using a geographic information system (GIS). Examination of the dates of first, second and third visits showed considerable overlap so for analysis they were reassigned to one of three periods: early = November-December, mid = January, late = February. Visits falling outside these periods were excluded from analysis. For most squares the total area surveyed did not sum to $1km^2$ because only farmland habitats were surveyed and/or the timed four hour search precluded complete coverage of a square. A preliminary analysis was made to determine what area of farmland was actually surveyed and to express this as the percentage of the available farmland in the square. The area of farmland in the sample 1-km square was estimated as the sum of arable and grass land cover types from the *Land Cover Map 2000* (*LCM2000*, Fuller *et al.* 2002).

Bird abundance and habitat relationships may differ in different agricultural landscapes (Robinson *et al.* 2001, Atkinson *et al.* 2002). The *LCM2000* grass cover and arable cover values were used to determine what percentage of the sample square's farmland was pasture. This figure was used in two forms: as a continuous gradient and as a discrete category by defining sample squares as one of three farmland types: Arable (0-33.3% grass), Mixed (33.4-66.6% grass) or Pastoral (66.7-100% grass). This procedure was repeated for the corresponding parent 10-km square for each sample square. Thus each sample square was assigned the percentage pasture and farmland type at both local (1-km square) and landscape (10-km square) scales. At the landscape scale this gave a polarisation of Britain (Fig. 5.2) virtually identical to that in Atkinson *et al.* (2002) derived from government agricultural statistics.

5.2.2.2 Ordinal logistic regression

The frequency distribution of counts was extremely zero-inflated and conventional regression techniques were unsuitable. Instead Ordinal Logistic Regression (OLR) was employed. For each analysis each count (or density) was assigned into one of five categories. The first category (category 1) included all zeroes. The remaining four categories were calculated as follows. The 25th, 50th and 75th percentiles of non-zero values were calculated and used as cut-offs for assigning all non-zero values to categories. For instance, category 2 was defined as counts greater than zero and less than or equal to the 25th percentile. OLR then models the cumulative probability distribution of observations falling in each category such that consecutive parameter estimates describe the frequency of counts falling in category 1, the frequency of counts falling in category 1 and 2, 1, 2 and 3 and so on. Once the data distribution had been described in this way covariates could be tested. This method suffers from lack of precision because the exact size of a count replaced by a range. However, the exact counts may imply false precision because of the difficulty in detecting all birds. OLR was performed using PROC LOGISTIC in SAS (SAS Inc. 2001). Factors were tested, and covariates were entered as linear and quadratic terms. The best model was sought by evaluating change in AIC and determining whether parameters differed significantly from zero.

Bird abundance was analysed in relation to region and farmland type by summarising for each visit to a square the total number of each species recorded in the boundary, margin and field interior (data on the number of individuals in transects from winter 1 were excluded to keep surveying effort consistent across winters). Totals were converted to densities (birds km^{-2}) using the area of land surveyed on each visit and analysed by OLR as described above.

5.2.2.3 Habitat availability

Broad habitat types were extracted from the dataset correcting first for the partial coverage of squares. We assumed that the fields surveyed were representative of the sample square's farmland and used the *LCM2000* estimate of the area of farmland within the sample square to scale up areas of individual habitat types. Habitat area estimates were derived by calculating mean area per 1-km square for each habitat within each stratum (region and landscape type) and extrapolating across the land area of that stratum. Boot-strapped confidence limits were calculated by resampling with replacement the squares to generate independent datasets from which resampled means and hence area estimates could be generated. Confidence limits were taken as the 25th and 975th ranked values for each habitat. These estimates were validated as far as possible against published government statistics, although direct comparisons are impossible since few winter statistics are available.

5.3 Results

Over the three winters, 1090 1-km squares were surveyed at least once; 870 in winter 1, 801 in winter 2 and 745 in winter 3. This resulted in a total of 18,025 habitat patches (= fields or part fields, orchards, farm yards) being surveyed at least once, with 14,222, 11,987 and 10,887 surveyed in the three winters respectively, representing over 400km^2 of farmland each winter. Bird surveys generated approximately 30,000 records of over 300,000 individual birds per winter of the 30 target bird species (Table 5.1). Note that a minority of observers gave incomplete survey forms (e.g. no habitat data collected, or bird presence indicated but no counts given) so sample sizes may differ for some analyses.

5.3.1 Coverage

Widespread coverage was achieved (Fig. 5.3). The 1090 1-km squares surveyed comprised: 395 in East England, 203 in North England, 145 in Scotland, 246 in West England, and 101 in Wales. Not all squares were surveyed in every winter but the percentage of squares surveyed in each region in each winter did not differ significantly from the original stratification (P = 0.10, P = 0.6 and P = 0.4). The stratification of squares across regions and landscape types did differ slightly, but significantly, from the original stratification in winters 1 (χ^2_4 = 13.3, P < 0.01) and 3 (χ^2_4 = 13.9, P < 0.01) but not winter 2 (χ^2_4 = 8.7, P > 0.05). For national analyses these slight biases in coverage were accounted for by weighting different strata in conjunction with adjusting square frequencies to account for the original stratification.

In each winter over 95% of squares were visited at least twice and in winters 1 and 3 over 85% of squares were visited three times (65% in winter 2). Assigning visits to periods yielding the following number of squares surveyed in each period (early, mid, late): winter 1: 707, 705, 708; winter 2: 628, 684, 542; winter 3: 591, 607, 635.

Across all the visits to all the squares (n = 6648) the mean area of land surveyed was 57.0 ± 0.3ha but varied widely (range, 2.1-100ha). The mean percentage surveyed of the available farmland in the square was 72.1 ± 0.3%. The area surveyed differed significantly between winters (LR χ^2_2 = 47.3, P < 0.0001) and regions (LR χ^2_4 = 385.2, P < 0.0001) but not visits (χ^2_2 = 2.6, P > 0.25), nor were there any first-order interactions. More farmland was surveyed in squares in Scotland and East England (Fig. 5.4). The actual mean area of farmland in squares (from *LCM2000*) differed significantly between regions (χ^2_4 = 11.1, P < 0.03, Fig. 5.4). The percentage of the square's farmland that was surveyed differed significantly between winters (χ^2_2 = 50.8, P < 0.0001) though the differences were small: from 75% in winter 1 to 70% in winter 3. The percentage of the square's farmland covered differed significantly between regions (χ^2_4 = 571.9, P < 0.0001): E. England = 78%, N. England = 71%, Scotland = 79%, W. England = 65% and Wales = 59%. No significant differences were apparent between visits in a winter.

5.3.2 Habitat availability

Appendix 1 provides summaries of the extent and abundance of common agricultural habitats throughout lowland Britain and in each of the five regions. All habitats differed significantly in their availability between regions (Table 5.2) generally in ways that one might predict, for example grass was more abundant in regions devoted to pastoral farming. With the exception of East England, grass was present in at least 90% of squares and covered upwards of 38ha. In contrast, crops and stubbles declined in prevalence and area from Arable to Pastoral regions. Bare till as a component of intensive arable systems was most abundant in East England. Farmyards never exceeded 1ha in size and were least abundant in East England. The regions differ markedly in size, and small differences in habitat area per square can generate pronounced differences in the area of habitats at the region scale (Fig. 5.5).

The broadly predictable spatial patterns (e.g. east-west arable-grass polarisations) are encouraging but there are few ways to quantitatively check the accuracy of these estimates. However, there was a close match between the WFBS estimate of the area of cereal present by mid winter and the area recorded by the governments June census the following spring. For example, estimates for individual English government office regions derived from winter 2000/2001 WFBS data were significantly related to June 2001 Defra census data ($n = 8$, $F_{1,6} = 297.8$, $P < 0.0001$, $R^2 = 0.98$, intercept = 0, slope parameter = 0.90 ± 0.05) indicating that WFBS cereal areas over-estimated actual cereal crop area by around 10% on average. Furthermore, the drop in area of winter cereals evident from 1999/2000 to 2000/2001 was also documented by Defra's December 2000 and June 2001 censuses and attributed to extremely wet weather in autumn 2000 which precluded sowing in many fields. The close agreement between WFBS and agricultural statistics in the areas of cereals and annual changes suggest WFBS data are a reliable source of quantified data on winter habitats in lowland Britain.

5.3.3 Species richness

Across all visits and all squares where complete bird data was provided ($n = 6548$) species richness for the 30 target species varied from 0 to 20, with mean 7.5. Considering the three conservation groupings, only 2-3 species on average from the FaBI, Red-list and BAP were recorded per square. Nationally, species richness was almost equally divided between granivores and invertebrate-feeders. With the exception of the number of invertebrate feeders, all estimates of species richness on a visit were positively correlated with the area surveyed on that visit (e.g. for target species, $n = 6502$, $r = 0.17$, $P < 0.0001$). After controlling for area where necessary, species richness differed slightly but significantly between regions. Target species richness was lowest in Scotland and highest in W. England. Despite having the highest overall species richness, squares in West England had low richness of FaBI species. Red-listed species richness did not differ significantly between regions. BAP species richness and granivores richness declined to the west and north, and invertebrate-feeder richness showed the opposite trend. In fact all classifications were positively correlated with the area of arable farmland in the 1-km square except invertebrate-feeders that were negatively correlated ($n = 6502$, $r = -0.16$, $P < 0.0001$).

Squares falling in predominantly Arable, Mixed or Pastoral farming landscapes (at the 10-km scale) showed differing patterns of species richness. Total species richness was greatest in Mixed areas, but for the conservation groupings Arable landscapes tended to be richest. Invertebrate feeders were the exception and were most diverse in Pastoral systems. Exactly the same patterns were evident when squares were classified instead as Arable, Mixed or Pastoral at the local scale (1-km square).

5.3.4 Species abundance and prevalence

Most species were highly localised with less than 50% of visits recording each species (Table 5.3) and densities were highly skewed. Median densities were generally low; across all regions and species, 90 of the 150 estimated densities were 10 birds/km^2 or fewer (Table 5.3).

All species tested showed significant differences in density between regions (OLR, all $P < 0.0001$, Wood Lark, Brambling, Twite and Snow Bunting were too scarce to test). In most cases this was a combination of differences in both the percentage of squares occupied and in the density where present. However, for Golden Plover, Lapwing, Stock Pigeon, Greenfinch, Redpoll and Corn Bunting there was no significant difference in non-zero density between regions (Kruskal-Wallis, all $P > 0.05$) indicating that the significant differences in density were attributable to differences in prevalence only. The most prevalent species (those recorded on the most visits) were Chaffinch, Song Thrush, Starling and Fieldfare. Tree Sparrow and Corn Bunting were recorded on less than 10% of visits across the whole country (Table 5.3). House Sparrow densities were significantly lower in East England compared to elsewhere (LR $\chi^2_1 = 56.4$, $P < 0.0001$). The prevalence of Greenfinch and Goldfinch were significantly positively correlated ($n = 6$, $r_s = 0.96$, $P < 0.003$) but densities were not ($n = 6$, $r_s = -0.5$, $P > 0.3$). Linnet densities were significantly higher in Scotland than elsewhere (LR

$\chi^2_1 = 79.3$, $P < 0.0001$). In Wales, although each species tended to be reported from few visits, densities tended to be relatively high (Table 5.3).

Throughout lowland Britain, 90% of visits reported at least one Farmland Bird Indicator species, and the median density of FaBI species was 61 birds/km^2 (Table 5.3). Densities differed significantly between regions (LR $\chi^2_4 = 84.2$, $P < 0.0001$) as follows: Wales>W=Scotland=N>E (E, N, W = East, North and West England respectively). Virtually the same trend was apparent for Red-listed species (LR $\chi^2_4 = 180.4$, $P < 0.0001$): Wales>W>Scotland=N>E. The dominance of Wales is surprising and appeared to be due to high densities of Starlings; when densities for FaBI and Red-list species were regenerated excluding Starling, Wales dropped to lowest. The density of BAP species differed significantly between regions as follows Scotland=E=W>Wales=N (LR $\chi^2_4 = 38.0$, $P < 0.0001$). Granivores appeared to be relatively uniformly distributed (Table 5.3) although differences between regions were statistically significant (LR $\chi^2_4 = 49.7$, $P < 0.0001$) as follows: W>N=Scotland>E>Wales. Finally, invertebrate feeders were most abundant as follows: Wales>W>N>E>Scotland (LR $\chi^2_4 = 433.6$, $P < 0.0001$). This was not simply due to high Starling densities in Wales since that region still dominated when densities were recalculated excluding Starlings.

5.3.5 Farmland type

Most species showed significant differences in abundance between farmland types (Arable, Pastoral or Mixed) whether this was at the local scale (1-km) or landscape scale (10-km). For 15 of the 26 species tested the ranking of farmland types was identical between local and landscape scales (Table 5.4). For Greenfinch no preference was evident at the local scale yet at the landscape scale a clear preference for Mixed farmland was evident (Table 5.4). At landscape and local scales eight and nine species respectively declined in density from Arable, through Mixed to Pastoral farmland. At both scales the only species to favour Mixed farmland was Fieldfare. At the local scale nine species favoured Pastoral farmland, and a further four favoured Pastoral and Mixed equally over Arable. At the landscape scale, respective figures were seven and four. The majority of these were invertebrate feeders, although surprisingly House Sparrow reached higher density in Pastoral farmland. Of the invertebrate feeders, Golden Plover and Lapwing were unusual in showing a preference for Arable farmland over Mixed and Pastoral. FaBI and Red-list species showed preference for Pastoral over Mixed and Arable farmland types. When the test was re-run without Starling the ranking was reversed with densities greatest in Arable followed by Mixed then Pastoral at both scales. BAP species preferences followed the same ordering. At the local scale, granivores preferred Arable and Mixed farmland equally over Pastoral whereas at the landscape scale Mixed farmland was favoured. In keeping with the individual species responses, invertebrate feeders preferred Pastoral farmland.

These designations of squares into farmland types ignore the fact that in reality a continuum of farmland types exists from wholly arable to wholly pastoral across which species densities changed (Fig. 5.4). Though these graphs show the same general trend as Table 5.4, they indicate more precise preference for different mixtures of arable and pastoral farmland at the species level. For instance Table 5.4 merely indicates that Stock Pigeons equally prefer Arable and Mixed farmland yet Fig. 5.4 indicates that the optimal mixture is around 25% pasture:75% arable at which only 20% of visits recorded no Stock Pigeons. The graphs further indicate the subtle difference between Redwing and Fieldfare, with the former preferring 80% grass and the latter only 55% grass.

As in Table 5.4, the responses of species to arable:grass ratio at the local and landscape scales were largely the same although some differences were apparent. For instance, at the landscape scale Curlew equally preferred completely arable and completely grass areas (Fig. 5.4), however at the local scale a clear preference for grass was apparent. Whereas for Stock Pigeon the optimal % grass at the landscape scale was 25% at the square scale it was 5%. House Sparrows occupied entirely pastoral squares at the landscape scale (Fig. 5.4) whereas at the local scale they preferred a mixture (Table 5.4). Tree Sparrow also showed a preference tending towards mixed farmland at the local scale compared to entirely arable at the landscape scale (Fig. 5.4). In contrast Linnet preferred arable squares within mixed landscapes. Some of these patterns were apparent in the list categories. So for instance, FaBI species preferred mixed squares within pastoral landscapes and BAP species preferred mixed squares within arable landscapes.

5.4 Discussion

This paper presents the first results from a winter survey of birds and their habitats undertaken throughout lowland Britain over three winters. Covering over 400km^2 of farmland and counting approximately 300,000 birds every winter for three years, this comprehensive coverage offers the potential to consider in detail bird data by region, season and habitat. The survey also provides winter habitat data of the type that has proved invaluable in studies of the breeding biology and ecology of birds in summer (e.g. Gates *et al.* 1994, Chamberlain & Fuller 2000). This discussion first considers the broad patterns in bird abundance before examining how habitat availability differs geographically. We then examine differences in bird abundance between farm landscape types before considering the implications for birds of conservation concern and targeting of agri-environment schemes.

5.4.1 Broad patterns of bird abundance

These data provide the first means of assessing the winter distribution of farmland birds since the 1980s. This is especially important given that we may expect ongoing winter range contractions owing to the rapidity of declines in some breeding populations (e.g. Tree Sparrow, Corn Bunting). In general the survey recorded low occupancy rates and low abundance where species were present. Nationally, 10 species were present on less than 10% of visits, 16 species were present on less than 50% of visits. Fieldfare, Common Starling and Song Thrush were present on half of visits and Chaffinch was present on 82% of visits. Whilst low densities may be expected for the declining farmland species it is perhaps a surprise for some of the ‘commoner’ species (e.g. Chaffinch, Greenfinch). This could reflect a methodological problem because the methods used were less detailed than those employed by smaller scale intensive studies such as Buckingham *et al.* (1999) or Hancock and Wilson (2003). However, pilot work suggested that the methods used by volunteer observers here were only likely to underestimate certain species, namely Grey Partridge, Snipe, Meadow Pipit and Sky Lark (Atkinson *et al.* submitted a), so this alone cannot explain the sparsity of finches for instance. This may instead reflect the fact that even relatively common species are now concentrated into a small number of food rich patches within farmland. Intensive studies show that even considering only stubble fields, the vast majority of fields are unoccupied by species such as Skylark and Linnet (Vickery *et al*. 2002). This has been related to the lack of food resources in most fields such that large number of birds aggregate in the small number of fields with high food resources (Robinson & Sutherland 1999). Ongoing analysis of the survey data will examine aggregations of individual species at the field scale.

There are few other surveys at the appropriate scale with which to compare these occupancy and abundance figures. Broadly speaking, percentage occupancy for each species from this survey were positively correlated with those recorded in the summer from the BBS (n = 23 resident species, r_s = 0.93, P < 0.0001; BBS summary data from Raven *et al.* 2003) although many species were more widespread in summer than winter. Whether this indicates differences in detectability between seasons or a measure of aggregation will be examined in the future. Hancock and Wilson (2003) present occupancy in Scottish squares for 13 species. Their occupancy rates were positively correlated with WFBS Scottish occupancy rates (n = 13, rs = 0.90, P < 0.0001) but were generally higher, probably due to the more intensive survey approach.

5.4.2 Regional and landscape differences in habitat composition

At the broad scale considered here WFBS data highlight well established patterns such as the east-west polarisation of arable and grass. On a regional scale these data highlight patterns such as the greater extent of stubbles in Scotland compared to elsewhere in Britain - a feature related to the known prevalence there of spring sowing. Also, the scarcity of farmyards (key feeding sites for granivores) in East England - reflecting the scale of farming enterprises in intensive arable farming. With the exception of grass (which was more abundant in pastoral systems) all broad habitat types were more abundant in arable areas, followed by mixed areas. Future analyses will relate these habitat characteristics directly to bird species abundance. For instance, hierarchical habitat data recorded for all the 18,000 fields surveyed will allow direct assessment of habitat associations and modelling of bird-habitat relationships at various spatial scales. The close agreement between WFBS and agricultural statistics in the areas of cereals and annual changes suggest WFBS data are a reliable source of quantitative data on winter habitats in lowland Britain.

5.4.3 Relationships with farm landscape type

Of the 30 farmland species considered here squares on average supported 7.5 species, though for individual squares species richness ranged from 0 to 20 species. Differences between regions and farmland types were small, so overall for the suite of species considered, species richness was relatively uniform. There was a slight tendency for mixed farming to support more species than arable or pastoral systems. A number of studies have shown that mixed farming is beneficial, both for individual species (e.g. Potts 1986, Chamberlain *et al*. 1999, Brickle *et al*. 2000, Wilson *et al.* 2001), but also more generally across the whole assemblage, especially in winter (e.g. Chamberlain & Fuller 2001, Atkinson *et al.* 2002). This is almost certainly because mixed systems provide a greater diversity of crop and non-cropped habitat types and provide essential resources throughout the year. In fact, based on previous studies one might have predicted more marked differences between mixed, arable and pastoral landscapes. One reason for the small differences may be the restrictive nature of the suite of species considered here. For instance we did not consider hedgerow species (e.g. Robin *Erithacus rubecula*; Dunnock *Prunella modularis*) which might comprise more of the farmland bird community of mixed squares.

Several studies have demonstrated how different farmland bird species are associated with particular types of farmland and have identified a broad suite of species associated with mixed farming in summer and especially winter (Atkinson *et al.* 2002). The patterns of abundance in the present study are generally as one would predict, with granivores most abundant in arable farmland and invertebrate feeders in pastoral farmland. Only one species, Starling, showed a marked difference from the 1980s patterns, perhaps because the apparent association with arable in the 1980s was caused by influxes associated with cold weather. Interestingly, given the ongoing declines, there is no evidence of pronounced contraction into favoured mixed habitats. Considering clear preferences, 7-9 species preferred Arable, and 7-9 preferred Pastoral and only 2-3 preferring Mixed. Bird-habitat relationships are often modified by the scale at which they are studied (e.g. Luck 2002, Robinson *et al*. 2004). Here we considered associations with farm landscape types at the landscape (10-km) and local (1-km) scale since species may prefer different optimum mixtures of grass and arable at different scales. Only six species showed markedly differing associations at the two scales, with three preferring more arable, two more mixed and one more pastoral at the local scale. These differences could reflect regional patterns of local and landscape scale square composition, or they could be genuine responses to scale but the mechanism by which farmland birds respond to mosaics of arable and pastoral farmland (plus their associated non-cropped features) remains unclear. The next stage will be to determine bird-habitat relationships for all species at the field/patch scale (e.g. Gillings & Fuller 2001) but this lies beyond the scope of this paper.

5.4.4 Birds of conservation significance and targeting of AESs

We have attempted to evaluate the current distribution and abundance of farmland birds in the context of three widely used ‘conservation groupings’. The Birds of Conservation Concern (Red list) and BAP species have traditionally provided a focus for policy and action. More recently action has been targeted at FaBI species, the rational being to restore farmland bird breeding populations throughout lowland England and Wales by 2020 - one of the government’s Public Service Agreements and known as the PSA target (Vickery *et al.* 2004). To achieve this PSA target requires habitat management to provide resources in winter, so understanding the distribution and associations of the groups as a whole may aid targeting and identify potential conflicts with other biodiversity groups.

The underlying 'ethos' of the PSA target is that it will result in increased numbers of many of the species throughout their geographical range. Achieving such a target will require action over a very large scale including options within agri environment schemes designed to provide food resources in winter. The extensive distribution of FaBI species throughout lowland farmland (90% of squares contained at least one FaBI species) suggests limited scope for targeting either towards hotspots or 'gaps' in abundance. However, the low density of these species across this broad geographical area suggests management action designed to improve over-winter survival of a range of species will be required over extensive areas of farmland if they are enhance breeding populations at the national level. Encouragingly this is exactly what agri-environment scheme, such as the new Entry-Level Scheme in England, are designed to deliver (Smallshire *et al*. 2004). There is also the scope for targeting more specific options at key species (e.g. High Tier in England), as may be needed for extremely scarce species such as Tree Sparrow and Corn Bunting. However we would also sound a note of caution in relation to targeting management solely to improve the Farmland Bird Index since there is diverse array of other species that use farmland for which the same recommendations may not apply. Species level analysis will be used to examine this in more detail.

5.5 Conclusions

This paper provides the first results from analyses of a unique new data set concerning birds and their habitats in British lowland farmland in winter. It provides novel information on farmland habitats, how they change geographically and seasonally, and how birds respond to these changes and provides a baseline against which to monitor future change. Results highlight the extent to which the current farmland bird community in winter is one of relatively low densities and low species richness throughout Britain. It seems likely that action designed to reverse the fortunes of farmland birds in winter will be required over a wide geographic area if it is to have an impact at the national population level.

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Appendix 1 Summary of the percentage of visits on which a habitat type was recorded in a square and the median area (ha) in those squares where the habitat type was present. Separate results are given for all of lowland Britain, and separately within each of five regions of Britain.

	All		**East**		**North**		**Scotland**		**West**		**Wales**	
No. visits	**6516**		**2338**		**1229**		**863**		**1476**		**610**	
	%	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**
Grass	91	39	81	21	94	38	94	40	98	51	100	73
Crop	66	29	85	39	62	27	51	16	61	21	30	11
Cereal	56	26	77	32	53	25	38	19	50	21	18	7
Stubble	56	14	59	14	55	14	65	19	56	13	33	11
Cereal	46	12	50	12	45	13	62	18	41	10	17	10
Other	66	7	73	12	66	6	66	8	62	5	50	1
Bare till	37	13	48	14	36	11	38	16	29	9	11	6
Farmyard	33	1	28	1	36	1	40	1	32	1	35	1

Table 5.1 List of the 30 target species for WFBS along with various listings of specialisation and threat status and the total number of individuals reported from sample squares across the three winters of the survey.

Target Species	Scientific name	FaBI[1]	Red[2]	BAP[3]	Diet[4]	Total
Grey Partridge	*Perdix perdix*	✓	✓	✓	G	6285
European Golden Plover	*Pluvialis apricaria*				I	17,763
Northern Lapwing	*Vanellus vanellus*	✓			I	52,364
Common Snipe	*Gallinago gallinago*				I	6118
Eurasian Curlew	*Numenius arquata*				I	6329
Stock Pigeon	*Columba oenas*				G	7317
Wood Lark	*Lullula arborea*		✓		G	103
Sky Lark	*Alauda arvensis*	✓	✓	✓	G	55,006
Meadow Pipit	*Anthus pratensis*				I	29,715
Pied Wagtail	*Motacilla alba*				I	10,896
Stonechat	*Saxicola torquata*				I	709
Fieldfare	*Turdus pilaris*				I	166,744
Song Thrush	*Turdus philomelos*		✓	✓	I	13,312
Redwing	*Turdus iliacus*				I	86,387
Mistle Thrush	*Turdus viscivorus*				I	7102
Common Starling	*Sturnus vulgaris*	✓	✓		I	290,889
House Sparrow	*Passer domesticus*		✓		G	31,928
Eurasian Tree Sparrow	*Passer montanus*	✓	✓	✓	G	4867
Chaffinch	Fringilla coelebs				G	115,151
Brambling	*Fringilla montifringilla*				G	1147
European Greenfinch	*Carduelis chloris*	✓			G	23,724
European Goldfinch	*Carduelis carduelis*	✓			G	20,330
Common Linnet	*Carduelis cannabina*	✓	✓	✓	G	44,993
Twite	*Carduelis flavirostris*		✓		G	1403
Lesser/Mealy Redpoll	*Carduelis cabaret/flammea*				G	1046
Common Bullfinch	*Pyrrhula pyrrhula*	✓	✓		G	3367
Snow Bunting	*Plectrophenax nivalis*				G	285
Yellowhammer	*Emberiza citrinella*	✓	✓		G	28,066
Reed Bunting	*Emberiza schoeniclus*	✓	✓	✓	G	5806
Corn Bunting	*Emberiza calandra*	✓	✓	✓	G	2671

[1] FaBI = Species included in the governments 'Farmland Bird Indicator'
[2] Red = Species red-listed as Birds of Conservation Concern (Gregory *et al.* 2002)
[3] BAP = Biodiversity Action Plan species
[4] Diet = G = species depending primarily on grain or vegetable matter during winter
I = species depending primarily on invertebrates during winter

Table 5.2 Results of Ordinal Logistic Regression testing for differences in area of different habitat types between regions and between squares classified as Arable, Marginal or Pastoral (A, M, P respectively) either at the 10-km resolution (landscape scale) or 1-km resolution (local scale). Habitats in italics are subcategories of the main types. * = $P < 0.05$, *** = $P < 0.001$. Likelihood Ratio (LR) tests of model improvement by adding region or square type are given. Note that in one case (Farmyard at local scale) the test was significant yet the ranking could not be determined clearly. For regional rankings, Wa = Wales, S = Scotland, E, N, W = East, North or West Englanfd respectively.

Habitat	**Region**		**Landscape scale**		**Local scale**	
	Rank	**LR χ^2_4**	**Rank**	**LR χ^2_2**	**Rank**	**LR χ^2_2**
Grass	Wa>W>S=N>E	1618.7***	P>M>A	2511.5***	P>M>A	2895.7***
Crop	E>N>W>S>Wa	1289.3***	A>M>P	1867.5***	A>M>P	2351.9***
Cereal	E>N>W>S>Wa	1104.6***	A>M>P	1507.0***	A>M>P	1917.0***
Stubble	S>(E=N=W)>Wa	184.7***	A>M>P	441.9***	A>M>P	739.4***
Cereal	S>E>N>W>Wa	373.5***	A>M>P	513.6***	A>M>P	812.1***
Other	E>S=N>W>Wa	380.7***	A>M>P	811.3***	A>M>P	771.9***
Bare till	E>S=N>W>Wa	354.7***	A>M>P	855.7***	A>M>P	857.1***
Farmyard	S>N=W=Wa>E	52.2***	-	4.7 ns	(M=A=P)	7.0*

Table 5.3 The percentage of visits on which a species was recorded and the median density (birds/km^2) for occupied squares across lowland Britain, and separately within each of five regions of Britain. Because most species were highly localised the table summarises the percentage of visits on which a species was recorded, and then the median density within occupied squares.

	All		East		North		Scotland		West		Wales	
No. of visits	**6648**		**2392**		**1249**		**883**		**1501**		**623**	
	%	**d**	**%**	**d**	**%**	**d**	**%**	**d**	**%**	**d**	**%**	**d**
Grey Partridge	13	7	15	6	22	9	22	9	4	5	3	7
European Golden Plover	4	24	6	31	4	21	2	15	2	43	2	39
Northern Lapwing	13	30	15	34	18	24	13	26	8	29	10	41
Common Snipe	15	4	10	3	17	4	18	4	18	6	24	7
Eurasian Curlew	5	14	4	11	5	7	12	29	2	35	5	12
Stock Pigeon	15	5	21	4	12	6	9	4	17	5	6	5
Wood Lark	>1	8	1	5	0	0	0	0	>1	17	0	0
Sky Lark	43	10	55	10	36	9	42	11	39	12	21	10
Meadow Pipit	35	10	35	7	26	9	27	6	46	17	43	14
Pied Wagtail	38	4	35	3	35	4	26	3	49	5	43	4
Stonechat	5	3	3	3	1	2	5	2	9	3	11	4
Fieldfare	51	38	51	38	54	41	38	23	56	45	47	35
Song Thrush	52	4	52	4	44	3	33	3	63	6	67	7
Redwing	45	26	37	16	44	26	29	18	59	37	62	42
Mistle Thrush	40	4	41	3	48	5	28	3	35	4	48	4
Common Starling	51	47	42	26	55	59	54	39	54	61	72	104
House Sparrow	40	15	35	12	43	18	39	15	42	16	46	16
Eurasian Tree Sparrow	8	8	4	6	16	9	17	9	3	5	4	4
Chaffinch	82	18	80	15	79	16	77	18	88	22	86	18
Brambling	2	6	2	5	2	3	2	5	2	10	1	20
European Greenfinch	41	7	45	7	39	7	34	7	45	8	30	6
European Goldfinch	26	8	29	7	26	9	21	8	28	8	21	9
Common Linnet	19	18	19	15	16	10	29	31	18	24	12	18
Twite	>1	26	>1	10	1	81	2	13	0	0	>1	7
Lesser/Mealy Redpoll	2	7	1	8	2	6	3	5	2	9	2	6
Common Bullfinch	19	4	22	3	13	4	6	3	23	4	29	3
Snow Bunting	>1	3	>1	2	0	0	1	5	>1	3	0	0
Yellowhammer	37	8	43	7	37	10	43	10	31	10	14	7
Reed Bunting	14	5	16	5	17	6	20	4	7	4	8	11
Corn Bunting	3	6	4	6	3	3	2	20	3	6	>1	17
FaBI	90	61	91	44	91	72	90	68	90	66	88	94
Red	92	56	91	40	92	62	91	64	93	66	95	90
BAP	81	15	85	15	76	15	76	23	83	16	81	11
Granivore	94	55	94	52	96	56	92	63	95	64	95	42
Invert.-feeder	92	84	91	59	93	88	88	48	95	125	98	161

Table 5.4 Results of Ordinal Logistic Regression testing for differences in density between squares classified as Arable, Marginal or Pastoral (A, M, P respectively) either at the 10-km resolution (landscape scale) or 1-km resolution (local scale). * = P < 0.05, ** = P < 0.01, *** = P < 0.001. LR χ^2_2 is the likelihood ratio test of model improvement by adding square type. Note that in one case (Goldfinch) the test was significant yet the ranking could not be determined clearly. A:G is the arable:grass ratio at which density peaked for each species, based on OLR using continuous variables (as in Fig. 5.4) rather than categories.

Species	**Landscape scale (10-km)**			**Local scale (1-km)**		
	Rank	**LR χ^2_2**	**A:G**	**Rank**	**LR χ^2_2**	**A:G**
Grey Partridge	A>M>P	289.6***	100:0	A>M>P	228.2***	100:0
European Golden Plover	A>M=P	120.1***	100:0	A>M=P	92.2***	100:0
Northern Lapwing	A>M=P	27.1***	100:0	A>M=P	37.5***	100:0
Common Snipe	P>A=M	213.9***	0:100	P>M>A	133.8***	0:100
Eurasian Curlew	A=P>M	13.8**	†	P>A=M	25.1***	0:100
Stock Pigeon	A=M>P	57.2***	75:25	A=M>P	23.9***	95:5
Sky Lark	A>M>P	430.8***	100:0	A>M>P	576.9***	100:0
Meadow Pipit	P>M>A	35.9***	0:100	M=P>A	31.1***	0:100
Pied Wagtail	M=P>A	73.9***	35:65	M=P>A	52.6***	35:65
Stonechat	M=P>A	46.6***	0:100	P>M>A	30.7***	0:100
Fieldfare	M>P>A	46.9***	45:55	M>P>A	72.3***	45:55
Song Thrush	P>M>A	138.1***	20:80	M=P>A	151.6***	25:75
Redwing	P>M>A	424.1***	20:80	P>M>A	440.8***	15:85
Mistle Thrush	P>A=M	25.9***	0:100	P>M>A	69.3***	0:100
Common Starling	P>M>A	462.5***	0:100	P>M>A	517.8***	0:100
House Sparrow	P>M>A	59.4***	0:100	P>M>A	53.2***	35:65
Eurasian Tree Sparrow	A>M=P	36.7***	100:0	A>M=P	61.0***	85:15
Chaffinch	M=P>A	141.0***	35:65	M=P>A	106.4***	40:60
European Greenfinch	M>A>P	61.2***	55:45	A=M=P	4.9 ns	55:45
European Goldfinch	M>A>P	29.0***	55:45	(M>A=P)	6.9*	50:50
Common Linnet	A=M>P	55.2***	70:30	A>M>P	92.2***	85:15
Lesser/Mealy Redpoll	A=M=P	3.3 ns	0:100	P>A=M	11.2**	0:100
Common Bullfinch	M=P>A	73.6***	30:70	P>M>A	85.2***	0:100
Yellowhammer	A>M>P	340.1***	75:25	A>M>P	384.5***	75:25
Reed Bunting	A>M=P	56.4***	100:0	A>M=P	29.8***	100:0
Corn Bunting	A>M>P	63.2***	85:15	A>M>P	86.6***	100:0
FaBI	P>A=M	21.6***	0:100	P>M>A	27.8***	30:70
Red	P>M>A	92.3***	0:100	P>M>A	77.5***	0:100
BAP	A>M>P	119.3***	70:30	A>M>P	154.5***	100:0
Granivore	M>A>P	33.2***	50:50	A=M>P	28.5***	55:45
Invert.-feeder	P>M>A	333.9***	0:100	P>M>A	436.3***	0:100

† Eurasian Curlew abundance peaked at ratios of both 0:100 and 100:0 (see Fig. 5.4).

Figure 5.1 Map showing the five regions used for analysis of WFBS data: A = Scotland, B = North England, C = Wales, D = West England, E = East England. Regions based on countries and in England, government administrative regions.

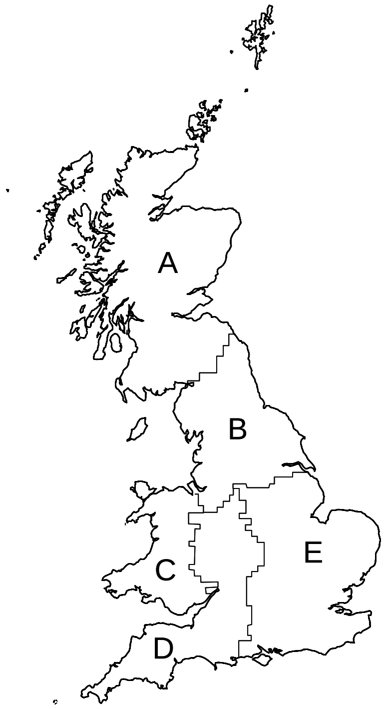


Figure 5.2 Division of Britain into Arable (grey), Mixed (black) and Pastoral (white) 10-km squares based on the *LCM2000* dataset.

Figure 5.3 Maps showing the geographic spread of coverage achieved in each of the three winters. In each case the uplands, which were excluded from square selection, are shown in grey.

Winter 1 (n = 868) Winter 2 (n = 801) Winter 3 (n = 745)

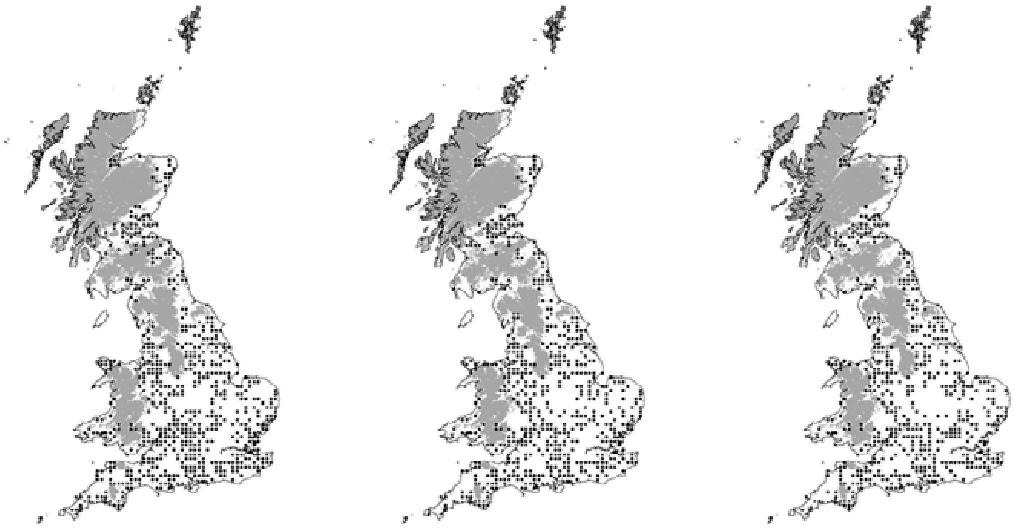


Figure 5.4 Estimated abundance plots of farmland birds in relation to the percentage of farmland under grass production. Each graph shows the cumulative percentage of visits on which different densities of birds were present. The solid line indicates the percentage of visits where none of a species was present. For individual species graphs, the dashed line shows the percentage of visits on which between zero and the non-zero median density (value given in superscript) was reported. For ease of interpretation and comparison with Atkinson *et al.* (2002) the y-axis has been inverted. For the last five graphs, lines represent zero density, lower quartile density, median density (as above) and upper quartile density. Cut-offs are again shown in superscript. For a list of species falling in each category see Table 5.1.

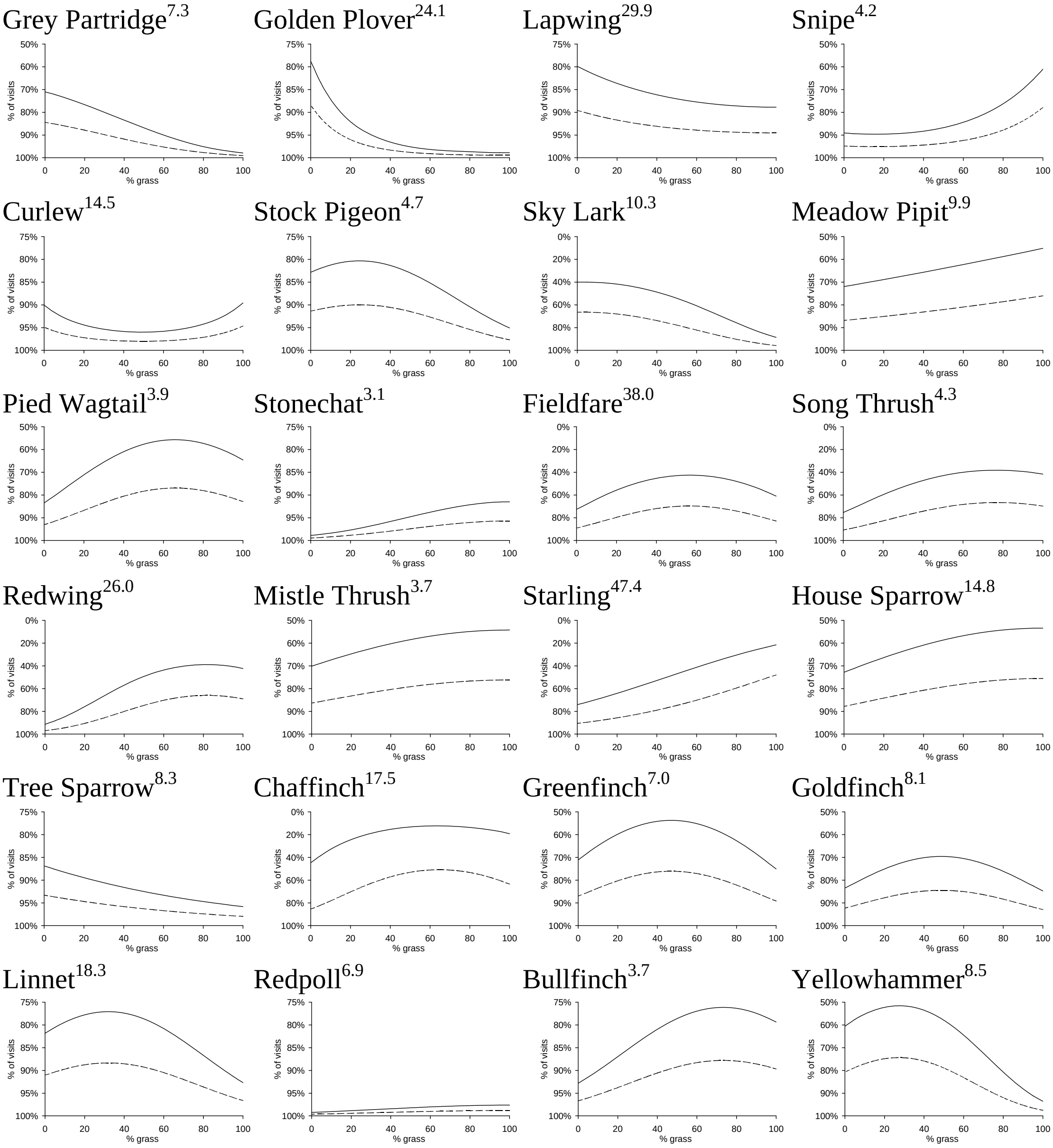
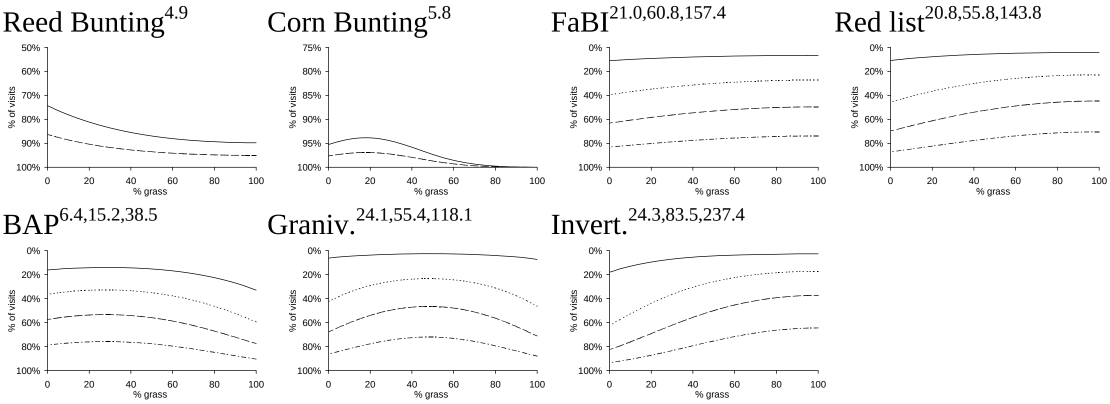


Figure 5.4 Continued**.**



6. PREDICTIVE POWER AND REGIONAL GENERALITY OF WINTER DISTRIBUTION MODELS OF FARMLAND BIRDS

6.1 Introduction

The decline of farmland birds in Britain and north-west continental Europe is widely documented (Fuller *et al*. 1995; Donald *et al*. 2001b), as are the causal links to changes in agricultural practices (Aebischer *et al*. 2000; Chamberlain *et al.* 2000). Demographic studies (e.g. Siriwardena *et al*. 1999) have highlighted the importance of non-breeding season mortality for some species. On the basis of this, many studies have now investigated the winter ecology of farmland birds, including broad habitat association surveys (Gillings and Fuller 2001; Wilson *et al*. 1996), detailed autecological studies (Donald *et al*. 2001a; Devereux *et al*. 2004) and correlative studies of the factors potentially impacting on population trends (Gillings *et al*. 2005). Increasingly, research is focussing on management solutions, by monitoring seed-rich habitats such as game cover crops (e.g. Henderson *et al*. 2004; Parish *et al*. 2004), through experimental manipulation of artificial food patches (Siriwardena *et al*. 2006), and evaluation of agri-environment schemes (AES) (Bradbury *et al*. 2004; Vickery *et al*. 2004).

Our knowledge of habitat requirements would now appear to be sufficiently well developed that we can make strong predictions about the effects of different management options. However, Chamberlain *et al*. (2004) showed that, even for five relatively well-studied species, rule-based models using expert knowledge performed extremely poorly at predicting species distributions. Several studies (e.g. Robinson *et al*. 2001, Bradbury *et al*. 2004, Tscharnkte *et al*. 2005) shows that the effects of providing suitable habitat may be context dependent. Similarly, Siriwardena and Stevens (2004) showed that use of artificial food patches by granivorous birds differed between species in relative unpredictable ways, and also in relation to local habitat configuration and availability. Thus there remain questions concerning our ability to produce robust predictive models of species distributions and in the generality of predictor variables across species and regions. Were such generalities to exist, we might have high expectations that generic AES would bring about desired recoveries in national breeding populations of farmland birds. Whittingham at al. (2003) tackled this issue by building detailed models of Skylark *Alauda arvensis* breeding distribution in one region and testing the ‘transportability’ of those models to other regions. For this species they found models to be good predictors of relative but not absolute abundance. Thus for this species, uniform management measures were likely to yield qualitatively similar benefits in all regions. However, in a larger study involving 11 breeding species, the effects of predictor variables differed between regions (Whittingham *et al*. 2007). This is more concerning, suggesting there is no single ‘fix’ that will work for all species.

In this study we ask similar questions but concerning farmland birds and habitats in winter. Given that over-winter survival is a key demographic factor underlying many population trends (Siriwardena *et al*. 2000), and that many of the AES options promote habitat features that provide winter food, it is important to investigate the strength and generality of species distribution models in winter. We use data from an extensive winter survey of farmland birds and their habitats (Gillings *et al*. in press) which provides a unique resource to model contemporary bird distributions in winter. We ask four questions: 1, how do different types of predictor variables contribute to describing species distributions?; 2, can robust models with high predictive power be constructed for individual species in winter?; 3, do particular variables, with biologically-realistic interpretations, consistently predict the presence of species with similar ecological requirements?; and 4, how general are models trained in one region when applied to other regions? Answering these questions will provide insights into the design and expected performance of AES for birds in winter.

6.2 Methods

6.2.1 Survey data

This analysis uses data from the BTO/JNCC Winter Farmland Bird Survey (see Gillings *et al*. in press for full details). During each of three winters (1999/2000-2002/03) up to three visits were made to sample 1-km squares throughout the lowland farmland areas of Britain. Volunteer observers surveyed the farmland within these squares for a suite of farmland species (Table 6.1) and recorded field habitat, boundary features and management information. The large between-visit differences in habitat availability and the bird community allows visits to the same square to be treated as independent. The initial sample of squares was stratified across five regions, broadly Scotland and Wales, plus North, West and East England (Gillings *et al*. in press). These data provide an opportunity to describe habitat associations through logistic regression modelling and to test the strength of these models, both nationally, and in regions other than in which they were trained, thus assessing the generality of models. Given that we are dealing with 25 species, five regions and a large number of potential independent variables the number of candidate models is large, as is the potential for spurious associations. Rather than tabulate the results for all species or apply overly-conservative significance corrections we sought general patterns across ecologically similar species by assigning species into three functional groups on the basis of their diet (Cramp and Simmons 1977): predominantly invertebrate feeders, predominantly granivorous, and omnivorous (mainly invertebrates and fruit) (Table 6.1).

6.2.2 Data analysis

Multiple binary logistic regression was used to identify models describing the distribution of each species. Though the original survey method involved counting birds, for most species the distribution of counts was extremely skewed, with a high proportion of zeroes, making Poisson regression inappropriate. Ordinal logistic regression was investigated, but the frequency distribution of counts was such that models mainly described the distinction between absence and presence. Therefore, we performed binary logistic regression and scored each species as 1/0 for presence/absence during the visit. The variable EFFORT was defined as the total area of farmland surveyed in the sample square on a particular visit. This was used in all models to control for variation in effort between squares or visit (because the area of farmland in a 1-km square is variable and a variable proportion of total farmland was surveyed during the 4 hr timed visit.

We identified six categories of variables, arranged in a hierarchy of complexity and scale: Broad habitat (H), Specific habitat (S), Management (M), Boundary type (B), Square context (L1) and Landscape context (L3) (Table 6.2). H variables described the broad mix of crops, grass or stubbles within the square, whereas S variables described, for example, the actual types of crops present, and M variables described the results of certain management practices (e.g. whether a stubble field was weedy). B variables gave a relative measure of the availability of field boundary features within the square and their derivation is detailed in Appendix 2. All these variables were taken directly from habitat information provided by observers on each visit to their square. L1 and L3 variables were derived from Landcover Map 2000 data (Fuller *et al*. 2002). L1 variables quantified the availability of the main habitat types within the sample square. Birds may also be influenced by surrounding habitat (e.g. Fuller *et al* 1997) so L3 variables quantified habitat availability in a 3km × 3km square centred on the sample square. Whilst the choice of square size is to some degree arbitrary, a 3-km square was selected based on the short movements of many farmland passerines (Siriwardena *et al*. 2006), although we accept that some of the species studied may move further.

Models were built using stepwise regression. A stepwise procedure was used for several reasons. Firstly, the large number of species (25) and variables (61) made computing all candidate models impractical. Moreover, we were principally interested in certain combinations of categories of variables and building models in a hierarchical manner. Variable reduction via principal components analysis was investigated, but whilst the first two axes were informative, reflecting a grass–arable gradient and a farmland–non-farmland gradient, further axes could not be interpreted. We therefore opted to retain the original variables. Prior to performing the stepwise procedure we tested for multicollinearity among the variables using the TOL options in the SAS REG procedure and removed three variables with low tolerance (<0.4, Allison 1999). These were arable and grass variables which were highly inter-correlated. Stepwise multiple logistic regression was performed in the SAS LOGISTIC procedure (SAS Institute 2001). EFFORT was forced into all models to control for effort prior to considering other variables. These were then entered via a stepwise procedure using a significance level of 0.05 for the Wald chi-square. Models were compared using the Akaike's Information Criterion (AIC) and the best model was that with the lowest AIC value.

6.2.3 Modelling procedure

At the national level, 10 models were produced for each species: six multivariate models each containing variables of only one category (denoted models H, S, M, B, L1 and L3) to test the relative importance of each category of variables to the species concerned; four models that sequentially added a 'higher' category of variable as follows: SM, SMB, SMBL1 and SMBL1L3. Note that H variables could not be included in these models since H and S variables could be expressed as linear combinations of one another.

To test for over-fitting, the dataset was randomly divided in half into a training dataset and an evaluation dataset. Rather than using Cohen's Kappa or other statistics that rely on dichotomisation of the predicted probabilities, and can be biased by prevalence (Fielding 2002), we used the concordance statistic *C* to compare model predictive power (Vaughan and Ormerod 2005). *C* has a clear interpretation as the probability that the model will correctly assign an occupied and an unoccupied site in the correct order of likelihood of occupancy (Harrell *et al*. 1982, cited in Vaughan and Ormerod 2005) and is equivalent to the area under a Receiver Operating Characteristic (ROC) Curve. *C* was chosen because it could be calculated for both the training and evaluation predictions and because it is unbiased by prevalence. *C* values range from 0.5 to 1 and values in the range 0.5-0.7 are generally regarded as poor, those >0.7 as adequate. We define C_t and C_e as the *C* statistic derived from the training and evaluation datasets respectively, and ΔC as the difference C_t-C_e which is a measure of model over-fitting. For the best model (minimum AIC), 95% confidence limits for C_e were calculated by boot strapping with replacement (200 iterations; Pearce and Ferrier 2000, Vaughan and Ormerod 2005).

Only species present on at least 10% of visits in all five regions were used in the regional analysis. The same 10 types of model were fitted, and at each stage C_t, C_e and ΔC were calculated, along with the C_{region} statistic for the model when applied to the whole dataset (i.e. training and evaluation halves) from each of the other four regions. For each species we looked for consistency in the variables retained in best models, and considered how well models predicted distributions in remote regions from where they were trained. The latter was determined by comparing the C_e for the training region and C_{region} for the evaluation region in question.

6.3 Results

In all, there were 6432 square visits, distributed as follows across the five regions: East = 2281, North = 1222, West = 1474, Scotland = 845 and Wales = 610. Species varied in overall prevalence from 3% to 83%, and regionally, only 14 species were recorded on at least 10% of square visits in all regions (Table 6.1). These differences in prevalence dictate the use of an unbiased measure of prediction success such as *C*.

6.3.1 National models – single category models

For all species, all single category models were a significant improvement on the intercept only model. In terms of the types of variables best explaining distributions, for 11 species the S model was the best single-category model (ΔAIC greater than 2 from next best model), and for five species B models were best (one species S model and B model indistinguishable on AIC). The number of species in each functional group associated with different variables is given in Table 6.3. For H models, three invertebrate-feeder and four omnivorous species were positively associated with Grass, but generally no significant associations were apparent. Nine granivore species were positively associated with Stubbles, and 7 with Farmyard. There were too many S variables to tabulate comprehensively, but for invertebrate feeders, the habitat types most commonly registering positive parameters were Improved grass, Potato crop, Maize stubble and Sugar beet stubble (all three species each). For omnivores the top habitats (number of species in brackets) were Improved grass (5), Orchard (5), Maize stubble (4) and Fodder crop (3); similarly for granivores: Cereal stubble (10), Farmyard (7), Maize stubble (6) and Gamecover crop (6). Some invertebrate feeders were associated with Flooding and Grazers, the latter also for omnivores (Table 6.3). Granivores were strongly associated with Weedy stubble, and to a lesser extent with Gamecover crop (Table 6.3). No clear patterns were evident for boundary features with the exception of omnivores for which a greater proportion were associated with hedges and tree-lines. The results for L1 and L3 models were almost identical: invertebrate feeders and omnivores were negatively associated with arable and most other habitats, and therefore by correlation, positively associated with grass. Granivores species were positively associated with arable and urban (Table 6.3).

6.3.2 National models – multi-category models

Table 6.4 shows the effect on model AIC of adding variables of increasing complexity and scale. For all species except Partridge, addition of M variables increased model fit, as did the subsequent addition of B variables for all species. With the exception of Linnet, addition of either or both of the sets of landscape variables increased model fit. For the majority of species the final best model contained S, M, B and one or more L variables (all full models are given in Appendix 2). However, although in all cases C_e was significantly different from 0.5, indicating that models performed better than chance, almost half were in the 0.5-0.7 range of poor predictive power, and the rest were only slightly better in 0.7-0.8 range. Only one species, Corn Bunting, had a model with C_e >0.8. The greatest ΔC was 0.05, and on average across all species was only 0.02, indicating no over-fitting problems.

6.3.3 Regional models

Regional models were produced for 14 species. Like national models, mean C_t (averaged across species) was 0.71-0.72 but C_e values were on average lower than for national models, being in the range 0.63-0.67. Although over-fitting was generally not a problem, with average ΔC values of 0.05 for East, North and West regions, 0.06 for Scotland and 0.07 for Wales, 10 individual models had ΔC values greater than 0.10. All the C_e and C_{region} values for regional models are given in Table 6.5. In general, models trained in the East were most transportable: C values were on average higher for models trained in the East region, and for each region ,7 or more of the 14 species were best predicted by a model from the East. In contrast, there was no single region that consistently predicted distributions in the East region. There were few consistent patterns for species, or functional groups. Snipe were best predicted by Scotland models, and in Scotland, by Wales. Meadow Pipit were best predicted by East models, and in East, by West. Goldfinch was unusual in being best predicted by models from East and Wales.

A range of variables were consistently present in models from three, four and rarely all five regions (Table 6.6). Linnet was the only species for which there was no consistency across regional models. Specific habitat and management variables were rarely retained in a consistent manner across species, whereas context variables (L1 or L3) were present in models for eight of the 14 species (Table 6.6).

6.4 Discussion

We use a large dataset of winter farmland birds and their habitats to answer questions about the predictors of, and regional generality in, winter distribution patterns. There are no other datasets available on this scale to assess such questions and our findings offer interesting insights into the ease with which winter distributions can be predicted and the factors limiting distributions. These issues are particularly topical given current interest in AES, their effectiveness and monitoring. In discussion of these results we return to the four questions outlined in the introduction.

1. How do different types of predictor variables contribute to describing species distributions?
For almost all species there was an improvement in model fit with the addition of management and boundary habitat variables, most of which were retained in best models. It is unclear why Linnet was the only species that did not show any model improvement (often quite large) with the addition of either (or both) square or landscape context variables. For all other species, this general pattern is in agreement with other studies of farmland birds that show context dependent use of food patches and habitat features in winter (Bradbury *et al*. 2004; Siriwardena *et al*. 2004). Also, Robinson *et al*. (2001) showed that the addition of arable habitats had a more pronounced affect on breeding farmland birds in pastoral landscapes than in arable landscapes. Taken together these studies mean that the use of AES by birds will probably depend upon the surrounding habitats. Recent calls for better monitoring of AES (Klein and Sutherland 2003) should also heed these results because unless monitoring schemes pay attention to landscape context, the apparent effectiveness of AES could be masked.

2. Can robust models with high predictive power be constructed for individual species in winter?
The work presented here suggest that bird distributions in winter were relatively poorly predicted by models based on farmland habitat type, boundary features, management and landscape context. There are several possible explanations for poor model performance. First, distributions may be 'inherently unpredictable' (Fielding and Haworth 1995). At the 1-km scale, winter distributions may be more volatile than breeding distributions because they reflect flocks nomadically following crop and agricultural practices rather than individuals tied to territories. Winter distributions may therefore give rise to similar problems to those encountered when measuring presence in unsaturated habitats. On one hand, repeated visits may have alleviated this problem, whilst also compounding the problem due to change in habitat availability between visits. Second, we may have failed to measure the ultimate causes of occupancy. Within farmland landscapes there are aspects of habitat quality that are very difficult to measure as part of an extensive survey. For instance, intensive studies tell us that granivorous passerines aggregate in only a fraction of stubble fields, and that these are the ones with an abundance of weed seeds (Vickery *et al*. 2002). Whilst volunteers can score 'weediness', they cannot be expected to provide it more quantitative data. Similarly, the use of pastures may be related to fine-scale variation in sward structure and prey availability (Perkins *et al*. 2000; Atkinson *et al*. 2005) but ascertaining this involves detailed measurements for which there may not be 'volunteer-friendly' proxies. For farmland birds, providing data on the finer elements of habitat quality for large-scale distribution modelling exercises is likely to be prohibitively costly but it would be worth investigating whether better indicators of habitat quality could be developed for use in extensive surveys. Third, we may have inaccurately recorded presence. Due to low detectability in winter, it is conceivable that flocks of birds were missed, giving 'false negatives' in the training data and less predictable 'true positives' in the evaluation data. Whilst under-detection is a serious concern for extensive winter surveys, pilot work has shown that this is generally only a problem for a small number of species, including Skylark, a species of particular conservation concern (Atkinson *et al*. 2006). Reassuringly, the Skylark model achieved the second highest predictive power of all national models.

3. Do particular variables consistently predict the presence of species with similar ecological requirements?
There was little generality in the types of variables explaining national distributions across individual species. However, when summarised by functional groups of species with similar diet there was more

consistency in line with published studies. For instance, 10 of the 13 granivorous species were positively associated with weedy stubbles. Management variables known to be positively associated with abundance or availability of invertebrates and weed seeds were positively associated with some but not all invertebrate feeders and granivores respectively. Parish *et al*. (1994, 1995) found association between bird species richness, and the abundance of individual species in winter and hedgerow size and structure. Though we found no clear patterns at the functional group level, many individual species showed associations with one or more types of boundary feature.

4. How general are models trained in one region when applied to other regions?

There was little drop in predictive power when models were trained in one region and evaluated in another, which initially suggests high regional generality of models. However, this is perhaps simply a result of relatively poor predictive power in the training region itself.

Although the true transportability of models is difficult to rigorously assess it is notable that variables relating to square or landscape consistently featured in many regional models. This suggests that landscape context is an important factor influencing bird habitat associations, a finding supported by work elsewhere (e.g., Robinson *et al*. 2001, Bradbury *et al*. 2004, Tscharnkte *et al*. 2005, Whittingham *et al*. 2007). Such regional specificity has extremely important implications for the design and targeting of options within AES. Although individual species are likely to have the same broad resource requirements at a national scale the sorts of habitats that provide those resources most cost-effectively may vary locally or regionally. For example, the creation of a habitat that is generally scarce in the surrounding landscape may be much more effective in providing resources (and hence appear much more important in bird-habitat models) than the same habitat in a 'richer' landscape (e.g. Robinson *et al*. 2001). Although detailed ecological research on a range of species in different regions and landscape types would be highly costly we do urge caution in relation to AES and management recommendations deployed at national scales. Careful monitoring and evaluation of their effectiveness in different parts of the country may provide highly valuable information in relation to the most cost effective deployment of options and combinations of options in different regions.

Alternatively, poor generality may not necessarily indicate different preferences between regions. For instance, winter habitat use by Lapwings differs between regions (Gillings and Beaven 2004). One interpretation of this is that the species rapidly adjusts to local conditions, in which case regional generalities are not to be expected. An alternative is that winter habitat use is temperature mediated (Shrubb 2007), in which case, regional generality can only be accomplished by building models that include parameters for climate-habitat interactions.

6.5 Conclusions

We find that despite using a large dataset on farmland birds and their habitats, we cannot produce powerful models of presence that can be effectively applied throughout the farmed regions of Britain. Whilst the majority of patterns we find are in agreement with intensive studies, the importance of landscape context variables for almost all species is notable. The main implication of this is that management aimed at restoring farmland bird populations must take account of the surrounding landscape matrix. Likewise, any studies aiming to evaluate the success of such management must consider the possible interaction between bird usage and landscape context.

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Appendix 1 Derivation of relative abundance measures for boundary features

For each field, observers were asked to report an ordinal series of boundary codes (8 types) in decreasing order of presence in the perimeter. Codes could be reported either as a list, simply implying progressively less of each boundary type, or with equal signs between pairs (or triplets etc) of codes to denote equal quantities of those types. For instance, LH TH=TL=F implies that the boundary around the field was predominantly low hedge, followed by equal quantities of tall hedge, tree line and fence/wall.

These ordinal scores were converted to continuous relative abundance scores using three simple rules. First, scores for a field must sum to 100%. Second, each code in a series was assumed to contribute 25% less to the boundary than the preceding type. Third, boundary types linked by an equals sign were given a score equal to the average of the score they would have received had there been no equals sign. So a field with two types had 57% of the 1st and 43% of the 2nd; a field with six types had the following sequence of score 30%, 23%, 17%, 13%, 10%, 7%; a field with 3 types TH LH=BB corresponds to the 43/32/24 score set and the LH and BB each receive a score of 28% (the average of 32 and 24).

All more complex sequences of codes and equalities could be dealt with using these simple rules, to provide relative abundance scores for each boundary type in each field. These were multiplied by the perimeter length, summed across all surveyed fields in a square, then divided by the total perimeter length in the square, to give an overall estimate of the relative availability of each boundary type in the sample square.

Appendix 2 Results of national logistic regressions, showing the variables (and sign of parameter estimate) retained in the final best model for each species. See Table 6.2 for variable definitions and Table 6.3 for AIC values.

Species	Retained variables
Partridge	+C_POTATO +C_OILSEED +C_CARROT +S_CEREAL –S_MAIZE +S_OILSEED +SUPPFEED -LOWHEDGE -TALLHEDGE +ARABLE3KM +SEA3KM +URBAN3KM
Golden Plover	+C_OTHER +ORCHARD +DITCH +LOWHEDGE +ARABLE1KM +SEA1KM -WOODLAND3KM
Lapwing	+C_GAMECOVER +C_POTATO -G_IMPROVED +S_OTHER +S_BEET +FLOODING +MANURE +DITCH +OTHERBDY -ARABLE3KM -WOODLAND3KM
Snipe	-C_FODDER +S_BEANS +FLOODING +DITCH +TALLHEDGE -BUILDING +PERIMETER -ARABLE1KM -URBAN1KM -URBAN3KM -WOODLAND1KM
Curlew	+G_OTHER +S_LINSEED +S_BEET +FLOODING -LOWHEDGE -ARABLE3KM +SEA3KM -WOODLAND3KM
Stock Dove	+C_FODDER -C_CARROT +FARMYARD +MANURE -FENCEWALL +PERIMETER -ARABLE1KM +ARABLE3KM -URBAN1KM +URBAN3KM
Skylark	+BARETILL +C_CARROT -G_IMPROVED +ORCHARD +S_BEANS +S_CEREAL +MANURE +WEEDY -TREELINE +ONLYVEG +OTHERBDY +ARABLE1KM +SEA1KM
Meadow Pipit	-C_CEREAL -C_GAMECOVER +OTHER +FLOODING +SUPPFEED +WEEDY +DITCH +TALLHEDGE -BUILDING -FENCEWALL -LOWHEDGE +PERIMETER -ARABLE3KM +SEA3KM +S_MAIZE -URBAN3KM -WOODLAND1KM
Pied Wagtail	+C_FODDER +C_POTATO +FARMYARD +G_IMPROVED +ORCHARD +PIGFARM +OTHER +S_CEREAL +S_LINSEED +S_MAIZE +S_BEET +GRAZER +MANURE +SUPPFEED -FENCEWALL +OTHERBDY +PERIMETER +URBAN3KM
Stonechat	+S_FODDER +S_MAIZE +GRAZER +DITCH -ARABLE3KM +SEA3KM -URBAN1KM
Fieldfare	-BARETILL +C_BEANS +C_CEREAL +G_IMPROVED +ORCHARD +S_MAIZE +S_OILSEED +GRAZER +MANURE +TALLHEDGE +TREELINE -SEA3KM -URBAN3KM -WOODLAND1KM
Song Thrush	+C_OILSEED -G_UNIMPROVED +ORCHARD +MANURE +SUPPFEED +WEEDY -FENCEWALL +TALLHEDGE +TREELINE +PERIMETER -ARABLE3KM -URBAN3KM
Redwing	-BARETILL -C_BRASSICA -C_OILSEED +C_FODDER +G_IMPROVED +ORCHARD +S_MAIZE -S_POTATO +FLOODING +GRAZER +MANURE -DITCH -FENCEWALL +LOWHEDGE +TALLHEDGE +TREELINE +ONLYVEG +PERIMETER -ARABLE1KM -SEA3KM -URBAN1KM
Mistle Thrush	+C_CARROT -G_UNIMPROVED +ORCHARD +FLOODING +GRAZER +OTHERBDY -DITCH -LOWHEDGE +PERIMETER -SEA1KM +WOODLAND1KM +WOODLAND3KM
Starling	+C_LINSEED +FARMYARD +G_IMPROVED +G_UNIMPROVED +ORCHARD +S_OILSEED +S_BEET +GRAZER +SUPPFEED +BUILDING -LOWHEDGE +PERIMETER -ARABLE1KM -WOODLAND1KM
House Sparrow	+C_BEET +FARMYARD +PIGFARM -S_POTATO +GRAZER +MANURE +BUILDING -DITCH +PERIMETER -SEA3KM -WOODLAND1KM
Tree Sparrow	+BARETILL +C_OILSEED +C_CARROT +FARMYARD +S_CEREAL +S_MAIZE +FLOODING +FENCEWALL +LOWHEDGE -DITCH -TALLHEDGE +ARABLE3KM -WOODLAND3KM
Chaffinch	-BARETILL -G_UNIMPROVED +FARMYARD +GAMECOVER +GRAZER +SUPPFEED +WEEDY -DITCH -FENCEWALL +TALLHEDGE +TREELINE +PERIMETER -URBAN3KM +WOODLAND3KM
Greenfinch	-G_IMPROVED +C_GAMECOVER +FARMYARD +ORCHARD +S_CEREAL +S_MAIZE +S_BEET +SUPPFEED +GRAZER -FENCEWALL -LOWHEDGE -ONLYVEG +TALLHEDGE +PERIMETER +ARABLE3KM +URBAN1KM +WOODLAND3KM
Goldfinch	-C_BRASSICA +C_GAMECOVER +C_MAIZE +ORCHARD +S_POTATO +GRAZER +SUPPFEED +WEEDY -FENCEWALL -LOWHEDGE +WOODLAND3KM
Linnet	+C_CARROT +G_OTHER +ORCHARD +OTHER +S_CEREAL +GAMECOVER +WEEDY +FENCEWALL -TREELINE
Bullfinch	-BARETILL -C_BRASSICA -G_OTHER +ORCHARD +TALLHEDGE -DITCH -FENCEWALL +PERIMETER -SEA3KM +WOODLAND3KM -URBAN1KM
Yellowhammer	+BARETILL +C_CEREAL +C_GAMECOVER -C_POTATO +C_OILSEED +S_CEREAL +SUPPFEED +WEEDY +GRAZER -DITCH -FENCEWALL +PERIMETER +ARABLE3KM -SEA1KM
Reed Bunting	+C_GAMECOVER +C_LINSEED +C_OILSEED +ORCHARD +OTHER +S_CEREAL +S_FODDER +S_BEET +FLOODING +SUPPFEED -LOWHEDGE -TALLHEDGE +DITCH +PERIMETER -WOODLAND3KM
Corn Bunting	+C_CEREAL +C_CARROT +G_OTHER +S_CEREAL +WEEDY +ONLYVEG +SEA1KM -WOODLAND3KM

Table 6.1 Species included in the analysis, their scientific names, functional group (G = granivore; I = invertebrate feeder; O = omnivore), the percentage of square visits on which they were recorded in each region and the national total (and percentage).

Species	Group	East	North	West	Scot	Wales	National
Grey Partridge (Perdix perdix)	G	15%	23%	4%	22%	3%	880 (14%)
Golden Plover (Pluvialis apricaria)	I	6%	4%	2%	2%	2%	236 (4%)
Lapwing (Vanellus vanellus)	I	16%	18%	8%	13%	11%	864 (13%)
Snipe (Gallinago gallinago)	I	10%	17%	18%	18%	24%	1005 (16%)
Curlew (Numenius arquata)	I	4%	5%	2%	12%	5%	318 (5%)
Stock Dove (Collumba oenas)	G	22%	12%	16%	9%	5%	998 (16%)
Skylark (Alauda arvensis)	G	57%	36%	38%	42%	20%	2763 (43%)
Meadow Pipit (Anthus pratensis)	I	36%	26%	46%	27%	43%	2314 (36%)
Pied Wagtail (Motacilla alba)	I	36%	35%	49%	26%	42%	2442 (38%)
Stonechat (Saxicola torquata)	I	3%	1%	9%	5%	11%	326 (5%)
Fieldfare (Turdus pilaris)	O	53%	54%	56%	39%	48%	3315 (52%)
Song Thrush (Turdus philomelos)	O	54%	44%	64%	34%	68%	3398 (53%)
Redwing (Turdus iliacus)	O	38%	44%	60%	29%	63%	2930 (46%)
Mistle Thrush (Turdus viscivorus)	O	42%	48%	35%	29%	49%	2601 (40%)
Starling (Sturnus vulgaris)	O	43%	55%	55%	54%	72%	3352 (52%)
House Sparrow (Passer domesticus)	G	36%	43%	42%	39%	46%	2577 (40%)
Tree Sparrow (Passer montanus)	G	4%	16%	2%	18%	4%	495 (8%)
Chaffinch (Fringilla coelebs)	G	82%	79%	88%	78%	86%	5313 (83%)
Greenfinch (Carduelis chloris)	G	46%	40%	45%	35%	30%	2679 (42%)
Goldfinch (Carduelis carduelis)	G	30%	27%	28%	22%	21%	1727 (27%)
Linnet (Carduelis cannabina)	G	20%	16%	18%	30%	12%	1226 (19%)
Bullfinch (Pyrrhula pyrrhula)	G	22%	13%	23%	6%	30%	1244 (19%)
Yellowhammer (Emberiza citrinella)	G	45%	37%	31%	44%	14%	2387 (37%)
Reed Bunting (Emberiza schoeniclus)	G	17%	17%	7%	20%	8%	900 (14%)
Corn Bunting (Emberiza calandra)	G	4%	3%	3%	2%	0%	189 (3%)

Table 6.2 Definitions of the variables comprising each of the six categories used for logistic regression modelling. Variables marked with an asterisk had to be removed from models due to multicollinearity problems.

Category	Definition and variable list
Broad Habitat	the proportion of the surveyed farmland classified as: ARABLE*, GRASS, CROP, STUBBLE, OTHERHAB [1], FARMYARD, BARETILL
Specific Habitat	the proportion of the surveyed farmland classified as: G_IMPROVED, G_UNIMPROVED, G_OTHER, C_CEREAL, C_BEET, C_LINSEED, C_OILSEED, C_BRASSICA, C_FODDER, C_GAMECOVER, C_CARROT, C_POTATO, C_MAIZE, C_BEANS, C_OTHER [2], S_CEREAL, S_BEET, S_LINSEED, S_OILSEED, S_BEAN, S_MAIZE, S_POTATO, S_FODDER, S_OTHER [2], BARETILL, FARMYARD, ORCHARD, PIGFARM, OTHER [3] where prefix G indicates grass, C indicates crop and S indicates stubble
Management	Presence or absence of the following within the square: FLOODING, GAMECOVER, GRAZERS, MANURE[4],SUPPFEED[5], WEEDY[6]
Boundary Type	Relative abundance of the following types of field boundary: TALLHEDGE, LOWHEDGE, TREELINE, FENCEWALL, BUILDING, DITCH, ONLYVEG[7], OTHERBDY[8] and, the total length of field perimeter surveyed (km): PERIMETER
Square Context	Landcover within the sample 1-km square: ARABLE1KM, GRASS1KM*, URBAN1KM, WOODLAND1KM, SEA1KM
Landscape Context	Landcover within a 3km × 3km square centred on the sample square: ARABLE3KM, GRASS3KM*, URBAN3KM, WOODLAND3KM, SEA3KM

[1] all other agricultural habitats, such as orchards, pig farms, poultry and unspecified
[2] a crop or stubble other than those listed, or unspecified/unknown by observer
[3] includes all unlisted agricultural habitats types, such as poultry and unspecified
[4] spread on fields or in heaps
[5] supplementary animal feed
[6] an abundance of weeds or crop volunteers present in stubble fields
[7] no structure, only vegetation between crops
[8] alternative unspecified boundary type
* variables removed due to multicollinearity issues.

Table 6.3 Results of logistic regressions using single categories of variables to predict national distributions. The table shows the number of species within each functional group with positive (+), negative (-) or no significant (0) association with each variable. The number of species in each functional group is shown in brackets.

	INVERT (7)			OMNIV (5)			GRANIV (13)		
	+	0	-	+	0	-	+	0	-
Broad habitat (H)									
Grass	3	3	1	4	1	0	1	6	6
Crop	0	5	2	0	4	1	2	9	2
Stubble	1	6	0	0	5	0	9	4	0
Baretill	2	3	2	0	2	3	1	10	2
Farmyard	1	6	0	2	3	0	7	6	0
Other	1	6	0	1	4	0	3	10	0
Management (M)									
Flooding	4	3	0	2	3	0	2	11	0
Gamecover crop	0	7	0	1	3	1	6	7	0
Grazers present	4	2	1	5	0	0	5	4	4
Manure spread/piled	3	4	0	4	1	0	5	8	0
Supp. Animal Feed	2	5	0	4	1	0	3	10	0
Weedy stubble	2	5	0	1	3	1	10	3	0
Boundary habitat (B)									
Tall hedge	1	5	1	3	1	1	5	6	2
Low hedge	3	4	0	2	2	1	2	5	6
Tree line	1	4	2	3	2	0	5	7	1
Buildings	0	5	2	2	3	0	1	12	0
Ditch	6	1	0	0	2	3	2	5	6
Fence/wall	1	4	2	1	3	1	1	5	7
Vegetation only	0	7	0	0	3	2	5	4	4
Other type	3	4	0	0	5	0	1	12	0
Perimeter length	5	1	1	5	0	0	5	5	3
Local context (L1)									
Arable1km	1	1	5	0	0	5	7	3	3
Woodland1km	0	1	6	1	2	2	5	5	3
Urban1km	0	3	4	0	1	4	5	6	2
Sea1km	4	3	0	0	1	4	3	5	5
Landscape context (L3)									
Arable3km	1	1	5	0	0	5	8	2	3
Woodland3km	0	1	6	1	2	2	5	5	3
Urban3km	0	4	3	0	1	4	6	4	3
Sea3km	3	4	0	0	1	4	4	5	4

Table 6.4 Results of logistic regressions relating different categories of variables to national distributions. Figures give the sequential improvement in AIC with increasing model complexity and additional of larger scale variables: +M = ΔAIC from S only model to SM; +B = ΔAIC from SM model to SMB; +L1 = ΔAIC from SMB to SMBL1; +L3 = ΔAIC SMBL1To SMBL1L3. VARS gives the model structure with the lowest AIC (categories of variables absent from the actual model are enclosed in brackets). C_t and C_e give the concordance statistic for the national training and evaluation datasets (with 95% confidence limits from boot-strapping). Species are grouped by diet (invertebrate-feeder/omnivore/granivore).

Species	**Sequential ΔAIC**				**Best model**		
	+M	**+B**	**+L1**	**+L3**	**VARS.**	C_t	C_e
Golden Plover	9.7	18.1	4.0	3.5	S(M)BL1L3	0.78	0.75 (0.71 - 0.77)
Lapwing	21.9	16.5	3.0	5.7	SMB(L1)L3	0.67	0.66 (0.64 - 0.68)
Snipe	48.7	70.0	54.2	10.6	SMBL1L3	0.73	0.72 (0.69 - 0.73)
Curlew	10.0	18.0	54.8	48.4	SMB(L1)L3	0.78	0.73 (0.69 - 0.77)
Meadow Pipit	51.0	61.1	38.1	25.3	SMBL1L3	0.67	0.63 (0.61 - 0.64)
Pied Wagtail	33.8	48.4	0.0	7.5	SMB(L1)L3	0.67	0.65 (0.63 - 0.67)
Stonechat	5.0	7.0	32.5	24.9	SMBL1L3	0.70	0.75 (0.71 - 0.78)
Fieldfare	35.5	13.3	40.6	21.3	SMBL1L3	0.68	0.65 (0.64 - 0.66)
Song Thrush	73.0	135.9	7.0	7.3	SMB(L1)L3	0.68	0.64 (0.62 - 0.65)
Redwing	68.7	89.6	15.2	14.6	SMBL1L3	0.72	0.72 (0.71 - 0.73)
Mistle Thrush	21.6	34.1	43.1	2.4	SMBL1L3	0.62	0.61 (0.59 - 0.63)
Starling	26.9	48.7	76.0	0.0	SMBL1	0.71	0.71 (0.69 - 0.72)
Grey Partridge	0.0	25.1	25.9	13.8	SMB(L1)L3	0.75	0.73 (0.71 - 0.75)
Stock Dove	3.9	16.4	0.0	21.5	SMBL1L3	0.66	0.63 (0.60 - 0.65)
Skylark	45.0	30.6	29.5	1.3	SMBL1	0.76	0.76 (0.75 - 0.77)
House Sparrow	27.9	95.2	38.2	11.1	SMBL1L3	0.71	0.69 (0.68 - 0.70)
Tree Sparrow	11.9	21.2	4.0	23.8	SMBL1(L3)	0.73	0.70 (0.66 - 0.73)
Chaffinch	86.5	142.2	18.7	8.7	SMB(L1)L3	0.75	0.73 (0.70 - 0.74)
Greenfinch	36.0	77.3	30.7	2.0	SMBL1L3	0.66	0.62 (0.60 - 0.64)
Goldfinch	30.4	20.8	7.7	3.4	SMB(L1)L3	0.64	0.61 (0.59 - 0.63)
Linnet	31.3	8.5	0.0	-5.6	SMB	0.68	0.67 (0.64 - 0.68)
Bullfinch	13.3	100.7	21.8	12.3	S(M)BL1L3	0.69	0.68 (0.66 - 0.70)
Yellowhammer	43.9	20.0	13.2	18.8	SMBL1L3	0.75	0.74 (0.72 - 0.75)
Reed Bunting	24.3	51.4	9.8	11.1	SMB(L1)L3	0.70	0.70 (0.67 - 0.72)
Corn Bunting	7.6	12.7	30.0	26.0	SMBL1L3	0.83	0.84 (0.81 - 0.88)

Table 6.5 Summary of the predictive power (concordance statistic) of regional models applied to the evaluation dataset in the region of training and to the whole dataset of other regions. Bold figures indicate the training region that produced the best model for each region (other than the home region). The final row contains mean values calculated across all 14 species.

Species	**Trained in East**		**Trained in North**		**Trained in West**		**Trained in Scotland**		**Trained in Wales**	
	C_e	**(N, W, Sc, Wa)**	**C_e**	**(E, W, Sc, Wa)**	**C_e**	**(E, N, Sc, Wa)**	**C_e**	**(E, N, W, Wa)**	**C_e**	**(E, N, W, Sc)**
Snipe	0.62	(0.64, 0.65, 0.65, 0.63)	0.71	(0.57, 0.67, 0.51, 0.61)	0.71	(0.59, 0.65, 0.65, 0.55)	0.70	(**0.64, 0.69, 0.69, 0.65**)	0.71	(0.62, 0.65, 0.68, **0.68**)
Skylark	0.69	(0.75, **0.74**, 0.65, **0.77**)	0.76	(0.65, 0.64, 0.66, 0.70)	0.76	(**0.71, 0.78**, 0.68, 0.76)	0.67	(0.65, 0.67, 0.67, 0.72)	0.76	(0.66, 0.72, 0.69, **0.69**)
Meadow Pipit	0.67	(**0.63, 0.60, 0.63, 0.63**)	0.69	(0.56, 0.54, 0.58, 0.57)	0.65	(**0.57**, 0.62, 0.55, 0.55)	0.63	(0.52, 0.51, 0.51, 0.48)	0.57	(0.55, 0.51, 0.54, 0.54)
Pied Wagtail	0.65	(0.57, **0.61**, 0.58, 0.55)	0.64	(**0.58**, 0.58, 0.55, 0.51)	0.62	(0.58, **0.59**, 0.55, 0.54)	0.64	(0.57, 0.57, 0.57, **0.59**)	0.57	(0.56, 0.53, 0.60, **0.60**)
Fieldfare	0.66	(**0.65**, 0.60, 0.61, **0.62**)	0.67	(**0.60**, **0.61**, **0.61**, 0.58)	0.62	(0.53, 0.55, 0.57, 0.56)	0.66	(0.57, 0.53, 0.53, 0.54)	0.63	(0.51, 0.65, 0.55, 0.55)
Song Thrush	0.67	(0.55, 0.57, 0.52, 0.58)	0.61	(**0.61**, **0.58**, 0.53, 0.60)	0.59	(0.60, **0.56**, **0.54**, 0.61)	0.57	(0.53, 0.52, 0.52, **0.61**)	0.53	(0.58, 0.48, 0.51, 0.51)
Redwing	0.69	(**0.64**, **0.64**, 0.68, **0.66**)	0.65	(**0.66**, 0.62, **0.69**, 0.63)	0.66	(0.65, 0.63, 0.64, 0.64)	0.67	(0.62, 0.61, 0.61, 0.61)	0.63	(0.66, 0.59, 0.63, 0.63)
Starling	0.69	(0.65, **0.66**, **0.71**, **0.59**)	0.68	(0.61, **0.65**, 0.68, 0.56)	0.68	(0.64, 0.68, 0.70, 0.57)	0.73	(**0.65**, 0.65, 0.65, 0.64)	0.57	(0.59, 0.58, 0.59, 0.59)
House Sparrow	0.69	(0.69, 0.66, 0.64, **0.67**)	0.71	(0.65, 0.64, 0.66, 0.61)	0.71	(**0.65**, **0.69**, 0.63, 0.66)	0.75	(0.56, 0.59, 0.59, 0.61)	0.64	(0.59, 0.63, **0.66**, **0.66**)
Chaffinch	0.73	(**0.63**, 0.63, **0.72**, 0.68)	0.61	(0.63, 0.57, 0.63, **0.69**)	0.66	(**0.68**, 0.59, 0.61, 0.66)	0.73	(0.66, 0.62, 0.62, 0.63)	0.69	(0.59, 0.57, **0.64**, 0.64)
Greenfinch	0.60	(**0.57**, **0.57**, **0.59**, 0.58)	0.60	(0.54, 0.56, 0.56, **0.60**)	0.60	(**0.60**, 0.56, 0.54, 0.55)	0.62	(0.56, 0.51, 0.51, 0.48)	0.61	(0.51, 0.52, 0.57, 0.57)
Goldfinch	0.61	(**0.57**, 0.56, **0.59**, **0.60**)	0.54	(0.50, 0.53, 0.53, 0.49)	0.55	(0.56, 0.54, 0.59, 0.55)	0.54	(0.50, 0.49, 0.49, 0.54)	0.59	(**0.58**, 0.57, **0.58**, 0.58)
Linnet	0.63	(**0.68**, 0.61, **0.63**, **0.64**)	0.68	(0.56, 0.57, 0.62, 0.64)	0.67	(**0.60**, 0.62, 0.59, 0.59)	0.67	(0.58, 0.64, **0.64**, 0.57)	0.64	(0.52, 0.49, 0.63, 0.63)
Yellowhammer	0.67	(0.68, **0.73**, **0.74**, **0.61**)	0.74	(0.57, 0.66, 0.70, 0.60)	0.76	(0.60, **0.70**, 0.71, 0.65)	0.73	(**0.61**, 0.64, 0.64, 0.58)	0.70	(0.56, 0.68, 0.69, 0.69)
MEAN	0.66	(0.64, 0.63, 0.64, 0.63)	0.66	(0.60, 0.61, 0.61, 0.60)	0.66	(0.61, 0.63, 0.61, 0.60)	0.67	(0.59, 0.60, 0.59, 0.59)	0.63	(0.58, 0.59, 0.58, 0.61)

Table 6.6 Variables represented with the same sign in best models in three, four, or all five regions. For the purpose of this summary, the scale (1km or 3km) of the context variables was ignored.

Species	Common variables
Snipe	3(+G_UNIMPROVED, +FLOODING), 4(-URBAN, -WOODLAND)
Skylark	3(+SEA), 4(+ARABLE), 5(+WEEDY)
Meadow Pipit	3(-WOODLAND)
Pied Wagtail	3(+GRAZERS)
Fieldfare	3(-SEA)
Song Thrush	3(+PERIM)
Redwing	3(+TALLHEDGE, -ARABLE, -SEA)
Starling	3(-WOODLAND, -ARABLE), 4(+PERIM)
House Sparrow	3(+PERIM), 5(+FARMYARD)
Chaffinch	4(+PERIM)
Greenfinch	3(-FENCEWALL, +URBAN)
Goldfinch	3(+WEEDY)
Linnet	none
Yellowhammer	3(+ARABLE), 4(+S_CEREAL)

7. WINTER AVAILABILITY OF CEREAL STUBBLES ATTRACTS DECLINING FARMLAND BIRDS AND POSITIVELY INFLUENCES BREEDING POPULATION TRENDS

Published as: Gillings *et al*. (2005). Winter availability of cereal stubbles attracts declining farmland birds and positively influences breeding population trends. *P. Roy. Soc. B-Biol. Sci.* **272**: 733-739.

7.1 Abstract

Many studies have demonstrated the selection of stubble fields by farmland birds in winter but none have shown whether provisioning of this key habitat positively influences national population trends for widespread farmland birds. We use two complementary extensive bird surveys undertaken at the same localities in summer and winter and show that the area of stubble in winter attracts increased numbers of several birds species of conservation concern. Moreover, for several farmland specialists, the availability of stubble fields in winter positively influenced the 10 year breeding population trend (1994-2003) whereas hedgerow bird species were less affected. For Skylarks and Yellowhammers, initially negative trends showed recovery with 10-20ha of stubble per 1-km square. Thus Agri-Environment Schemes that promote retention of over-winter stubbles will attract birds locally and are capable of reversing current population declines if stubbles are available in sufficient quantity.

7.2 Introduction

There are now well documented large-scale population declines and range contractions in many bird species inhabiting farmland across north-west Europe (Pain & Pienkowski 1997; Donald *et al.* 2001a). Agricultural intensification since the 1970s, principally through the Common Agricultural Policy, has fostered an increased use of chemical inputs, a switch from spring to autumn sowing of crops, the loss of non-cropped habitats and the loss of rotations and farm-scale mosaics due to local specialisation (Chamberlain *et al.* 2000; Vickery *et al.* 2001; Robinson & Sutherland 2002; Benton *et al.* 2003). A wealth of research has shown that one or more components of these changes have negatively affected either farmland bird productivity, survival or both (e.g. Siriwardena *et al.* 2000).

In 2000 the UK government adopted a Public Service Agreement (PSA) target to reverse the farmland bird declines by 2020. Achieving this PSA target is likely to require sympathetic land management across large areas of the UK (Vickery *et al.* 2004). Given that reduced over-winter survival explains patterns of declines for several granivorous species (Siriwardena *et al*. 2000) and their preferred winter feeding habitat is stubble fields (e.g. Wilson *et al.* 1996; Moorcroft *et al.* 2002), the retention of over-winter stubbles is one of the most widely advocated conservation measures. Prior to the 1970s most crops were planted in spring, allowing seed-rich stubble fields to remain undisturbed and provide an essential food resource in winter. With the subsequent switch to autumn sowing, many stubbles are now ploughed before winter (Evans *et al.* 2004) with a consequent loss of winter food for farmland birds. Moreover, many modern stubble fields now provide poor resources due to more efficient harvesting and weed control, depleting seed banks and reducing the abundance of broad-leaved weeds important in the diet of many farmland passerines (e.g. Donald *et al.* 2001b). For widespread species such as Skylarks *Alauda arvensis*, the provision of seed-rich stubbles will be required throughout Britain but the quantity (and quality) and spatial arrangement of stubble required to stem and reverse bird population declines is unknown (Bradbury *et al.* 2004). However, it is clear that Agri-Environment Schemes (AES) may be the most cost effective means of deploying sympathetically managed habitats on a national scale.

To date AES have been successful in reversing population declines in only four farmland species (Aebischer *et al.* 2000). Two of these (Corncrake *Crex crex* and Stone Curlew *Burhinus oedicnemus*) require highly specialised breeding habitat and AES could encompass the entirety of their restricted breeding ranges. The other two species (Grey Partridge *Perdix perdix* and Cirl Bunting *Emberiza cirlus*) required provision of winter and breeding habitat. The Grey Partridge is relatively widespread but management has only been effective at the local level. The Cirl Bunting recovery might be informative because the species is ecologically similar to several of the more widespread species of concern. However, population recovery followed *ad libitum* provision of over-winter stubbles and breeding habitats (Peach *et al.* 2001), hence no relationships between stubble provision rate and population trends can be determined. Therefore though these success stories show promise they do not help in determining levels of resource provisions needed for birds of the wider countryside. Moreover, in most cases management was intensive and expensive and unlikely to be tenable nationally.

The populations of widespread species must be restored if the PSA target is to be achieved. Here we investigate the effects of stubble availability in winter on local breeding populations to determine the levels of sympathetically managed farmland required to reverse farmland bird declines. We use data from two extensive surveys in which volunteer surveyors visited the same 1-km squares in summer and winter providing a unique opportunity to link summer and winter abundance with winter habitat data and answer two key questions:

1. relative to the number of birds present in summer, does the presence of stubble fields in winter attract further birds into areas;
2. does the winter availability of stubble fields within squares positively affect recent breeding population trends of farmland birds.

The first question considers whether AES are capable of having effects over wider areas of surrounding countryside, and the second question attempts to ascertain what resource levels are required to reduce or reverse farmland bird declines.

7.3 Methods

7.3.1 Survey methods

This study utilises two extensive volunteer surveys, the British Trust for Ornithology/Royal Society for the Protection of Birds/Joint Nature Conservation Committee (BTO/RSPB/JNCC) Breeding Bird Survey (BBS) and the BTO/JNCC Winter Farmland Bird Survey (WFBS). Since 1994 the BBS has been the national monitoring scheme for breeding bird populations within the UK (Raven *et al.* 2004). The WFBS aimed to document winter abundance, distribution and habitat selection by farmland birds in the three winters 1999/2000, 2000/2001 and 2002/2003 (Gillings *et al.* 1999). Both were undertaken on stratified random samples of 1-km squares: BBS squares (*c*.2000 squares annually) were stratified regionally and by human population density to afford representative coverage of regions and habitats whilst making the most of available volunteer resources (Raven *et al.* 2004); WFBS square selection (1090 squares) was constrained to lowland farmland areas and avoided largely urbanised or wooded areas (Gillings *et al.* 1999). Any BBS squares that met the latter constraints were included within the WFBS sample. This gave a sample of 601 squares surveyed in both winter and the breeding season. Both survey methods aimed to sample bird populations within the square rather than yield exact population figures: BBS essentially involved two visits to each square each summer (May-July) with all bird species counted along two 1km transects; WFBS involved three timed visits each winter in which a suite of 30 farmland bird species and habitats were surveyed from field perimeters.

Of the 30 species surveyed in winter 12 were excluded from analysis because they were strictly winter visitors (e.g. Fieldfare *Turdus pilaris*) or essentially absent from lowland farmland in summer (e.g. Stonechat *Saxicola torquata*) and thus not present in summer to make comparisons. The remaining 18 species were typical of lowland farmland in summer and winter (Table 7.1). We used the maximum count across visits in each season as the measure of bird abundance. On each winter visit, the area of broad agricultural habitat type (e.g. grass, crop, stubble) per 1-km square was estimated from WFBS habitat data. For classifying sites for the trend analysis, these values were averaged across all visits to derive an overall description of the farmland present in each sample square during the late 1990s/early 2000s.

7.3.2 Are birds drawn into squares with key habitats in winter?

If all individuals are sedentary, the number of birds in a square in winter should be proportional (though not equal due to recruitment, mortality and different survey methods) to the number in the preceding spring. However, differences in habitat composition between squares ought to be apparent. For instance, a square with an abundance of seed-rich habitats in winter might be expected to have higher winter bird populations than the 'average' square due to reduced mortality and by attracting birds in from surrounding squares.

Since visits to the same square across years cannot be considered statistically independent, tests were performed using a repeated measures generalised linear model which modelled winter abundance as a function of summer abundance, then tested the additive effect of winter habitat availability. Summer counts for 1999, 2000 and 2002 were merged with winter counts and habitat areas for 1999/2000, 2000/2001 and 2002/2003 respectively. Initial analysis used Poisson errors and a log link but over-dispersion was extreme. Instead both counts were $\ln(x + 1)$ transformed which gave acceptable model over-dispersion (values of deviance/degrees of freedom in the range 0.4-4.7) and the square-root of the deviance/degrees of freedom was used for scaling. For the repeated measures, square grid reference identified subjects and year denoted the within-subject order. Habitat effects were tested by examining the drop in deviance (with a likelihood ratio test) when a variable describing the availability of a single habitat type was added to the winter-summer relationship. The effect of each habitat was tested in a separate model thus avoiding statistical problems associated with the unit sum constraint. The model was run separately for each species after excluding any squares that never recorded any individuals of the species in either summer or winter. All tests were performed using the GENMOD procedure in SAS (SAS Institute 2001).

7.3.3 Does over-winter stubble availability influence breeding population trends?

If preferred winter habitats reduce over-winter mortality, squares with those habitats should have higher populations in the subsequent breeding season than squares without those habitats. Over several seasons there should be detectable differences in trends between squares with and without these supposedly beneficial winter habitats, with higher growth rates (or at least lessoned declines) in squares with preferred habitats.

This was tested by computing breeding population trends for squares with and without cereal stubbles. For each of the 601 BBS squares we used WFBS habitat data to derive an estimate of the area of cereal stubble present during winter in the late 1990s/early 2000s and then computed separate breeding population trends from BBS data (1994-2003) for squares with and without over-winter cereal stubbles. Two separate sets of trends were produced: national lowland trends using all 601 squares and eastern England trends using 248 squares in the East Midlands, East of England and South East Government Office Regions. The reason for this dual approach was that the national trend benefited from greater between-square variation in stubble availability but suffered from the problem that declines may have different drivers in different parts of the country. The eastern England only analysis reduced this problem by concentrating on the predominantly arable zone of Britain, thus reducing the likelihood of multiple drivers. The eastern region also provided the most squares and thus the best power to detect what could be quite small changes in trends over just a 10-year period.

Breeding population trends were estimated from BBS data using a log-linear model with Poisson error terms (Raven *et al.* 2004). A baseline trend was calculated using site effects and a linear year effect. Models were re-run with a year × winter stubble presence-absence interaction term to test for trends specific to the availability of over-winter stubble. Trends were derived for the 18 resident farmland species targeted by both surveys, plus eight common species of farmland that were adequately monitored by BBS. Of this pool of 26 species we expected to see beneficial effects of stubble presence on trends for some species and not for others. Specifically, based on current knowledge of habitat preferences (e.g. Wilson *et al.* 1996; Moorcroft *et al.* 2002) Grey Partridge, Skylark, sparrows, finches and buntings (hereafter referred to as '*Stubble species*') should show positive effects of stubble presence because they will benefit from the associated seed resources. In contrast, Wren *Troglodytes troglodytes*, Robin *Erithacus rubecula*, Dunnock *Prunella modularis*, thrushes and tits (hereafter referred to as '*Hedge species*') rarely use field habitats and should show no consistent effect of stubble presence on population trends. It is not clear what effect might be expected for the remaining six '*Other species*'.

Trends for Skylark and Yellowhammer *Emberiza citrinella* were investigated further. Both are widespread species of particular conservation concern but whereas Yellowhammers may benefit simply from the provision of stubble fields though over-winter effects (Bradbury *et al.* 2000), Skylarks may benefit doubly due to the additional presence of spring-sown crops (Chamberlain *et al.* 1999) associated with over-wintering of stubble fields. Thus squares were classified as having no, low or high stubble availability and trends computed and tested for significant differences. The threshold between low and high availability was varied from 5ha to 20ha (of a maximum of 100ha of land in the square). For visual presentation, annual indices were determined using categorical year factors. Finally, trends were modelled with a continuous stubble covariate.

Models were corrected for over-dispersion using the square root of the deviance/degrees of freedom and were weighted to account for the original square stratification. Only squares that were surveyed in at least two summers, and thereby generating a measure of 'change', were included in the analysis. Trends were only computed for species for which the mean number of sites contributing counts in each year was 30 or more (Raven *et al.* 2004).

7.4 Results

7.4.1 Are birds drawn into squares with key habitats in winter?

Abundance of individual species was significantly related across seasons for 12 of the 18 species; seven negative and six positive (Table 7.1). Of those species showing negative relationships, Grey Partridge, Pied Wagtail *Motacilla alba*, Bullfinch *Pyrrhula pyrrhula* and Reed Bunting *Emberiza schoeniclus* relationships were caused by a large number of sites that were apparently unoccupied in summer but with an abundance of birds in winter. In addition to these patterns of seasonal abundance, winter habitat covariates explained significant variation (at $P<0.01$) in the summer-winter relationship, with the availability of grass and stubbles benefiting six and seven species respectively and crops negatively affecting five species. Thus, for a species such as Skylark, squares with high densities of Skylarks in summer had relatively higher densities in winter if stubbles to some degree replaced crops. Notably, the availability of farmyards positively influenced House Sparrow *Passer domesticus* and Chaffinch *Fringilla coelebs* winter abundance.

7.4.2 Does over-winter stubble availability influence breeding population trends?

Nationally, significant baseline trends were detected for 20 of the 26 species considered (Table 7.2). Significant declines were evident for 50% of the *Stubble species* but none of the *Hedgerow species*. Moreover, significant increases occurred in only 25% of *Stubble species* compared to 75% of *Hedgerow species*. Results were similar in the east: 19 of the 27 species analysed showed a significant trend: 58% of *Stubble species* declined compared to 13% of *Hedgerow species*, and 17% of *Stubble species* increased compared to 50% of *Hedgerow species*. Mixed patterns were evident for the *Other species*.

In total, 16 species showed a positive effect of stubble presence on national trends and ten species showed a negative influence. For example, Skylarks declined by 34% on squares with no stubble compared to only 13% on squares with stubble present (Table 7.2). Only five positive effects were statistically significant: two for *Stubble species*, none were for *Hedgerow species* and three for *Other species*. Of the *Other species* showing significant effects, Lapwing *Vanellus vanellus*, Stock Dove *Columba oenas* and Pied Wagtail responded positively to stubble presence and Rook *Corvus frugilegus* negatively.

Whether squares had stubble or not differed markedly between regions of Britain. In East England only 30% of squares had no stubble compared to 83% of Welsh squares. Constraining the analysis to East England removed much variation in stubble availability but still 18 species (eight significantly) showed a benefit of stubbles and seven a negative influence (only Rook significantly). Of the species showing significant positive effects of stubble, four were *Stubble species*, two were *Hedgerow species* and two were *Other species*.

The effect of increasing the area of over-winter stubble on trends was evaluated further for Skylark and Yellowhammer. Of the 601 squares, 237 contained no stubble, leaving 364 squares amongst which there was appreciable variation in the extent of stubble (quartiles for non-zero squares = 9ha and 69ha). For different thresholds of stubble availability (5ha to 20ha) Skylark declines were lessoned with greater stubble availability (Table 7.3a. Populations on <10ha stubble squares declined by 20% compared to the 34% decline in the complete absence of stubbles. Moreover, populations on >10ha stubble squares declined by only 4% (Fig. 7.1). Crucially, only when stubble availability exceeded 20ha per square was the ten year linear trend stable/increasing (Table 7.3a). Results were similar for Yellowhammer, with a lessoning of declines in the highest stubble availability category and approximate stability above 15ha of stubble (Table 7.3b). Tested more formally, when stubble area was included as a covariate there was a significant interaction with year for Skylark (likelihood ratio $\chi^2_1 = 18.3$, $P < 0.001$) and Yellowhammer (likelihood ratio $\chi^2_1 = 10.4$, $P < 0.01$). For Skylarks, for each addition of 5ha of stubble, the 10 year decline was lessoned by 4% points. Six other species showed a significant positive linear effect of stubble area (Lapwing, Stock Dove, Mistle Thrush *Turdus viscivorus*, Starling *Sturnus vulgaris*, Goldfinch *Carduelis carduelis* & Bullfinch) and two a significant negative effect (House Sparrow *Passer domesticus* & Tree Sparrow *Passer montanus*) on breeding population trends.

7.5 Discussion

A wealth of research has focussed on diagnosing the causes of population declines in farmland birds in Europe. For many species the underlying demographic and environmental causes are known and land management options have been developed to reverse these population declines. One of the key questions that remains is how much of a given resource is required to have an impact at the national population level? This is the first study to link summer and winter bird communities on farmland across broad geographic areas and to attempt to relate breeding season trends to the availability of a such a resource - over-winter stubbles. The results show that the availability of over-winter stubble can explain some of the variation in population trends for several declining species.

For most species, abundance in winter relative to summer was significantly affected by winter habitat availability, indicating that certain habitat features in one locality were consistently capable of attracting birds from the surrounding countryside. No species increased in response to presence of crops. Species responding positively to grass were primarily invertebrate feeders whereas those responding positively to stubbles were primarily granivorous passerines. Many autecological studies have shown strong preferences for stubble fields in winter by the latter (e.g. Wilson *et al.* 1996, Donald *et al.* 2001b, Gillings & Fuller 2001, Moorcroft *et al.* 2002). Interestingly, House Sparrow, Chaffinch and Greenfinch *Carduelis chloris*, showed a positive association with the availability of farmyards.

As expected, the benefits of stubble differed between species in relation to their foraging ecology. More of the positive significant effects were for *Stubble species* than for *Hedgerow species*. Furthermore, the remaining non-significant benefits tended to be greater for *Stubble species* than for *Hedgerow species*. That some benefits of stubble (albeit small) were apparent for *Hedgerow species* may be due to landscape effects if farms that retain stubbles also tend to have greater availability or higher quality non-cropped habitats (e.g. hedgerows). This may be the case if stubbles are more common on lower intensity (or organic) farms that tend to retain more non-cropped habitat (Benton *et al.* 2003). The beneficial effects of the stubble are likely to be two-fold: over-winter stubbles provide essential seed-rich resources for a wide array of species, plus stubbles are associated with summer cropping which benefits productivity in Skylarks (Chamberlain *et al.* 1999) and Lapwings (Wilson *et al.* 2001). Possibly this dual mechanism explains why the response is greater in Skylark than Yellowhammer.

The detailed examples for Skylark and Yellowhammer clearly show that increasing the quantity of stubble in squares can reduce, and even reverse local population trends during the 10 year period considered here. The Skylark results can be used to indicate how much stubble might be needed in the wider countryside to reverse population trends for this species. At the 10ha threshold, all three categories of squares showed a decline until around 1997/1998 since when populations in >10ha stubble squares have increased slightly. Though only >20ha stubble squares demonstrated an absolute Skylark recovery to 1994 levels by 2003, trends in >10ha stubble squares might recover by around 2011 whereas those in 0ha stubble squares might continue to decline down to -40% by 2011. Nationally, only 50% of squares contained stubble and of those, the median area was 12ha (Gillings unpublished data). Therefore only 25% of squares have the >10ha of stubble required for recovery whereas 75% of squares will probably show sustained Skylark declines.

These increases in stubble availability may be achieved either through AES or changes in wider farm management practices such as incorporating more fallow land or spring cropping in rotations, or the addition of pockets of arable land in grass dominated areas (Robinson *et al.* 2001). In Britain the 'national roll-out' of the new Entry Level Agri-Environment Scheme has the potential to provide beneficial resources on the national scale necessary to aid population recovery. This work suggests that if stubble areas can be increased from the current average of 3ha per 1-km (Gillings & Fuller 2001) to 10ha or more this should be sufficient to stem breeding population declines. Gillings and Fuller (2001) estimated that only 46% of stubbles were weedy and hence valuable as foraging habitat for birds. If management options are developed to enhance weed abundance in stubbles the area required could be significantly reduced. It should be borne in mind that the area and spatial arrangement of food patches required may differ between species. Skylarks avoid small fields and hedgerows (Donald *et al.* 2001; Gillings & Fuller 2001) so stubble patches must be carefully sited if they are to be fully exploited by this species.

These are crude extrapolations and three points should be considered. Firstly, the 1994 'recovery' value used here is simply the beginning of the BBS scheme - Skylarks have been in decline since the mid 1970s - so a full recovery will take considerably longer. Second, these extrapolation could be misleading because only the processes operating under the current conditions are taken into account (e.g. density dependent effects are ignored, Bradbury *et al.* 2001). Thirdly, there is enormous variability in the quality of stubble fields (Robinson 2003) and these extrapolations refer to the 'average' stubble field. Ideally, behaviour-based models alongside empirical data on stubble field quality should be used to predict future population trajectories under different management scenarios but data are currently lacking (Stephens *et al.* 2003). Nevertheless, these results indicate that provision of sufficient high quality, suitably placed stubble could at least make a significant contribution to population recovery for many of these species.

7.6 Conclusions

These results demonstrate that the availability of over-winter stubbles in the last three years can explain some of the variation in population trends for several declining farmland birds. The thresholds of stubble availability at which changes in population trends were apparent suggests that significant changes in land management may be required to sustain population recovery. Changes of this magnitude and scale are only likely to be possible within AES and monitoring the benefits of these schemes is essential (Kleijn & Sutherland 2003). In particular the collection of spatially referenced information on the take-up of schemes and resulting areas of beneficial habitats that can be linked to bird population trend information at different spatial scales is advised. Whilst we show that stubbles benefit population trends in squares with stubbles, the fact that birds were also attracted into those squares from outside indicates a likely effect on trends in the countryside surrounding the squares in question. However, the distance over which this effect extends remains unknown but is needed to determine the optimum spatial arrangement of resource patches.

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Table 7.1 Results of a repeated measures generalised linear model predicting winter numbers as a function of summer numbers, then testing the additional effect of increasing availability of different habitats. n = number of squares recording the species at least once. Slope = the direction and magnitude of the relationship between winter and summer abundance (significance tested against zero). r = correlation coefficient between observed and predicted winter numbers. Columns for habitats show the direction and significance of the presence of each habitat type on winter bird abundance relative to summer abundance. * = P < 0.05, ** = P < 0.01, *** = P < 0.001, + = positive, - = negative.

Species	n	Slope	r	Grass	Crop	Stubble	Farmyard
Grey Partridge	219	-0.43***	0.24			+	
Lapwing	327	-0.32***	0.16	-			
Stock Dove	345	-0.03	0.02				
Skylark	512	0.74***	0.40	---		+++	
Pied Wagtail	521	-0.22***	0.12	++	--		
Song Thrush	557	0.20***	0.13	+++	-		
Mistle Thrush	500	-0.05	0.04	+	---		
Starling	566	0.06	0.04	+++	---	-	
House Sparrow	481	0.28***	0.19	++	-	++	+++
Tree Sparrow	119	-0.36	0.23			+	
Chaffinch	586	0.69***	0.36	+++	---	+++	++
Greenfinch	549	0.25***	0.16	-		++	+
Goldfinch	513	-0.30***	0.16			+	
Linnet	476	-0.10	0.05	---		+++	
Bullfinch	350	-0.45***	0.29	++	--		
Yellowhammer	478	0.51***	0.26	---		+++	
Reed Bunting	248	-0.34*	0.20			++	
Corn Bunting	97	-0.09	0.05				

Table 7.2 Percent change in breeding bird numbers on BBS squares between 1994 and 2003. All includes 601 squares distributed throughout Britain. East includes 248 squares in east England. A baseline trend is given followed by separate trends for squares with (Y) and without (N) over-winter cereal stubble. For baseline trends, asterisks indicate a significant change. For stubble trends, asterisks indicate a significant difference between trends in the presence or absence of stubble. * = P < 0.05, ** = P < 0.01, *** = P < 0.001.

Species	N° Squares		Baseline		Stubble (Y / N)	
	All	East	All	East	All	East
Stubble species						
Grey Partridge	68	34	-43***	-42***	-40 / -58	-38 / -58
Skylark	348	167	-18***	-18***	-13 / -34 ***	-14 / -31 **
House Sparrow	300	122	5	-14**	7 / 1	-12 / -20
Tree Sparrow	40	12	139***	-69***	30 / 434 ***	-
Chaffinch	414	175	2	15***	5 / -3	19 / 4 *
Greenfinch	332	144	15***	15*	11 / 24	25 / -10 *
Goldfinch	273	113	12*	-13	14 / 7	-8 / -28
Linnet	272	122	-22***	-36***	-18 / -32	-29 / -57 **
Bullfinch	102	45	-25**	-22	-19 / -32	-28 / -4
Yellowhammer	305	148	-20***	-15***	-16 / -30 *	9 / 0
Reed Bunting	84	42	-7	-1	-13 / 4	-3 / 1
Corn Bunting	50	30	-35***	-32**	-37 / -22	-33 / -28
Hedge species						
Wren	396	169	21***	16***	21 / 22	22 / -3 **
Dunnock	367	156	18***	12*	17 / 20	15 / 6
Robin	388	163	17***	18***	14 / 21	14 / 28
Blackbird	420	181	17***	10***	18 / 15	13 / 4
Song Thrush	315	132	23***	-3	23 / 21	27 / -81
Mistle Thrush	211	99	-9	-34***	-3 / -18	-25 / -50 *
Blue Tit	393	164	-5	-7	-3 / -7	-6 / -9
Great Tit	358	152	15***	5	15 / 14	7 / 3
Other species						
Lapwing	142	57	16*	56***	44 / -33 ***	84 / -1 *
Stock Dove	173	88	14	8	24 / -8 *	94 / 19 **
Woodpigeon	423	183	19***	20***	18 / 22	-2 / -1
Pied Wagtail	229	91	20***	54***	31 / 4 *	50 / 66
Rook	262	110	-13*	-7	-20 / 3 *	-26 / 47 ***
Starling	348	151	-36***	-46***	-41 / -29	-18 / -33

Table 7.3 Breeding population changes for a) Skylark and b) Yellowhammer under different levels of over-winter cereal stubble availability. Using different thresholds of stubble availability to denote the difference between low and high availability, trends are given for squares with no, low or high stubble availability. Sample sizes are given for each category. The likelihood ratio (LR) tests for difference in trend in relation to stubble availability. * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$

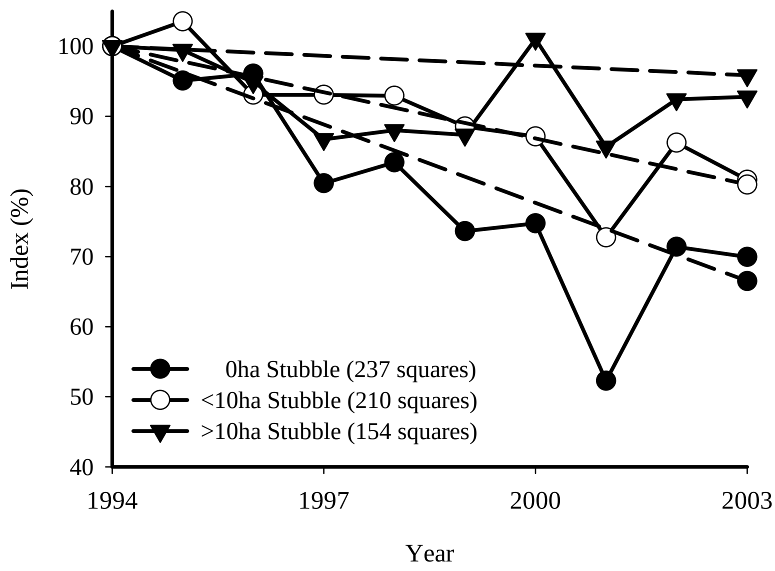
a) Skylark

Low-High threshold	Trend by stubble area			Number of squares			LR test χ^2_1
	None	Low	High	None	Low	High	
5ha	-34%	-22%	-9%	237	116	248	24.2***
10ha	-34%	-20%	-4%	237	210	154	27.9***
15ha	-34%	-17%	-5%	237	266	98	23.5***
20ha	-34%	-16%	1%	237	308	56	26.4***

b) Yellowhammer

Low-High threshold	Trend by stubble area			Number of squares			LR test χ^2_1
	None	Low	High	None	Low	High	
5ha	-30%	-9%	-19%	237	116	248	6.3*
10ha	-30%	-23%	-9%	237	210	154	9.5**
15ha	-30%	-23%	0%	237	266	98	14.8***
20ha	-30%	-20%	-1%	237	308	56	9.7**

Figure 7.1 Skylark breeding population trends in squares with 0ha, ≥10ha or >10ha of over-winter stubble. Dashed lines indicate linear trends from Tables 7.3. Solid lines with symbols indicate annual fitted values. The same symbols are used for the last point of each linear trend (dashed lines) to aid interpretation.



8. INCREASING USE OF GARDENS BY FARMLAND BIRD SPECIES THROUGH THE WINTER

In review: Gillings, S. & Toms, M. Increasing use of gardens by farmland bird species through the winter. *British Birds*.

8.1 Abstract

Gardens often support birds more usually thought of as farmland species, but to what extent do farmland birds move into gardens? We use two volunteer surveys, the BTO/JNCC Winter Farmland Bird Survey and the BTO/CJ Garden BirdWatch to assess trends in farmland and garden use within winters to evaluate the evidence that species leave farmland and move into gardens. We find increasing use of gardens within the winter by several species, but in few is this mirrored by a decline in use of farmland. Nevertheless, the use of gardens by farmland birds is clear, even if the extent to which individuals move remains unclear.

8.2 Introduction

Bird communities of farmland and gardens offer a stark contrast. In 2001, farmland accounted for 68% of the land area of the UK (Office for National Statistics 2001) and a wide variety of bird species are associated primarily with farmland, or habitats comprising the farmed landscape. In contrast, though gardens only account for a seemingly small c3% of the total land area in England and Wales (Owen 1991) this is still around half the area designated as Sites of Special Scientific Interest in England and Wales. Bird populations in farmland have declined dramatically through agricultural intensification (Fuller *et al*. 2000). Meanwhile, those in gardens have seemingly gone from strength to strength, with increasing realisation that gardens may provide important habitat for many species (Gregory & Baillie 1998) and dedicated surveys of garden birds now take place. Cannon *et al*. (2005) assessed trends in use of gardens by 40 species between 1995 and 2002. For at least 18 species, statistically significant trends in garden use were evident over this period. A second study found that of 41 species monitored, 21 had significantly increased in their occurrence at garden feeders between 1970 and 2000 (Chamberlain *et al*. 2005).

Since some of the species that have declined in farmland are now increasingly using gardens (Cannon *et al*. 2005; Chamberlain *et al*. 2005) there have been some suggestions that gardens may be able to provide a refuge for declining farmland bird species (e.g. Mason 2000). Winter is known to be a critical time for many farmland species, with over-winter mortality being one of the main factors driving population declines (Siriwardena *et al*. 2000). Against this background one might expect to find an increasing tendency for farmland birds to seek resources in alternative habitats, such as garden. The evidence for this is mixed. Cannon *et al*. (2005) found mixed patterns of correlation between garden usage trends and national breeding population trends (1994-2002). Chamberlain *et al*. (2005), analysing data for a longer period (1970-2000), found significant positive and negative correlations between national breeding population trends and use of garden feeders in winter for most species.

In an effort to understand more about the use of gardens by wider countryside species, we consider seasonal patterns of garden use. A feature apparent from the reporting rate plots in Cannon *et al*. (2005) is the strong cyclic nature of occurrence. All 40 species studied showed seasonal peaks in occurrence in gardens. Here we ask how use of gardens varies through the winter, and how this pattern compares with use of farmland by the same species. We might hypothesise that if farmland birds deplete food supplies in the countryside and move to gardens, then the seasonal patterns of occupancy of farmland and gardens should be negatively correlated. If birds are responding to some wider process (e.g. immigration on a national scale), then trends should be positively correlated. We assess this hypothesis using data collected between 1999 and 2002 in two national volunteer surveys of birds of gardens and farmland.

8.3 Methods

8.3.1 Field methods

For the BTO/CJ Garden BirdWatch, volunteer birdwatchers monitor the birds using their garden each week. The survey has been running since 1995 and boasts a current membership of 16,500 gardens. Coverage is not absolutely complete, but every week c70% of volunteers record the birds using their garden. For each of ten predefined abundant species volunteers assign the peak count in each week to one of four abundance categories (e.g. House Sparrow 1-5; 6-10; 11-20; 21+). For a further 31 species they simply record the presence of each species in each week. These data can provide weekly, seasonal and annual figures on reporting rates and relative abundance. The distribution of gardens submitting records (http://blx1.bto.org/gbw-dailyresults/results/gbw-gardens.html) is correlated with human population density but includes rural and urban habitats and all major landscape types in the UK (Chamberlain *et al*. 2005).

For the BTO/Joint Nature Conservation Committee *Winter Walks* survey, volunteer birdwatchers were asked to select a route of at least 1km through farmland and to make frequent visits between November and February of the three winters 1999/2000, 2000/2001 and 2001/2002. The survey focussed on 30 target species including declining species and specialist winter visitors to farmland. Observers recorded the number of each seen during each visit to their route. The distribution of sites was broadly correlated with human population density (Gillings & Beaven 2004).

Of the 30 species targeted by WFBS, 15 regularly occur in gardens (Table 8.1). Note that several common bird species of both farmland and gardens (e.g. Blackbird *Turdus merula*, Robin *Erithacus rubecula*) were not specifically targeted by *Winter Walks* and so seasonal trends cannot be examined. This analysis is therefore confined to the 15 species listed in Table 8.1.

8.3.2 Data preparation and analysis

For both *Winter Walks* and *Garden BirdWatch* we determined which farmland routes and gardens were visited in each of the 17 weeks from November to February in the three winters 1999/2000 to 2001/2002 (hereafter referred to as Winters 1 to 3). To reduce problems of poor coverage, we excluded any sites not visited at least 10 times in any one winter. The number of farmland sites visited per week (Table 8.2) was relatively constant. In contrast, the membership of *Garden BirdWatch* is still growing and so there was a gradual increase in coverage in two of the three winters (Table 8.2) (linear regression, winter 1, $F_{1,15} = 6.3$, $P < 0.05$; winter 2, $F_{1,15} = 11.3$, $P < 0.01$; winter 3, $F_{1,15} = 3.9$, $P > 0.06$, ns). Therefore, we determine for each week the proportion of visited gardens that were occupied by a species. For consistency we did the same for farmland sites. We refer to these proportions as ‘reporting rates’.

For some species the raw reporting rates showed wide fluctuations from one week. This was especially true for farmland sites where the smaller number of sites meant chance events such as missing a species that was actually there had a more pronounced effect on the trend, thus making it difficult to determine if there was an underlying seasonal trend. We therefore used logistic regression (Sokal & Rohlf 1995) which enabled us to statistically test whether or not there was a consistent underlying trend in reporting rates in a habitat, and if there was, to generate a *smoothed* summary trend (full details of analytical technique given in Appendix 1). This statistical testing enabled us to determine if a) reporting rate differed between years, b) if reporting rate varied through the season and c) whether any seasonal trend varied between years. Finally, for any species in which a trend was detected in both habitats we correlated trends to determine the extent of any possible switching between habitats.

8.4 Results

In both gardens and farmland the 15 species varied in their average reporting rate, with rare species being seen in 5% of less of sites and the more widespread species like House Sparrow and Chaffinch being reported in over 50% of sites (Table 8.1). Although for some species the reporting rate was similar in both habitats (e.g. Song Thrush, Table 8.1), across all species there was no significant correlation in between habitats ($n = 15$, $r_s = 0.37$, $P > 0.17$).

Graphs showing reporting rates for each species in farmland and gardens are shown in Fig. 8.1. As mentioned earlier, the reporting rates for gardens were particularly ‘noisy’ but the logistic regression analysis helped to determine if there were underlying differences between winters or across the season. The ‘fit’ values in Table 8.1 indicate that for most species the logistic regression fitted the data well but where fit was substantially less than 1 the results should be treated with caution (e.g. Tree Sparrow and Brambling). For farmland and gardens separately, these model fit statistics were significantly correlated with mean reporting rates from Table 8.1 (farmland $n = 15$, $r_s = 0.98$, $P < 0.0001$; gardens $n = 15$, $r_s = 0.85$, $P < 0.0001$), i.e. model fit was poorest for the scarcest species. Nonetheless, all fitted trends were generally good descriptions of the underlying data (Fig. 8.1).

In farmland, only Fieldfare and Brambling showed variation in reporting rates between winters, whereas in gardens, only Greenfinch and Reed Bunting did not (Table 8.1). However, it should be noted that the large number of gardens (over 6000 each week) gave high statistical power to detect differences that in biological terms might be considered insignificant. Thus though statistically speaking there was a difference in the reporting rate of Tree Sparrows between years (Table 8.1), the magnitude of that difference was extremely small (Fig. 8.1). Nine species showed significant trends in reporting rate in farmland, and all 15 showed significant trends in gardens (Table 8.3). Again, in reality, some of the garden trends were actually very minor (e.g. House Sparrow, Fig. 8.1). Likewise, the preponderance of significantly different trends between winters in gardens is not surprising, but Fig. 8.1 suggests real differences at least for Brambling and Goldfinch, and for Fieldfare in farmland.

Our hypothesis, that birds shift from farmland to gardens, should result in opposing trends between the two habitats. We tested this by measuring the strength and direction of any correlation between trends. This was performed for both the raw reporting rates and the smoothed trends. Trends for three of the thrushes were positively correlated between farmland and gardens (Table 8.3). Three of the finches showed negative correlations between habitats though only for Goldfinch were these correlations significant in most winters (Fig. 8.1, Table 8.3).

8.5 Discussion

All of the 15 bird species studied showed consistent significant seasonal trends in reporting rates in either, or both, gardens and farmland. Reporting rates of all of the granivorous passerines significantly increased in gardens during all winters. That such patterns could be related to a reduction in the availability of food in the farmed environment is supported by the work of Siriwardena *et al.* (submitted) who found pronounced seasonal patterns in the use of artificial patches of food in farmland. We found limited correlative evidence for birds shifting from farmland to gardens. Chaffinch and Greenfinch showed this pattern in all winters though significantly so in only one winter. Pied Wagtail showed this pattern in one winter but not in the others. The strongest evidence was for Goldfinch, which showed a clear decline in reporting in farmland concurrent with a clear increase in gardens in all three winters. Also, the significant increases in garden usage by other granivorous farmland passerines such as Tree Sparrow, Yellowhammer and Reed Bunting confirms that an influx from farmland does take place. In this respect it is surprising that we did not detect a corresponding decline in reporting rates on farmland.

The similarity in farmland and garden trends for thrushes point to larger-scale factors such as timing of migration or weather in dictating their presence across habitats. Comparing patterns annually is also revealing. For instance, Bramblings were exceptionally rare in both habitats in winter 2 whereas in winters 1 and 3 the species was more widely reported in both habitats. Such patterns are typical of this species that responds at large scales to fluctuations in natural seed availability within woodland. Chamberlain *et al*. (2007) showed that Bramblings were scarcest at garden bird feeders in years with high natural Beech *Fagus sylvaticus* mast availability. The data used by Chamberlain *et al*. (2007) rated the availability of beech mast in winters 1, 2 and 3 as low, high and low respectively. Therefore, our Brambling reporting rates in both farmland and gardens conform to the findings of Chamberlain *et al*. (2007), indicating that both farmland and gardens are secondary habitats for Bramblings. Goldfinches were present in 5-10% more gardens in winter 3 than either winters 1 or 2. If this was due to a greater than usual influx from farmland we would expect low occupancy of farmland throughout winter 3. This was not the case and actually, reporting rates in farmland were similarly elevated in winter 3. This perhaps points to a combination of local and large-scale patterns in determining Goldfinch occupancy of farmland and gardens.

Are there alternative explanations for trends other than local movements? In farmland, trends in detectability could generate apparent trends in reporting rate. For example, it may become increasingly difficult for casual observers to find the birds in farmland if they spread out in smaller flocks, gradually move from hedges to field centres, or increasingly use tall vegetation (or vegetation becomes increasingly tall). However, the fact we find variation in farmland reporting rate trends between sparrows, finches and buntings that are similar in size and requirements suggest such variations in detectability cannot be the only cause of these trends. Detectability issues are likely to be less of an issue in gardens.

Thus it would appear that there are strong and repeated seasonal patterns in the occurrence of several farmland birds in gardens in winter. That these species are labelled farmland birds is perhaps unfortunate since many are probably more associated with open scrub habitats (Fuller *et al*. 2004) and their use of farmland is merely an indication of where the majority of such habitat now exists. In this sense, use of shrubby gardens may not be so surprising, especially if suitable seed sources have been provided by garden owners. The degree to which these individuals use gardens as an alternative source of food is still unclear. Further analysis, for instance to determine whether rural gardens are more likely to be used by farmland birds than urban gardens, would be worthwhile. Also, reporting rates may alone may mask changes in absolute abundance. Since 2003 GBW participants have optionally recorded the peak abundance of species each week. Though not contemporary with this study, these data offer interesting possibilities to further assess the use that birds make of British gardens.

8.6 References

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Appendix 1 Analysis of reporting rates

For this analysis, an observation was the presence or absence of a given species at a site (GBW garden or Winter Walk route) in a certain week (week numbered 1 to 17). These data were analysed using an events/trials syntax in the SAS GENMOD procedure using a logit link function and binomial error structure (Anon 2001). Since counts at sites in sequential weeks cannot be considered statistically independent we used a *repeated measures* approach (Littell *et al*. 1996) which accepts that weeks close together are more highly correlated than weeks further apart and accounts for this in testing the strength of seasonal trends. All possible models were constructed with winter, week and $week^2$ terms, plus first-order interactions. The model with the lowest deviance and significant likelihood ratio tests of the parameters was identified. This is the model reported in tables and used to generate smoothed reporting rates for graphical purposes. Model fit was assessed by examining the deviance divided by degrees of freedom.

Initially it was hoped that datasets could then be combined to test for similarity or differences in trends between gardens and farmland. However, the large number of gardens contributing data (over 7000 per week) gave incredibly high power to detect extremely small differences in trends, such that even the slightest differences with farmland were likely to be statistically significant even if the general trend was similar. Instead, trends were compared by computing Spearman correlation coefficients between reporting rates from farmland and gardens. Separate correlations were performed for each winter, and separately for actual reporting rates and smoothed values for all species showing significant trends in both habitats.

Table 8.1 Species considered and results of reporting rate analysis. *Rate* is the mean reporting rate for each species in each habitat (F = farmland; G = garden). For farmland this is the mean of all reporting rates of all 17 weeks in all three winters. For gardens this is the approximate mid-winter average reporting rate based on the midpoint of the two long-term mean reporting rates for quarter 4 (October to December) and quarter 1 (January to March). *Fit* is a measure of model fit from the logistic regression with values near 1 being considered good fit. *Regression* denotes significant differences (at $P < 0.05$) in reporting rate for farmland or gardens: W = differences between winters; S = seasonal trend; W*S seasonal trends differing between winters.

Species	**Scientific name**	***Rate* (%)**		***Fit***		***Regression***		
		F	**G**	**F**	**G**	**W**	**S**	**W*S**
Pied Wagtail	*Motacilla alba*	27	12	1.2	0.7	G	F G	G
Fieldfare	*Turdus pilaris*	43	4	1.4	0.3	F G	F G	F G
Song Thrush	*Turdus philomelos*	30	27	1.2	1.1	G	F G	G
Redwing	*Turdus iliacus*	31	5	1.2	0.4	G	F G	G
Mistle Thrush	*Turdus viscivorus*	30	8	1.2	0.5	G	G	G
Starling	*Sturnus vulgaris*	49	68	1.4	1.3	G	G	G
House Sparrow	*Passer domesticus*	22	76	1.0	1.2	G	G	-
Tree Sparrow	*Passer montanus*	5	5	0.4	0.4	G	G	G
Chaffinch	*Fringilla coelebs*	59	76	1.4	1.0	G	F G	G
Brambling	*Fringilla montifringilla*	2	2	0.2	0.2	F G	G	G
Greenfinch	*Carduelis chloris*	26	72	1.1	1.2	-	F G	G
Goldfinch	*Carduelis carduelis*	19	21	0.9	1.1	G	F G	G
Bullfinch	*Pyrrhula pyrrhula*	13	6	0.8	0.4	G	F G	G
Yellowhammer	*Emberiza citrinella*	30	2	1.2	0.2	G	G	G
Reed Bunting	*Emberiza schoeniclus*	12	1	0.7	0.1	-	G	-

Table 8.2 Number of sites (*Winter walks* routes through farmland or *GBW* gardens) contributing records in each week (and over the whole winter) for each of three winters.

Habitat	Winter	Week number																	Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Farmland	1	67	75	74	73	78	65	83	63	76	73	80	75	77	80	69	73	73	96
	2	43	47	44	49	53	47	54	48	49	55	53	45	52	36	55	52	38	62
	3	50	49	63	55	50	61	63	55	59	55	59	56	47	47	57	55	48	73
Garden	1	6727	6805	6867	6919	6966	7058	7086	7018	6743	7001	7082	7059	7054	7022	7006	7022	6955	7265
	2	7871	7967	8034	7995	8091	8161	8040	7333	8351	8549	8566	8530	8490	8452	8447	8389	8452	8767
	3	8148	8185	8246	8309	8484	8578	8557	8149	8453	8576	8532	8463	8444	8452	8421	8395	8418	8782

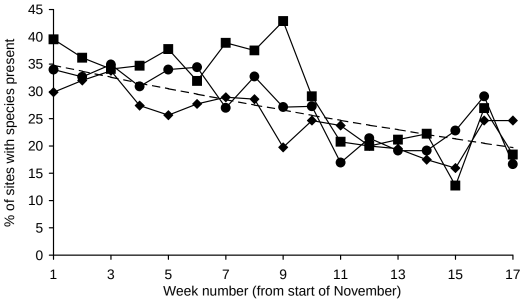
Table 8.3 Spearman correlation coefficients between farmland and garden reporting rates in each of three winters for the eight species with significant trends in both habitats. Separate coefficients are computed for actual reporting rates and for model fitted values ('smoothed'). Asterisks indicate significant correlations: * P < 0.05, ** P < 0.01, *** P < 0.001.

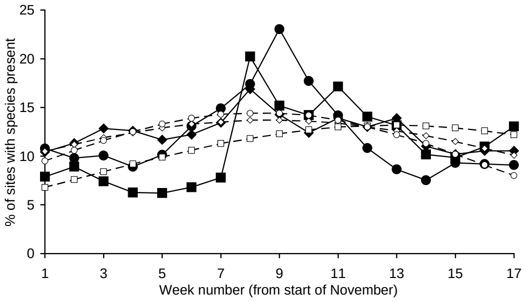
Species	Actual values			Model results		
	Winter 1	Winter 2	Winter 3	Winter 1	Winter 2	Winter 3
Pied Wagtail	0.0	-0.3	0.2	0.1	-0.8***	0.2
Fieldfare	0.8***	0.6*	0.6*	0.9***	0.5*	0.5*
Song Thrush	0.6**	0.6**	0.6*	1.0***	1.0***	0.8***
Redwing	0.5	0.5	0.6*	0.9***	0.7***	1.0***
Chaffinch	-0.4	0.2	-0.1	-0.5*	-0.3	-0.4
Greenfinch	-0.4	-0.2	-0.5*	-0.4	-0.4	-0.4
Goldfinch	-0.9***	-0.3	-0.3	-1.0***	-1.0***	-1.0***
Bullfinch	0.1	0.2	0.4	0.3	0.1	0.3

Figure 8.1 Reporting rate graphs for 15 species in farmland and gardens. Actual reporting rates are shown by solid lines and symbols. Smoothed values are shown as dashed lines. Dashed lines without symbols indicate the same general trend was apparent for all winters. Where smoothed trends differed between winters open symbols on dashed lines denote the winter. Diamond = winter 1, Square = winter 2, Circle = winter 3.

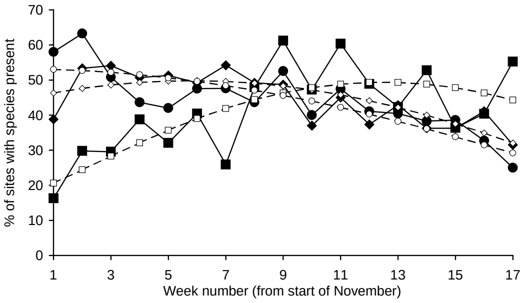
Farmland **Gardens**

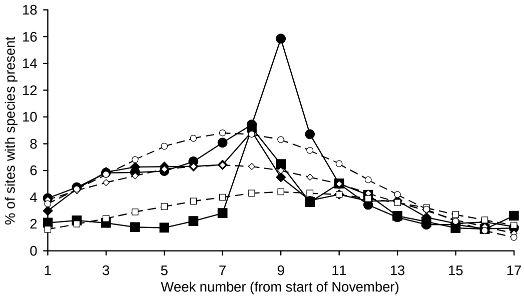
Pied Wagtail



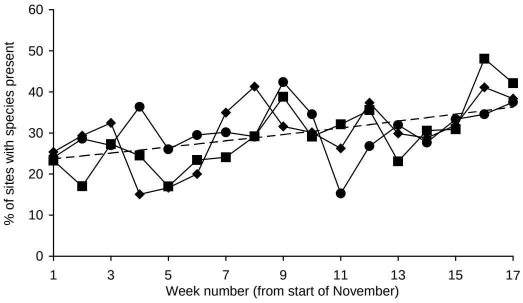


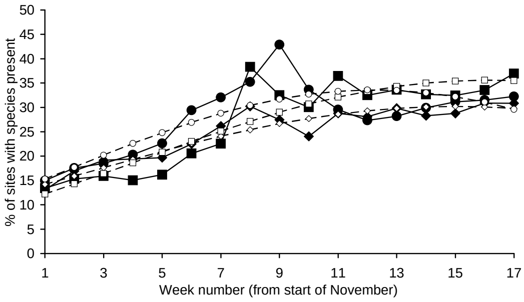
Fieldfare



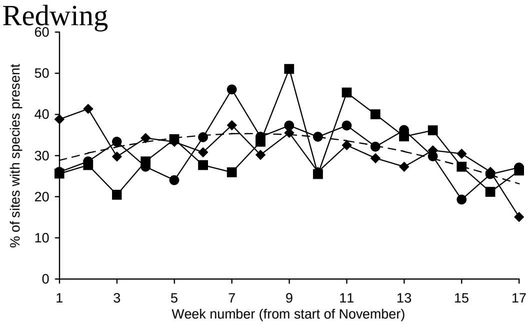


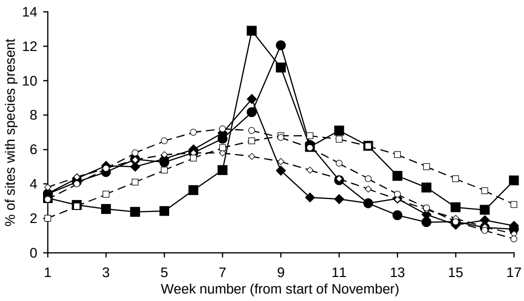
Song Thrush



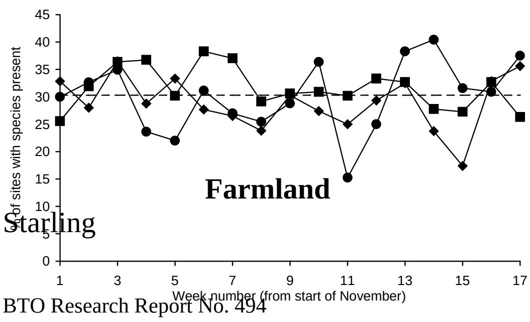


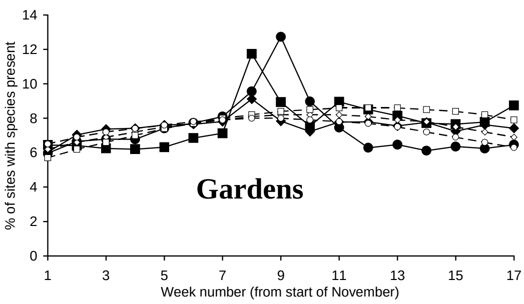
Redwing





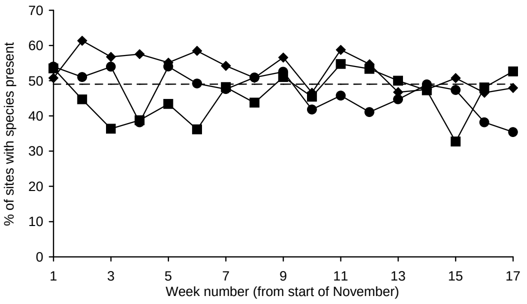
Mistle Thrush

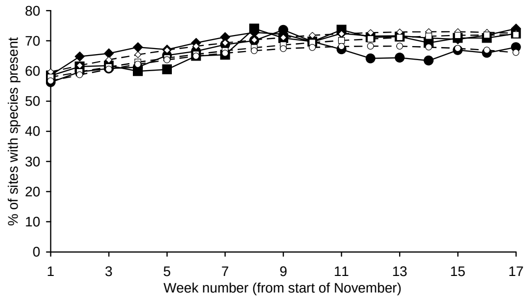




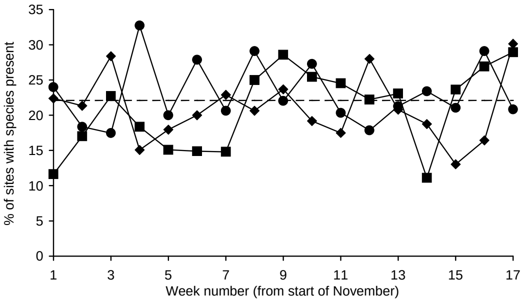
Farmland **Gardens**

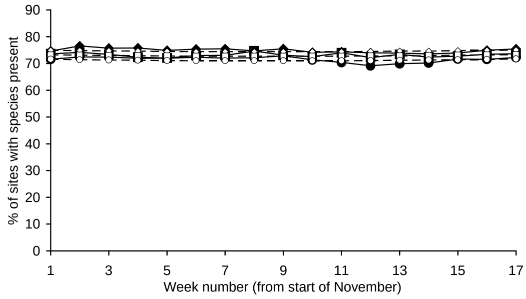
Starling



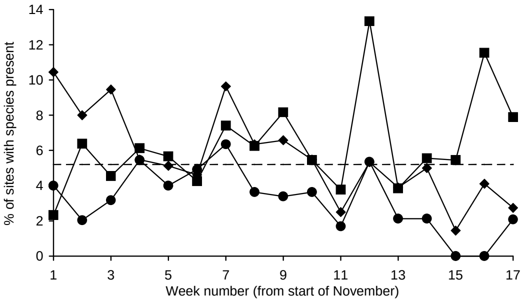


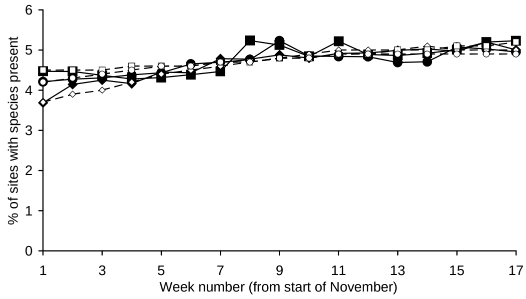
House Sparrow



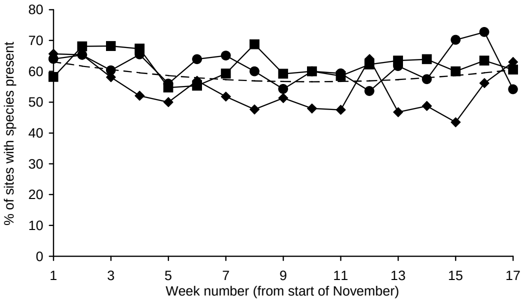


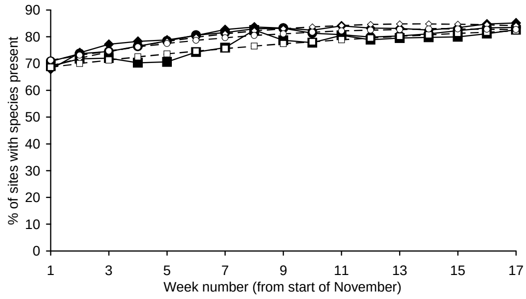
Tree Sparrow



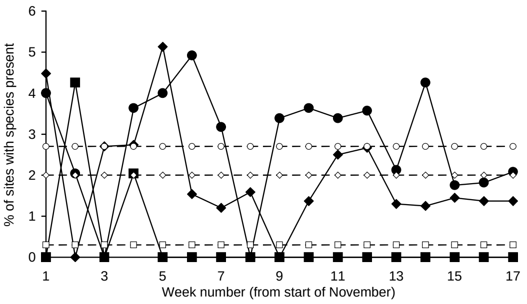


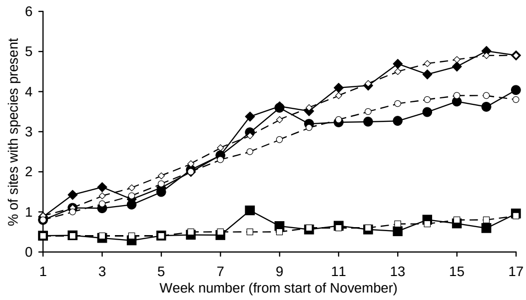
Chaffinch





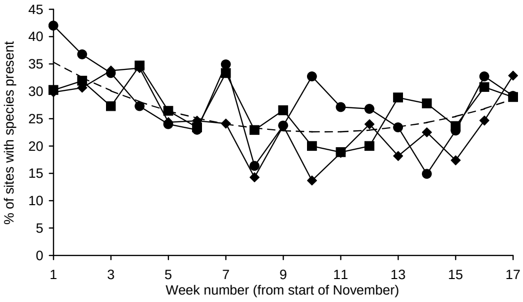
Brambling

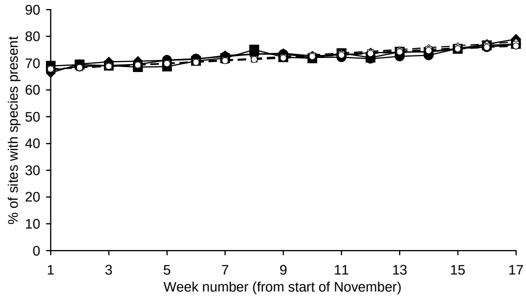




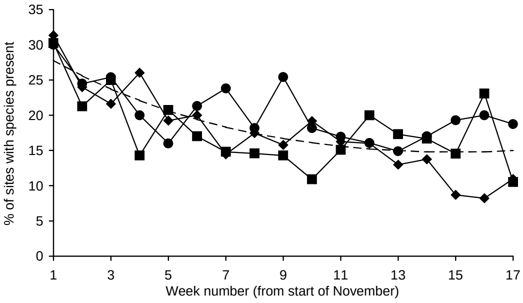
Farmland | **Gardens**

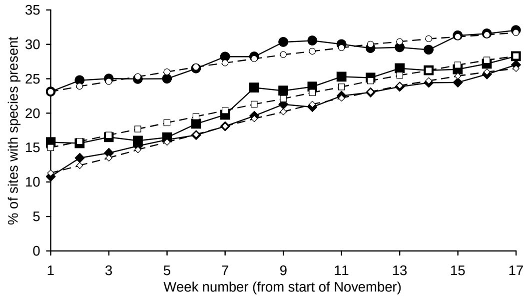
Greenfinch



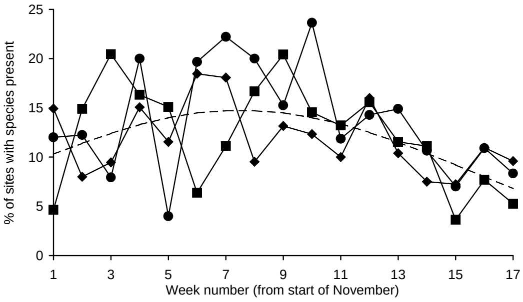


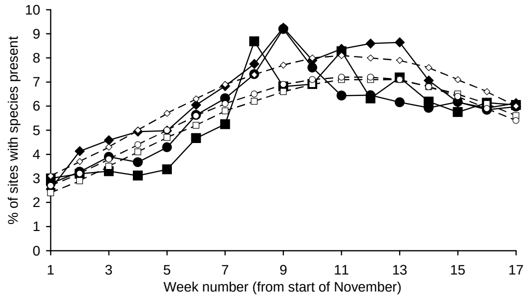
Goldfinch



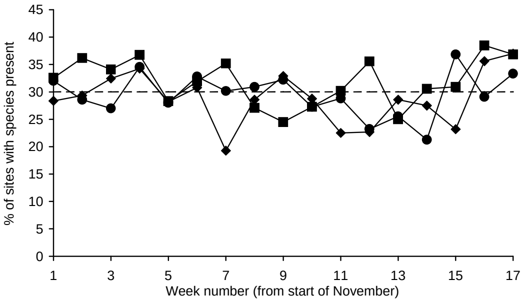


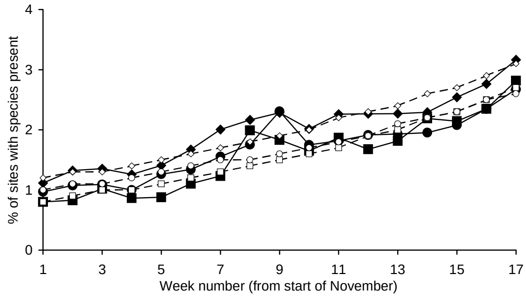
Bullfinch



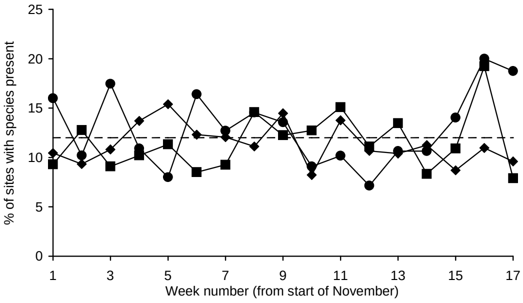


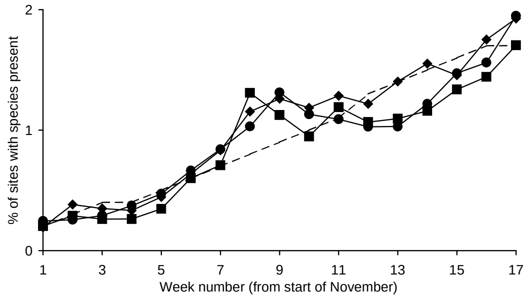
Yellowhammer





Reed Bunting





9. SUPPLEMENTARY ANALYSES

This chapter simply pulls together various preliminary analyses. Many of these aimed to assess the quality of the data provided by WFBS and to check for potential sources of bias. They also form useful background for interpretation or for considering potential for ongoing research using WFBS data.

9.1 Square and Geographic Coverage

Over the three-year course of the survey 1090 squares were surveyed: 395 in East England, 203 in North England, 145 in Scotland, 246 in West England, and 101 in Wales. Not all squares were surveyed in every winter, and Table 9.1 shows the number per winter, region and landscape stratum. Total coverage declined from winter 1 to winter 3. The percentage of squares surveyed in each region in each winter did not differ significantly from the original stratification (P = 0.10, P = 0.6 and P = 0.4) and coverage was geographically wide (Figure 9.1). However, the stratification of squares across regions and landscape types differed slightly but significantly from the original stratification in winters one ($\chi^2_4 = 13.3$, $P < 0.01$) and three ($\chi^2_4 = 13.9$, $P < 0.01$) but not winter 2 ($\chi^2_4 = 8.7$, $P > 0.05$). These slight biases in coverage meant that for any national analyses, data from different strata had to be weighted otherwise results might be biased towards certain strata. Coefficients were required in any case because the initial stratification was weighted in favour of some landscape strata in order to boost sample sizes (e.g. in Wales, see methods). The expected and actual stratification, along with coefficients are given in Table 9.2.

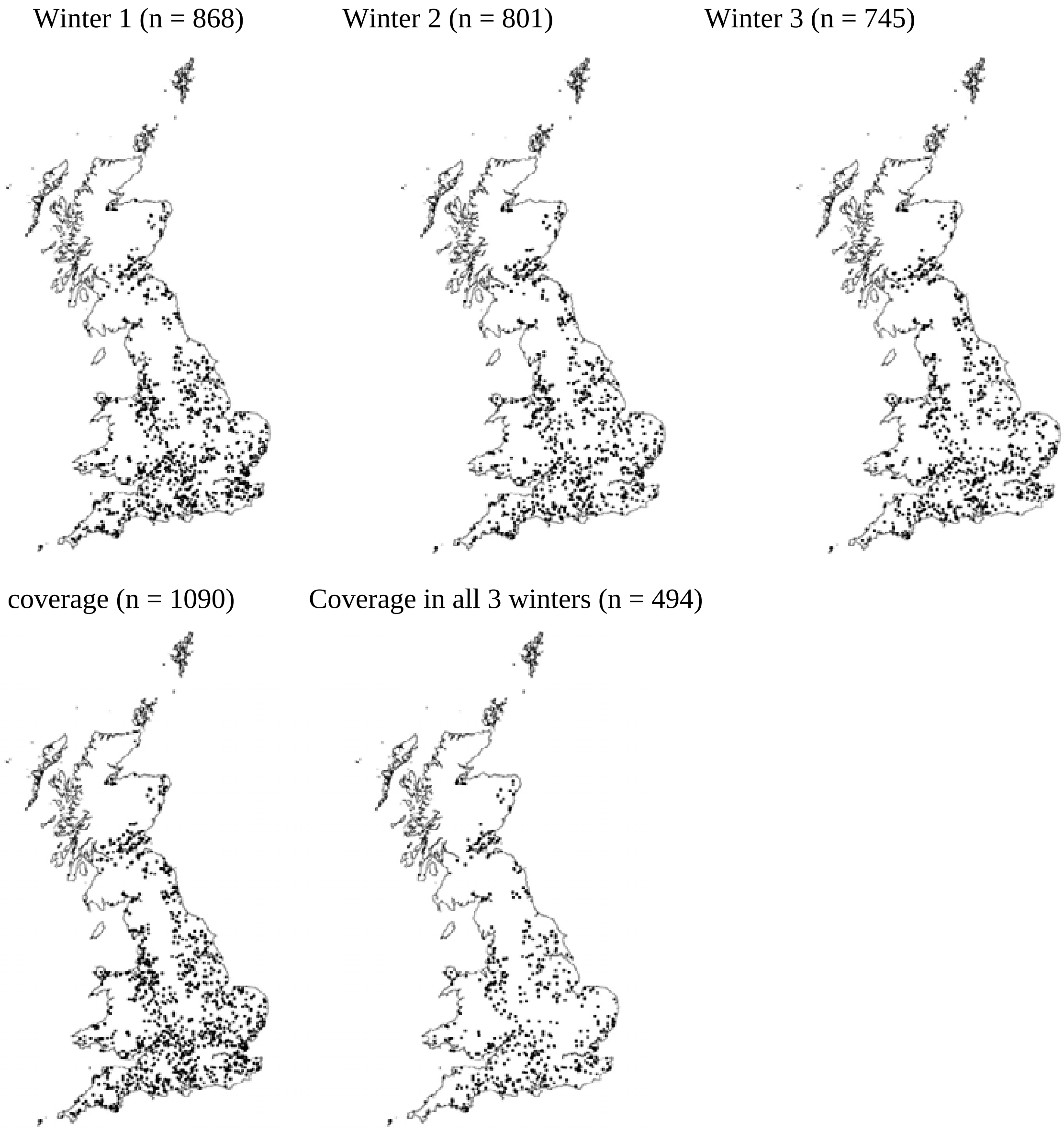
Table 9.1 The number of 1-km squares surveyed in each winter in each region, summarised by Landscape type (A = Arable, P = Pastoral).

Region	Winter 1			Winter 2			Winter 3		
	A	P	Total	A	P	Total	A	P	Total
E. England	297	32	329	247	27	274	236	23	259
N. England	46	104	150	51	102	153	51	94	145
Scotland	63	41	104	78	37	115	73	28	101
W. England	59	144	203	52	132	184	48	120	168
Wales	20	62	82	21	54	75	22	50	72
Total	485	383	868	449	352	801	430	315	745

Table 9.2 Summary by region and landscape stratum of the number (and %) of 1-km squares present in reality, and surveyed in each winter. The original stratification is shown along with coefficients required for the built-in weighting towards some strata, and the slight coverage bias apparent in winters 1 and 3.

Reality	E. England		N. England		Scotland		W. England		Wales	
	A	P	A	P	A	P	A	P	A	P
1-kms	41604	5632	7082	15547	10925	5788	9033	21736	735	7977
%	33.0	4.5	5.6	12.3	8.7	4.6	7.2	17.2	0.6	6.3
Strat.	30.8	4.2	5.3	11.7	9.0	6.0	6.7	16.3	3.5	6.5
Coverage										
Winter 1	297	32	46	104	63	41	59	144	20	62
%	34.2	3.7	5.3	12.0	7.3	4.7	6.8	16.6	2.3	7.1
Winter 2	247	27	51	102	78	37	52	132	21	54
%	30.8	3.4	6.4	12.7	9.7	4.6	6.5	16.5	2.6	6.7
Winter 3	236	23	51	94	73	28	48	120	22	50
%	31.7	3.1	6.8	12.6	9.8	3.8	6.4	16.1	3.0	6.7
Coefficients										
Winter 1	0.965	1.212	1.060	1.029	1.194	0.972	1.054	1.039	0.253	0.886
Winter 2	1.070	1.325	0.882	0.969	0.890	0.994	1.104	1.046	0.222	0.939
Winter 3	1.042	1.447	0.821	0.977	0.884	1.222	1.112	1.070	0.197	0.943

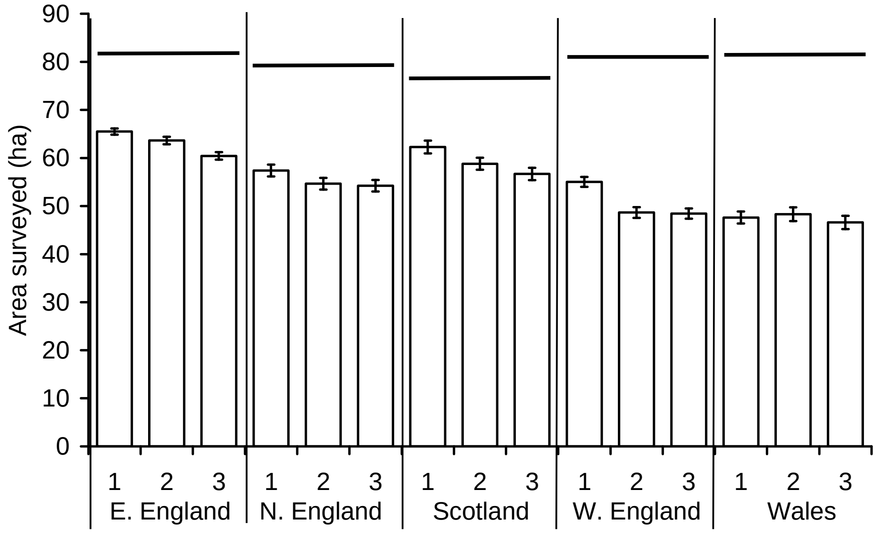
Figure 9.1 Coverage maps.



9.2 Within-Square Coverage

Across all 6648 visits across winters, the mean area of land surveyed was 57.0 ± 0.3ha but varied widely (range, 2.1-100ha). The area surveyed differed significantly between winters (Likelihood ratio $\chi^2_2 = 47.3$, $P < 0.0001$) and regions (Likelihood ratio $\chi^2_4 = 385.2$, $P < 0.0001$) but not visits ($\chi^2_2 = 2.6$, $P > 0.25$), nor any first-order interactions. The area surveyed per winter declined through the course of the survey and more farmland was surveyed in squares in Scotland and East England (Figure 2). The latter may have been because there was more farmland 'available' to be surveyed in these areas. Though the area of farmland in a square (as determined from LCM2000) does not change annually, a slightly differing selection of squares each winter could generate an artificial difference in farmland area. However this was not the case ($\chi^2_2 = 1.9$, $P > 0.3$). The mean area of farmland in squares differed significantly between regions ($\chi^2_4 = 11.1$, $P < 0.03$, Figure 9.2). Combining these two, the percentage of the square's farmland that was surveyed differed significantly between winters ($\chi^2_2 = 50.8$, $P < 0.0001$) though the differences were small: from 75% in winter 1 to 70% in winter 3. Percent square coverage differed significantly between regions ($\chi^2_4 = 571.9$, $P < 0.0001$): E. England = 78%, N. England = 71%, Scotland = 79%, W. England = 65% and Wales = 59%. No significant differences were apparent between visits in a winter.

Figure 9.2 Mean ± SE area (ha) of farmland surveyed in 1-km squares in each region in winters 1, 2 and 3 (bars) and mean area of farmland in those squares in each region (from LCM2000) shown by horizontal lines.



9.3 Number of Fields Surveyed Each Winter

For 251 squares in which complete coverage was attained on every visit, and in which the square was visited in every year, I looked at whether there was a change in the number of fields surveyed. This is matched data, so a Friedman chi-squared test was used. There was a significant difference between winters in the number of fields surveyed in a square ($\chi^2_2 = 26.2$, $P < 0.0001$).

Were there regional differences in field-level coverage? First, each square was classified as whether or not coverage was uniform across visits and then contingency tables used to test for regional differences. In winter 1 there was no significant association of uniformity with region ($\chi^2_4 = 7.4$, $P = 0.11$), but in winters 2 and 3 there was a significant association (winter 1 $\chi^2_4 = 17.2$, $P < 0.002$; winter 3 $\chi^2_4 = 14.1$, $P < 0.007$).

What difference does this make? Across all winters, I looked to see if there were significant differences in LEVEL1 habitat type areas between periods, and computed area estimates with or without period differences. I did this for all data, and then repeated using just those squares with uniform coverage. Table 9.3 shows mean areas (with 95% C.I.) for all squares and just squares with uniform coverage. As can be seen from this table, the area of grass estimated differed significantly between methods by 2.4ha. Crop differences were less marked. This indicates that in those squares where coverage changed, relatively more grass and relatively less crops were surveyed. Also, relatively more stubble and relatively less other habitat was surveyed. However, for the latter two habitat types there was no significant seasonal trend. This is reassuring because it suggests that observers did not increasingly focus their attention on interesting habitats such as stubbles. Some of these differences may be due to regional differences. When comparing the regional breakdown of all squares versus those with uniform coverage, those with uniform coverage contain relatively more eastern squares and fewer western squares, potentially corresponding with elevated crop and reduced grass area.

Table 9.3 Estimated area of each broad habitat type based on all surveyed squares and all squares with uniform coverage across winters and visits.

Habitat	Period	All	Uniform only	χ^2_1
Grass	All	38.5 (37.7-39.3)	36.1 (35.1-37.0)	14.2***
Crop	All	21.6 (21.0-22.3)	22.8 (22.0-23.6)	5.0*
Stubble	1	12.2 (11.6-12.9)	12.4 (11.6-13.2)	0.1 NS
	2	10.3 (9.7-10.9)	10.2 (9.5-10.9)	
	3	8.4 (7.9-9.0)	8.4 (7.8-9.1)	
Other	1	7.6 (7.1-8.1)	7.8 (7.2-8.5)	0.8 NS
	2	8.8 (8.3-9.4)	9.0 (8.4-9.7)	
	3	10.6 (10-11.2)	10.8 (10.1-11.6)	

9.4 Does the Grass-Arable Ratio of Surveyed Land Match the Grass-Arable Ratio from LCM2000?

I took the WFBS data for each square and each visit and determined the proportion of the surveyed farmland that was classified by the volunteer as grass. For each square I obtained the LCM2000 data and determined the area of farmland (sum of grass and arable landcover types) and calculated the proportion under grass cover types. On all visits and in all winter there was a significant positive relationship between the estimated cover of grass and the actual cover of grass (Table 9.4), suggesting that there was broad agreement between observed and expected habitat coverage (condensed down to the arable-grass ratio). Nevertheless, there was considerable scatter around the relationship. This may have several causes. Firstly, observers on average surveyed 75% of the agricultural land and therefore some sampling error is likely. Secondly, changes may have occurred since the LCM2000 data were produced (based on satellite coverage between 1998-2001). Thirdly, in some areas, the grass coverage extracted from LCM coverage may include some non-agricultural grassland (e.g. recreational areas, lawns) but this will probably only arise in a small number of squares.

Table 9.4 Spearman rank correlations between the proportion of WFBS surveyed land under grass and the proportion of the square under grass (LCM2000 data). *** $P < 0.001$.

Winter	Visit	N	r_s
1	1	849	0.79***
	2	826	0.80***
	3	681	0.80***
2	1	763	0.82***
	2	731	0.83***
	3	497	0.81***
3	1	732	0.78***
	2	710	0.78***
	3	629	0.78***

9.5 Frequency and Dates of Survey Visits

In each winter over 95% of squares were visited at least twice (Table 9.5). In winters one and three 86% and 89% of squares were visited three times but in winter two on 65% of squares were visited twice. This was due to access restrictions imposed in early 2001 due to the Foot and Mouth disease outbreak.

Visit dates varied widely from October 23rd to well into April, falling outside the main observation period. In each winter dates for visits 1, 2 and 3 overlapped considerably (Figure 9.3) because, for instance some observers made only two visits, started in January but still numbered them 1 and 2. For this reason visit number could not be used as a surrogate for time. Instead individual visits were reassigned to a period of the winter. Ideally three periods each of 40 days would have been used. However, this led to markedly differing sample sizes in each period (twice as many squares in period 3 as in period 1). Instead the three periods were defined as 1 November/December, 2 January and 3 February yielding the following number of visits in each period: winter 1: 837, 757, 796. winter 2: 765, 750, 565 and winter 3: 694, 659, 729. Note that even then, the number of visits in period 3 of winter 2 was low. This was undoubtedly due to the Foot and Mouth disease outbreak at that time.

Inevitably, reassigning visits to periods in this way meant that some squares were not visited in a given period, or were visited more than once in a given period. Furthermore, some visits were excluded because they fell outside the November to February observation period. Consequently the number of squares available for some analyses changed (Table 9.6).

Table 9.5 Summary of the number of squares receiving one, two or the full three visits during each winter.

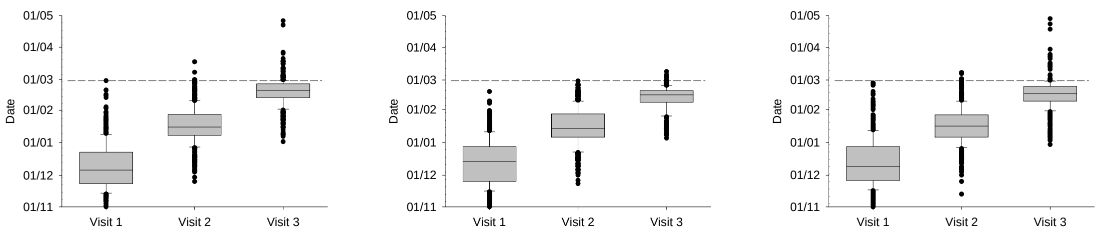
Number of visits	Winter 1	Winter 2	Winter 3
1	20 (2.3%)	34 (4.2%)	19 (2.5%)
2	101 (11.6%)	246 (30.7%)	61 (8.2%)
3	747 (86.1%)	521 (65.0%)	665 (89.3%)

Table 9.6 Summary of the total number of visits falling within each period, and the actual number of squares this comprised, totalling those surveyed once, twice or three times during within a period.

Winter	Period	Visits	Number of times square visited			
			1	2	3	Total
1	1	831	583	124	0	707
	2	757	653	52	0	705
	3	796	621	86	1	708
2	1	765	491	137	0	628
	2	750	618	66	0	684
	3	565	519	23	0	542
3	1	694	489	101	1	591
	2	659	555	52	0	607
	3	729	541	94	0	635

Figure 9.3 Box and whisker plots of the dates of 1st, 2nd and 3rd visits in each winter. Dots show outliers. The box shows the inter-quartile range, with the median (line) and the whiskers indicate 10th and 90th percentiles. The dashed line delimits the end of the requested recording period (end of February).

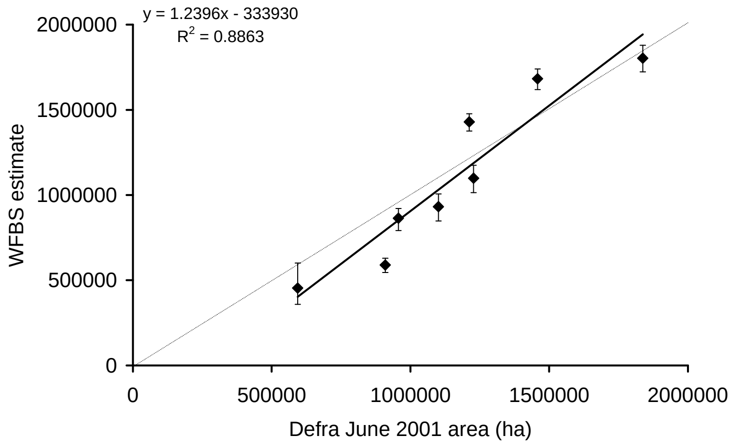
Winter 1 Winter 2 Winter 3



9.6 How do the WFBS Estimates of the Area of Crops and Grass Compare with Defra June Census statistics?

There was a reassuringly close correlation (Figure 9.4).

Figure 9.4. Plot of the area of various crops from the June 2001 Defra agricultural census and estimates of crop area in winter from WFBS. The line of equality is shown by the dotted line.



9.7 Analysis of Habitat Areas and Availability

First I calculated estimates of the area of each habitat in each square. These were corrected for the area of the square surveyed using LCM2000 data. These values were log(x+1) transformed and analysed to assess significant differences in habitat areas between winters, periods, regions and landscape types (Arable vs Pastoral). The analysis was repeated for data within each survey stratum (landscape type × region). For this analysis a two stage approach was taken whereby I first determined the percentage of visits on which a habitat was reported; secondly for each habitat, I calculated the mean area (with confidence limits) of habitat across those visits where the habitat type was present. This two-stage procedure was employed due to the highly skewed nature of the data.

The majority of habitats showed differences in availability between regions (Tables 9.7-9.17; Figures 9.5-9.14), and in many cases also landscape type. Four crops, two types of grass, three types of stubble and four other habitats showed strong significant differences between winters. Only sugar beet crop, cereal stubble and bare till showed significant differences between periods.

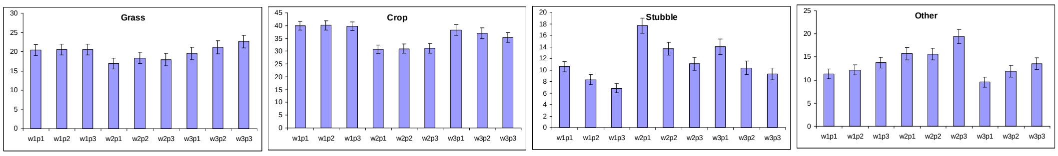
Table 9.7 Results of generalised linear models testing for differences in the area of habitats per 1-km square between regions, landscape types, winters and periods. Figures are type-3 likelihood ratio statistics tested against the chi-squared distribution. * = P < 0.05, ** = P < 0.01, *** = P < 0.001.

Habitat	deviance/df	Region	Landtype	Winter	Period
Crop					
Cereal	2.23	719.8***	191.6***	105.1***	0.6
Bean	0.17	66.2***	0.7	5.3	0.5
Brassica	0.25	9.3	0.8	2.4	0.2
Carrot	0.04	64.9***	1.4	4.7	4.8
Fodder Root	0.24	67.2***	26.0***	1.5	4.5
Gamecover	0.12	73.6***	28.8***	14.4***	0.2
Linseed	0.05	7.8	0.7	15.7***	0.1
Maize	0.05	16.2**	0.0	1.0	1.9
Oilseed	0.80	116.9***	28.6***	4.6	1.3
Other Vegetable	0.08	24.3***	28.3***	0.6	0.8
Potato	0.06	39.2***	0.4	22.4***	2.7
Sugar Beet	0.12	37.0***	0.6	3.2	32.5***
Unknown	0.17	47.1***	0.0	1.3	1.4
Grass					
Improved	2.25	627.7***	71.3***	4.5	0.3
Recently sown	0.64	141.1***	8.8**	34.2***	0.5
Unimproved	2.12	59.0***	2.0	27.4***	0.2
Unknown	0.40	8.2	1.3	3.7	0.4
Stubble					
Cereal	1.77	278.3***	25.1***	77.2***	49.1***
Bean	0.06	16.3**	0.4	0.1	1.6
Fodder Root	0.05	18.4***	7.8**	6.9*	3.9
Linseed	0.11	21.9***	1.2	34.9***	2.3
Maize	0.43	176.1***	0.1	0.6	1.6
Oilseed	0.15	28.5***	0.2	1.6	2.6
Potato	0.17	47.4***	11.9***	1.8	5.3
Sugar Beet	0.14	45.5***	0.0	4.5	0.7
Unknown	0.14	9.7*	0.6	86.5***	4.4
Other					
Bare tillage	1.66	205.9***	41.6***	89.0***	67.9***
Fallow	0.37	60.7***	6.4*	22.9***	2.3
Farmyard	0.22	42.9***	2.3	5.1	0.1
Orchard	0.15	104.1***	4.8*	0.4	0.3
Pig farm	0.18	10.3*	9.1**	0.8	2.5
Poultry	0.01	11.5*	0.2	3.4	0.2
Scrub patch	0.04	8.4	0.1	286.9***	0.0
Small farm wood	0.06	4.4	0.3	300.4***	1.6

Stratum = East England - Arable

Across periods, on average 20ha grass, 36ha crops, 11ha stubble, 14ha other and 1ha unknown. There was a significant difference in the estimate of grass area between winters (least in w2,χ^2_2 = 10.8, P=0.0044) but not periods (or interaction w*p, both P>0.8). Significant difference between winters χ^2_2 = 18.1, P < 0.0001) but not periods. Significant difference in stubble area between winters (χ^2_2 = 40.5, P < 0.0001) and periods (χ^2_2 = 29.5, P < 0.0001), but no interaction (P>0.9). Winter 1 not significantly different from winter 3, but winter 2 higher. Period 1 availability is higher and periods 2 and 3 are no significantly different. Significant difference in Other area between winters (χ^2_2 = 32.1, P < 0.0001) and periods (χ^2_2 = 12.5, P = 0.002) but not interaction (P>0.8). Winter 2 higher, and period 1 different (lower).

Figure 9.5 Area (ha) of broad habitat types in the region by winter (w) and period (p).



Cereal crops were by far the most prevalent habitat, being found in 78% of visits. When present, on average they accounted for c27ha, but there was significant variation between winters, with less in winter 2. The second most widespread crop was oilseed rape, being found on 22% of visits. When present, it accounted for between 10ha and 14ha. Gamecover crops were widespread, being found on 16% of visits, but accounted for only 2ha on average. Grass was also widespread. Improved and unimproved grass were found on 58% and 45% of visits respectively, though their respective areas were only 11ha and 9ha respectively. In both cases there was significant annual variation, with less grass recorded in winter 2. Farmyards were present in 28% of visits, and bare tillage on just under half. Bare tillage averaged 13ha per square when present, but was higher in winter 2. Of all the stubbles, cereal stubbles were by far the most widespread, being present in 51% of visits, and when present accounting for on average 10ha. However there was both significant annual and seasonal variation, with firstly more stubble in winter 2, plus a decline in area from early to late winter. All other stubbles were rare, with only sugar beet stubbles and maize stubbles being recorded from more than 5% of visits.

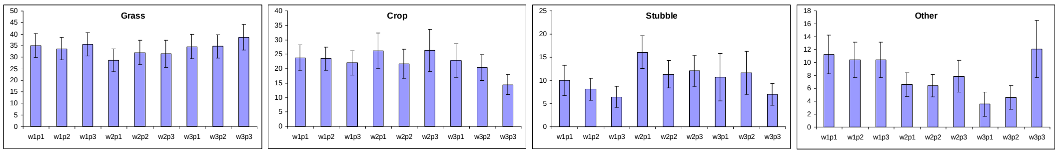
Table 9.8 Summary of presence and area where present by Level2 habitat type. East England Arable.

	East A		EFFECTS		DIFFERENCES		
Crop	**% occ**	**area (95% ci)**	**WINTER**	**PERIOD**	**W1**	**W2**	**W3**
Cereal	78.2%	26.9 (25.6-28.1)	40.5***	3.3	30.9	21.7	27.3
Bean	5.7%	10.5 (8.8-12.6)	10.9**	0.8	7	11.6	13.9
Brassica	6.5%	6.4 (5.1-8)	3.3	0.2			
Carrot	0.7%	10 (8.1-12.4)					
Fodderroot	3.3%	6.2 (4.8-8.1)	7.2*	0.5	4.5	7.1	10.6
Gamecover	15.7%	1.8 (1.6-2)	1.8	1.7			
Linseed	1.0%	9.8 (6.7-14.3)					
Maize	2.1%	2.5 (1.5-4.1)					
Oilseed	21.6%	12.6 (11.4-13.9)	9.4**	0.1	10.4	14.4	14
Other vegetable	2.2%	5.6 (3.9-8)					
Potato	1.1%	7.3 (5.4-9.7)					
Sugar beet	4.7%	5.4 (4.2-6.8)	4.6	2.4			
Unknown	5.3%	8.3 (6.6-10.4)	1.8	0.8			
Grass							
Improved	58.1%	10.9 (10.1-11.7)	6.5*	2	11.2	9.5	12
Recently-sown	8.0%	6.6 (5.8-7.6)	9*	1.1	5.9	5.3	8.6
Unimproved	45.3%	8.6 (7.9-9.3)	2.8	0.3			
Unknown	9.9%	5.1 (4.3-6.1)	2.6	0			
Other							
Bare tillage	49.2%	13.1 (12.3-14.1)	25.9***	2.5	11.1	16.5	12.5
Fallow	16.6%	4.9 (4.3-5.6)	0.2	0			
Farmyard	28.0%	1.1 (1-1.2)	2.5	0.9			
Orchard	7.9%	3 (2.2-3.9)	0.5	0.9			
Pig farm	3.0%	13.7 (10.9-17.1)	2.5	1.4			
Poultry	1.5%	1.1 (0.7-1.8)					
Scrub patch	3.5%	1 (0.8-1.3)	0	0.1			
Small farm wood	6.4%	0.9 (0.7-1.1)	0.3	0			
Stubble							
Cereal	51.3%	10.3 (9.7-11.1)	33.1***	12.7**	9.3/7.6/7.0	14.2/11.6/10.7	13.5/11.0/10.2
Bean	1.1%	3.9 (2.1-7.2)					
Fodder root	0.5%	12.7 (8.6-18.9)					
Linseed	2.1%	6.9 (4.8-9.9)					
Maize	5.1%	4.3 (3.3-5.5)	7.0*	1.2	4.8	5.5	2.3
Oilseed	4.7%	6.7 (4.9-9.1)	0.9	0.1			
Potato	2.7%	8.1 (6.4-10.1)					
Sugar beet	6.2%	5.7 (4.7-6.8)	17.4***	1.7	5.5	4	10.6
Unknown	3.9%	6.1 (4.6-8.1)	0.4	2.4			

Stratum = East England – Pastoral

No significant difference in Grass between winters or periods (P>0.5 for all).
No significant difference in Crop between winters or periods (P>0.6 for all).
Significant difference in stubble between winters (χ^2_2 = 6.3, P =0.04) but not periods (P>0.6) nor interaction (P>0.9). Winter 2 stubble area higher.
Marginally significant difference in Other between winters (c22 = 5.5, P = 0.06), but no significant difference between periods (P>0.5) or interaction (P>0.7).

Figure 9.6 Area (ha) of broad habitat types in the region by winter (w) and period (p).



Grass, cereal crops, bare tillage and cereal stubbles were the most prevalent habitats in pastoral east England. At 59%, fewer visits had cereal crops than corresponding arable squares in the region (78%). Similarly, the mean area of cereal crop where present was less at 22ha compared to 27ha. The area of cereal crop varied significantly between winters, with greatest in winter 2 and least in winter 3. More visits and a greater area of grass was present in pastoral squares than in arable squares. Improved and unimproved grass were reported in 63% and 53% of visits and mean areas where present were 18ha and 15ha respectively. Reassuringly these differences in grass and cereal crop conform to the separation of these squares as arable and pastoral from the ITE Land classification system. Just over one third of visits had bare tillage and a similar proportion had cereal stubbles. Of the other stubbles, the most prevalent was maize stubbles, with were present on 9% of visits and accounted for on average 13ha. This is again in agreement with these squares being pastoral in character as maize is often grown as a fodder crop for domestic cattle. Other than the difference in cereal crop area, no seasonal or annual differences were apparent, although few habitat types were sufficiently widely recorded to be analysed.

Table 9.9 Summary of presence and area where present by Level2 habitat type. East England Pastoral.

	East P		EFFECTS				
Crop	**% occ**	**area (95% ci)**	**WINTER**	**PERIOD**	**W1**	**W2**	**W3**
Cereal	58.8%	22.4 (19.4-25.9)	11.9**	0.1	25.5	28.3	15.5
Bean	2.2%	3 (2.4-3.9)					
Brassica	0.0%	0					
Carrot	1.2%	9.8 (9.7-9.8)					
Fodderroot	1.8%	9.2 (5.6-15.2)					
Gamecover	7.4%	0.7 (0.4-1.4)					
Linseed	1.4%	8.9 (2.5-31.3)					
Maize	0.0%	0					
Oilseed	15.2%	13.3 (9.2-19.3)					
Other vegetable	6.6%	4.9 (2.9-8.1)					
Potato	0.5%	1.2 (0.2-8.8)					
Sugar beet	1.5%	4.1 (1.4-11.9)					
Unknown	6.1%	8.6 (5-14.7)					
Grass							
Improved	62.9%	18.1 (15-22)	2.6	0.1			
Recently-sown	6.8%	4.9 (2.2-11)					
Unimproved	52.8%	14.5 (11.2-18.7)	1.9	1.4			
Unknown	5.1%	5.3 (4.4-6.4)					
Other							
Bare tillage	36.7%	12.2 (10-14.9)	0.8	1.5			
Fallow	6.8%	2.1 (1.6-2.7)					
Farmyard	22.7%	1.3 (1-1.6)					
Orchard	6.7%	3.7 (2.1-6.7)					
Pig farm	5.2%	9.2 (5.2-16.4)					
Poultry	0.0%	0					
Scrub patch	4.0%	0.4 (0.2-1)					
Small farm wood	4.4%	1.7 (1.2-2.4)					
Stubble							
Cereal	39.0%	13.4 (11-16.4)	1.1	1			
Bean	0.4%	3.6 (0.5-25.5)					
Fodder root	0.0%	0					
Linseed	4.7%	10.9 (7.4-16)					
Maize	8.5%	12.5 (8.3-18.8)					
Oilseed	2.0%	8.9 (6.7-11.9)					
Potato	2.2%	3.6 (2.3-5.6)					
Sugar beet	1.6%	7.3 (4.8-11.1)					
Unknown	2.3%	4 (0.7-22.8)					

Stratum = **North England – Arable**

No significant difference in Grass between winters or periods (P>0.5 for all).
Not quite significant difference in Crop between winter (χ^2_2 = 5.4, P = 0.07) or periods (P>0.9). Marginally significant difference in stubble between winters (χ^2_2 = 5.7, P = 0.06), and period (χ^2_2 = 4.1, P = 0.13). No interaction (P>0.9). Significant difference in Other between winters (χ^2_2 = 16.7, P = 0.0002) and periods (χ^2_2 = 8.2, P = 0.02). Winter 1 significantly higher than winter 3. Winter 2 marginally significantly higher than winter 3 (P=0.07). Winters 1 and 2 not different. Period 1 significantly lower than period 3. Period 2 lower than winter 3 but not significantly so. No difference between periods 1 and 2.

Figure 9.7 Area (ha) of broad habitat types in the region by winter (w) and period (p).

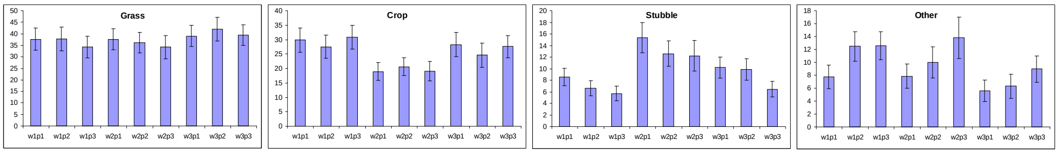


Table 9.10 Summary of presence and area where present by Level2 habitat type. North England Arable.

	North A		EFFECTS		DIFFERENCES		
Crop	**% occ**	**area (95% ci)**	**WINTER**	**PERIOD**	**W1**	**W2**	**W3**
Cereal	67.9%	21.8 (19.3-24.7)	2.8	0.5			
Bean	1.1%	1.9 (1.3-2.9)					
Brassica	3.9%	5.5 (3.3-9.1)					
Carrot	3.9%	4.6 (2.6-8.2)					
Fodderroot	13.0%	5.2 (3.8-7.2)					
Gamecover	12.8%	1.6 (1-2.4)					
Linseed	0.9%	21.4 (6.9-66.2)					
Maize	1.9%	4 (2.3-7)					
Oilseed	17.2%	6.3 (4.9-8.1)	0.4	0.4			
Other vegetable	0.0%	0.0					
Potato	1.4%	7.5 (2.4-23)					
Sugar beet	1.7%	4 (1.8-8.9)					
Unknown	4.5%	3.1 (1.9-5)					
Grass							
Improved	72.7%	22 (19.2-25.1)	3.1	0.7			
Recently-sown	19.0%	6.7 (5.1-8.7)	1.4	1.1			
Unimproved	54.3%	9.7 (8.2-11.6)	2.9	0			
Unknown	4.7%	6.6 (4.6-9.6)					
Other							
Bare tillage	43.1%	11.7 (10.1-13.6)	0.1	0.6			
Fallow	12.2%	5 (3.8-6.6)					
Farmyard	29.9%	1.1 (0.9-1.2)	0.9	0.1			
Orchard	0.8%	1.5 (0.2-10.3)					
Pig farm	3.4%	16.5 (12.6-21.7)					
Poultry	0.0%	0.0					
Scrub patch	3.8%	0.5 (0.2-1.2)					
Small farm wood	4.6%	2 (1.2-3.4)					
Stubble							
Cereal	52.3%	9.9 (8.6-11.4)	23.6***	5.5	6.8	14.9	9.2
Bean	1.4%	15.6 (6.8-35.8)					
Fodder root	1.8%	3.5 (1.6-7.5)					
Linseed	2.0%	8.8 (5.5-14.1)					
Maize	8.2%	9.8 (6.9-13.9)					
Oilseed	3.1%	3.2 (2.2-4.6)					
Potato	3.6%	3.1 (2.2-4.3)					
Sugar beet	2.3%	4.8 (3.5-6.5)					
Unknown	3.2%	7.7 (5.3-11.3)					

Stratum = **North England – Pastoral**

No significant difference in Grass between winters or periods (P>0.16 for winter, >0.9 for period). Significant difference in Crop between winters (χ^2_2 = 9.5, P < 0.0088) but not periods (P > 0.7). Significant difference in Stubble between winters (χ^2_2 = 12.9, P = 0.0016), but not periods (P>0.3) nor interaction (P>0.6). Significant difference in Other between winters (c22 = 22.0, P < 0.0001) but not periods (P>0.18) nor interaction (P>0.8). Winter 2 significantly higher than winter 3, but not different from winter 1.

Figure 9.8 Area (ha) of broad habitat types in the region by winter (w) and period (p).

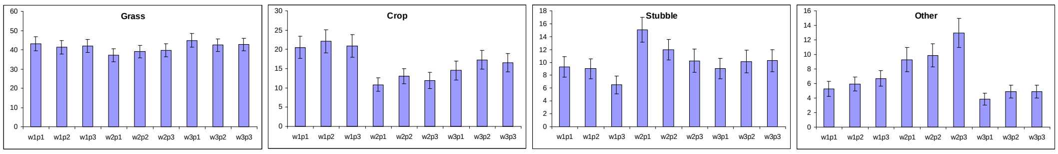


Table 9.11 Summary of presence and area where present by Level2 habitat type. North England Pastoral.

	North P		EFFECTS		DIFFERENCES		
Crop	**% occ**	**Area (95% ci)**	**WINTER**	**PERIOD**	**W1**	**W2**	**W3**
Cereal	45.6%	18.8 (17-20.7)	6.4*	1.9	21.8	16.2	18.7
Bean	1.4%	8.7 (6-12.7)					
Brassica	6.0%	6.2 (4.3-8.9)					
Carrot	3.3%	5.9 (5-7.1)					
Fodderroot	4.7%	4 (2.6-6.3)					
Gamecover	6.1%	1.5 (1.3-1.8)					
Linseed	1.1%	5.2 (4.4-6.2)					
Maize	1.4%	10.9 (5.4-22.1)					
Oilseed	10.1%	10.5 (8-13.7)	2.8	2.2			
Other vegetable	2.9%	3.8 (2.8-5)					
Potato	4.0%	7.6 (5.5-10.5)					
Sugar beet	3.5%	7.5 (5.8-9.7)					
Unknown	3.2%	1.8 (0.9-3.4)					
Grass							
Improved	82.4%	24.7 (22.7-26.8)	0.1	0			
Recently-sown	16.1%	7.4 (6-9)	0	2.2			
Unimproved	48.2%	8.4 (7.3-9.8)	0.4	0.5			
Unknown	7.0%	3.4 (2.4-4.9)					
Other							
Bare tillage	34.0%	9.6 (8.3-11.1)	20.4***	0.5	7.4	14.4	5.9
Fallow	11.2%	3.7 (2.8-5)	6.6*	0.3	2	4.5	1.2
Farmyard	39.8%	1 (0.9-1.2)	1.7	0.9			
Orchard	4.5%	0.6 (0.5-0.9)					
Pig farm	1.1%	11.9 (4.7-30.2)					
Poultry	0.7%	0.5 (0.2-1)					
Scrub patch	4.0%	1.4 (0.9-2.1)					
Small farm wood	3.6%	0.9 (0.6-1.4)					
Stubble							
Cereal	40.8%	11.8 (10.6-13.2)	6.3*	1.6	9.7	13	7.9
Bean	1.2%	7.8 (5.5-11)					
Fodder root	0.5%	13.1 (8.9-19.4)					
Linseed	0.8%	3 (1.1-8.5)					
Maize	7.7%	8.7 (6.2-12.1)	1	0.2			
Oilseed	4.1%	4.7 (3.2-6.7)					
Potato	10.2%	6.7 (5.6-8.1)	0.4	0.3			
Sugar beet	3.4%	4.7 (3.4-6.5)					
Unknown	5.0%	4.2 (3.1-5.9)					

Stratum = Scotland – Arable

No significant difference in Grass between winters or periods (P>0.5 for all).
Significant difference in Crop between winters (χ^2_2 = 7.8, P = 0.02) but not periods (P > 0.8). No significant difference in Stubble between winters (P =0.5), but significant difference between periods (χ^2_2 = 20.3, P < 0.0001), and no interaction (P>0.9). No significant difference in Other between winters (P=0.12), but significant difference between periods (χ_2 = 12.8, P = 0.0017). Winter 1 significantly lower than winter 3, but no difference with winter 2.

Figure 9.9 Area (ha) of broad habitat types in the region by winter (w) and period (p).

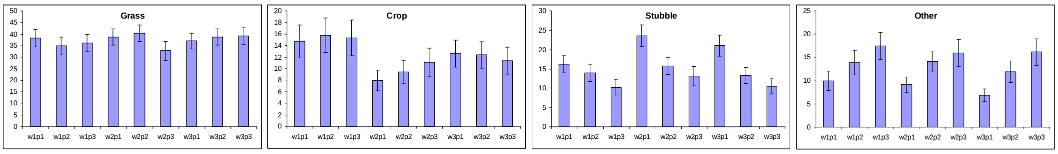


Table 9.12 Summary of presence and area where present by Level2 habitat type. Scotland Arable.

		Scot A	EFFECTS		DIFFERENCES		
Crop	**% occ**	**area (95% ci)**	**WINTER**	**PERIOD**	**W1**	**W2**	**W3**
Cereal	40.8%	16.7 (14.7-19.1)	0.1	0.1			
Bean	0.0%	0					
Brassica	3.0%	4.1 (2.6-6.6)					
Carrot	0.5%	10.4 (2.6-41.4)					
Fodderroot	7.5%	4.3 (3.2-5.8)					
Gamecover	4.5%	2.3 (1.7-3.2)					
Linseed	0.9%	2.2 (1.2-4)					
Maize	0.0%	0					
Oilseed	11.5%	9.1 (7.1-11.6)	6.6*	0.9	10.7	4	10
Other vegetable	0.9%	4.9 (3.3-7.3)					
Potato	1.5%	2.9 (1.7-5)					
Sugar beet	0.9%	2.7 (1.3-5.7)					
Unknown	1.8%	2.3 (1.9-2.8)					
Grass							
Improved	75.1%	20 (17.9-22.4)	0.6	0.4			
Recently-sown	11.5%	9.8 (7.8-12.3)	3.2	0.3			
Unimproved	52.6%	11.1 (9.5-13)	0	0.1			
Unknown	6.8%	6.3 (3.8-10.5)					
Other							
Bare tillage	45.2%	15.3 (13.5-17.4)	5.18.1*		12.0/15.4/18.4	12.0/15.4/18.4	12.0/15.4/18.4
Fallow	9.1%	4.2 (3-5.8)					
Farmyard	44.1%	1.3 (1.1-1.4)	7.30.6*		1.2/1.3/1.2	1.2/1.3/1.2	1.2/1.3/1.2
Orchard	0.3%	0.3 (0.1-1.1)					
Pig farm	4.5%	12.9 (8.8-18.9)					
Poultry	0.7%	0.6 (0.3-1.3)					
Scrub patch	4.2%	2 (1.2-3.3)					
Small farm wood	5.1%	0.8 (0.4-1.4)					
Stubble							
Cereal	64.3%	16.1 (14.6-17.8)	10.8**	8.8*	15.2/11.5/11.1	22.3/16.8/16.3	20.6/15.5/15.0
Bean	0.0%	0					
Fodder root	1.1%	7.8 (6.2-9.8)					
Linseed	0.8%	5.4 (1-28.3)					
Maize	0.0%	0					
Oilseed	3.2%	5.1 (3.5-7.4)					
Potato	3.0%	9.2 (6.8-12.5)					
Sugar beet	1.0%	7.7 (4.5-13.1)					
Unknown	1.2%	3 (1.6-5.5)					

Stratum = **Scotland – Pastoral**

No significant difference in Grass between winters or periods (P>0.2 for winter, >0.8 for period). Significant difference in Crop between winters (χ^2_2 = 19.7, P < 0.0001) but not periods (P > 0.8). Marginally significant difference in Stubble between winters (χ^2_2 = 5.0, P = 0.08) but not period (P>0.5) nor interaction (P>0.8). Marginally significant difference in Other between winters (c22 = 5.1, P = 0.08) and significant difference between periods (c22 = 12.1, P = 0.0024) but no interaction. Winter 1 significantly lower than winter 3, but no difference with winter 2.

Figure 9.10 Area (ha) of broad habitat types in the region by winter (w) and period (p).

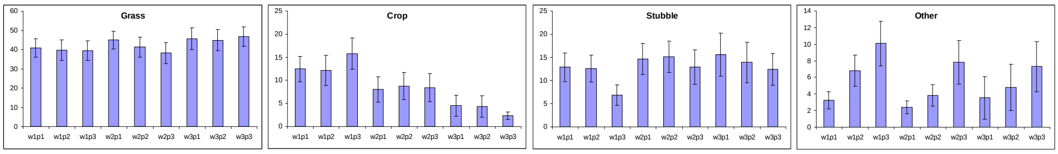


Table 9.13 Summary of presence and area where present by Level2 habitat type. Scotland Pastoral

	Scot P		EFFECTS		DIFFERENCES		
Crop	**% occ**	**area (95% ci)**	**WINTER**	**PERIOD**	**W1**	**W2**	**W3**
Cereal	30.2%	14.1 (11.3-17.5)	1	0.1			
Bean	0.4%	8.4 (1.2-59.4)					
Brassica	6.3%	4.7 (3-7.4)					
Carrot	1.7%	5.6 (4.2-7.6)					
Fodderroot	7.5%	3.8 (2.9-4.9)					
Gamecover	10.3%	1 (0.8-1.2)					
Linseed	0.4%	2.1 (0.3-14.7)					
Maize	0.0%	0.0					
Oilseed	8.4%	10.1 (6.8-15)					
Other vegetable	1.7%	1.8 (0.6-5.3)					
Potato	0.7%	5.4 (4.1-7)					
Sugar beet	0.4%	9.4 (1.3-66.7)					
Unknown	0.4%	0.6 (0.1-4.6)					
Grass							
Improved	81.5%	19.2 (16.4-22.5)	1.6	0			
Recently-sown	10.2%	5.4 (3.6-8.2)					
Unimproved	76.8%	9.8 (8.2-11.8)	10.8**	0.2	9.6	6.8	14.6
Unknown	7.2%	9 (4.5-18.1)					
Other							
Bare tillage	26.6%	8.7 (6.3-12)	1.7	4.5			
Fallow	7.8%	1.8 (1.1-3.1)					
Farmyard	32.5%	1.2 (1-1.5)	4	0.2			
Orchard	0.4%	20.4 (2.9-144.8)					
Pig farm	0.3%	1.7 (0.2-11.9)					
Poultry	0.0%	0.0					
Scrub patch	6.4%	1.1 (0.6-1.9)					
Small farm wood	6.1%	2 (1.1-3.7)					
Stubble							
Cereal	57.0%	11.6 (9.3-14.4)	0.1	0.4			
Bean	0.9%	6.8 (5.4-8.4)					
Fodder root	0.0%	0.0					
Linseed	0.6%	9.2 (2.3-36.6)					
Maize	0.0%	0.0					
Oilseed	2.2%	21.7 (16.5-28.5)					
Potato	4.7%	8.3 (5.9-11.6)					
Sugar beet	0.0%	0					
Unknown	3.8%	4.2 (1.4-12.6)					

Stratum = **West England –** Arable

No significant difference in Grass between winters or periods (P>0.2 for winter, >0.8 for period). No significant difference in Crop between winters or periods (P>0.57 for winter, >0.76 for period). No significant difference in Stubble between winters (P>0.15) or periods (P>0.2) nor interaction (P>0.6). Marginally significant difference in Other between winters (χ^2_2 = 5.5, P = 0.06), but no difference between periods (P=0.11). No interaction (P = 0.7).

Figure 9.11 Area (ha) of broad habitat types in the region by winter (w) and period (p).

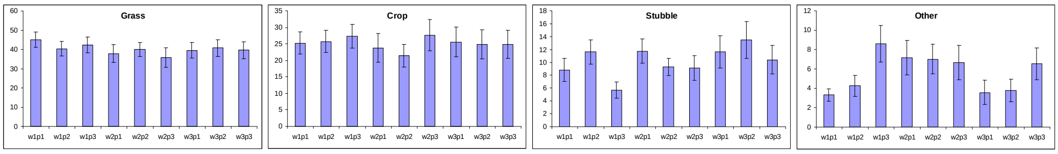


Table 9.14 Summary of presence and area where present by Level2 habitat type. West England Arable.

	West A		EFFECTS		DIFFERENCES		
Crop	**% occ**	**area (95% ci)**	**WINTER**	**PERIOD**	**W1**	**W2**	**W3**
Cereal	65.5%	21.8 (19.4-24.5)	0.7	1.8			
Bean	1.9%	11.1 (4-30.7)					
Brassica	7.4%	2.9 (1.8-4.8)					
Carrot	0.0%	0.0					
Fodderroot	9.7%	8.3 (6-11.5)					
Gamecover	5.7%	1.6 (1.2-2.2)					
Linseed	1.5%	8.9 (5.1-15.4)					
Maize	0.4%	2.1 (0.3-15.1)					
Oilseed	14.2%	16 (12.1-21)					
Other vegetable	0.0%	0.0					
Potato	0.0%	0.0					
Sugar beet	1.0%	8.9 (5-15.7)					
Unknown	1.9%	5 (2.5-10)					
Grass							
Improved	78.8%	19.5 (17.3-22)	1.2	0.2			
Recently-sown	21.9%	8.2 (6.5-10.4)	6.2*	0.4	7.2	6.1	12.4
Unimproved	57.1%	11.7 (9.8-13.9)	1.9	0.7			
Unknown	6.0%	18 (11.3-28.7)					
Other							
Bare tillage	32.5%	7.1 (5.8-8.8)	4	2.3			
Fallow	6.3%	6.6 (4.6-9.4)					
Farmyard	25.8%	0.8 (0.7-1)	0.1	0			
Orchard	2.5%	4 (2.2-7.6)					
Pig farm	4.3%	9.4 (8.1-10.9)					
Poultry	0.3%	0.2 (0-1.8)					
Scrub patch	3.9%	2.1 (1.6-2.8)					
Small farm wood	7.7%	0.8 (0.6-1.1)					
Stubble							
Cereal	46.7%	9.8 (8.4-11.5)	4.3	2.1			
Bean	1.4%	20 (14.7-27.3)					
Fodder root	3.1%	5.5 (3.9-7.6)					
Linseed	2.0%	4.6 (3.8-5.5)					
Maize	16.9%	9.9 (8.2-11.8)	1.6	0			
Oilseed	1.6%	11.6 (6.4-21)					
Potato	0.0%	0					
Sugar beet	0.2%	3.3 (0.5-23.6)					
Unknown	3.6%	5.5 (3.6-8.5)					

Stratum = West England – **Pastoral**

Significant difference in grass area between winters (χ^2_2 = 8.7, P 0.01) but not periods (P>0.7). Significant difference in crop area between winters (χ^2_2 = 18.1, P 0.0001) but not periods (P>0.6). No significant difference in Stubble between winters (P>0.8) nor periods, though only marginally (χ^2_2 = 4.7, P>0.09) nor interaction (P>0.9). Significant difference in Other between winters (χ^2_2 = 22.5, P<0.0001) but not periods (P>0.5)or interactions (P>0.9). Winters 1 and 2 significantly higher than winter 3.

Figure 9.12 Area (ha) of broad habitat types in the region by winter (w) and period (p).

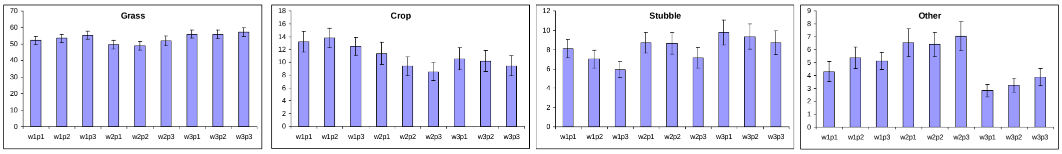


Table 9.15 Summary of presence and area where present by Level2 habitat type. West England Pastoral.

	West P		EFFECTS		DIFFERENCES		
Crop	**% occ**	**area (95% ci)**	**WINTER**	**PERIOD**	**W1**	**W2**	**W3**
Cereal	41.9%	13.9 (12.7-15.3)	1.4	0.3			
Bean	3.2%	9.5 (7.3-12.3)					
Brassica	9.3%	3.5 (2.9-4.4)	1.7	0.4			
Carrot	0.0%	0.0					
Fodderroot	9.0%	4.4 (3.8-5.2)	20***	0.3	3.4	4.0	7.6
Gamecover	1.4%	1.6 (1-2.6)					
Linseed	1.1%	4.8 (3.5-6.5)					
Maize	1.2%	1.5 (0.8-2.8)					
Oilseed	3.0%	10.3 (6-17.8)					
Other vegetable	2.7%	6.4 (4.9-8.4)					
Potato	0.4%	4.8 (2.8-8.2)					
Sugar beet	2.9%	5 (3.8-6.6)					
Unknown	3.5%	4.6 (3-7)					
Grass							
Improved	87.2%	35.3 (33.1-37.6)	10.7**	0.7	31.3	35.2	40.5
Recently-sown	19.6%	9.3 (8.2-10.6)	2.2	0.3			
Unimproved	49.2%	10.7 (9.5-12.1)	5.7	3.6			
Unknown	8.5%	5.9 (4.4-7.9)	17.1***	0.6	5.5	14.8	3.0
Other							
Bare tillage	27.2%	8 (7.2-8.9)	5.8	2.3			
Fallow	9.6%	3.4 (2.8-4.1)	12.8**	0.8	2.6	5.1	2.8
Farmyard	34.5%	1.1 (1-1.3)	1.7	0.1			
Orchard	11.0%	1.7 (1.4-2)	2.2	0.9			
Pig farm	2.7%	4.7 (2.9-7.8)					
Poultry	0.5%	0.6 (0.4-0.7)					
Scrub patch	3.7%	0.9 (0.6-1.3)					
Small farm wood	5.7%	0.7 (0.4-1.1)	2.2	0.2			
Stubble							
Cereal	38.9%	8.1 (7.3-9)	7.2*	0.8	6.8	9.6	8.3
Bean	2.2%	5.6 (4.1-7.5)					
Fodder root	1.7%	4.2 (2.9-6)					
Linseed	3.4%	9.8 (7.4-12.9)					
Maize	14.4%	10.1 (9.1-11.3)	19.9***	1.1	7.7	10.4	13.5
Oilseed	0.8%	3 (2.4-3.8)					
Potato	3.6%	7.1 (4.8-10.6)					
Sugar beet	2.6%	10.4 (7.9-13.7)					
Unknown	2.1%	6.3 (3.4-11.7)					

Stratum = **Wales –** Arable

No significant difference in Grass between winters or periods (P>0.6 for all). No significant difference in Crop between winters or periods (P>0.8 for all). No significant difference in Stubble between winters (P>0.7) or periods (P>0.9) nor interaction (P>0.9). No significant difference in Other between winters (P=0.4), significant difference between periods (χ^2_2 = 8.8, P =0.01) and no interaction (P>0.7). Period 1 significantly lower than period 3. No difference between period 1 and 2.

Figure 9.13 Area (ha) of broad habitat types in the region by winter (w) and period (p).

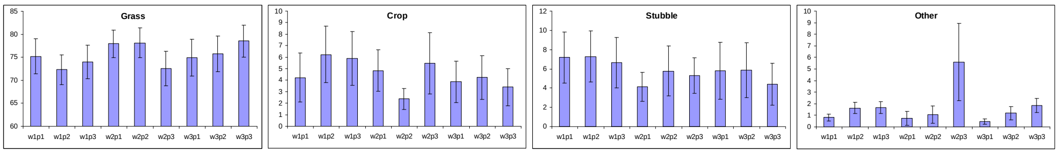


Table 9.16 Summary of presence and area where present by Level2 habitat type. Wales Arable.

	Wales A		EFFECTS		DIFFERENCES		
Crop	**% occ**	**area (95% ci)**	**WINTER**	**PERIOD**	**W1**	**W2**	**W3**
Cereal	25.0%	7.8 (6.1-9.9)					
Bean	3.7%	2.9 (1.9-4.6)					
Brassica	4.3%	4.3 (3.7-4.8)					
Carrot	0.0%	0.0					
Fodderroot	13.0%	5.3 (4.3-6.6)					
Gamecover	3.8%	4.2 (3.3-5.4)					
Linseed	0.0%	0.0					
Maize	0.0%	0.0					
Oilseed	1.8%	2.7 (0.9-8.4)					
Other vegetable	0.0%	0.0					
Potato	2.6%	13.1 (10.9-15.9)					
Sugar beet	0.0%	0.0					
Unknown	2.5%	7 (3.8-12.9)					
Grass							
Improved	86.3%	59.2 (55.1-63.6)	4	0.3			
Recently-sown	21.9%	6.3 (4.6-8.6)					
Unimproved	48.7%	17.1 (12.7-23.2)	3.1	0.5			
Unknown	9.6%	11.2 (4.6-27)					
Other							
Bare tillage	12.7%	4.1 (2.4-7)					
Fallow	3.2%	0.6 (0.3-1.1)					
Farmyard	36.3%	0.9 (0.7-1.2)	0.9	0.7			
Orchard	1.4%	0.3 (0.1-1)					
Pig farm	0.0%	0.0					
Poultry	0.0%	0.0					
Scrub patch	1.2%	6.6 (1.6-26.3)					
Small farm wood	3.6%	1.5 (0.7-3.1)					
Stubble							
Cereal	15.5%	7.7 (5.8-10.2)					
Bean	1.2%	5.2 (1.3-20.6)					
Fodder root	3.2%	3.7 (2.1-6.5)					
Linseed	3.2%	8.7 (7.6-10.1)					
Maize	16.8%	10 (6-16.7)					
Oilseed	0.0%	0.0					
Potato	7.0%	7.5 (5.7-9.8)					
Sugar beet	1.8%	3.9 (3.3-4.7)					
Unknown	8.1%	3.1 (1.8-5.5)					

Stratum = Wales – Pastoral

No significant difference in Grass between winters or periods (P>0.5 for all). No significant difference in Crop between winters (P > 0.25) or periods (P>0.9). No significant difference in Stubble between winters (P>0.18) or periods (P>0.7) nor interaction (P>0.9). No significant difference in Other between winters (P=0.2) or periods (P=0.14) or interaction (P>0.7).

Figure 9.14 Area (ha) of broad habitat types in the region by winter (w) and period (p).

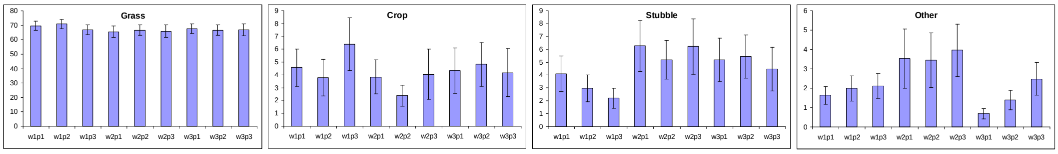


Table 9.17 Summary of presence and area where present by Level2 habitat type. Wales Pastoral.

	Wales P		EFFECTS		DIFFERENCES		
Crop	**% occ**	**area (95% ci)**	**WINTER**	**PERIOD**	**W1**	**W2**	**W3**
Cereal	16.8%	9.4 (7.5-11.7)	2.2	0.1			
Bean	0.0%	9.4 (7.5-11.7)					
Brassica	5.3%	5.2 (3.1-8.9)					
Carrot	0.8%	2.4 (0.8-7.5)					
Fodderroot	5.6%	2.3 (1.1-5.1)					
Gamecover	0.0%	0.0					
Linseed	0.0%	0.0					
Maize	1.0%	17.4 (12.7-24)					
Oilseed	1.9%	11.3 (4.9-26.2)					
Other vegetable	2.1%	5.8 (3.1-10.9)					
Potato	0.3%	12.9 (1.8-91.3)					
Sugar beet	0.5%	9.1 (4.8-17.3)					
Unknown	2.8%	2.5 (1-6.2)					
Grass							
Improved	88.7%	49 (45.2-53.3)	1.6	2.6			
Recently-sown	6.9%	8.3 (5.7-12)					
Unimproved	55.2%	13.9 (11.9-16.1)	0.3	0.3			
Unknown	4.7%	15.3 (8.2-28.6)					
Other							
Bare tillage	11.4%	8 (5.6-11.4)					
Fallow	3.8%	2 (0.9-4.6)					
Farmyard	34.7%	0.7 (0.6-0.9)		4.00.6			
Orchard	3.3%	1.3 (0.7-2.3)					
Pig farm	0.2%	2.8 (0.4-19.8)					
Poultry	2.1%	0.5 (0.4-0.5)					
Scrub patch	4.2%	1.6 (0.9-2.6)					
Small farm wood	3.4%	1.3 (1-1.7)					
Stubble							
Cereal	16.9%	9.7 (7.5-12.6)	6.5*	0.6	6.3	10.9	15
Bean	0.0%	0.0					
Fodder root	1.4%	8.9 (5.5-14.5)					
Linseed	0.0%	0.0					
Maize	11.6%	9.5 (7.6-12)					
Oilseed	1.2%	10.6 (8.1-14)					
Potato	0.3%	6.5 (0.9-46.3)					
Sugar beet	1.3%	4.9 (1.9-12.1)					
Unknown	2.2%	3.3 (1.8-6)					

Acknowledgements

The authors would like to thank the many field observers and regional organisers whose hard work has made this survey such a success.

For Chapter 2, we would also like to thank Su Gough for digitising help and Steve Freeman for statistical advice. The production of the identification tapes was supported by Birds Eye Wall's, Zeneca Agrochemicals and British Sugar plc. For Chapter 3, thanks to Andy Wilson for organisational support and Juliet Vickery and Phil Atkinson for useful comments. For Chapter 6, we would like to thank Ian Vaughan for advice on logistic regression testing. For Chapter 7, thanks to Steve Freeman and Phil Atkinson for statistical advice. Comments from Dan Chamberlain, Rob Fuller and two anonymous referees improved an earlier draft.

This work was funded by a partnership between the British Trust for Ornithology and the Joint Nature Conservation Committee (on behalf of English Nature, Scottish Natural Heritage, the Countryside Council for Wales and the Environment and Heritage Service in Northern Ireland).