AN ASSESSMENT OF THE WINTER DISTRIBUTION, ABUNDANCE & HABITAT ASSOCIATIONS OF FARMLAND BIRDS ON AGRICULTURAL LAND IN SOUTH CORK

Skylark in winter stubble (Photo Gemma Kelleher)

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Background

The tasks and deliverables, as set out in the Request for Tender and following planning and desktop review of the data known to us, were to :

Tasks -

- Identify a minimum of 30 farms within the SECAD study area across a range of land use types.
- Assess bird abundance and diversity over winter on the study farms using appropriate methodology.
- Identify and assess the different habitat characteristics on farms and key habitats features associuated with bird abundance and diversity.

Deliverables -

- Recommend appropriate locally specific, innovative and targeted measures for biodiversity enhancement on agricultural land within SECAD's South Cork Leader Zone (May 2023).
- Provision of a comprehesive report of the survey, including sites, survey design, and results, on all aspects of the wintering bird survey to the SECAD Partnership (July 2023).
- Provisions of a guide to biodiversity-friendly tillage farming to the SECAD Partnership (July 2023).

Project Team

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EXECUTIVE SUMMARY

Agricultural intensification at a continental scale in Europe has led to serious declines in farmland bird populations. Ireland has also seen dramatic changes and losses especially in recent decades, with declines across most of our once more widespread farmland associated bird species leading to regional and local extinction of some species. Several farmland bird species are highly dependent on seed resources left after harvesting cereal crops as well as cover crops and wild bird food crops planted specifically for farmland birds under agri-environment schemes. These include a number of species that have declined in abundance and range in recent decades and are of conservation concern as breeding birds, including Yellowhammer, Linnet, and Skylark. Comparative densities and habitat associations of wintering farmland birds are poorly known in Ireland despite ongoing declines in the area covered by tillage (7% of agricultural land in Ireland) and more recent changes to regulations under the Nitrates Directive potentially impacting the extent of winter stubbles. Here, we aimed to address this gap in our knowledge by assessing the diversity, abundance and habitat associations of winter farmland birds on tillage and pasture. We identified farms within 91 1km squares in the SECAD project area in south-east Co. Cork as survey farms. A total of 51 survey (tillage) transects were identified, including winter stubble, cover crops, shallow cultivation and wild bird food crops as field types, with 32 control (pasture) transects for comparison. All transects were visited twice, once in 'early' winter (Nov-early Jan) and again in 'late' winter (mid Jan-early Mar). Birds were surveyed along transects within standard distance bands (0-25m, 25-100m, >100m) of surveyors and habitat features (field type, hedgerow quality and management etc) recorded. Data was entered directly in the field using the QFIELD app and later uploaded. Data was downloaded and mapped in QGIS.

Results of the winter farmland bird surveys confirmed the importance of tillage crops for farmland birds of conservation concern such as Skylark, Yellowhammer, Linnet, as well as wintering Snipe. Seed dependent winter farmland birds, especially Skylark, Linnet and Yellowhammer, were almost exclusively found on tillage transects. The most impotent field type for winter farmland birds in terms of numbers (48%) and scale was winter stubble. This was especially so for wintering farmland birds of conservation concern, especially Skylark, Linnet and Yellowhammer which made up some 63% of the birds recorded on winter stubble. Moreover, winter stubble was the most important

field type for Skylark (72% of all records in stubble), Linnet (39%), Yellowhammer (56%) and Snipe (41%). Although not common across the survey area (just 9 transects), results reiterate the importance of wild bird food crops for wintering farmland where these were provided. Cover Crops were the most important field type for Snipe (50% of species total in CCs), Redwing (48%), as well as Song Thrush (62%). Cover crops were less important than expected when the data for only seed-eating birds were examined. Shallow cultivation held good numbers of Skylark (37% of all birds in SC) and Redwing (12%), holding more birds per area available than cover crops in early winter. However, the importance of shallow cultivation for winter farmland birds declined by late winter (from 15% to 9.6% of all birds recorded) and it was the poorest field type/area available for birds in late winter. This may be explained by a decline in seed availability for seed-eating birds in late winter although birds numbers on winter stubble largely held up in late winter (49.6% to 46.2%).

Winter farmland birds were found at highest densities in wild bird food crops and, at lower densities but on a much bigger scale in winter stubble in this study. While, other than wild bird food, birds were found at highest density in cover crops when all species were included in the dataset, winter stubble held the highest densities of threatened (BoCCI) birds as well as seed-dependent species. Likewise, cover crops in late winter, and, when both visits were combined, winter stubble and wild bird food crops were utilised by winter farmland birds more than expected.

This study strongly indicates that shallow cultivation is significantly poorer for winter farmland birds than winter stubbles. While a diversity of winter field uses including cover crops and, especially, wild bird food crops are highly beneficial for farmland birds, our results indicate that maintaining or increasing the area of winter stubble, especially unsprayed, is the single most important action to benefit winter farmland birds at scale. Maintaining or improving hedgerow quality is also important for species such as Yellowhammer that are largely absent from areas lacking in hedgerow cover.

1. OVERVIEW

1.1 LAND USE CHANGE AND FARMLAND BIRD DECLINES

Habitat loss and land use change has been one of the primary drivers of declines in biodiversity loss and species extinctions worldwide (Sánchez-Bayo & Wyckhuys 2019, Betts et al. 2022), and rates of species loss have accelerated in recent decades (Pimm et al. 2014). Although the large-scale losses of areas of the planet that hold much of the world's biodiversity (e.g., tropical rainforest) are well documented and an increasing challenge globally, the transformation of much of the agricultural landscapes in Western Europe in the late 20th and early 21st centuries have been equally devastating for wildlife populations. Agricultural intensification at a continent-wide scale in Europe has led to massive declines in bird populations (Donald et al. 2006, Bowler et al. 2019) as well as regional and local extinction of many bird species characteristic of and benefitting from extensive, low-intensity farming systems (Doxa et al. 2010).

Farmland bird populations are considered to be a good indicator of environmental and land-use change in farmland biodiversity, given that birds play a significant role in the food chain, and are found in a variety of habitats. The EU Farmland Bird Index shows a 34% decline among 39 species common on farmland since 1990 (Fig. 1), with declines in species in forest being much less severe, suggesting that agriculture is a significant driver for biodiversity loss (EEA, 2019). In Europe, agricultural intensification has been accelerated by the requirements of, and incentives provided by, the Common Agricultural Policy (CAP), resulting in larger farms, the loss of smaller, lower-input farming systems, increased pesticide and herbicide use to grow larger scale crop and livestock monocultures (Sanderson et al. 2013, Reif & Vermouzek 2019). As well driving declines in bird populations, this has led to massive losses in pollinators (e.g., butterflies, hoverflies, bees) and other insects, with consequent implications for biodiversity loss as well as real and potential future impacts on agricultural output and food security (Sánchez-Bayo & Wyckhuys 2019).

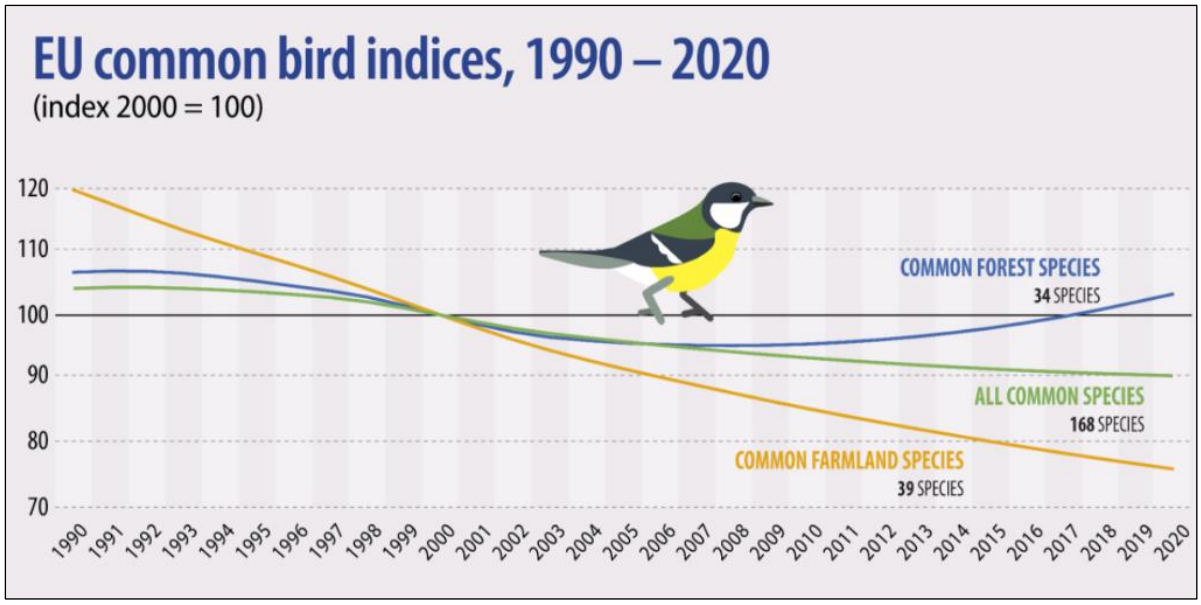

Fig. 1 EU common birds indices, 1990-2020. European Bird Census Council (EBCC), national BirdLife organisations, Royal Society for the Protection of Birds, Czech Society for Ornithology (CSO). Source: www.ec/europa.eu/eurostat.

Agricultural intensification has also seen dramatic changes and losses in Ireland over the same time-period, with declines across most of our once more widespread farmland associated bird species. None has been more dramatic than the loss of the once ubiquitous Conrcrake across almost all of mainland Ireland, following the switch from hay to silage and earlier and more frequent cutting of grass crops (Green & Stowe 1993). This has more recently been mirrored by the catastrophic decline in the Irish Curlew population from 3-5,500 pairs in the 1980s to probably less than 100 pairs today, and similar if not as dramatic declines in other breeding wader species (e.g., Lapwing, Redshank, Snipe) with the loss of wet grassland and bogs for nesting (Colhoun et al. 2015). Similarly other birds often dependent on farmland for nesting and foraging have declined, including Barn Owl and Stock Dove, while one farmland associated bird, the Corn Bunting, declined to extinction in the latter half of the 20th century (Taylor & O'Halloran 2002). Farmland birds make up a significant proportion of birds listed as of high (Red) or medium (Amber) conservation concern in the most recent assessment of Birds of Conservation Concern in Ireland (Gilbert et al. 2021), including birds once more abundant and widespread such as the Yellowhammer, which has become extinct as a breeding bird is some counties (e.g., Kerry) in recent decades.

1.2 TILLAGE AND FARMLAND BIRDS

Farmed landscapes which include arable crops in a predominantly grassland environment are important for the conservation of granivorous (seed eating) passerine birds (Robinson et al 2001). However, specialisation towards a single land-use can also cause homogenisation and loss of biodiversity in agricultural ecosystems on a landscape scale (Emmerson et al. 2016). This is the case in Ireland, where grassland-orientated production has steadily increased over the past fifty years and is now the dominant land-use, with 90% of the agricultural land devoted to pasture, meadow and silage (CSO, 2020). Much of this is improved grassland, which is associated with a low species diversity. Although tillage (7%) is the next most common agricultural land use in Ireland after grassland, the area involved in growing crops is relatively small and the proportion of tillage had declined dramatically since famine times and later, the founding of the Irish State (CSO 1997). More recently the area covered by tillage has declined by over 40% since the 1980s (CSO 2020) and by 57% (-57,000ha) between 2008 and 2018 (Wallace 2020). The tillage sector is dominated by barley (57% of the tillage area in 2014-2018) with wheat (19%) and oats (7%) respectively (Wallace 2020). Other tillage crops include oilseed rape, fodder maize, potatoes and pulses (peas and beans). Between 1985 and 2018 the area of spring sown cereals halved while winter sown crops increased (Wallace 2020). This is significant for wintering birds as much of the foraging and survival value of tillage is retained by winter stubble, while the proportion of winter sown crops have inreased, with a consequent loss of foraging habitat for birds. Likewise, the retention of field margins and extensive hedgerows, even where tillage crops are primarily winter sown, are also likely to be important for the winter survival of species such as Yellowhammer and Tree Sparrow which tend to preferentially forage in the margins of fields (Wilson et al. 1999, Vickery et. al 2002).

Winter stubble remaining after harvesting of cereal crops has been shown to be a critically important source of food, mostly spilt grain and weed seeds, for sparrows, finchs and buntings (Buckingham et al. 1999, Evans et al. 2004). Moreover, it has been shown that the availability of winter stubble in the landscape positively impacts long-term breeding population trends for a number of farmland bird species while Skylark and Yellowhammer populations recovered when winter stubble was retained at 10-20ha in a 1km square (Gillings et al. 2005). However, although targeted agri-

environment schemes (AES) have had a positive impact on the abundance of some species, other research has shown that even where winter stubble is retained, some bird species (Yellowhammer, Reed Bunting, Chaffinch and Dunnock) experience a critical late-winter 'hungry gap', indicated by a peak in uptake of supplementary food at that time (Siriwardena et al. 2007).

1.3 BIRDS OF CONSERVATION CONCERN (BOCCI) ON FARMLAND IN IRELAND

Farmland holds a number of birds species in decline or threatened with extinction in Ireland, several of which are known to occur in the SECAD project area in winter (Table 1). These were the focal species for winter surveys in the SECAD project area although all farmland bird species wintering in the SECAD area, including those of lower conservation concern (Green listed) but for which farmland is important, especially in winter, were surveyed and their populations assessed (e.g., Dunnock, Chaffinch).

Table 1. Birds of Conservation Concern in Ireland (BoCCI) occurring or likely to occur on farmland in the SECAD area in winter.

Species	Status	BoCCI4	SECAD area
Stock Dove *Columba oenas*	Resident	Red	Y
Barn Owl *Tyto alba*	Resident	Red	Y
Kestrel *Falco tinnunculus*	Resident	Red	Y
Golden Plover *Pluvialis apricaria*	Winter	Red	?
Lapwing *Vanellus vanellus*	Winter	Red	?
Snipe *Gallinago gallinago*	Winter	Red	Y
Black-headed Gull *Larus ridibundus*	Winter	Amber	Y
Lesser Black-backed Gull *Larus fuscus*	Winter	Amber	Y
Meadow pipit *Anthus pratensis*	Winter	Red	Y
Skylark *Alauda arvensis*	Winter	Amber	Y
House Sparrow *Passer domesticus*	Resident	Amber	Y
Greenfinch *Carduelis chloris*	Resident	Amber	Y
Linnet *Carduelis cannabina*	Resident?	Amber	Y
Yellowhammer *Emberiza citrinella*	Resident	Red	Y
Brambling *Fringilla montifringilla*	Winter	Amber	?
Redwing *Turdus Iliacus*	Winter	Red	Y

Previous survey work in the SECAD project area (funded by SECAD & IDL) has shown that South-east Cork holds higher breeding densities of Yellowhammer than those known from other parts of Ireland (Finch et al. 2022). Thus, population and ecological data on the requirements of this species and other granivores (seed eaters) in winter

is critical to any future agri-environment scheme aimed at consolidating and enhancing habitat for Yellowhammer and other farmland bird species. Recent changes to the regulations regarding the shallow cultivation of winter stubble under the Nitrates Directive (SI 113/2022) has the potential to place additional pressure on the retention of winter stubble in the SECAD area and the farmland birds that depend on the habitat. This fundamental change, along with a move to winter sown cereals and conversion of tillage to dairy, are all likely to have cumulative impacts on seed dependent winter farmland birds. However, whether shallow cultivation has a negative, neutral or positive impact on farmland birds is as yet unknown. The timing and results of this study are therefore highly pertinent to addressing this question.

Therefore, questions to be addressed by this study are:

- How important are tillage field types and associated habitats for winter farmland birds in the SECAD area?
- How are winter farmland birds distributed across the survey farms?
- What field types are most important for winter farmland birds?
- What are the densities of winter farmland birds and how do they differ, if at all, across field types?
- Does species abundance and density differ over the winter?
- What are the key field types and habitat associations of BoCCI and seed dependent species?

Based on the results of the study of winter farmland birds presented here we outline some key recommendations for their conservation. While there is huge scope for implementing positive action for declining farmland birds thought dedicated AES, identifying key criteria to benefit winter farmland birds at a landscape level across much of the country are important to halt and reverse decade long declines in range and abundance.

2. SURVEY METHODS

The survey methodology described briefly here was designed to:

- Identify a minimum of 30 tillage and pasture-based farms within the SECAD project area.
- Assess the winter diversity and abundance of farmland birds on farms in the SECAD project area, most specifically diversity and abundance of birds on land used for arable crops (including areas of wild bird cover and other crops maintained for biodiversity) and pasture for dairying and silage.
- Assess the habitat types available to wintering farmland birds.
- Assess the relationship between bird species abundance and diversity and farmland habitats: winter stubble, shallow cultivation, cover crops, wild bird food crops, and hedgerow quality.
- Assess differences, if any, between 'experimental' (survey sites including tillage crops) and 'control' sites (pasture)

2.1 FARM TRANSECT SELECTION

The winter farmland birds project was located in the South-east Cork Area Development (SECAD) area of operation (Fig. 1). Initially the same fifty-four 1km squares selected for the breeding Yellowhammer study in 2021 (Finch et. al. 2021) were identified as the basis for the winter farmland birds transect as these were known to hold high densities on Yellowhammer in summer as well as likely holding suitable areas of tillage in winter (Fig. 1). However, winter stubble and other tillage types was highly fragmented (interspersed with pasture) in its distribution even within these 'core' survey squares. Thus, survey transects could not be randomly selected and suitable tillage areas holding winter stubble and other field types were identified by ground truthing and mapping fields using Google Maps. In total, 91 1km squares were identified with sufficient tillage and pasture field types to allow for statistical comparison.

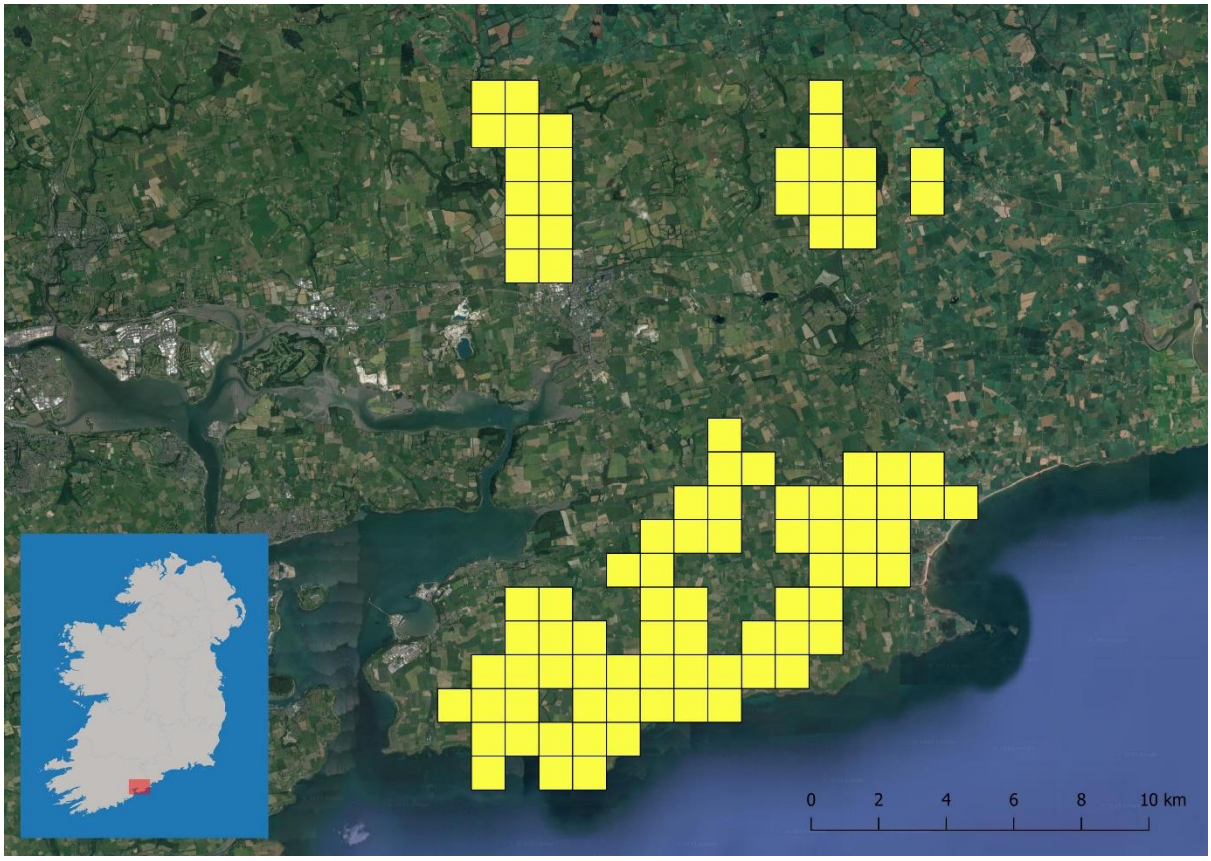

Fig. 1 The distribution of survey squares (91) within the SECAD area.

One kilometre line transects were mapped within the areas of tillage identified from ground surveys. In total. 83 one kilometre transects were identified, including 51 survey and 32 control transects (Table 2, Fig. 2). A higher number of survey transects was selected as these were made up of a number of different tillage crops including stubble, shallow cultivation, cover crops and wild bird food. Thus, for statistical comparison with other field types at least 30 of these were wholly or primarily stubble. Additional transects outside the initial fifty-four 1km squares were added to complete all the grassland control transects and to add additional transects in winter stubble (Table 2).

Table 2. Survey areas and number of survey and control (grassland) transects. Transects were classed as 'survey' (stubble, cover crops etc) or 'control' (pasture). The aim was to gain enough 'registrations' (observations or vocalisations) to calculate bird densities or for the key winter farmland bird species.

Area	1km sqs	Survey	Control
Trabolgan-Ballycroneen	24	24	14
Churchtown	5	4	3
Mogeely	8	7	3
Midleton	10	5	3
Shanagarry	13	8	5
Cloyne	10	3	4
Total	70	51	32

In total, 39 of the 52 1km survey transects included winter stubble with 27 (75%) transects holding >50% stubble. Other survey field types included shallow cultivation (n=20), cover crops (n=23) and wild bird food (n=9). Six tillage transects were incomplete (701-828m), four of which were fragmented by grassland. Thus, 46 survey transects were the full 1km in distance while all grassland (control) transects were 1km in length.

Fig. 2 Winter farmland bird transect locations in the SECAD project area. Survey transects (red) were sited in arable fields while 'control' transects were sited on pasture.

2.2 FIELD TYPES

2.2.1 WINTER STUBBLE

Winter stubble, the remains of a cereal crop after harvest, are traditionally left fallow in winter and potentially provides food resources (spilt grain, weed seeds, insects) for farmland birds throughout the winter when food is scarcest (Fig. 3). Cereal stubble fields are usually ploughed and a new crop sown in late winter-early spring.

Fig. 3 Winter stubble field surveyed for farmland birds, Buckstown, Co. Cork, in November 2022.

Winter stubble constituted the most abundant field type surveyed, being found in 39 of the 52 transects surveyed (Table 3). However, some stubble transects were lost to ploughing by early February.

Table 3. Field type distribution on survey (tillage, N=51) and control (pasture) transects in the project area during winter 2022-2023.

Field type	1st visits		2nd visits	
	Field type number	% field type	Field type number	% field type
Stubble	39	54.12	37	53.36
CCs	23	24.5	21	22.06
SC	20	17.08	24	20.42
WBF	9	3.99	9	3.30
Pasture	32	100	32	100

2.2.2 SHALLOW CULTIVATION

This field type was introduced in 2022 under regulations relating to post-harvest shallow cultivation of winter stubble under the Nitrates Directive (*SI 113 of 2022*) but amended to retain a proportion of winter stubbles (*SI 393 of 2022*). This regulation requires that shallow cultivation take place within 14 days of harvest of a cereal crop and within 10 days of chopping/baling of straw. Where required, a minimum of 20% and a maximum of 25% of tillage on each holding must not be subject to shallow cultivation (i.e.., retained as winter stubble) to preserve food resources for farmland birds. Exemptions apply to organic farms, root crops or late harvested crops, cereals or beans harvested after 15th September and/or land due to be sown as winter cereal crops by 31st October. Shallow cultivation, shallow tilling of the stubble, to promote greening over winter and to help mitigate nitrate leaching, occurred on 20 transects on 1st visits and 24 transects on 2nd visits (Table 3). In the field shallow cultivation appears similar to stubble with the cereal stalks flattened by tilling (Fig. 4).

Fig. 4 Shallow cultivation field surveyed for winter farmland birds at Ballycroneen, in the SECAD project area, in winter 2022-2023.

2.2.3 COVER CROPS

Cover crops included crops specifically grown as a green cover crop (e.g. mainly winter Brassica mixes) and crops such as fodder beet (Fig. 5). Cover crops were the second most widely occurring field type surveyed across 23 transects (Table 3).

Fig. 5 Cover crops surveyed for winter farmland birds in the SECAD project included primarily fodder brassica mixes and fodder beet.

2.2.4 WILD BIRD FOOD CROPS

Wild bird food crops were grown specifically to provide food, typically seed resources, to attract and feed farmland birds in winter (Fig. 6). Wild bird food crops are typically grown to feed winter farmland birds as part of an AES (e.g., GLAS, ACRES) and include seed mixes such as Linseed, Mustard and Triticale. In the SECAD area wild bird food crops were either in whole fields or patches or strips within existing fields of other crops. Wild bird food was a relatively scarce field type within the project area, only found on nine transects during winter surveys (Table 3).

Fig. 6 Wild bird food crop surveyed for winter farmland birds near Cloyne, in the SECAD project area, winter 2022-2023

2.2.5 WINTER CROPS

Growing crops such as winter barley were not surveyed. However, one survey transect was partly (30%) made up of bare ground in early winter that proved to be ridges of a large crop of Daffodils on the late winter visit (Fig. 7).

Fig. 7 Winter growing crop of daffodils, part of transect T6, Ballycroneen, in the SECAD project area, winter 2022-2023

2.2.6 SCRUB

Scrub made up a very small proportion (3%) of two transects within the survey (tillage) transects surveyed, although a number of transects had small or more extensive patches of scrub on field boundaries (Fig. 8). Scrub provides important cover in winter for farmland birds as well as a source of winter food (berries etc) and breeding sites in summer.

Fig. 8. Patches of scrub, such as this mix of gorse and whitethorn, on a coastal transect at Ballycroneen, in the SECAD project area, in winter 2022-2023.

2.2.7 PASTURE

A total of 32 control (grassland) transects were surveyed in the project area in winter 2022-2023 (Table 3). Most pasture in the project area was improved grassland that has been ploughed and reseeded in recent years rather than permanent pasture.

2.3 BIRD SURVEYS

In preparation for surveys all transects were mapped on Google Maps and QGIS Version 3.32 (www.qgis.org) and distance estimated using the distance tool on Google Maps. A bespoke winter farmland birds survey project was set up using QField software (https://qfield.org/) to record data in the field. Within the QFIELD project two datafields were set up, one to record bird data and another to record habitat data. Bird species were assigned a British Trust for Ornithology (BTO) code for recording in the field.

Bird surveys were undertaken on farms in early winter (November 2022-early January 2023) and repeated later in the winter (mid-January-early March 2023) using appropriate standardised methods (1km line transects). Line transects are the best method for surveying most bird species in large, open areas (Bibby et al. 1992, Gilbert 1998). Transect routes were mapped with the start and end point at a fixed GPS location. Transects were divided into 200m sections to be comparable to the methods used in standard Countryside Bird Surveys (CBS). All sites had two visits over the winter to assess bird diversity, numbers and habitat associations. Line transects used the standard methods of registering bird locations using the 0-25m, 25-100m and >100m distance bands used in CBS (https://birdwatchireland.ie/our-work/surveys-research/research-surveys/countryside-bird-survey/) and conventional bird surveys designed to estimate densities (Bibby 2000). Surveys began at least an hour after sunrise and ended at least an hour before sunset to minimise counting birds moving to and from night-time roosts. Except for raptors which 'use' a site for hunting, birds flying over the site and not landing or otherwise using the site were not recorded. Likewise, every effort was made to avoid duplication of records (i.e.., a bird flushing in front of the surveyor and moving to another section on the transect). Bird survey and habitat data was recorded using QField software, including date, transect number and section (0-200m etc). Bird locations and habitat data were logged directly using the QField app on a handheld mobile phone and uploaded to the cloud (Fig. 9).

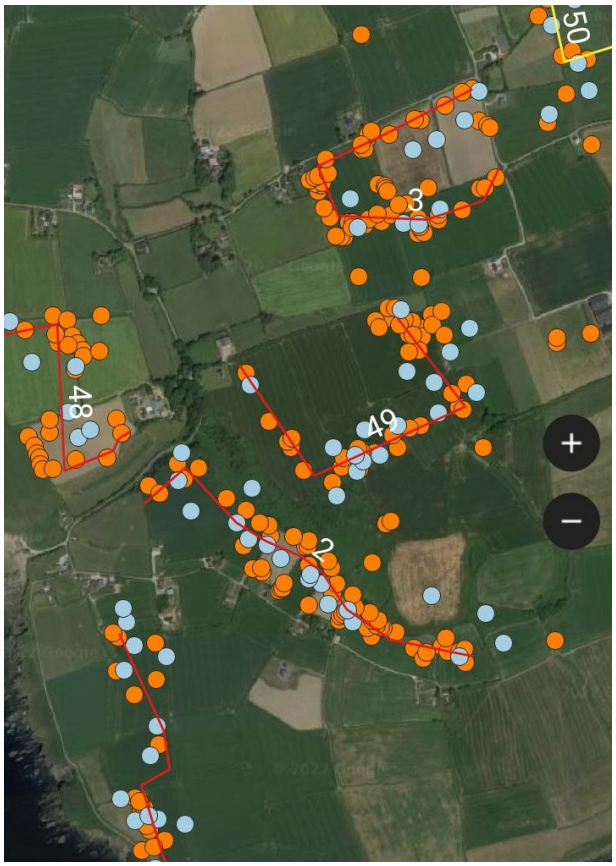

Fig. 9 Example of results of winter farmland bird transect locations in the Lahard-Inch area on 1st visits. Numbers refer to the transect identifying number. Bird locations (orange) and habitat features (blue) were added in real time in the field.

Where flocks of small birds (e.g., mixed finch flocks) were encountered, time was taken to accurately estimate number and species. Birds were registered where they were first encountered. Thus, for example, a flock of Linnet feeding in a crop but flushed and subsequently landing in a nearby hedgerow were recorded only where they were first seen feeding. Bird data recorded in QFIELD included the following bird data: transect number, date, start time, sighting time, section (0-200m etc), BTO code, number of birds, distance band and additional notes.

As the time window for surveys in mid-winter was limited by daylength and, excluding the first and last hour of daylight, the latter to avoid the possible confounding effects of counting birds commuting to and from roosts, typically 3-4 1km transects were completed in any one day (mean 42.3mins ± SD 10.7). Where transects were visited in the morning (<1200hrs) on 1st visits, repeat visits reversed the sequence of visits on 2nd visits so transects were surveyed in the afternoon (>1200hrs) to minimise time of day effects.

The aim of winter farmland bird surveys was to gain enough 'registrations' (observations or vocalisations) to calculate bird densities or for most species, an index of abundance. Thus, the main results generated by the line transects were (i) a density estimate and/or index of abundance, (ii) an index of species diversity, and (iii) habitat, especially field type, associations. While the purpose of the survey was to determine population densities and habitat associations in winter 2022/2023, these methods could, potentially, be repeated in future years to allow population trends for some species to be compared over time (i.e. repeat visits in future years in a future EIP project) using the winter 2022/2023 data as a baseline.

2.4. HABITAT ASSOCIATIONS & LAND USE

The extent of habitat and land use types may have a significant influence on the presence/absence and/or density of different bird species along transects, or sections of transects where particular field types or field boundary habitats (i.e.., hedgerows, scrub, forestry, woodland) occur. A minimum of 30 independent transects are needed to generate enough statistical power to allow bird diversity and abundance to be investigated in relation to these habitat and land use features. This is especially important in determining key characteristics of farms that are related to the presence and abundance of BOCCI species (e.g., Yellowhammer) in winter. Of special interest were the effects, if any, of requirements for shallow cultivation post-harvest and green cover on farmland birds occurrence and density.

Habitat data included field, hedgerow and other habitat types (Table 4). As well as recording general habitat and land use features (e.g., % wild bird cover), the relative abundance of hedgerow shrub/tree species were estimated along transect routes using the DAFOR scale (Smith et al. 2011), where transects crossed a field boundary and on the nearest boundary if the transect was running parallel to the transect. This scale can be used to quickly estimate the relative abundance of species in a given area as: **D** = Dominant; **A** = Abundant, **F** = Frequent, **O** = Occasional, **R** = Rare.

Table 4. Habitat variables collected during winter farmland bird surveys.

Type	Other habitats	Hedgerow quality			
Field type		% cover	Width (m)	Mgmt.	DAFOR scale
Cover crops	Drainage ditch	0	<1	Intensive	Species 1
Grassland	Field margin	1-25	1-2	Non-intensive	Species 2
Shallow cultivation	Grass briar wall	25-50	2-4		Species 3
Stubble	Hedgerow	50-75	>4		Species 4
Wild bird food	Forestry	75-100			Species 5
Winter crops	Scrub				
Other	Woodland				
	Other				

2.4 MAPPING & PHOTOGRAPHS

All transects, bird locations and site boundaries were digitised and mapped using QGIS. A complete dataset including all shapefiles were compiled as well as photographs relevant to each transect.

2.5 STATISTICAL ANALYSES

Data from QGIS was exported to Excel for collation and checking. All data files were checked for errors including bird (BTO) codes. A small number of bird records entered as Other in FIELD without supporting data in the notes section were included in overall bird numbers but were excluded from further analyses. Unfortunately, data for a small number of tillage (4) and pasture (1) transects surveyed on late visits were lost during an upgrade of QFIELD (beta). Thus, the complete dataset was composed of 51 and 47 tillage transects on 1st and 2nd visits respectively, and 32 and 31 pasture transects on 1st and 2nd visits respectively.

Density estimates for farmland bird species were calculated from for both 1st and 2nd visits as well as for pooled data using R version 4.2.3 (R Core Team, 2020). Density estimates were calculated using the line transect method (Bibby et al., 2000, Buckland et al., 2001). In line transect distance sampling, bird counts are made within a fixed width and detections are allocated to distance bands measured from the transect line, a minimum of two distance bands are required for accurate density estimates.

An assumption of line transect distance sampling is that all birds on the transect line are detected and that detection decreases with increasing distance from the transect line, the other key assumptions are that birds are detected at their initial location and that measured distances are exact.

The main limiting factor in the use of distance sampling for attaining reliable density estimates tends to be the sample of birds encountered, a minimum sample size of 60 encounters per species for line transects is recommended (Bibby et al. 2000, Buckland et al. 2001). For samples for which there is an insufficient number of encounters, the multi covariate distance sampling (MCDS) approach can be taken, where the species or habitat is treated as a covariate in the modelling of the detection function (Marques & Buckland, 2003; Bibby et al., 2000).

To estimate bird density we used the statistical software R (R Core Team, 2020) and the Distance package (Miller, 2019). The data was pooled from both the 1st and 2nd visits, all species with a sufficient sample of encounters on either survey (tillage) or control (pasture) transects had individual detection functions fitted with survey visit included as a covariate in the detection function to acquire separate density estimates for both the early and late visits. The data was then pooled from both the survey (tillage) and control (pasture) transects (1st and 2nd visits), species with a sufficient sample size then had individual detection functions fitted with transect type (tillage, pasture) included as a covariate in the detection function to acquire separate density estimates on both tillage and pasture.

To estimate the density of birds on the different field types (cover crops, grassland, shallow cultivation, stubble and wild bird food), only the first two distance bands were used, the data was separated into three groups; all birds on transects, Birds of Conservation Concern in Ireland (BoCCI species), and granivores (seed-eating bird species). Field type was treated as a covariate in the modeling of the detection function across the three groups so that each field type received its own unique detection function to acquire density estimates.

Species diversity indices were calculated using the Vegan package (Oksanen et al., 2016) in R (R Core Team, 2020) to measure the diversity within survey (tillage) and control (pasture) transects. Species diversity increases with the complexity of habitat,

this diversity considers both the richness and evenness of species. The diversity indices Shannon Index (Shannon & Weaver 1949) and Simpson Index (Simpson 1949) are two commonly used indices to evaluate the bird species diversity and Pielou's evenness index is used to assess evenness, which is a measure of the relative abundance of different species making up the richness of an area.

The Shannon Index assumes that individuals are randomly sampled from an independent large population and all the species are represented in the sample. Shannon diversity is a very widely used index for comparing diversity between various habitats (Clarke & Warwick, 2001). The Shannon index increases as both the richness and the evenness of the community increase, denoted as H, typical values range between 1.5 and 3.5. The lower the value of H the lower the diversity of species in a particular community and the higher the value of H the higher the diversity of species in a particular community.

The Simpson's Index of Diversity is based on the probability of any two individuals drawn at random from an infinitely large community belonging to the same species. Denoted as 1–D values range between 0 and 1. The higher the value of 1-D the higher the diversity of species in a particular community.

Species evenness refers to how close in numbers each species in an environment is and can be represented by Pile's evenness index (Pielou 1966). Denoted as J values range from 0 to 1, higher values indicate higher levels of evenness.

3. RESULTS

3.1 TOTAL BIRD ABUNDANCE

A total of 8,787 birds of 56 species were recorded during 1st visits to survey (tillage) and control (pasture) transects combined. Skylark (17.3%), Linnet (10.8%), Rook (10.2%) and Woodpigeon (8.2%) were the most numerous birds recorded on transects (Fig. 10).

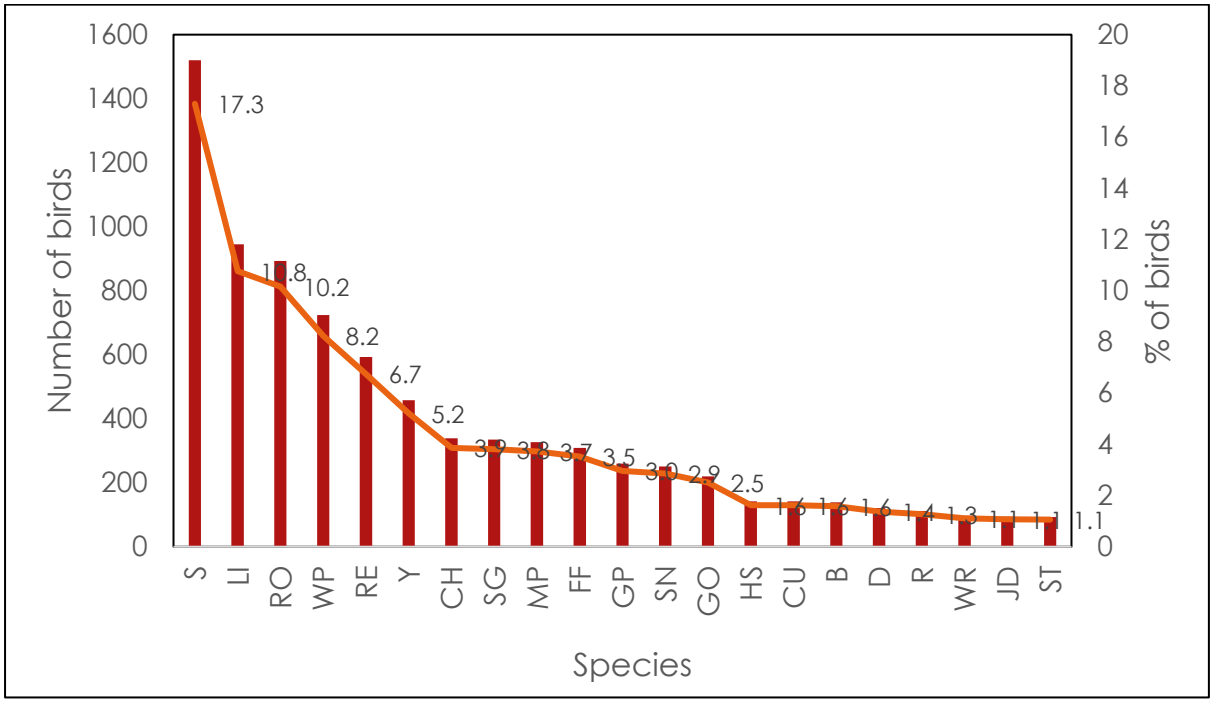

Fig. 10 Bird numbers and % totals for species recorded during 1st visits on farmland bird transects (survey and control). Species codes: Skylark (S), Linnet (LI), Rook (RO), Woodpigeon (WP), Yellowhammer (Y), Chaffinch (CH), Starling (SG), Meadow Pipit (MP), Fieldfare (FF), Golden Plover (GP), Snipe (SN), Goldfinch (GO), House Sparrow (HS), Curlew (CU), Blackbird (B), Robin (R), Dunnock (D), Robin (R), Wren (WR), Jackdaw (JD), & Song Thrush (ST).

Numbers recorded on transects later in the winter, on 2nd visits, were slightly higher than on 1st visits with 9,461 birds of 56 species counted during 2nd visits to survey (tillage) and control (pasture) transects combined. Woodpigeon (16.9%), Skylark (13.4%), Redwing (13.2%) and Rook (11.6%) were the most numerous birds recorded on transects, comprising over 50% of all birds recorded (Fig. 11).

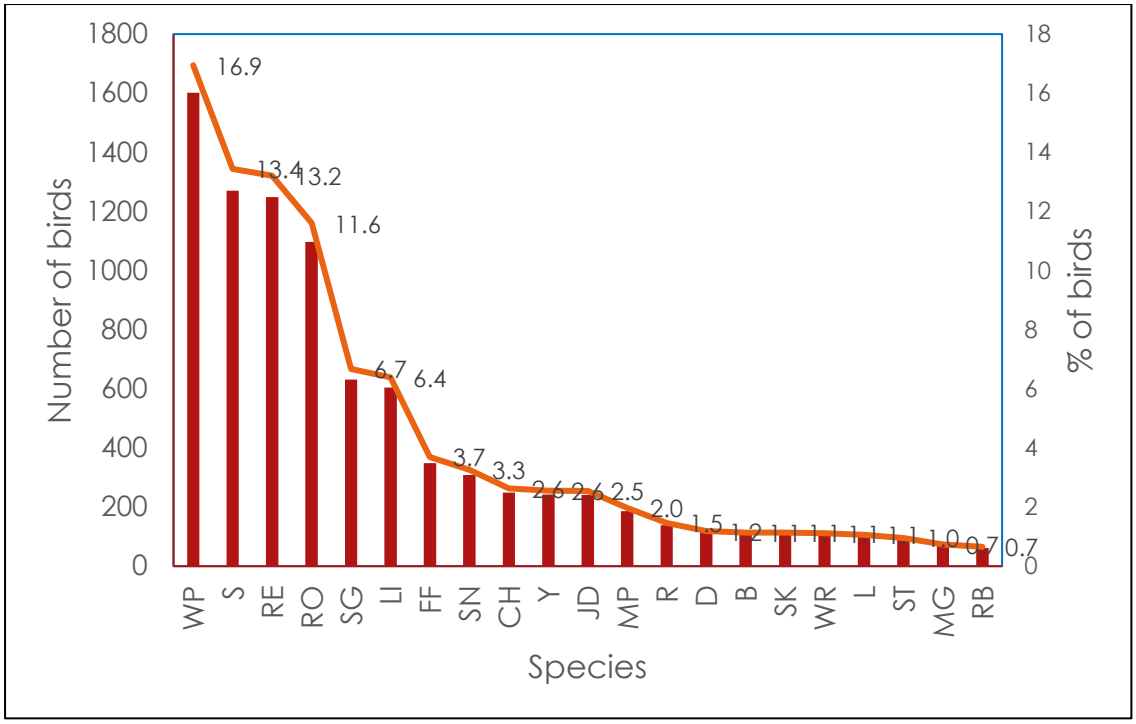

Fig. 11 Bird numbers and % totals for species recorded during 2nd visits on farmland bird transects. Species codes: Woodpigeon (WP), Skylark (S), Redwing (RE), Rook (RO), Starling (SG), Linnet (LI), Fieldfare (FF), Snipe (SN),), Chaffinch (CH), Yellowhammer (Y), Jackdaw (JD), Meadow Pipit (MP), Robin (R), Dunnock (D), Blackbird (B), Siskin (SK), Wren (WR), Lapwing (L), Song Thrush (ST), Magpie (MG) & Reed Bunting (RB).

A total of 1,861 records of birds (individuals & flocks) were obtained during 1st visits to survey (tillage) and control (pasture) transects combined. Skylark (11.9%), Meadow Pipit (8.9%), Snipe (7.3%) and Yellowhammer (6.7%) were the most frequently recorded species (Fig. 12).

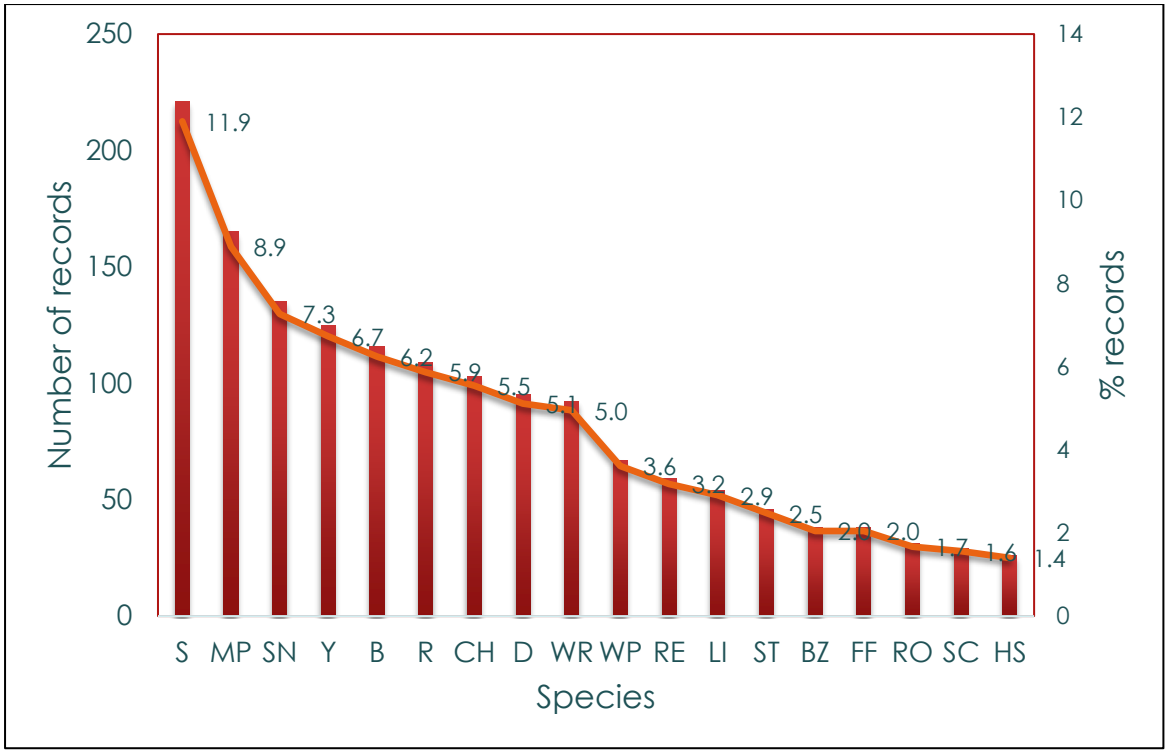

Fig. 12 Bird species records and % recorded during 1st visits to farmland bird transects (survey and control). Species codes: Skylark (S), Meadow Pipit (MP), Snipe (SN), Yellowhammer (Y), Blackbird (B), Robin (R), Chaffinch (CH), Dunnock (D), Wren (WR), Woodpigeon (WP), Redwing (RE), Linnet (LI), Song Thrush (ST), Buzzard (BZ), Fieldfare (FF), Rook (RO), Stonechat (SC) & House Sparrow (HS).

A total of 1,701 records of birds (individuals & flocks) were obtained during 2nd visits to survey (tillage) and control (pasture) transects combined. Skylark (10.4%), Robin (7.7%), Wood Pigeon (6.2%), Snipe (6.1%), Dunnock (6%), Blackbird (5.9%), Wren (5.9%) and Meadow Pipit (5.6%) were the most frequently recorded species, accounting for over 50% of all records on 2nd visit surveys (Fig. 13).

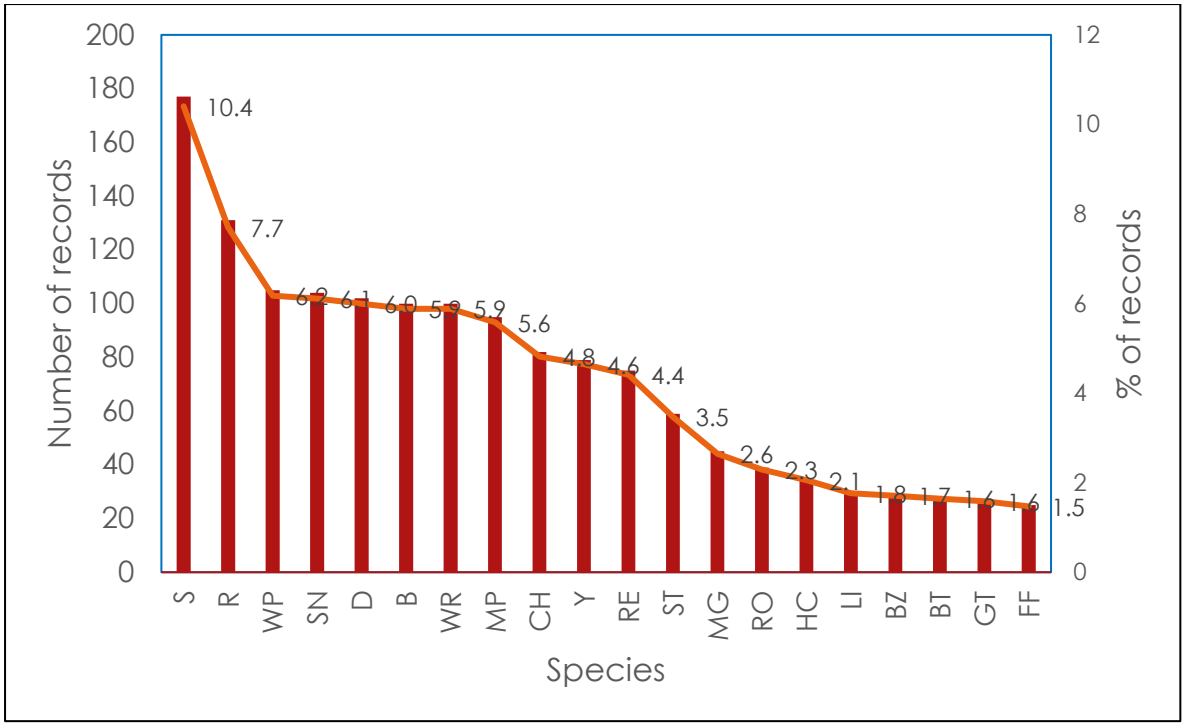

Fig. 13 Bird species records and % recorded during 2nd visits to farmland bird transects (survey and control). Species codes: Skylark (S), Robin (R), Woodpigeon (WP), Snipe (SN), Dunnock (D), Blackbird (B), Wren (WR), Meadow Pipit (MP), Chaffinch (CH), Yellowhammer (Y), Redwing (RE), Song Thrush (ST), Magpie (MG), Rook (RO), Hooded Crow (HC), Linnet (LI), Buzzard (BZ), Blue Tit (BT), Great Tit (GT), and Fieldfare (FF).

3.2 BIRD ABUNDANCE ON SURVEY AND CONTROL TRANSECTS

Number of birds and species were, on average, higher on tillage transects than on pasture on both visits (Table 5). However, the proximity of tillage crops adjacent to some control transects may have inflated the number of birds recorded on pasture while some species occur in large numbers across both farm types in winter (e.g., Redwing, Fieldfare) but were more often recorded on pasture (Redwing).

Table 5 Number of birds and species on tillage and pasture transects.

	No birds/transect		No species/transect	
	Tillage	Pasture	Tillage	Pasture
1st visits	N=51	N=32	N=51	N=32
Mean	119.82	83.59	13	10
Median	99	68		
SD	77.10	61.60	3.82	3.86
95% CI	21.16	22.11		
Range	16-304	7-265	4-19	3-19
2nd visits	N=47	N=31	N=47	N=31
Mean/Median	150.35	80.29	12	10
SD	106.62	73.42	4.20	3.83
95% CI	30.74	25.85		
Range	7-399	4-304	3-24	4-19

In both field types there was large variation within each group, whether tillage or pasture (Fig. 14) with the highest number of birds recorded on 1st visits to tillage transects (304) on transect T79 in the Ballycroneen area, where 82% of birds recorded were Skylark. The highest number of birds recorded on a pasture transect (265) was on transect T51 at Ballybranagan, where 42% of birds were Rook, but also included two flocks of waders, including Curlew (47) and Oystercatcher (42).

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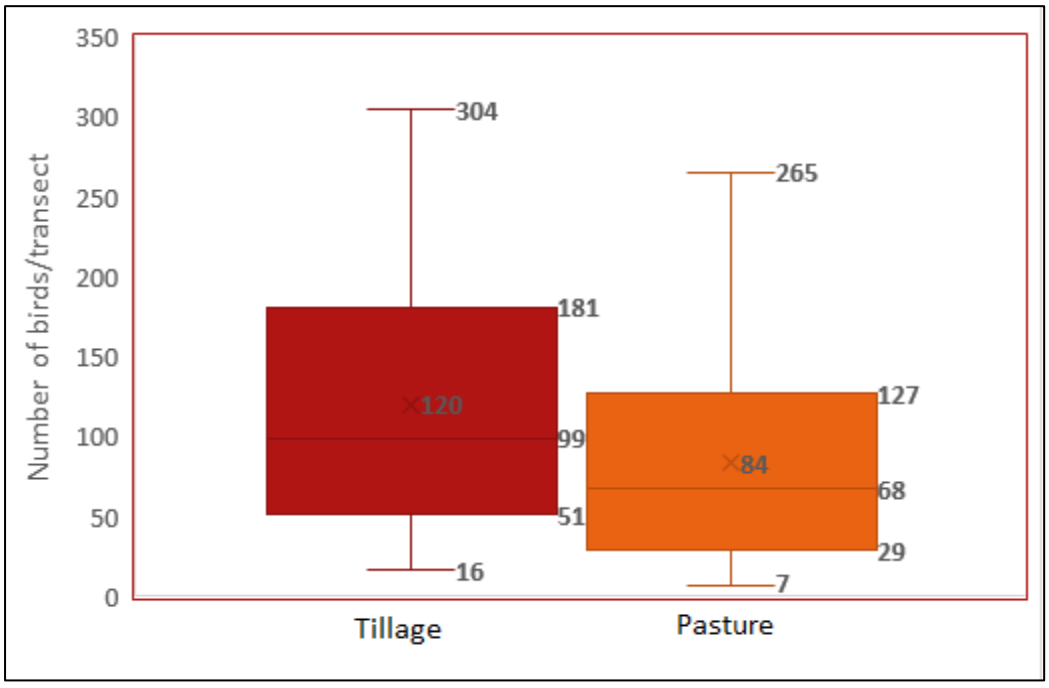

Fig. 14 Number of birds on tillage (n=51) and 'control' (n=32) transects during 1st visits in winter 2022/2023. Upper (max) and lower (min) bars show range. Box plots show mean*, median (mid-line), upper and lower quartiles.

3.2.2 SURVEY (TILLAGE) TRANSECTS: 1ST VISITS

A total of 6,130 birds of 50 species were recorded during 1st visits to survey (tillage) transects. Four species, Skylark (24.7%), Linnet (14.5%), Woodpigeon (9.1%) and Yellowhammer (7.0%) made up more than 50% of all birds recorded on tillage transects (Fig. 15).

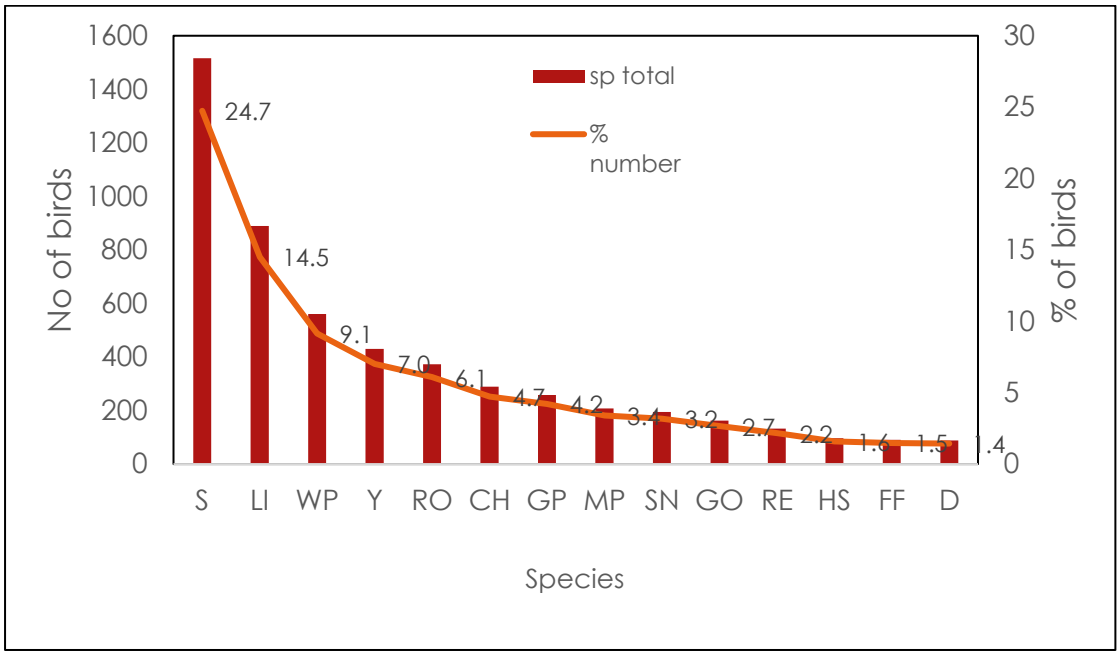

Fig. 15 Bird species number and % totals recorded on farmland bird 'survey' (tillage) transects during 1st visits. Species codes: Skylark (S), Linnet (LI), Woodpigeon (WP), Yellowhammer (Y), Rook (RO), Chaffinch (CH), Golden Plover (GP), Meadow Pipit (MP), Snipe (SN), Goldfinch (GO), Redwing (RE), House Sparrow (HS), Fieldfare (FF), & Dunnock (D).

Skylark, Yellowhammer, Snipe, Meadow Pipit, Chaffinch and Dunnock made up over 50% of all records (individual birds and flocks) on tillage transects (Fig. 16). Most records of Dunnock, Blackbird, Wren and Robin were of single birds while Skylark, Yellowhammer and Snipe were more often recorded as multiple birds.

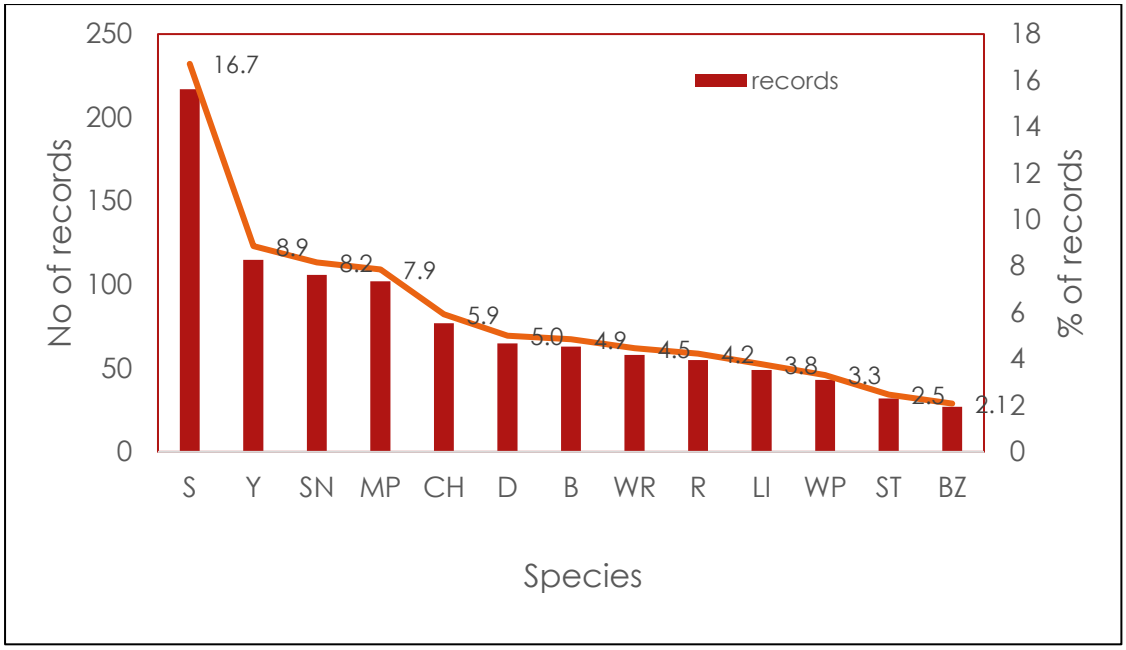

Fig. 16 Bird species records and % recorded on farmland bird 'survey' (tillage) transects during 1st visits. Species codes: Skylark (S), Yellowhammer (Y), Snipe (SN), Meadow Pipit (MP), Chaffinch (CH), Dunnock (D), Blackbird (B), Wren (WR), Robin (R), Linnet (LI), Woodpigeon (WP), Song Thrush (ST), & Buzzard (BZ).

3.2.3 Survey (tillage) transects: 2nd visits

A total of 6,972 birds of 50 species were recorded during 2nd visits to survey (tillage) transects. Five species, Skylark (18.1%), Woodpigeon (17.5%), Redwing (11.5%), and Rook (10.5%) made up more than 50% of all birds recorded on tillage transects (Fig. 17). Skylark (16.1%), Snipe (6.7%), Yellowhammer (6.7%), Dunnock (6.2%), and Robin (5.7%) made up over 50% of all records (individual birds and flocks) on tillage transects (Fig. 18). Most records of Dunnock, Blackbird, Wren and Robin were of single birds while Skylark, Yellowhammer and Snipe were more often recorded as multiple birds.

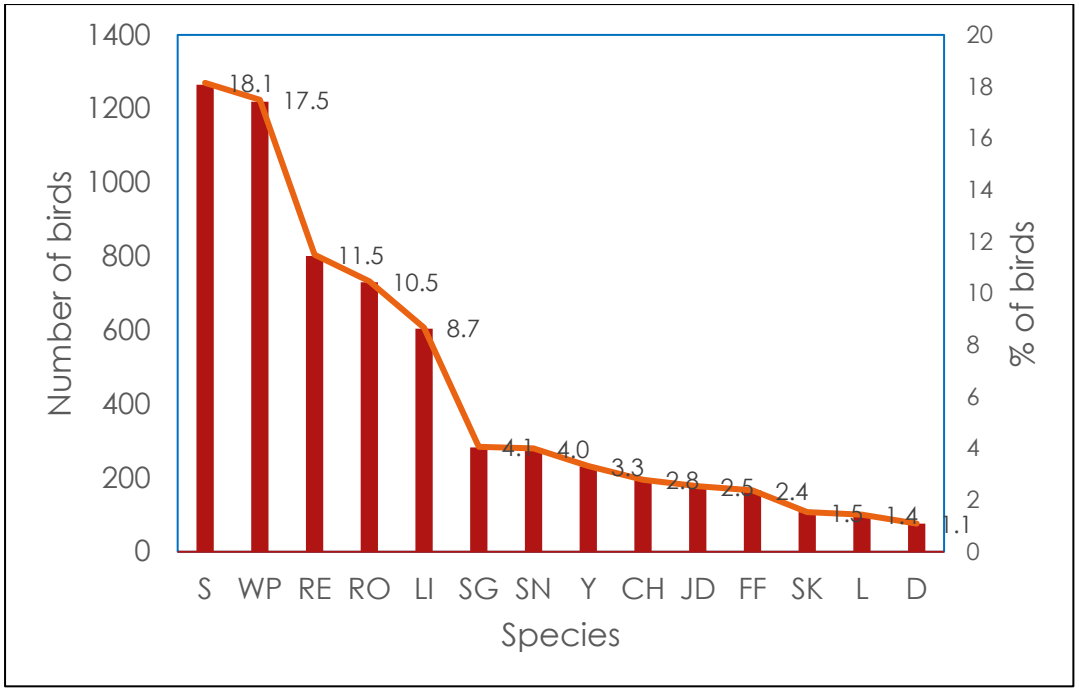

Fig. 17 Bird species number and % totals recorded on farmland bird 'survey' (tillage) transects during 2nd visits. Species codes: Skylark (S), Woodpigeon (WP), Redwing (RE), Rook (RO), Linnet (LI), Starling (SG), Snipe (SN), Yellowhammer (Y), Chaffinch (CH), Jackdaw (JD), Fieldfare (FF), Siskin (SK), Lapwing (L), & Dunnock (D).

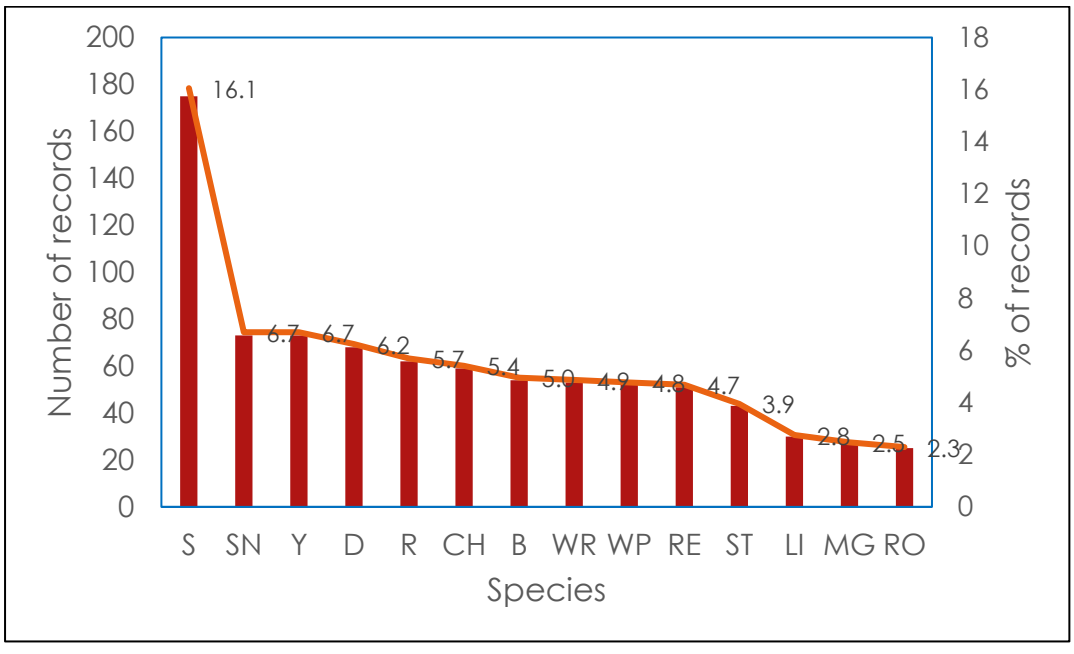

Fig. 18 Bird species records and % recorded on farmland bird 'survey' (tillage) transects during 2nd visits. Species codes: Skylark (S), Snipe (SN), Yellowhammer (Y), Dunnock (D), Robin (R), Chaffinch (CH), Blackbird (B), Wren (WR), Woodpigeon (WP), Redwing (RE), Song Thrush (ST), Linnet (LI), Magpie (MG), and Rook (RO).

3.2.4 CONTROL (PASTURE) TRANSECTS: IST VISITS

A total of 2,657 birds of 44 species were recorded during 1st visits to control (pasture) transects. Four species, Redwing (21.6%), Starling (11.8%), Fieldfare (10.2%) and Woodpigeon (9.1%) made up more than 50% of all birds recorded on tillage transects (Fig. 19). Waterbird species, including Curlew (5.3%) and Black-headed Gull (3%), were recorded in flocks on some coastal transects on pasture.

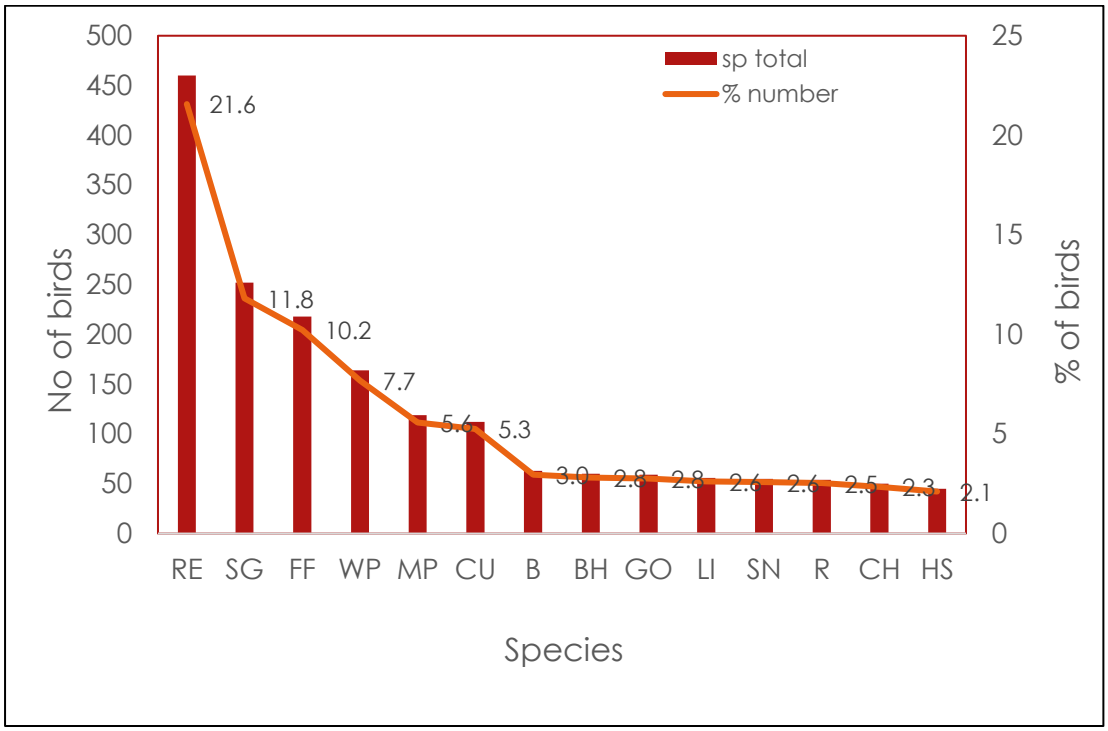

Fig. 19 Bird species number and % totals recorded on farmland bird 'control' (pasture) transects during 1st visits. Species codes: Redwing (RE), Starling (SG), Fieldfare (FF), Woodpigeon (WP), Curlew (CU), Blackbird (B), Black-headed Gull (BH), Goldfinch (GO), Linnet (LI), Snipe (SN), Robin (R), Chaffinch (CH), & House Sparrow (HS).

Meadow Pipit, Robin, Blackbird, Wren and Dunnock made up 50% of all records of bird species on control (pasture) transects (Fig. 20). Most records of Meadow Pipit, Robin, Blackbird, Wren, and Dunnock were of single birds while Redwing and Fieldfare were most often in flocks.

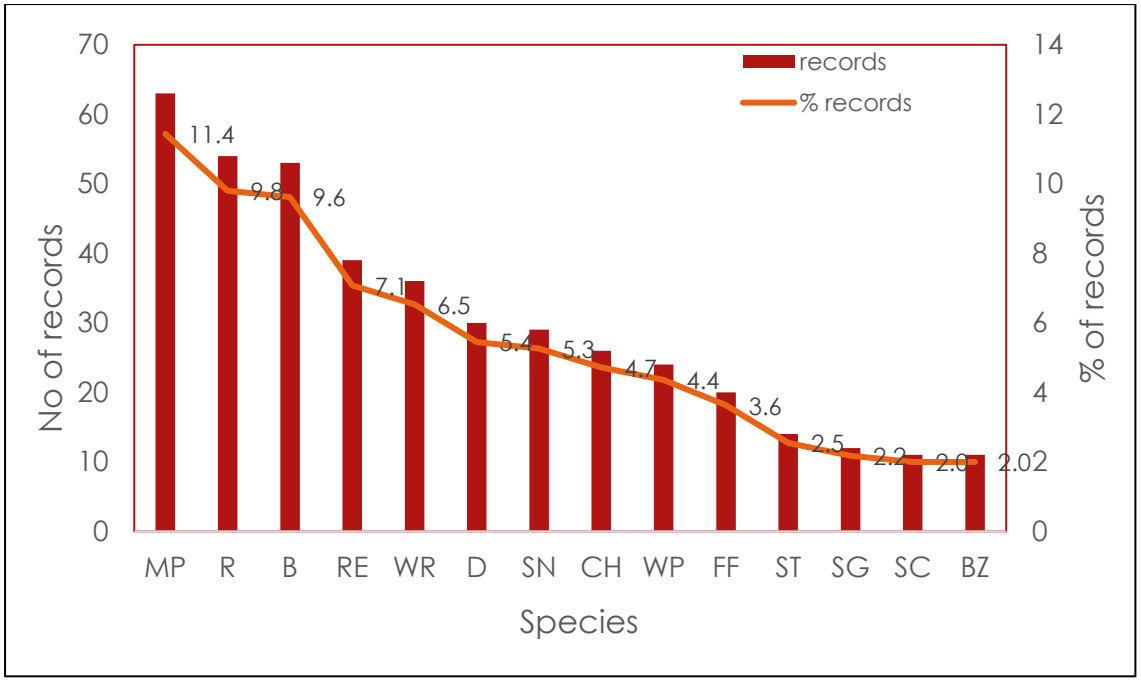

Fig. 20 Bird species records and % recorded on farmland bird 'control' (pasture) transects during 1st visits. Species codes: Meadow Pipit (MP), Robin (R), Blackbird (B), Redwing (RE), Wren (WR), Dunnock (D), Snipe (SN), Chaffinch (CH), Woodpigeon (WP), Fieldfare (FF), Song Thrush (ST), Starling (SG), Stonechat (SC), & Buzzard (BZ).

3.2.5 Control (pasture) transects: 2nd visits

A total of 2,490 birds of 46 species were recorded during 2nd visits to control (pasture) transects. Four species, Redwing (18.0%), Woodpigeon (15.4%), Rook (14.7%), and Starling (14.0%), made up more than 60% of all birds recorded on pasture transects (Fig. 21). Waterbird species, including Oystercatcher (0.9%) and Curlew (0.2%), were recorded in flocks on some coastal transects on pasture.

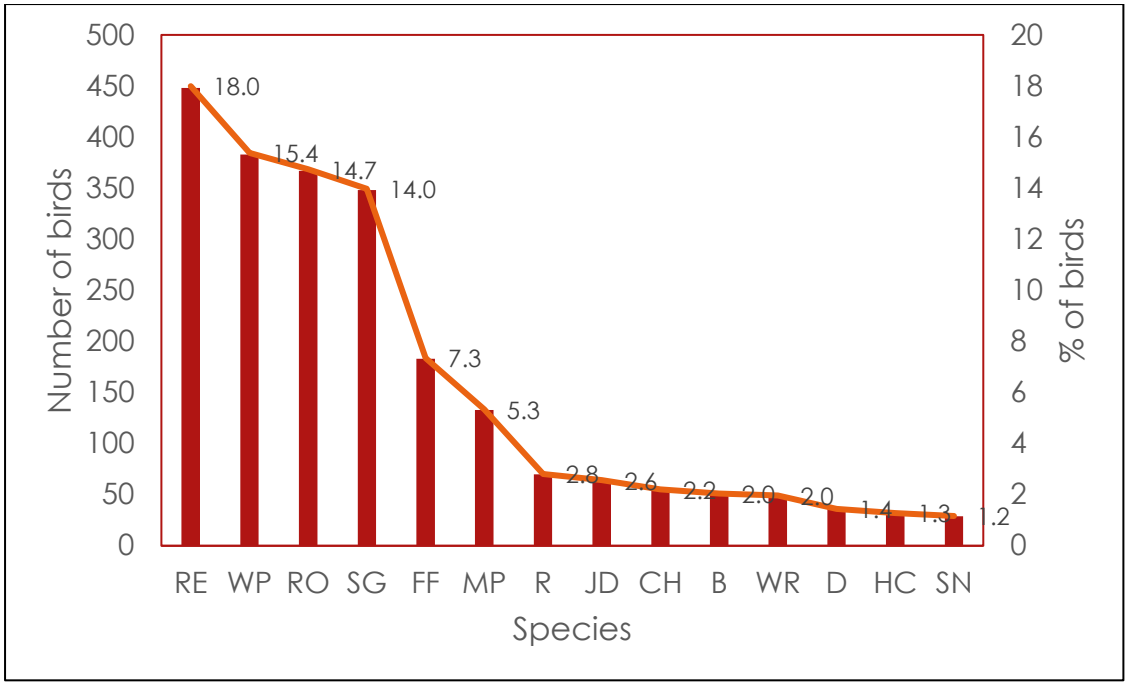

Fig. 21 Bird species number and % totals recorded on farmland bird 'control' (pasture) transects during 2nd visits. Species codes: Redwing (RE), Woodpigeon (WP), Rook (RO), Starling (SG), Fieldfare (FF), Meadow Pipit (MP), Robin (R), Jackdaw (JD), Chaffinch (CH), Blackbird (B), Wren (WR), Dunnock (D), Hooded Crow (HC) & Snipe (SN).

Meadow Pipit (12.6%), Robin (11.4%), Woodpigeon (8.8%), Wren (7.8%), Blackbird (7.6%) and Dunnock (5.6%) made up more than 50% of all birds recorded on pasture transects during 2nd visits to control (pasture) transects (Fig. 22). Most records of Meadow Pipit, Robin, Blackbird, Wren, and Dunnock were of single birds while Redwing, Woodpigeon, Rook and Fieldfare were most often in flocks.

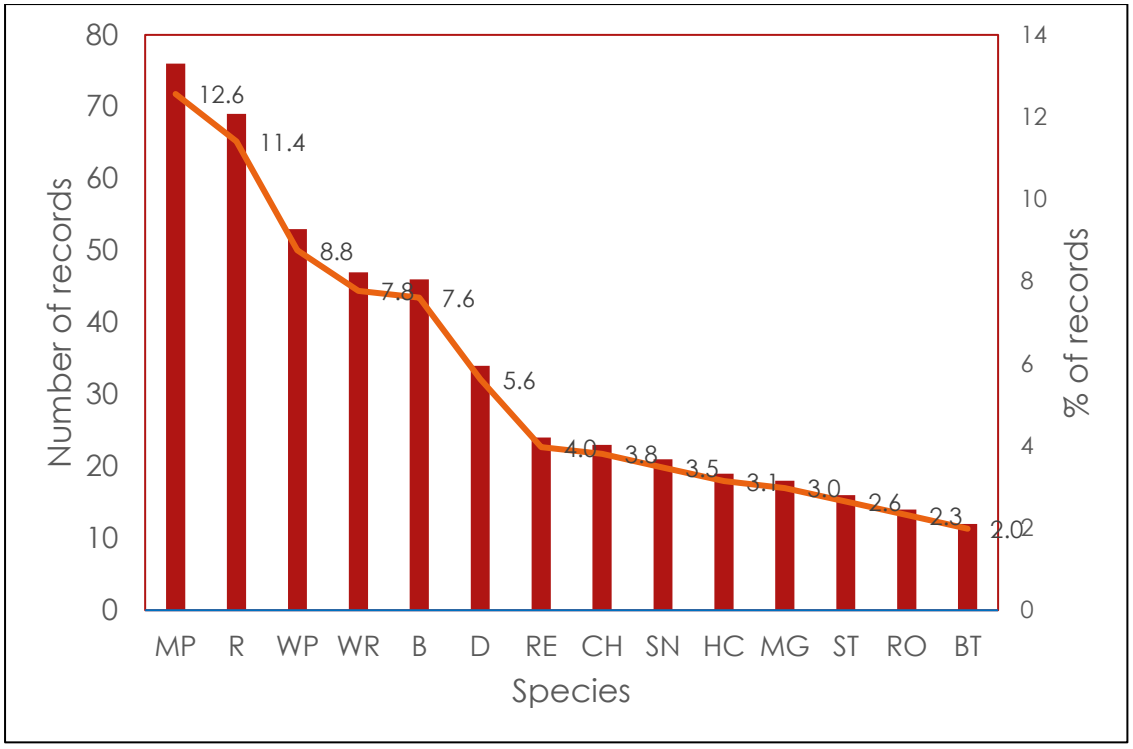

Fig. 22 Bird species records and % recorded on farmland bird 'control' (pasture) transects during 2nd visits. Species codes: Meadow Pipit (MP), Robin (R), Woodpigeon (WP), Blackbird (B), Dunnock (D), Redwing (RE), Chaffinch (CH), Snipe (SN), Hooded Crow (HC), Magpie (MG), Song Thrush (ST), Rook (RO) & Blue Tit (BT).

3.3 FARMLAND BIRD DISTRIBUTION

Skylark, Meadow Pip[it and Yellowhammer were the most widely distributed bird species on survey (tillage) transects during 1st visits, with Skylark occurring on more than 80% of transects (Fig. 23). Several winter farmland bird species, such as Skylark and Yellowhammer, remained widely distributed throughout the winter, occurring across a similar proportion of transects on both 1st and 2nd visits. However, some species, especially Meadow Pipit and to a lesser extent Wren, Chaffinch and Snipe, declined in distribution later in the winter. Wood Pigeon, Magpie and Redwing increased is distribution somewhat over the winter.

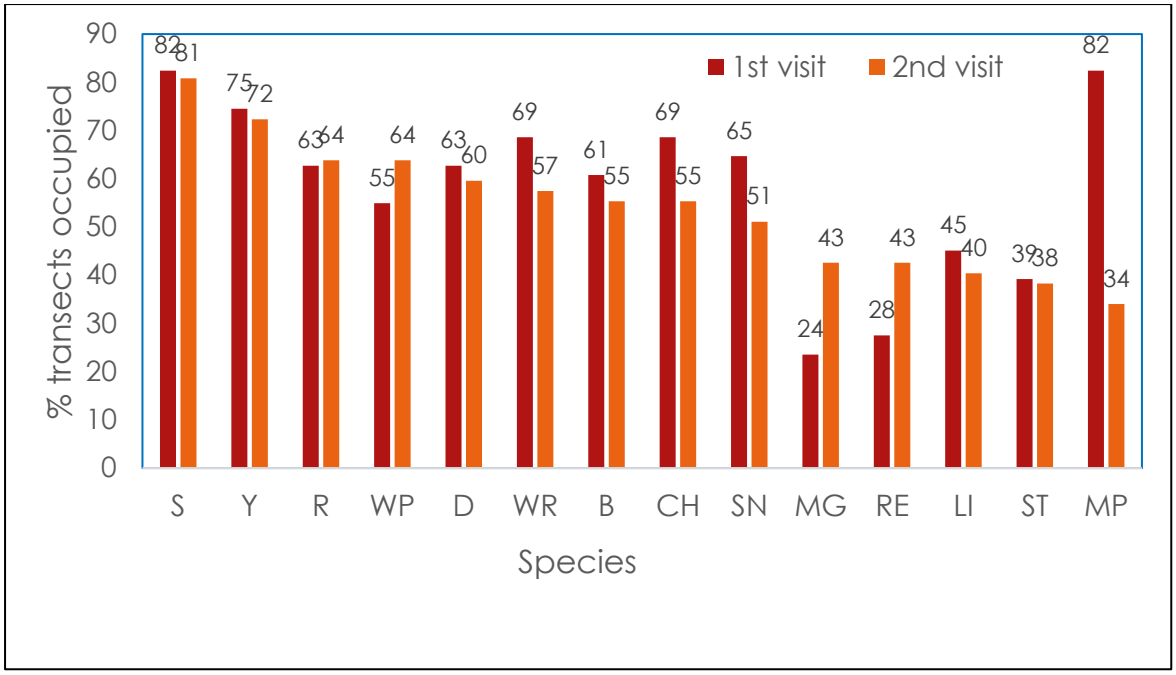

Fig. 23 Distribution of bird species on farmland bird survey (tillage) transects during 2nd visits (Jan-Mar 2023). Species codes: Skylark (S), Yellowhammer (Y), Robin (R), Woodpigeon (WP), Dunnock (D), Wren (WR), Blackbird (B), Chaffinch (CH), Snipe (SN), Magpie (MG), Redwing (RE), Linnet (LI), Song Thrush (ST) & Meadow Pipit (MP).

Blackbird, Robin, Meadow Pipit and Wren were the most widely distributed bird species on control (pasture) transects on 1st visits with Blackbird occurring on more than 80% of transects. Granivorous birds, those utilising spent seeds on tillage crops (e.g., stubble) and wild bird food crops, such as Skylark, Yellowhammer. Chaffinch, and Linnet occurred on fewer transects in pasture than in tillage (Fig. 24). Almost all Yellowhammer and Linnet on control were recorded adjacent to tillage crops (on hedgerows or powerlines). In contrast, Robin and Blackbird occurred more widely on control (pasture) transects.

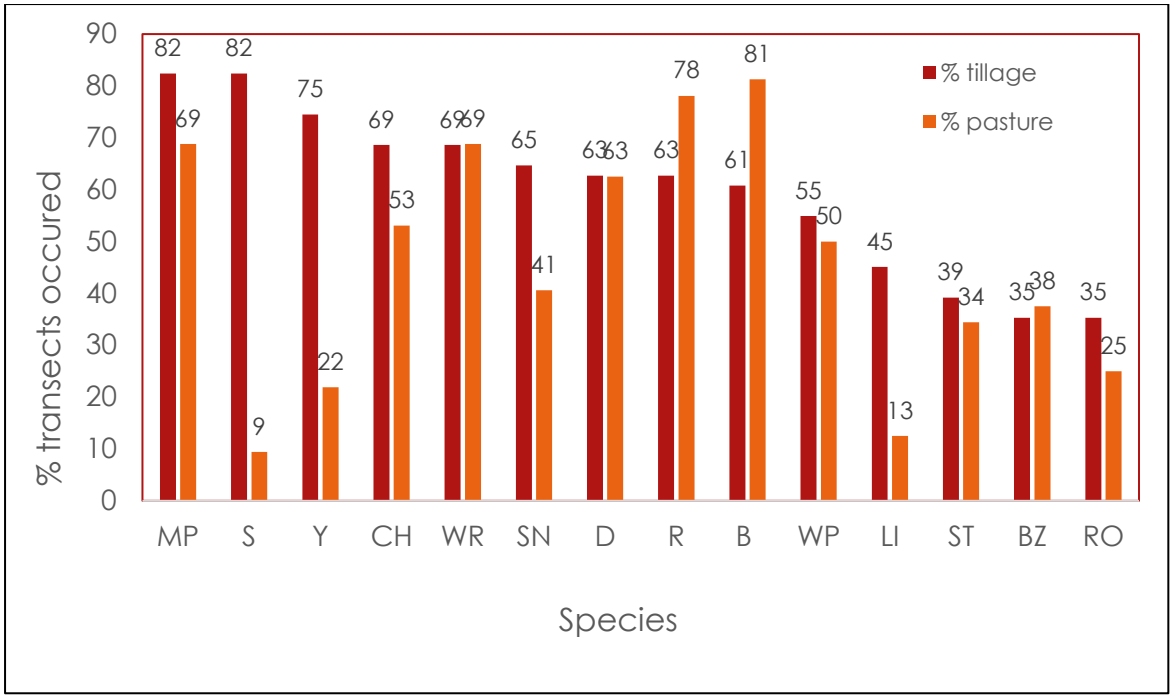

Fig. 24 Distribution of bird species on farmland bird survey (tillage) and control (pasture) transects during 1st visits. Species codes: Meadow Pipit (MP), Skylark (S), Yellowhammer (Y), Chaffinch (CH), Wren (WR), Snipe (SN), Dunnock (D), Robin (R), Blackbird (B), Woodpigeon (WP), Linnet (LI), Song Thrush (ST), Buzzard (BZ), & Rook (RO).

As on 1st visits, Robin and Blackbird were the most widely distributed species on control (pasture) transects on 2nd visits while Skylark, Yellowhammer and Linnet were largely absent (Fig. 25). Linnets were found on 40% of survey (tillage) transects but on none of the control (pasture) transects on 2nd visits. In contrast, Wood Pigeon and Meadow Pipit were more widely distributed on control (pasture) transects on 2nd visits.

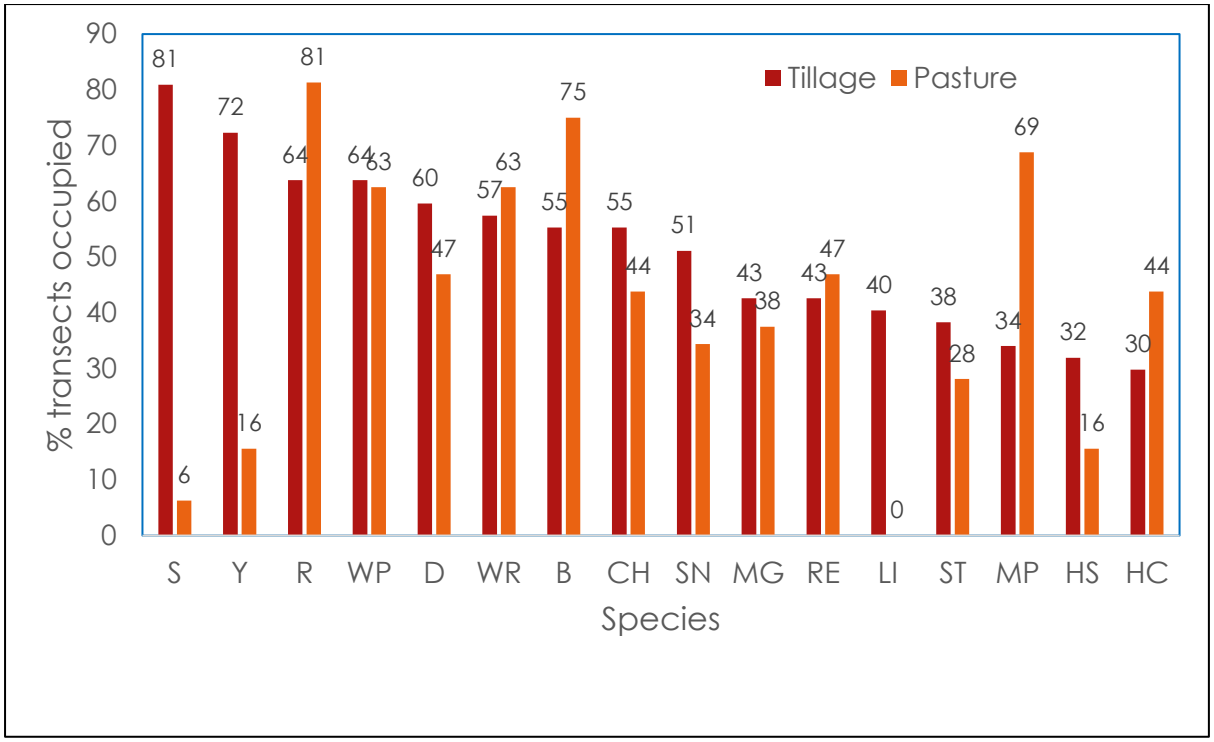

Fig. 25 Distribution of bird species on farmland bird survey (tillage) and control (pasture) transects during 2nd visits. Species codes: Skylark (S), Yellowhammer (Y), Robin (R), Woodpigeon (WP), Dunnock (D), Wren (WR), Blackbird (B), Chaffinch (CH), Snipe (SN), Magpie (MG), Redwing (RE), Linnet (LI), Song Thrush (ST), Meadow Pipit (MP), House Sparrow (HS) & Hooded Crow (HC).

3.4 FIELD ASSOCATIONS

3.4.1 WINTER STUBBLE

A total of 4,429 birds of 44 species were recorded utilising winter stubble during visits to survey (tillage) transects (1st & 2nd visits combined), when distance band 3 (>100m) records were excluded. Three species, Skylark (42.8%), Linnet (12.8%) and Yellowhammer (7.5%) made up more than 60% of all birds recorded in winter stubble (Fig. 26).

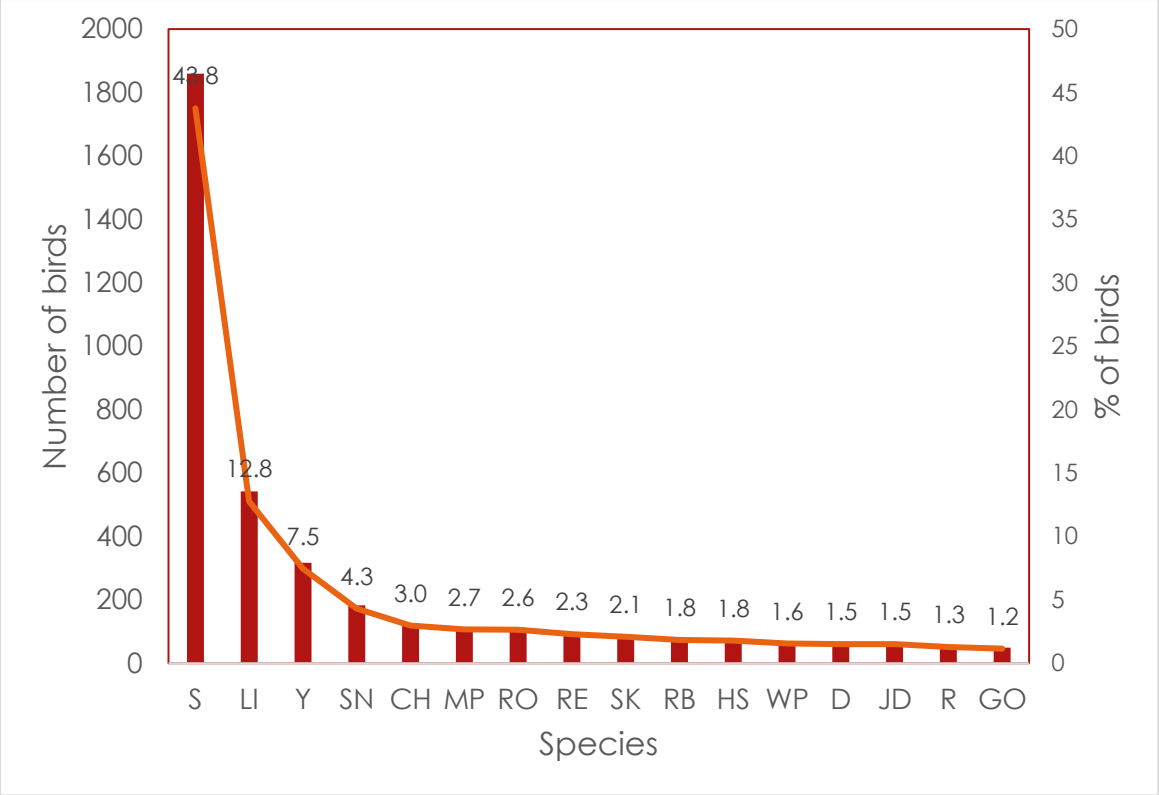

Fig. 26 Bird species number and % totals recorded in winter stubble fields on farmland bird 'survey' (tillage) transects. Species codes: Skylark (S), Linnet (LI), Yellowhammer (Y), Snipe (SN), Chaffinch (CH), Meadow Pipit (MP), Rook (RO), Redwing (RE), Siskin (SK), Reed Bunting (RB), House Sparrow (HS), Woodpigeon (WP), Dunnock (D), Jackdaw (JD), Robin (R) & Goldfinch (GO). Numbers excludes birds assigned to band 3 (>100m) or birds located on the boundary of different field types.

3.4.2 Cover crops

A total of 2,398 birds of 41 species were recorded utilising cover crops during visits to survey (tillage) transects (1st & 2nd visits combined), when distance band 3 (>100m) records were excluded. Three species, Linnet (16.7%), Rook (13.4%) and Snipe (9.3%) made up c40% of all birds recorded in cover crops (Fig. 27).

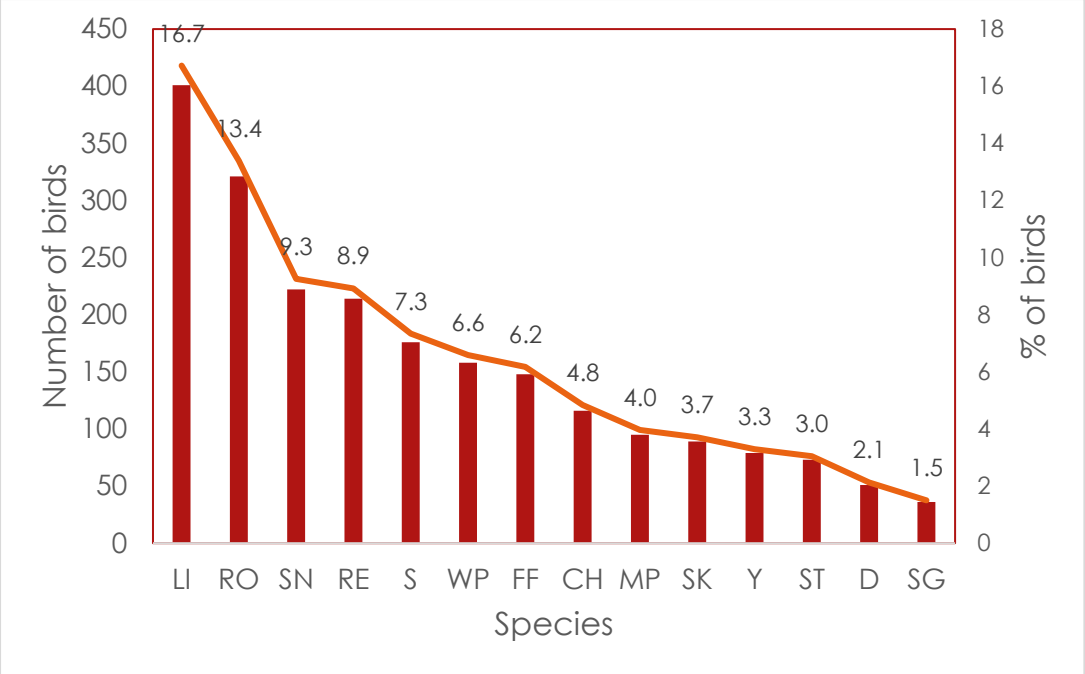

Fig. 27 Bird species number and % totals recorded on farmland bird 'survey' (tillage) transects. Species codes: Skylark (S), Linnet (LI), Yellowhammer (Y), Snipe (SN), Chaffinch (CH), Meadow Pipit (MP), Rook (RO), Redwing (RE), Siskin (SK), Reed Bunting (RB), House Sparrow (HS), Woodpigeon (WP), Dunnock (D), Jackdaw (JD), Robin (R) & Goldfinch (GO). Numbers excludes birds assigned to band 3 (>100m) or birds located on the boundary of different field types.

3.4.3 SHALLOW CULTIVATION

A total of 1,102 birds of 32 species were recorded utilising shallow cultivation during visits to survey (tillage) transects (1st & 2nd visits combined), when distance band 3 (>100m) records were excluded. Four species, Skylark (37.1%), Redwing (11.8%), Chaffinch (8.6%), and Linnet (7.8%) made up over 50% of all birds recorded in shallow cultivation (Fig. 28).

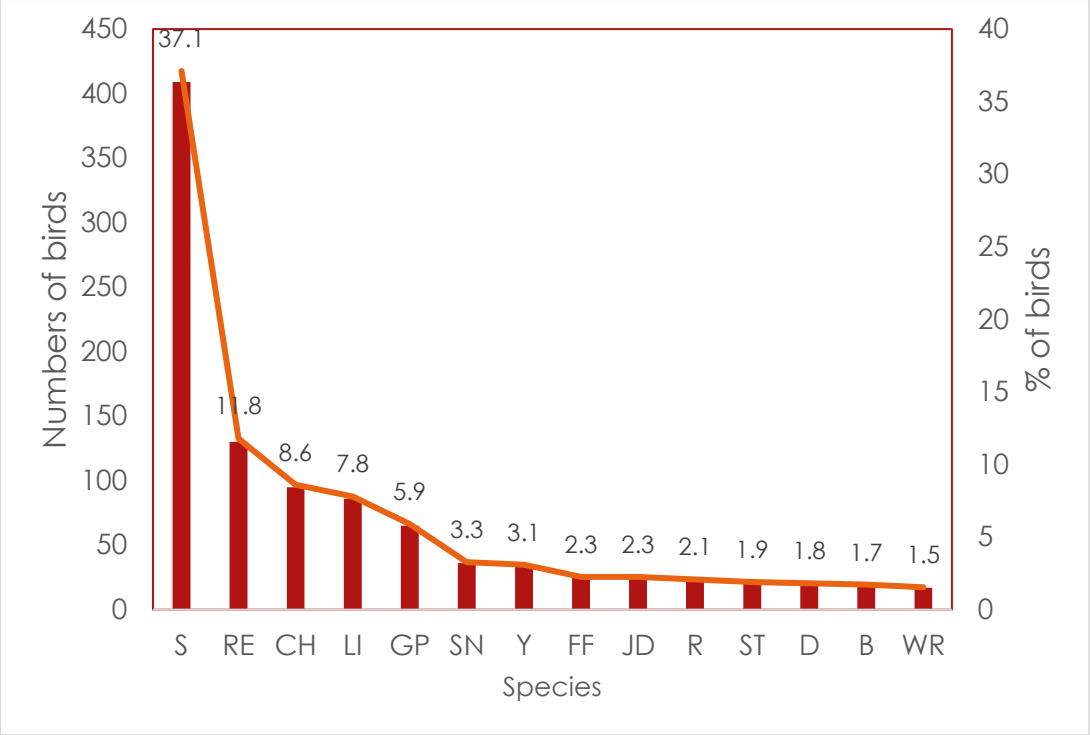

Fig. 28 Bird species number and % totals recorded in shallow cultivation fields on farmland bird 'survey' (tillage) transects. Species codes: Skylark (S), Redwing (RE), Chaffinch (CH), Linnet (LI), Golden Plover (GP), Snipe (SN), Yellowhammer (Y), Fieldfare (FF), Jackdaw (JD), Robin (R), Song Thrush (ST), Dunnock (D), Blackbird (B) & Wren (WR). Numbers excludes birds assigned to band 3 (>100m) or birds located on the boundary of different field types.

3.4.4 WILD BIRD FOOD

A total of 1,060 birds of 29 species were recorded utilising wild bird food crops during visits to survey (tillage) transects (1st & 2nd visits combined), when distance band 3 (>100m) records were excluded. Four species, Linnet (34.5%), Yellowhammer (12.5%), Skylark (11.8%), and Goldfinch (11.1%) made up over 60% of all birds recorded in wild bird food crops (Fig. 29).

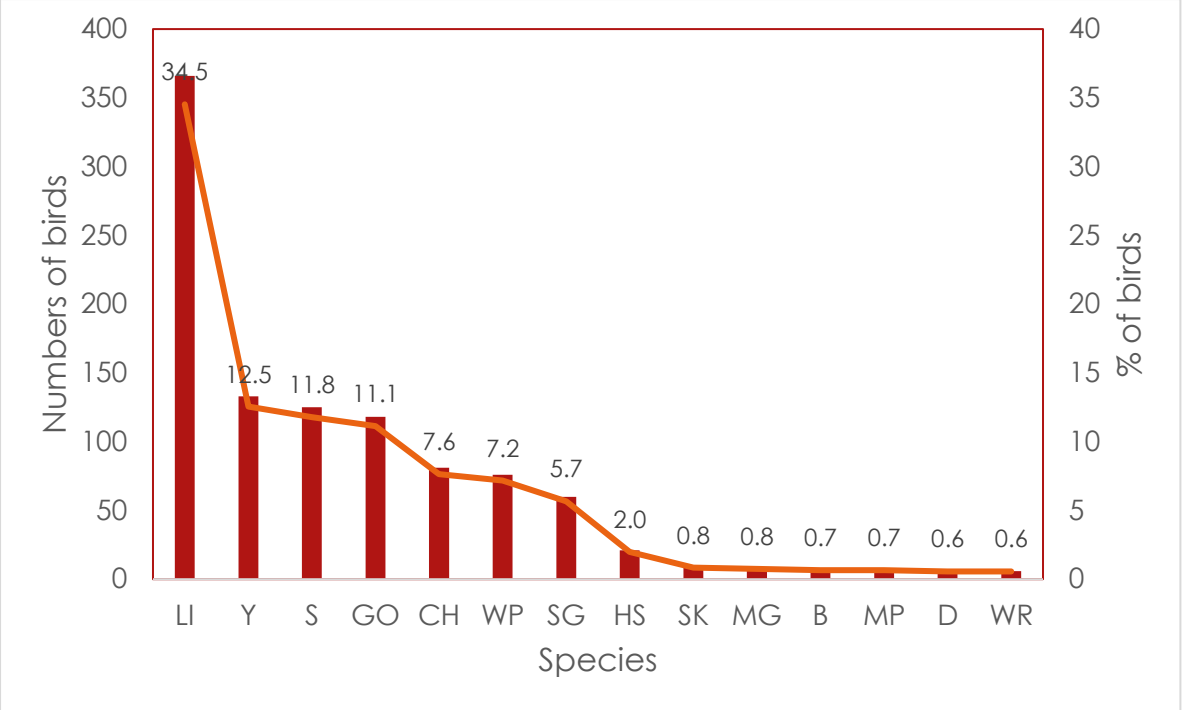

Fig. 29 Bird species number and % totals recorded in wild bird food crops on farmland bird 'survey' (tillage) transects. Species codes: Linnet (LI), Yellowhammer (Y), Skylark (S), Goldfinch (GO), Chaffinch (CH), Woodpigeon (WP), Starling (SG), House Sparrow (HS), Siskin (SK), Magpie (MG), Blackbird (B), Dunnock (D) & Wren (WR). Numbers excludes birds assigned to band 3 (>100m) or birds located on the boundary of different field types.

3.4.5 SEED-EATING BIRDS: FIELD TYPE UTILISATION

When granivorous (seed eating) bird species were treated separately from the other winter farmland birds recorded, winter stubble and, most especially, wild bird food, held a higher proportion of the population than expected (Table 6).

Table 6. Field type associations of granivorous (seed eating) farmland birds on survey (tillage) transects (1st & 2nd visits combined). Field types are Stubble, Cover Crops (CC), Shallow Cultivation (SC) & Wild Bird Food (WBF). Numbers exclude birds assigned to band 3 (>100m) or birds located on the boundary of different field types. Expected value = 1. Species group: Bullfinch, Chaffinch, Goldfinch, Greenfinch, House Sparrow, Linnet, Reed Bunting, Siskin, Skylark, Stock Dove & Yellowhammer. Expected value = 1. Values above/below 1 are higher/lower than expected in relation to availability.

Field type	No birds	% field availability	% birds	Observed value
Stubble	3140	53.74	56.41	1.05
CCs	940	23.28	16.89	0.73
SC	627	18.75	11.26	0.60
WBF	859	3.65	15.43	4.23
Total	5566			

Within the seed-eating group of species, winter stubble held the highest proportion of Skylark, Linnet, Yellowhammer, Reed Bunting and House Sparrow when the data from both visits were combined (Fig. 30). Cover crops held most Snipe as well as much of the few Stock Dove and Greenfinch that were recorded. Wild bird food crops held most of the Goldfinch recorded.

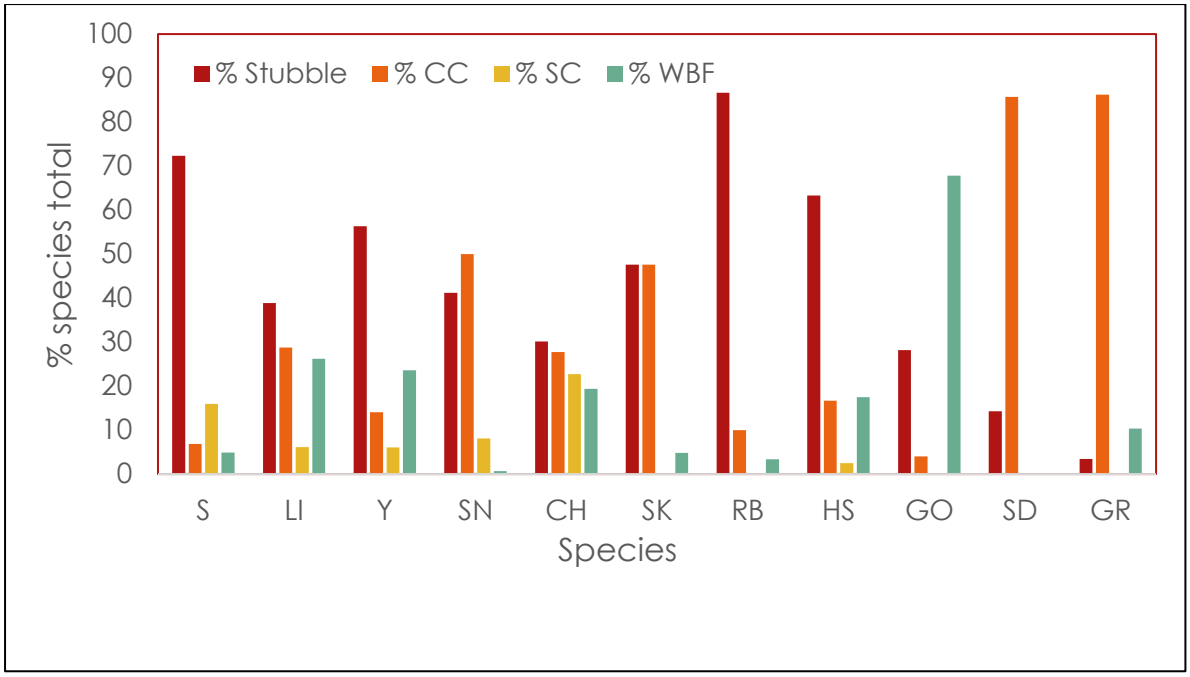

Fig. 30 % Species totals for seed-eating birds recorded on farmland bird 'survey' (tillage) transects. Species codes: Skylark (S), n=2569;, Linnet (LI), n=1395; Yellowhammer (Y), n=563; Snipe (SN), n=444; Chaffinch (CH), n=418; Siskin (SK), n=187; Reed Bunting (RB), n=90; House Sparrow (HS), n=120; Goldfinch (GO), n=174; Stock Dove (SD), n=21; Greenfinch (GF), n=29. Numbers excludes birds assigned to band 3 (>100m) or birds located on the boundary of different field types.

3.5 DENSITY ESTIMATES

3.5.1 SURVEY (TILLAGE) VS. CONTROL (PASTURE) TRANSECTS

Density estimates were generated for 12 winter farmland bird species on 1st and 2nd visits where the number of registrations were sufficient to allow for analyses (Appendix 7.3). Skylark, Linnet, Yellowhammer and Snipe were found at higher densities (birds per kilometre square) that other farmland birds on surveys (Fig. 31). Densities for most birds tended to be higher on early than late transects although Redwing and Snipe peaked later in winter.

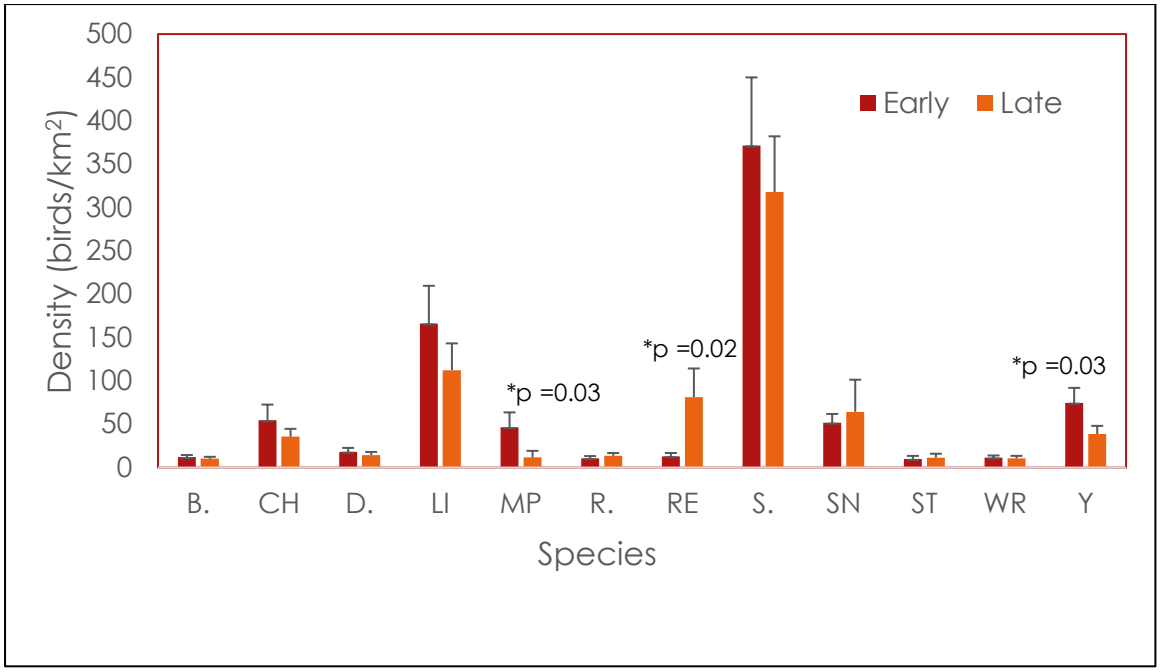

Fig. 31 Density estimates for winter farmland birds on survey (tillage) transects during early and late visits. Density estimates are means ± SE. *statistically significant p values.

Skylark, Linnet and Yellowhammer were found at much higher densities on survey (tillage)than on control (pasture) transects when data from both visits were pooled (Fig. 32). In contrast, Fieldfare, Meadow Pipit and Redwing tended to occur at high densities on control (pasture) transects.

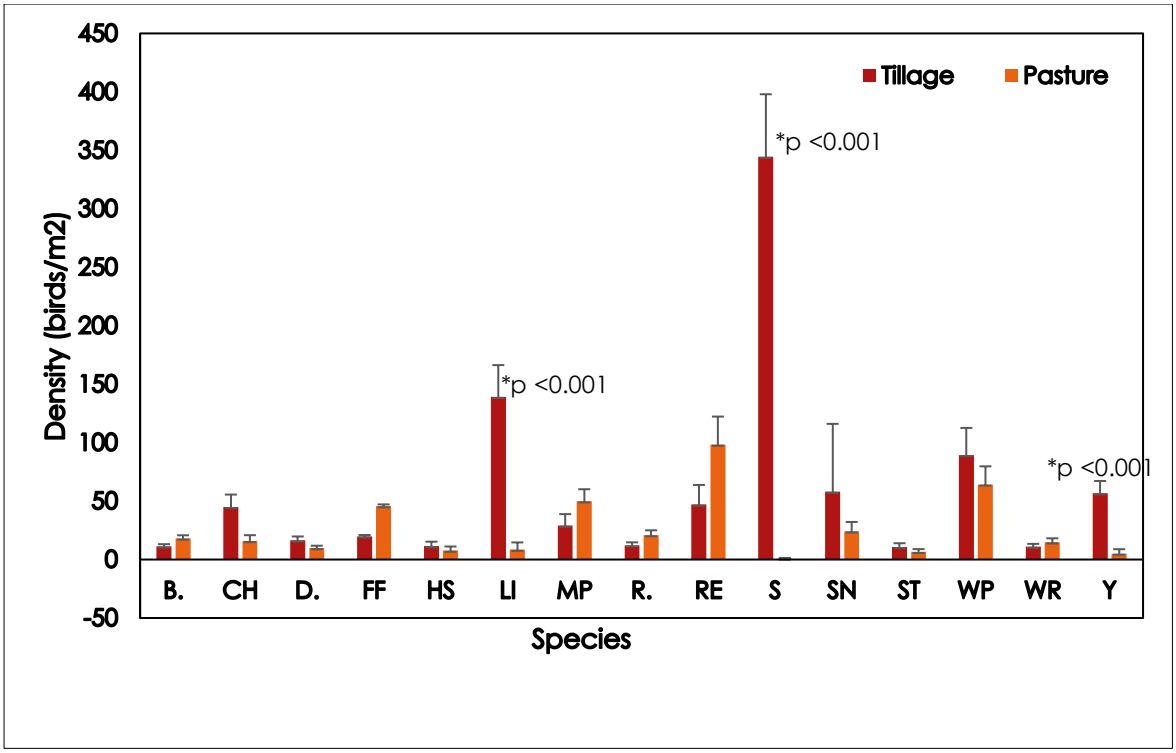

Fig. 32 Density estimates for winter farmland birds on survey (tillage) and control (pasture) transects over both visits combined. Density estimates are means ± SE. *statistically significant p values.

3.5.2 BIRD DENSITIES BY FIELD TYPE

Density estimates were generated for all birds recorded on transects, Birds of Conservation Concern in Ireland (BoCCI species), and granivores (seed-eating bird species (Table 7). By far the highest densities in all three species groups was in wild bird food crops. However, the wide variability in the standard error attached to the means is likely to be at least partly a result of the small sample size (n=9) for this field type. Therefore, although bird numbers were significantly higher in wild bird food compared to other field types, these densities should be treated with caution.

Table 7. Density estimates for three bird groups across field types: all bird species recorded, BoCCI species, and granivorous (seed-eating) bird species. Density estimates are means ± SE.

Field type	All birds		BoCCI species		Granivores	
	Density (birds/km^2)	Density ± S.E	Density (birds/km^2)	Density ± S.E	Density (birds/km^2)	Density ± S.E
Cover crops	970.9	0	453.6	51.0	292.6	26.7
Shallow cultivation	580.6	103.7	453.7	125.1	322.5	98.3
Stubble	872.34	93.7	795.5	46.7	661.9	617.7
Wild bird food	3218.0	27250	2198.5	394.3	2767.9	1192.5
Pasture	519.2	0	219.5	46.6	32.9	3.7

When the estimates for wild bird food are excluded, winter stubble was the most attractive field type for both BoCCI species and granivores (Fig. 33). Cover crops were heavily utilised by most birds but were less attractive to BoCCI and granivorous bird species.

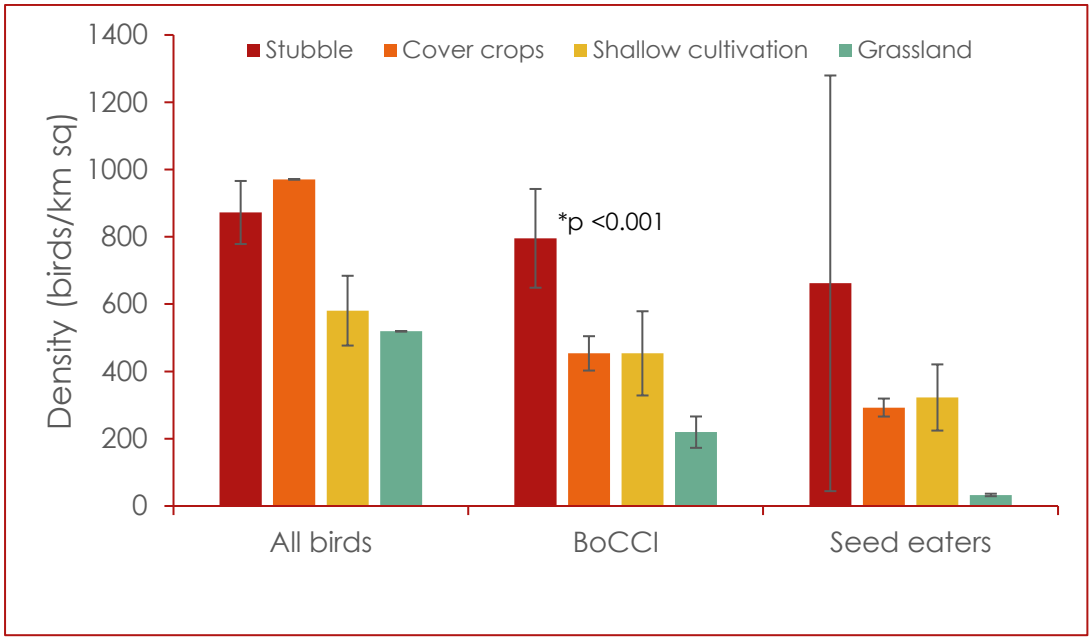

Fig. 33 Density estimates for three bird groups across field types but excluding Wild Bird Food: all bird species recorded, BoCCI species, and granivorous (seed-eating) bird species. Density estimates are means ± SE. * statistically significant p values.

3.5.3 SUMMARY

In summary, seed dependent and BoCCI birds, apart from Meadow Pipit, were predominantly found on tillage crops while winter stubble was most important for

Skylark, Yellowhammer and Linnet. Densities of seed eating winter farmland birds were higher in early winter and tended to decline later in winter. Winter stubble and cover crops held the highest densities of all birds when the small areas of wild bird food were excluded while winter stubble held the highest densities of BoCCI and seed dependent species.

Winter stubble fields held the highest proportion of Skylark in the project area, as well as significant numbers of Linnet, Yellowhammer and Snipe. Shallow cultivation held lower numbers of seed dependent species, in particular Skylark, Yellowhammer and Linnet. Cover crops held numbers of Linnet, Yellowhammer and especially Snipe, and to a lesser extent Song Thrush. Wild bird food held numbers of Linnet, Yellowhammer and Goldfinch while control transects (pasture) held a high numbers of Redwing, Starling and Woodpigeon (Table 8).

Table 8. Field type associations of some winter farmland birds on survey (tillage) and control (pasture) transects during 1st and 2nd visits combined. Numbers exclude birds assigned to band 3 (>100m) or birds located on the boundary of different field types.

Species	Stubble		Shallow cultivation		Cover crops		Wild bird food		Pasture	
	No birds	% birds	No birds	% birds	No birds	% birds	No birds	% birds	No birds	% birds
Skylark	1859	43.75	409	37.11	176	7.34	125	11.79	7	0.24
Linnet	542	12.76	86	7.80	401	16.72	366	34.53	16	0.55
Yellowhammer	317	7.46	34	3.09	79	3.29	133	12.55	13	0.44
Snipe	183	4.31	36	3.27	222	9.26	3	0.28	79	2.70
Chaffinch	126	2.97	95	8.62	116	4.84	81	7.64	75	2.57
Meadow Pipit	113	2.66	13	1.18	95	3.96	7	0.66	246	8.42
Rook	112	2.64	6	0.54	321	13.39	1	0.09	243	8.32
Redwing	97	2.28	130	11.80	214	8.92	3	0.28	596	20.40
Siskin	89	2.09	0	0	89	3.71	9	0.85	0	0
Reed Bunting	78	1.84	0	0	9	0.38	3	0.28	11	0.38
House Sparrow	76	1.79	3	0.27	20	0.83	21	1.98	23	0.79
Woodpigeon	66	1.55	15	1.36	158	6.59	76	7.17	282	9.65
Dunnock	64	1.51	20	1.81	51	2.13	6	0.57	64	2.19
Jackdaw	64	1.51	25	2.27	2	0.08	0	0.00	57	1.95
Goldfinch	49	1.15	0	0	7	0.29	118	11.13	24	0.82
Blackbird	48	1.13	19	1.72	28	1.17	7	0.66	107	3.66
Wren	45	1.06	17	1.54	27	1.13	6	0.57	83	2.84
Fieldfare	39	0.92	25	2.27	148	6.17	0	0	229	7.84
Golden Plover	35	0.82	65	5.90	0	0	0	0	2	0.07
Song Thrush	23	0.54	21	1.91	73	3.04	0	0	46	1.57
Starling	18	0.42	8	0.73	36	1.50	60	5.66	307	10.51
Buzzard	9	0.21	4	0.36	2	0.08	3	0.28	14	0.48
Kestrel	3	0.07	2	0.18	0	0	0	0	2	0.07
Stock Dove	3	0.07	0	0	18	0.75	0	0	1	0.03
Greenfinch	1	0.02	0	0	25	1.04	3	0.28	2	0.07
Merlin	1	0.02	0	0	1	0.04	0	0	0	0
Peregrine	1	0.02	1	0.09	1	0.04	1	0.09	0	0
Total	4061	95.6	1034	93.83	2319	96.71	1032	97.36	2529	86.55

Based on the availability of the different field types, wild bird food crops held significantly higher numbers of birds than expected on both early and late visits, although the proportion of birds recorded in wild bird food was much lower on 2nd visits (Table 9). Cover crops held a higher proportion of birds compared to availability on late but not early visits.

Table 9. Field type associations of winter farmland birds on survey (tillage) transects during 1st and 2nd visits. Field types are Stubble, Cover Crops (CC), Shallow Cultivation (SC) & Wild Bird Food (WBF). Numbers excludes birds assigned to band 3 (>100m) or birds located on the boundary of different field types. Expected value = 1. Values above/below 1 are higher/lower than expected in relation to availability.

	1st visits				2nd visits			
Field type	No birds	% field availability	% birds	Observed value	No birds	% field availability	% birds	Observed value
Stubble	2294	54.12	49.62	0.92	1955	53.36	46.20	0.87
CCs	795	24.5	17.20	0.70	1603	22.06	37.88	1.72
SC	695	17.08	15.03	0.88	407	20.42	9.62	0.47
WBF	839	3.99	18.15	4.55	267	3.30	6.31	1.91
Total	4623				4232			

When both visits were combined, cover crops and wild bird food held a higher proportion of the winter farmland bird population that expected. Winter stubble held the highest number of birds overall but held slightly fewer birds while shallow cultivation held the lowest proportion of the winter bird population, especially in late winter (Table 10).

Table 10. Field type associations of winter farmland birds on survey (tillage) transects (1st & 2nd visits combined). Field types are Stubble, Cover Crops (CC), Shallow Cultivation (SC) & Wild Bird Food (WBF). Numbers excludes birds assigned to band 3 (>100m) or birds located on the boundary of different field types. Expected value = 1. Values above/below 1 are higher/lower than expected in relation to availability.

Field type	No birds	% field availability	% birds	Observed value
Stubble	4249	53.74	48.23	0.90
CCs	2398	23.28	27.22	1.17
SC	1102	18.75	12.51	0.67
WBF	1060	3.65	12.03	3.30
Total	8809			

3.6 SPECIES DIVERSITY INDICES

The Shannon index increases as both the richness and the evenness of the community increase, denoted as H, typical values range between 1.5 and 3.5. The higher the value of H the higher the diversity of species in a particular community. Likewise, the higher the value of 1-D (Simpson Index) the higher the diversity of species in a particular community. Species diversity indices showed little or no differences in diversity overall between survey (tillage) and control (pasture) when compared across all sites (Table 11). Further, species richness values were high and showed little difference between land uses (Pielou's Evenness Index).

Table 11. Alpha diversity statistics Shannon Index and Simpson's Index of Diversity values for the field types Tillage and Pasture.

Field Type	Shannon Index (H)	Simpson Index of Diversity (1 - D)	Pielou's Evenness Index (J)
Tillage	3.18	0.94	0.98
Pasture	3.24	0.94	1

4. DISCUSSION

4.1 WINTER FARMLAND BIRD HABITAT USE

Results of the winter farmland bird surveys confirm the importance of tillage crops for farmland birds of conservation concern such as Skylark, Yellowhammer, Linnet, as well as wintering Snipe, all of which occur in higher numbers and are more widely distributed across survey (tillage) transects than control (pasture) transects. Likewise, overall numbers of birds on tillage transects were higher than control (pasture) transects on both early and late winter visits. Skylark, Linnet, Woodpigeon and Yellowhammer were the most abundant birds on 1st visits to tillage transects. Skylark, Woodpigeon, Redwing and Rook were most abundant on 2nd visits, reflecting perhaps the arrival and build-up of numbers of winter migrants (Redwing) and decline in numbers of some resident seed dependent species (Linnet, Yellowhammer) over the winter. While seed dependent winter farmland birds, especially Skylark, Linnet and Yellowhammer, were almost exclusively found on tillage transects, control (pasture) transects held numbers of migratory thrushes (Redwing, Fieldfare) but also flocking resident species such as Woodpigeon and Starling.

By far the most impotent field type for winter farmland birds in terms of numbers (48%) and scale is winter stubble. This is especially so for key wintering farmland birds currently on the BoCCI list, especially Skylark, Linnet and Yellowhammer which made up some 63% of the birds recorded on winter stubble. Moreover, winter stubble was the most important field type for Skylark (72% of all records in stubble), Linnet (39%), Yellowhammer (56%) and Snipe (41%). Stubble was also important for Reed Bunting (87% of the species total) and House Sparrow (63%) although total numbers of these were relatively low (90 & 120 respectively) for birds that assigned to a specific field type (Table 12).

Although not widespread in distribution across the survey area (9 of 51 tillage transects in this study), results reiterate the importance of wild bird food crops for wintering farmland birds such as Linnet (35% of all birds in WBF), Yellowhammer (13%), Skylark (12%) and Goldfinch (11%). This was especially so in the early winter visits when WBF held 18% of all birds recorded in just 4.4% of the land area surveyed. Wild bird food crops were the most important field type for Goldfinch (68% of the species total), as

well as holding a high proportion of Linnet (26%), Yellowhammer (24%) as well as Woodpigeon (24%), Chaffinch (19%), House Sparrow (18%).

Table 12. Field type associations of some BoCCI listed winter farmland birds on survey (tillage) and control (pasture) transects (1st and 2nd visits combined). Numbers excludes birds assigned to band 3 (>100m) or birds located on the boundary of different field types.

Species	BTO Code	Species total	% Stubble	% CC	% SC	% WBF
Red-listed species (High conservation concern)						
Yellowhammer	Y	563	56.3	14.0	6.0	23.6
Snipe	SN	444	41.2	50.0	8.1	0.7
Meadow Pipit	MP	228	49.6	41.7	5.7	3.1
Redwing	RE	444	21.8	48.2	29.3	0.7
Golden Plover	GP	100	35.0	0.0	65.0	0.0
Amber-listed species (Medium conservation concern)						
Skylark	S	2569	72.4	6.9	15.9	4.9
Linnet	LI	1395	38.9	28.7	6.2	26.2
House Sparrow	HS	120	63.3	16.7	2.5	17.5
Stock Dove	SD	21	14.3	85.7	0.0	0.0
Greenfinch	GR	29	3.4	86.2	0.0	10.3
Green-listed species (Low conservation concern)						
Chaffinch	CH	418	30.1	27.8	22.7	19.4
Siskin	SK	187	47.6	47.6	0.0	4.8
Reed Bunting	RB	90	86.7	10.0	0.0	3.3
Goldfinch	GO	174	28.2	4.0	0.0	67.8
Woodpigeon	WP	315	21.0	50.2	4.8	24.1
Song thrush	ST	117	19.7	62.4	17.9	0.0

Cover crops were an important field type for several bird species including Linnet (17% of all birds in CC), Rook (13%) and Snipe (9%). Cover crops were more important for wintering farmland birds in late winter than early winter when this field type led 38% of all bird recorded. When compared to field type availability Cover crops held more birds than expected. This appeared to be mainly related to the high numbers of Rook (19.8%) and Redwing (11.8%) recorded on 2nd visits. Moreover, cover crops were the most important field type for Snipe (50% of species total in CCs), Redwing (48%), as well as Song Thrush (62%), Woodpigeon (50%), Siskin (48%), Meadow Pipit (42%), and Linnet (28%). Most (68%) of all Stock Dove and Greenfinch were recorded in cover crops although both species were rarely recorded. Cover crops were less important than expected when the data for only seed-eating birds were examined.

Shallow cultivation held good numbers of Skylark (37% of all birds in SC) and Redwing (12%), holding more birds per area available than cover crops in early winter. However, the importance of shallow cultivation for winter farmland birds had much declined by late winter (from 15% to 9.6% of all birds recorded) and it was the poorest field type/area available for birds in late winter. This may be partly explained by a decline in seed availability for seed-eating birds in late winter (Siriwardena et al. 2008) although birds numbers on winter stubble largely held up in late winter (49.6% to 46.2%). However, this suggests that even minimum cultivation of stubbles results in reduced seed availability in comparison with intact stubble.

Other bird groups using both tillage and pasture during winter included raptors and waterbirds. Raptors (day flying birds of prey) recorded included Kestrel, Merlin, Sparrowhawk, Buzzard and Peregrine. All except for Merlin breed in the survey area. Of 120 raptors recorded, 82 (68%) were in tillage with Buzzard by far the most frequently recorded on tillage (65% of all raptors) and pasture (68%). Merlin (3) were only recorded on tillage. Stubble (45% of all raptors) was the most heavily used field type for raptors. Waterbirds such as Curlew, Black-headed Gull, Oystercatcher were recorded almost exclusively found on pasture while Golden Plover (7 records of 258 birds) were only recorded on tillage transects. Perhaps the most surprising result of the survey was the high numbers of wintering Snipe recorded on visits to tillage transects, almost always solitary or individuals in small groups (mean group size 1.8-3.8) utilising mainly cover crops (50% of all snipe recorded) and winter stubble (41%).

Previous studies have shown the importance of winter stubble, cover crops and wild birds food crops for winter farmland birds (Hancock & Wilson 2003, Henderson et al 2004). McMahon et al. (2003) also found highest numbers of Skylark on winter stubble (14.1% of total bird numbers) in a study across four sites in Co. Kildare and found higher numbers of winter farmland birds on pasture than on winter sown cereals (wheat) but found species of conservation concern (Skylark, Yellowhammer) largely or wholly in stubble and winter cereals.

Most seed-dependent bird species are largely restricted in their range by the prevalence of arable and weed seeds, as well as factors such as hedgerow cover

and quality, and often most abundant on where seed availability is highest (Moorcroft et al. 2002). Yellowhammer are largely restricted to foraging close to hedgerows while Skylarks forage in the centre of fields but move closer to the field margins as the winter progresses and seed sources are depleted (Robinson & Sutherland 1999). Evidence suggests that winter seed depletion may be the main driver of population declines in seed dependent birds (Siriwardena et al. 2008).

Although birds that forage on invertebrates rather than on seeds are known to prefer undisturbed pasture over stubble (Wilson et al. 1996), some species such as Golden Plover were recorded on tillage (shallow cultivation and stubble) in this study although this was relatively rare. Golden Plover (and possibly other wading birds) may use tillage fields occasionally as safe, undisturbed roost sites rather than for foraging per se. However, both Golden Plover and Lapwing are known to forage extensively in both winter stubble, growing cereal crops as well as newly harrowed/drilled crops instead of pasture in an area which is predominantly tillage in SE Britian (Gillings et al. 2007). Furthermore, Golden Plover forage more heavily at night in crops and pasture (Gillings & Sutherland 2007). Thus, it is likely than numbers of nocturnal foraging species are underestimated in this study where surveys were only conducted during daylight hours. Studies using thermal imaging binoculars and drones may be particularly useful in the future in addressing this gap in our knowledge. The high level of use of tillage field types, particularly stubble and cover crops, by wintering Snipe, an invertebrate feeder, is interesting. Moreover, Snipe densities were much higher on tillage (58 birds/km^2) transects than on pasture (24 birds/km sq^2) transects when the opposite might be predicted.

4.2 WINTER FARMLAND BIRD DENSITIES

Winter farmland birds were found at highest densities in Wild Bird Food crops and, at lower densities but on a much bigger scale in winter stubble in this study. While, other than wild bird food, birds were found at highest density in cover crops when all species were included in the dataset, winter stubble held the highest densities of threatened (BoCCI) birds as well as seed-dependent species. Likewise, cover crops in late winter, and, when both visits were combined, winter stubble and wild bird food crops were utilised by winter farmland birds more than expected. Hancock & Wilson (2003) also

found the highest densities of winter farmland birds in fodder brassica (cover crops in this study) and winter stubble (Table 13).

Table 13 Densities of winter farmland bird species in the SECAD project area in comparison to other published studies.

Species	Density (birds/km sq)					Hancock & Wilson 2003	Stoate et al (2003)*	Henderson et al. 2004
	Pooled	Stubble	CCs	SC	WBF			
High conservation concern								
Snipe	58.0	63.8	161	38	14.7	-	-	-
Meadow Pipit	29.1	30.3	43	10	23.8	-	-	-
Yellowhammer	56.7					87	20-45*	470
Redwing	47.1							
Medium conservation concern								
House Sparrow	11.4					457		
Linnet	139.2					1154	20-50	650
Skylark	344.6	609	117	386	569	318		60
Low conservation concern								
Chaffinch	45.1					607	75-160	1230
Song Thrush	10.7							100
Wood Pigeon	89.4							1110

Crops grown specifically to feed birds in winter (e.g. linseed, fodder radish, Phacelia), usually within agri-environmental schemes, have been shown to be particularly important, holding higher densities of winter farmland birds than winter stubble, other winter crops or pasture (Henderson *et al.* 2004). Likewise, location of winter stubble in proximity to field margins with weed seed availability and retention of bare patches in stubble are beneficial to farmland birds (Moorcroft et al. 2002). Linnet and Reed Bunting were rarely found in fields where seed density fell below 250 seeds/m^{-2} while Yellowhammer disappeared from fields where seed density dropped below 50 seeds/m^{-2} (Moorcroft et al. 2002).

Yellowhammer breeding density is related to the quality and quantity of field boundaries, especially hedgerows and field margins managed sympathetically under an AES (Burgess et al. 2015), and Yellowhammers are typically absent from areas of suitable winter crop habitats, such as winter stubble, where there is little or no hedgerow cover. While early successional hedgerows and enhanced field margins

appear to be important for breeding Yellowhammer (McHugh et al. 2017), the presence of trees had a negative impact on Yellowhammer and Linnet breeding territory density in one study (Tresise et al 2021). Whittingham et al. (2005) also found that winter habitats had an important role in where Yellowhammers establish breeding territories. Thus, the extent and quality of habitats used by Yellowhammer and other non-migratory seed-dependent winter farmland birds are likely to be important in breeding habitat selection.

Although AES have not always been shown to deliver tangible benefits for birds at the population level through increased survivorship and, ultimately, increased abundance and positive population trends (Kleijn et al. 2006, Princé et al. 2012), several studies have found positive effects of targeted AES on bird abundance leading to increases in the number of breeding territories in subsequent years (McHugh et al. 2017, Redhead et al. 2018). Moreover, AES have been shown to have positive effects on territory settlement of two declining farmland bird species and arable specialists, Yellowhammer and Corn Bunting (Burgess et al. 2015), the latter the most recent bird species extinction on the island of Ireland (Taylor & O'Halloran 2002). Most recently, highly targeted conservation measures have reversed the long-term decline of Corn Bunting in the UK resulting in a 43% increase in population in the last 10 years (Heywood et al. 2023). Further, AES measures have been shown to be highly beneficial to small mammal populations (Broughton et al. 2014), a key ecological component of the diet of several important and threatened avian predators (e.g., Barn Owl, Hen Harrier, Kestrel) occurring in winter in the SECAD project area (Cooke et al. 1996, McCarthy et al. 2021).

4.3 CONCLUSIONS

Tillage is a relatively small (7%) but important sector in Irish agriculture. Tillage is important for several threatened farmland bird species, even more so in winter when a number of birds which rarely breed in conventional cereal crops (e.g., Skylark, Snipe) utilise important food sources such as winter stubbles, cover crops and wild bird food crops. Despite this, studies of winter farmland bird populations and their habitat requirements in lowland tillage in Ireland are lacking and most of our existing knowledge and data on the importance of tillage crops for winter farmland birds

comes from studies in the UK and elsewhere in Europe (e.g., Hancock & Wilson 2003, Henderson et al. 2004, Burgess et al. 2015). This study, although limited to a single winter season, attempts to bridge this gap in our knowledge.

Moreover, results to date show the importance of tillage habitats, especially winter stubble, wild bird food and cover crops, for a suite of birds of conservation concern (BoCCI). A number of farmland birds are red (high concern) or amber (medium concern) listed in Ireland as they have small and declining breeding population (Gilbert et al. 2021). Several of these species are also resident throughout the winter or augmented by immigrants from other parts of their range. Thus, this study confirms the importance of the SECAD area and tillage in particular for BoCCI species, especially Snipe, Yellowhammer, Linnet and Skylark. While maintaining or expanding the extent of winter stubbles appears to be critically important for the conservation of seed dependent winter farmland birds, a diverse mix including cover crops and wild bird food crops is important to benefit other wintering bird species (e.g., Snipe, Song Thrush). Wild bird food crops held by far the highest density of birds, especially seed eaters, the scale of such crops is currently small in area and its expansion is likely to be closely tied to the provision of funding under AESs. Currently, wild bird food is supported through the ACRES scheme where strips are planted close to and parallel to hedgerows. Crops used are a mix of triticale, fodder radish and linseed with Phacelia and vetches to add diversity.

Despite the apparent 'hungry gap' in late winter when winter stubble and other field types become largely depleted of field seed resources (Robinson & Sutherland 1999, Siriwardena et al. 2008), studies have shown that seed availability in winter stubble may be replenished over the winter through germination and seeding of weed seeds important for overwintering birds in late winter when other seed sources are largely depleted (Wilson et al. 1999, Robinson et al. 2002). Thus, field margins have the potential to provide seed-rich habitats during the breeding season and over winter and, can potentially produce food resources for birds more cost-effectively than whole farm practices (Vickery et al. 2009). Maintaining the availability of seeds through much of the winter is important as seed depletion, especially in late winter, is critical to over-winter survival of farmland birds. Therefore, retention of field margins

helps provide additional weed seeds during the critical 'hungry gap' period in late winter.

Consistent with worries that changes and amendments to regulations relating to post-harvest shallow cultivation of winter stubble under the Nitrates Directive (SI 113 of 2022) within 14 days of harvest, this study strongly indicates that shallow cultivation is significantly poorer for winter farmland birds that winter stubbles. Moreover, one of the core reasons for the introduction of the shallow cultivation measure, promotion of seed germination and 'greening' over to retain nitrates and mitigate nitrate runoff, was also visibly achieved by unsprayed winter stubble. Therefore, we believe this regulation is not only an unwarranted additional requirement, both in terms of time and expense for farmers and its negative impact of winter farmland birds due to the loss of winter stubbles.

Hedgerows with wide field margins are preferred by many seed-eating birds as weed seed densities are higher than in crops (Marshall 1989) and sympathetically managed hedgerows provide excellent cover for nesting birds as well as a refuge from detection by avian predators (e.g., Sparrowhawk, Merlin). Most bird detections in this survey were within 25m of hedgerows and some species (e.g., Yellowhammer) are largely absent from field boundaries lacking high quality hedgerows. Therefore, measures to improve hedgerow quality, such as more sympathetic management (side-trimming rather than topping) and hedgerow planting where none or gaps exist should be beneficial.

5. RECOMMENDATIONS

Based on the results of this study and cognisant of previous research on winter farmland birds, we recommend the follow actions:

- Retain post-harvest cereals as winter stubble where possible – this field type provides the best winter food resource for a suite of declining winter farmland birds.
- No/reduced post-harvest spraying of winter stubble to allow the growth of 'volunteer' cereals and other seed sources.
- Delay spring ploughing and sowing until March to retain stubble into the late winter – especially to minimise the late winter 'hungry gap' for winter farmland birds when seed resources are at their lowest.
- Scrap the requirement to shallow cultivate stubbles under the Nitrates Directive – promoting the retention of unsprayed winter stubble has the potential to achieve the same requirements without loss of winter stubble and without additional time and expense for tillage farmers.
- Promote the uptake of wild bird food crops through ACRES or other AES – this 'crop' type provides the best 'bang for your buck' in a relatively small area by feeding a high density of some key winter farmland birds over much of the winter.
- Retain and expand existing hedgerows – some declining species such as Yellowhammer are sensitive to the loss of hedgerow cover. Improving hedgerow cover and quality provides multiple benefits including breeding sites in summer and food resources and cover over winter.
- Manage hedgerows sympathetically by trimming lightly only every three years (or more) – this allows hedgerow shrubs and trees to provide fruit and set seed, providing food for winter farmland birds. Side trimming rather than topping is less impactful and allow trees and shrubs to set seed and fruit.
- Trim hedgerows as late as possible in the winter/early spring (before 1 March) to retain food resources such as berries as late into the winter as possible.
- Plant new hedgerows to fill gaps or where none exist, using native trees and shrubs.
- Plant a diverse mix of native hedgerow shrubs (e.g., whitethorn, blackthorn, guelder rose, spindle) to provide multiple food resources.

- Incorporate field margins as a food source for farmland birds.
- Retain and/or create a wet area (pond).

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7. APPENDICES

7.1 STATUS & DISTRIBUTION OF BOCCI SPECIES IN THE SECAD PROJECT AREA IN WINTER

Table 7.1.1. Status of Birds of Conservation Concern in Ireland (BoCCI) wintering on survey (tillage) transects (1st visits, n=51; 2nd visits, n=46) in the SECAD area in 2022/3023. Status codes: Resident (R), Wintering (W); Abundance codes (% transects): rare (<5%), scarce (5-10%), uncommon (10-25%), fairly common (25-50%), common (>50%).

		% birds		% tetrads		
Species	Species code	1st visits	2nd visits	1st visits	2nd visits	Status
RED LISTED (High conservation concern)						
Kestrel	K	0.2	<0.1	19.6	6.5	Scarce R
Golden Plover	GP	4.2	0	9.8	0	Scarce W
Snipe	SN	3.2	4.0	64.7	52.2	Common W
Meadow Pipit	MP	3.4	0.8	80.4	32.6	Common W
Yellowhammer	Y	7.0	3.3	74.5	76.1	Common R
Redwing	RE	2.2	11.5	27.5	43.5	Uncommon W
Stock Dove	SD	<0.1	0.6	5.9	8.7	Scarce R
AMBER LISTED (Medium conservation concern)						
Merlin	ML	<0.1	0	5.9	0	Scarce W
Chough	CF	0.1	0.1	5.9	10.9	Uncommon R
House Sparrow	HS	1.6	0.7	31.4	32.6	Fairly common R
Linnet	LI	14.5	8.7	47.1	39.1	Fairly common W
Skylark	S	24.7	18.1	80.4	82.6	Common W
Starling	SG	1.4	4.1	7.8	19.6	Uncommon R
Greenfinch	GR	0.1	0.4	3.9	4.3	Rare R
Brambling	BL	0.1	0	5.9	0	Scarce W
GREEN LISTED (Least concern)						
Peregrine	PE	<0.1	0.1	3.9	10.9	Scarce R
Reed Bunting	RB	0.6	0.7	21.6	19.6	Uncommon R

7.2 FIELD TYPE ASSOCIATIONS OF WINTER FARMLAND BIRDS

Table 7.2.1. Numbers and proportion of birds of some winter farmland birds on survey (tillage) and control (pasture) transects during 1st visits. Numbers excludes birds assigned to band 3 (>100m) or birds located on the boundary of different field types.

Species	Stubble		Shallow cultivation		Cover crops		Wild bird food		Pasture	
	No birds	% birds	No birds	% birds	No birds	% birds	No birds	% birds	No birds	% birds
Skylark	965	**42.07**	359	**51.65**	46	5.79	36	4.29	2	0.12
Linnet	267	**11.64**	14	2.01	254	**31.95**	302	**36.00**	16	1.00
Yellowhammer	205	**8.94**	17	2.45	60	**7.55**	104	**12.40**	26	1.62
Rook	101	4.40	1	0.14	5	0.63	9	1.07	175	**10.92**
Meadow Pipit	100	4.36	0	0	63	7.92	9	1.07	117	**7.30**
Snipe	89	3.88	19	2.73	76	**9.56**	0	0	55	3.43
Chaffinch	79	3.44	85	**12.23**	39	4.91	64	7.63	51	3.18
House Sparrow	48	2.09	0	0	13	1.64	18	2.15	13	0.81
Redwing	37	1.61	10	1.44	25	3.14	3	0.36	375	**23.41**
Golden Plover	35	1.53	65	**9.35**	0	0	0	0	2	0.12
Reed Bunting	29	1.26	0	0	7	0.88	2	0.24	1	0.06
Dunnock	27	1.18	12	1.73	34	4.28	5	0.60	32	2.00
Goldfinch	27	1.18	0	0	0	0	120	**14.30**	21	1.31
Woodpigeon	24	1.05	4	0.58	22	2.77	65	7.75	81	5.06
Song Thrush	35	4.40	0	2.01	35	4.40	0	0.00	37	2.31
Stock Dove	2	0.09	0	0	0	0	0	0	0	0
Greenfinch	1	0.04	0	0	0	0	4	0.48	0	0
Total birds	2294		695		795		839		1602	

Table 7.2.2. Numbers and proportion of birds of some winter farmland birds on survey (tillage) and control (pasture) transects during 2nd visits. Numbers excludes birds assigned to band 3 (>100m) or birds located on the boundary of different field types.

Species	Stubble		SC		Cover crops		WBF	
	No birds	% birds	No birds	% birds	No birds	% birds	No birds	% birds
Skylark	894	45.75	50	12.29	130	8.11	92	34.46
Linnet	275	14.07	72	17.69	147	9.17	70	26.22
Yellowhammer	112	5.73	17	4.18	19	1.19	32	11.99
Snipe	94	4.81	17	4.18	146	9.11	3	1.12
Redwing	60	3.07	120	29.48	189	11.79	0	0.00
Reed Bunting	49	2.51	0	0.00	2	0.12	1	0.37
Chaffinch	47	2.41	10	2.46	77	4.80	28	10.49
Jackdaw	44	2.25	17	4.18	0	0.00	0	0.00
Woodpigeon	42	2.15	11	2.70	136	8.48	11	4.12
Dunnock	37	1.89	8	1.97	17	1.06	2	0.75
Robin	36	1.84	12	2.95	7	0.44	0	0.00
Siskin	35	1.79	0	0.00	65	4.05	7	2.62
House Sparrow	28	1.43	3	0.74	7	0.44	3	1.12
Wren	27	1.38	5	1.23	10	0.62	3	1.12
Blackbird	25	1.28	10	2.46	11	0.69	1	0.37
Goldfinch	22	1.13	0	0	7	0.44	0	0
Starling	15	0.77	8	1.97	36	2.25	0	0.00
Meadow Pipit	12	0.61	0	0	32	2.00	0	0
Magpie	11	0.56	4	0.98	3	0.19	0	0
Rook	11	0.56	5	1.23	316	19.71	0	0
Song Thrush	10	0.51	7	1.72	38	2.37	0	0
Bullfinch	5	0.26	0	0	0	0	4	1.50
Stock Dove	1	0.05	0	0	18	1.12	0	0
Greenfinch	0	0	0	0	25	1.56	1	0.37
Total	1892	96.8	376	92.4	1438	89.7	258	96.6

7.3. DENSITY ESTIMATES OF WINTER FARMLAND BIRDS

Table 7.3.1. Density estimates for winter farmland birds on survey (tillage) transects during early and late visits. Density estimates are means ± SE.

Species	Density (birds per km^2)			Density S.E		
	Early	Late	Total	Early	Late	Total
B.	12.00	10.23	11.12	2.49	2.20	1.94
CH	54.50	35.61	45.06	18.19	9.09	10.52
D.	18.20	14.52	16.36	4.47	3.51	3.37
LI	166.14	112.33	139.23	43.54	30.93	27.07
MP	46.43	11.68	29.05	17.23	7.66	9.81
R.	10.8	13.6	12.2	2.5	3.20	2.51
RE	13.07	81.2	47.13	3.75	33.12	16.67
S.	371.42	317.79	344.6	78.66	64.33	53.37
SN	51.68	64.36	58.02	10.2	37.00	58.02
ST	9.83	11.6	10.71	3.66	4.38	3.26
WR	11.44	10.68	11.06	2.53	2.86	2.36
Y	74.7	38.73	56.72	17.23	9.40	10.48

Table 7.3.2. Density estimates for winter farmland birds on control (pasture) transects during early and late visits. Density estimates are means ± SE.

	Density (birds per km^2)			Density S.E		
Species	Early	Late	Total	Early	Late	Total
B.	20.6	14.45	18.02	3.75	2.96	2.72
CH	15.0	16.8	15.9	3.98	8.37	4.93
D.	9.5	10.07	9.78	2.18	2.89	2.05
MP	47.09	52.63	49.86	14.22	14.12	10.28
R.	18.39	23.4	20.9	4.13	5.1	4.1
RE	105.33	91.3	98.32	31.58	32.24	23.96
SN	31.64	16.68	24.16	12.35	6.73	7.98
WP	39.0	89.43	64.22	15.69	25.72	15.49
WR	12.29	17.2	14.74	3.03	4.67	3.41

Table 7.3.3. Pooled (early& late visits) density estimates for winter farmland birds on survey (tillage) and control (pasture) transects during early and late visits. Density estimates are means ± SE.

	Density (birds per km^2)		Density S.E	
Species	Tillage	Pasture	Tillage	Pasture
BT	1.63	1.41	0.6	0.63
BZ	2.67	2.19	0.49	0.45
FF	19.83	45.65	1.15	1.5
HC	2.17	5.16	4.8	1.56
HS	11.44	7.62	3.84	3.53
LI	145.03	8.44	32.84	6.2
MG	4.15	3.46	0.95	0.85
S.	345.46	0.9	59.88	0.49
ST	13.15	6.59	3.88	2.33
WP	89.43	64.29	23.13	18.52
Y.	57.97	5.1	11.44	3.75

Table 7.3.4. Density estimates for three bird groups across field types: all bird species recorded, BoCCI species, and granivorous (seed-eating) bird species. Density estimates are means ± SE.

Habitat	All birds		BOCCI		Seed Eaters	
	Density (birds per km^2)	Density S.E	Density (birds per km^2)	Density S.E	Density (birds per km^2)	Density S.E
Cover Crops	970.85	0	453.63	51.03	292.61	26.74
Shallow Cultivation	580.59	103.7	453.67	125.14	322.51	98.34
Stubble	872.34	93.71	795.51	146.74	661.87	617.67
Wild Bird Food	3218.0	27250	2198.51	394.26	2767.9	1192.48
Grassland	519.2	0	219.48	46.62	32.86	3.72

7.4 BIRD SPECIES NAMED IN THE REPORT

Barn Owl *Tyto alba*

Blackbird *Turdus merula*

Black-headed Gull *Larus ridibundus*

Blue Tit *Cyanistes caeruleus*

Brambling *Fringilla montifrigilla*

Bullfinch *Pyrrhula pyrrhula*

Buzzard *Buteo buteo*

Chaffinch *Fringilla coelebs*

Chiffchaff *Phylloscopus collybita*

Chough *Pyrrhocorax pyrrhocorax*

Collared Dove *Streptopelia decaocto*

Curlew *Numenius arquata*

Dipper *Cinclus cinclus*

Dunnock *Prunella modularis*

Feral Pigeon *Coumba livia domestica*

Fieldfare *Turdus pilaris*

Goldcrest *Regulus regulus*

Goldfinch *Carduelis carduelis*

Great Tit *Parus major*

Greenfinch *Chloris chloris*

Grey Wagtail *Motacilla cinerea*

Hooded Crow *Corvus cornix*

House Sparrow *Passer domesticus*

Jackdaw *Corvus monedula*

Jack Snipe *Lymnocryptes minimus*

Jay *Garrulus glandarius*

Kestrel *Falco tinnunculus*

Lapwing *Vanellus vanellus*

Lesser Redpoll *Carduelis flammea*

Linnet *Carduelis cannabina*

Long-tailed Tit *Aegithalus caudatus*

Magpie *Pica pica*

Mallard *Anas platyrhynchos*

Meadow Pipit *Anthus pratensis*

Merlin *Falco columbarius*

Mistle Thrush *Turdus viscivorus*

Oysercatcher *Haemotopus ostralagus*

Peregrine *Falco peregrinus*

Pheasant *Phasianus colchicus*

Pied Wagtail *Motacilla alba*

Raven *Corvus corax*

Redwing *Turdus iliacus*

Reed Bunting *Emberiza shoeniclus*

Robin *Erithacus rubecula*

Rook *Corvus frugilegus*

Siskin *Carduelis spinus*

Skylark *Alauda arvensis*

Snipe *Gallinago gallinago*

Song Thrush *Turdus philomelus*

Sparrowhawk *Accipiter nisus*

Starling *Sturnus vulgaris*

Stock Dove *Columba oenas*

Stonechat *Saxicola rubicola*

Water Rail *Rallus aquaticus*

Whimbrel *Numenius phaeopus*

Woodpigeon *Columba palumbus*

Wren *Troglodytes troglodytes*

Yellowhammer *Emberiza citrinella*