Counting birds on farmland habitats in winter

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Capsule Perimeter counts underestimate the number of birds using agricultural fields.

Aims To determine the degree to which farmland birds may be undercounted on field surveys and the factors influencing this.

Methods In a study of 96 fields, birds in the field were counted during a walk of the perimeter. Afterwards transects were walked across the field to determine the number of birds missed. Additionally in a national survey we looked at the birds seen in field transects expressed as a proportion of the total seen in the transect and on perimeter counts.

Results To obtain an accurate count of birds on a field requires the use of the whole-area search methodology especially for species such as Grey Partridge Perdix perdix, Snipe Gallinago gallinago, Skylark Alauda arvensis and Meadow Pipit Anthus pratensis. However, for a large number of species, including thrushes, flocking finches and buntings, over 90% of individuals can be recorded using the much less time-consuming perimeter count method.

Conclusions Perimeter counts are likely to be reliable for most species but special efforts may be required for a few cryptic species.

Detectability and bias are often problems in sampling animal populations (Greenwood 1996). Animals tend to be mobile, sometimes cryptic and travel in groups violating assumptions of independence between individuals. The habitats in which they live are also variable in nature (e.g. vegetation height or density) which may cause variation in detectability. For studies where counts or densities are required, the sampling techniques need to be tailored to the questions being asked and the biology of each species (Greenwood 1996). This can range, for example, from complete censuses for populations of conspicuous species (Gibbons & Wotton 1996) to estimates of population size or density based on randomized sampling (e.g. Skylarks Alauda arvensis; Gillings & Fuller 2001).

In recent years much effort has been directed towards assessing the impacts of modern agriculture on bird populations. Many species of farmland bird have undergone rapid population declines and range contractions in the last 25 years (Fuller et al. 1995, Siriwardena et al. 1998, Gregory et al. 2004) and these have been linked to changes in farming practice (Fuller et al. 1995, Campbell et al. 1997, O’Connor & Shrubb 1986). One problem with surveying birds on arable land in winter is that birds vary in their detectability. There is approximately a 20-fold difference in size between a Linnet Carduelis cannabina, one of the smallest species to regularly use fields in winter, and a Wood-pigeon Columba palumbus, one of the largest. Some species travel in flocks, e.g. Linnet, whereas others such as Skylark are cryptic and tend to occur singly.

Studies which estimate population size or density of birds in agricultural habitats in winter have tended to use one of two methods. The first method uses counts from the perimeter only (‘perimeter counts’; Gillings et al. 2005, Tucker 1992); the second involves walking parallel transects across the field sufficiently close together to ensure that everything is flushed and counted (‘whole-area search’; Moorcroft et al. 2002, Wilson et al. 1996). For small-scale studies the more accurate whole-area search method is preferable but at larger scales, e.g. for national surveys, it is prohibitively time-consuming and expensive. Instead, for the Winter Farmland Bird Survey (Wilson & Gillings 2002), which was a national survey, a compromise method was employed involving field edge counts and across-field transect counts which subsequently could be used to
identify problem species or habitats for which edge
counts alone might be biased.

Although perimeter counts are frequently used in
surveys of wintering birds, and are known to under-
estimate numbers of some species, there have been few
attempts to quantify the magnitude of such under-
estimates. Here we use field data from a national survey
of birds in winter (the BTO/JNCC Winter Farmland
Bird Survey, WFBS) and a small-scale field survey of
birds on stubble fields in East Anglia, UK, to directly
compare numbers of birds detected through perimeter
counts and whole-area search. We address three
questions: first, to what extent do perimeter counts
underestimate birds using agricultural fields; second,
how does this differ between species (i.e. for which
species are perimeter counts least effective); and third,
how does this differ between habitats? These results can
then be used to inform future studies.

METHODS

Small-scale surveys: whole-area search

Over a period of 20 days between February and March
1998, winter bird surveys were carried out on 96 arable
fields in Norfolk, England, comprising 47 fields of young
cereal crop, 35 of cereal stubble and 14 of sugar beet
stubble. The area of these fields was about 1090 ha (528,
384, 178 ha of cereal crop, cereal and beet stubble,
respectively) ranging in size from 3.13 to 37.56 ha (Fig.
1). Two survey methodologies were adopted: ‘perimeter
counts’ and ‘whole-area searches’. In the former, an
observer walked slowly around the field edge at a
distance of no more than 6–10 m into the field and
recorded all birds seen using the hedge, field margin
(defined as a 10 m strip from the hedge into the field
itself) and field centre. Following the perimeter count, a
whole-area search was conducted in which the observer
then walked in a series of parallel transects across the
field ensuring all parts of the field were covered to within
approximately 20 m. Any birds seen during field
transects, but not during the perimeter counts, were
recorded separately allowing an estimate of the percent-
age of birds missed by the first, less intensive method.
Double counting may have been an issue but as the
flocks of birds were well spread out and as numbers were
low, it was straightforward to locate birds previously seen
from the edge, whilst performing the field transect.

The number of birds seen during the field transects
but not the perimeter count and the total number of
birds recorded were tabulated and species recorded on
15 or more fields subjected to statistical analysis, unless
all birds were recorded from the perimeter count over
all the fields surveyed. As the physical characteristics of
the field were likely to influence the detectability of
birds, the percentage cover of bare earth, weeds and
crop volunteers (newly emerging crop plants from seeds
left in the stubble) were estimated by eye from twenty
0.5 × 0.5 m quadrats placed at random along the tran-
sect walks. Stubble and vegetation heights were
measured within these quadrats using a ruler. The
effects of field area, vegetation or stubble height, the
total green cover (weeds and crop volunteers) and bare
ground on the proportion of each bird species seen only
during the field transects was examined using a series of
single species univariate logistic regressions with the
dependent variable being of the form: (numbers of
birds seen from the perimeter/total number of birds
recorded in the field).

Winter Farmland Bird Survey

In the winter of 1999/2000 a total of 870 randomly
selected 1-km squares were surveyed by volunteer
observers under the BTO/JNCC Winter Farmland Bird
Survey. The numbers of 30 farmland bird species on each
field were recorded on three four-hour visits between
November and February. This suite of 30
‘target’ species included declining species of conserva-
tion concern and winter visitors, but in 1999/2000 did
not include highly abundant species (e.g. Woodpigeon,
corvids). Observers walked around the edge of each field
and recorded birds in three zones: boundary (all birds in
hedges and other boundary structures including any
‘verge’ vegetation adjacent to the crop or uncropped
margin); margin (all birds in the outer 20 m of the crop);
interior (all birds in the field beyond the margin zone).
Birds were assigned to the zone in which they were first
detected. After completing a circuit of the field, observers walked a single straight transect across the middle of the field. Any birds in the first or last 20 m of the transect would have already been counted in the margin component of the perimeter walk so were not double counted. Transects were only 20 m wide (10 m either side) to ensure that all birds in the strip would be detected irrespective of vegetation height. The habitat (i.e. crop type) of each patch was recorded.

Three of the target species (Woodlark Lullula arborea, Twite Carduelis flavirostris and Snow Bunting Plectrophenax nivalis) were recorded on too few squares to include in analyses. For the remaining 27 species we summarize the percentage of total individuals that were recorded solely from the transect as opposed to from the field edge (i.e. in any field zone, but seen from the perimeter). Since the transect did not cover the whole area it could not give a complete estimate of the number of birds 'missed' from the field perimeter. Instead we use these data to derive an index that can be compared across species and identify those for which potentially large numbers of individuals are missed by perimeter counts alone. For these species the effects, on detectability, of field area (ha) and broad habitat type (three levels: grass, crop, stubble) and the interaction between three variables were examined using logistic regression in the Genmod procedure in SAS. We used an events/trials syntax with the number of birds seen from the transect as events and total number recorded in the patch (transect plus perimeter walk) as trials. Since a large proportion of patches were not occupied by a given species on a particular visit, on 75% of visits only two patches contributed data per square for most species (three patches for Skylark, Song Thrush Turdus philomelos, Starling Sturnus vulgaris and Yellowhammer Emberiza citrinella, four patches for Chaffinch Fringilla coelebs). We therefore considered patches as suitable independent units, though there may have been issues relating to over-dispersion for flocking species. We used the square root of the deviance/degrees of freedom to scale models and reduce over- or under-dispersion. Significant effects of area and habitat were determined from sequential type III likelihood ratio (LR) statistics (i.e test for habitat effects after first controlling for area effects).

RESULTS

Small-scale survey

A total of 7699 birds of 32 species were recorded: 754 birds of 23 species on cereal crop fields, 4060 birds of 26 species on cereal stubble fields and 2885 birds of 24 species on sugar beet stubble fields (Table 1). The percentage of individual birds seen using the perimeter count (assuming that detectability using the whole-area search method is 100%) is given for 32 species of farmland bird in Table 2. Fourteen species were recorded on more than ten fields. Of these 14 species, no additional birds were detected by the whole-area search for four species (Fieldfare Turdus pilaris, Woodpigeon, Goldfinch Carduelis carduelis and Pied Wagtail Motacilla alba), and over 90% of individuals were detected from the perimeter for six species (Chaffinch, Greenfinch Carduelis chloris, Mistle Thrush Turdus viscivorus, Linnet, Red-legged Partridge Alectoris rufa and Pheasant Phasianus colchicus). For the remaining species, the boundary method under-recorded birds relative to the whole-area search and was least accurate for Skylark (47% of individuals detected, n = 745) and Meadow Pipit Anthus pratensis (48%, n = 42), Yellowhammer (89%, n = 485), and Grey Partridge Perdix perdix (74%, n = 87).

With the exception of Chaffinch, the amount of bare ground, height of vegetation or stubble and the area of the field had a significant effect on the proportion of birds missed on the perimeter counts (Table 3). Field area had a significant effect for only two species whereas the height of the vegetation or stubble and the amount of bare ground had a significant effect for the majority of species (six out of seven species considered). The numbers of birds missed increased as vegetation height increased and/or the extent of bare ground decreased.

Winter Farmland Bird Survey (WFBS)

A total of 14 222 patches were surveyed in 1999/2000, covering over 400 km² of farmland and generating approximately 30 000 records of over 300 000 individual birds of the 30 target bird species.

Figure 2 shows that the percentage of individuals seen from the field transect varied markedly between species. For 17 species, less than 5% of all individuals reported from all 801 squares were seen on field transects. However, a further ten exceeded the arbitrary 5% cut-off. Snipe Gallinago gallinago, Skylark and Meadow Pipit were extreme with over one-fifth of individuals seen from transects. This is despite the fact that transects comprised only a small fraction of the surveyed area of each field, being only 20 m wide. If this transect area were extrapolated over the rest of each field, the number of individuals of these species missed...
by conventional field perimeter counts becomes a serious issue.

The degree to which field edge counts underestimate numbers of birds differed between habitat types. Table 4 summarizes the percentage of individuals in transects separately for crops, grass and stubble. Note that no Redpolls *Carduelis flammea* were recorded on transects.

The effect of habitat type may be confounded by field area if field size differs in a consistent way with habitat type. However, after controlling for differences in field area, 13–15 species showed strongly significant differences (either area * habitat or habitat at *P* < 0.0001) in the percentage of birds seen on transects (compared to transects plus edge counts) between habitat types. For example, around one-quarter of Skylarks were recorded on transects in crops and grass but in stubble this figure rose to 40%. A similar pattern was apparent for Goldfinch, with only 5–6% recorded on transects in crops and grass but 15% on transects in stubble.

**DISCUSSION**

**Bird detectability using perimeter counts and whole-area searches**

The results suggest that significant numbers of birds may be missed in the field centre using a perimeter method of surveying, particularly where the field vegetation is tall or dense. The magnitude of differences between the two survey methods was large for some key farmland bird species. For example, over 50% of Skylarks and Meadow Pipits were missed from perimeter counts in a small-scale intensive survey and, together with Snipe, were found to be the species most

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**Table 1.** Total number of birds recorded on cereal crop, cereal stubble and sugar beet stubble fields in Norfolk during the small-scale survey in winter (February/March 1999). The number of fields on which birds were recorded appears in parentheses.

<table>
<thead>
<tr>
<th>Species</th>
<th>Cereal crop (n = 47 fields)</th>
<th>Cereal stubble (n = 35 fields)</th>
<th>Sugar Beet stubble (n = 14 fields)</th>
<th>Total (n = 97 fields)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black-headed Gull <em>Larus ridibundus</em></td>
<td>1 (1)</td>
<td>70 (2)</td>
<td>59 (1)</td>
<td>130 (4)</td>
</tr>
<tr>
<td>Brambling <em>Fringilla montifringilla</em></td>
<td>0 (0)</td>
<td>366 (6)</td>
<td>0 (0)</td>
<td>366 (6)</td>
</tr>
<tr>
<td>Carrion Crow <em>Corvus corone</em></td>
<td>3 (2)</td>
<td>9 (3)</td>
<td>6 (2)</td>
<td>18 (7)</td>
</tr>
<tr>
<td>Chaffinch <em>Fringilla coelebs</em></td>
<td>6 (2)</td>
<td>672 (15)</td>
<td>172 (4)</td>
<td>850 (21)</td>
</tr>
<tr>
<td>Common Gull <em>Larus canus</em></td>
<td>0 (0)</td>
<td>14 (1)</td>
<td>1 (1)</td>
<td>15 (2)</td>
</tr>
<tr>
<td>Egyptian Goose <em>Alopochen aegyptiacus</em></td>
<td>3 (2)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Fieldfare <em>Turdus pilaris</em></td>
<td>148 (5)</td>
<td>460 (1)</td>
<td>408 (5)</td>
<td>1016 (11)</td>
</tr>
<tr>
<td>Goldfinch <em>Carduelis carduelis</em></td>
<td>0 (0)</td>
<td>103 (11)</td>
<td>39 (2)</td>
<td>42 (13)</td>
</tr>
<tr>
<td>Green Sandpiper <em>Tringa ochropus</em></td>
<td>1 (1)</td>
<td>1 (6)</td>
<td>0 (3)</td>
<td>1 (10)</td>
</tr>
<tr>
<td>Greenfinch <em>Carduelis chloris</em></td>
<td>1 (1)</td>
<td>208 (0)</td>
<td>39 (0)</td>
<td>248 (1)</td>
</tr>
<tr>
<td>Grey Partridge <em>Perdix perdix</em></td>
<td>32 (12)</td>
<td>50 (10)</td>
<td>5 (2)</td>
<td>87 (24)</td>
</tr>
<tr>
<td>Jackdaw <em>Corvus monedula</em></td>
<td>6 (1)</td>
<td>180 (1)</td>
<td>16 (3)</td>
<td>202 (5)</td>
</tr>
<tr>
<td>Lapwing <em>Vanellus vanellus</em></td>
<td>1 (1)</td>
<td>0 (0)</td>
<td>492 (2)</td>
<td>493 (3)</td>
</tr>
<tr>
<td>Linnnet <em>Carduelis cannabina</em></td>
<td>0 (0)</td>
<td>132 (9)</td>
<td>52 (3)</td>
<td>184 (12)</td>
</tr>
<tr>
<td>Magpie <em>Pica pica</em></td>
<td>0 (0)</td>
<td>1 (1)</td>
<td>2 (1)</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Meadow Pipit <em>Anthus pratensis</em></td>
<td>10 (4)</td>
<td>97 (15)</td>
<td>43 (5)</td>
<td>150 (24)</td>
</tr>
<tr>
<td>Mistle Thrush <em>Turdus viscivorus</em></td>
<td>8 (2)</td>
<td>7 (4)</td>
<td>8 (4)</td>
<td>23 (10)</td>
</tr>
<tr>
<td>Moorhen <em>Gallinula chloropus</em></td>
<td>2 (1)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Pheasant <em>Phasianus colchicus</em></td>
<td>15 (10)</td>
<td>35 (12)</td>
<td>13 (7)</td>
<td>63 (29)</td>
</tr>
<tr>
<td>Pied Wagtail <em>Motacilla alba</em></td>
<td>2 (1)</td>
<td>45 (2)</td>
<td>78 (7)</td>
<td>125 (10)</td>
</tr>
<tr>
<td>Pink-footed Goose <em>Anser brachyrhynchus</em></td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>600 (1)</td>
<td>600 (1)</td>
</tr>
<tr>
<td>Red-legged Partridge <em>Alectoris rufa</em></td>
<td>51 (11)</td>
<td>87 (17)</td>
<td>25 (8)</td>
<td>163 (36)</td>
</tr>
<tr>
<td>Redwing <em>Turdus iliacus</em></td>
<td>11 (1)</td>
<td>0 (0)</td>
<td>23 (3)</td>
<td>34 (4)</td>
</tr>
<tr>
<td>Reed Bunting <em>Emberiza schoeniclus</em></td>
<td>1 (1)</td>
<td>61 (7)</td>
<td>0 (0)</td>
<td>62 (8)</td>
</tr>
<tr>
<td>Rook <em>Corvus frugilegus</em></td>
<td>27 (1)</td>
<td>221 (2)</td>
<td>0 (0)</td>
<td>248 (3)</td>
</tr>
<tr>
<td>Skylark <em>Alauda arvensis</em></td>
<td>199 (21)</td>
<td>514 (26)</td>
<td>32 (4)</td>
<td>745 (51)</td>
</tr>
<tr>
<td>Snipe <em>Gallinago gallinago</em></td>
<td>0 (0)</td>
<td>23 (1)</td>
<td>0 (0)</td>
<td>23 (1)</td>
</tr>
<tr>
<td>Starling <em>Sturnus vulgaris</em></td>
<td>0 (0)</td>
<td>140 (1)</td>
<td>169 (4)</td>
<td>309 (5)</td>
</tr>
<tr>
<td>Stock Dove <em>Columbia oenas</em></td>
<td>10 (1)</td>
<td>27 (1)</td>
<td>21 (5)</td>
<td>58 (7)</td>
</tr>
<tr>
<td>Tree Sparrow <em>Passer montanus</em></td>
<td>0 (0)</td>
<td>28 (4)</td>
<td>0 (0)</td>
<td>28 (4)</td>
</tr>
<tr>
<td>Woodpigeon <em>Columbia palumbus</em></td>
<td>213 (8)</td>
<td>28 (3)</td>
<td>582 (7)</td>
<td>823 (18)</td>
</tr>
<tr>
<td>Yellowhammer <em>Emberiza citrinella</em></td>
<td>3 (2)</td>
<td>482 (21)</td>
<td>0 (0)</td>
<td>485 (23)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>754</strong></td>
<td><strong>4060</strong></td>
<td><strong>2885</strong></td>
<td><strong>7699</strong></td>
</tr>
<tr>
<td><strong>Total number of species</strong></td>
<td><strong>32</strong></td>
<td><strong>32</strong></td>
<td><strong>32</strong></td>
<td><strong>32</strong></td>
</tr>
</tbody>
</table>
likely to be under-recorded from the field edge in a national survey of wintering farmland birds. Failure to detect species from the perimeter is undoubtedly due to a combination of species behaviour, foraging ecology and field characteristics. Skylarks and Meadow Pipits, in general, do not form such large flocks on fields and individuals tend to flush at much shorter distances than species such as Linnet and Chaffinch. In general, detectability was reduced more by increases in the density or height of vegetation than by increasing field area.

Tucker (1992) stated that perimeter surveys in winter might not detect species smaller than thrushes and thus restricted his study to larger species. In the current study, this was also generally the case, with the exception of Snipe and, perhaps surprisingly, Grey Partridge.

Table 2. The proportion of the total number of birds seen on a field in the small-scale surveys, which were detected by the initial perimeter count. Species are listed in descending order of abundance.

<table>
<thead>
<tr>
<th>Species</th>
<th>Birds seen from edge of field (%)</th>
<th>Number of fields with species present</th>
<th>Total number of individuals seen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fieldfare</td>
<td>100</td>
<td>11</td>
<td>1016</td>
</tr>
<tr>
<td>Chaffinch</td>
<td>99.9</td>
<td>21</td>
<td>850</td>
</tr>
<tr>
<td>Woodpigeon</td>
<td>100</td>
<td>18</td>
<td>823</td>
</tr>
<tr>
<td>Skylark</td>
<td>46.9</td>
<td>51</td>
<td>745</td>
</tr>
<tr>
<td>Pink-footed Goose</td>
<td>100</td>
<td>1</td>
<td>600</td>
</tr>
<tr>
<td>Lapwing</td>
<td>100</td>
<td>3</td>
<td>493</td>
</tr>
<tr>
<td>Yellowhammer</td>
<td>89.0</td>
<td>23</td>
<td>485</td>
</tr>
<tr>
<td>Brambling</td>
<td>100</td>
<td>6</td>
<td>366</td>
</tr>
<tr>
<td>Starling</td>
<td>100</td>
<td>5</td>
<td>309</td>
</tr>
<tr>
<td>Greenfinch</td>
<td>99.2</td>
<td>10</td>
<td>248</td>
</tr>
<tr>
<td>Rook</td>
<td>100</td>
<td>3</td>
<td>248</td>
</tr>
<tr>
<td>Jackdaw</td>
<td>100</td>
<td>5</td>
<td>202</td>
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<tr>
<td>Linnet</td>
<td>94.0</td>
<td>12</td>
<td>184</td>
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<tr>
<td>Red-legged Partridge</td>
<td>90.2</td>
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<tr>
<td>Meadow Pipit</td>
<td>48</td>
<td>24</td>
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<td>Goldfinch</td>
<td>100</td>
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<td>142</td>
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<td>Black-headed Gull</td>
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</tr>
<tr>
<td>Pied Wagtail</td>
<td>100</td>
<td>10</td>
<td>125</td>
</tr>
<tr>
<td>Grey Partridge</td>
<td>74.7</td>
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<td>87</td>
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<tr>
<td>Pheasant</td>
<td>95.2</td>
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<tr>
<td>Reed Bunting</td>
<td>95.2</td>
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<td>Redwing</td>
<td>88.2</td>
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<td>Tree Sparrow</td>
<td>100</td>
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<td>Mistle Thrush</td>
<td>91.3</td>
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<td>Snipe</td>
<td>100</td>
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</tr>
<tr>
<td>Carrion Crow</td>
<td>100</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>Common Gull</td>
<td>100</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Egyptian Goose</td>
<td>100</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Magpie</td>
<td>100</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Moorhen</td>
<td>100</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Green Sandpiper</td>
<td>100</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3. Field characteristics that significantly affected the proportion of birds missed on the perimeter counts in the small-scale survey. Only significant relationships as indicated by likelihood ratio tests are shown.

<table>
<thead>
<tr>
<th>Species/parameter</th>
<th>Size of field (ha)</th>
<th>Height of vegetation or stubble (cm)</th>
<th>Bare ground (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chaffinch</td>
<td></td>
<td>+ ***</td>
<td></td>
</tr>
<tr>
<td>Grey Partridge</td>
<td></td>
<td>+ ***</td>
<td></td>
</tr>
<tr>
<td>Meadow Pipit</td>
<td></td>
<td>+ ***</td>
<td>***</td>
</tr>
<tr>
<td>Pheasant</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Red-legged Partridge</td>
<td></td>
<td>+ ***</td>
<td>– ***</td>
</tr>
<tr>
<td>Skylark</td>
<td></td>
<td>+ ***</td>
<td>– ***</td>
</tr>
<tr>
<td>Yellowhammer</td>
<td></td>
<td>+</td>
<td>– ***</td>
</tr>
</tbody>
</table>

+, Positive relationship; –, negative relationship. ***P < 0.001, **P < 0.01, *P < 0.05.
However, results from this study are encouraging in that they indicate that some smaller species, such as Linnet, may be adequately censused from the perimeter of a field. Where detectability is an issue, comparisons of bird densities or numbers between fields will not be possible purely from using perimeter counts, as the mean height of vegetation or amount of bare ground is likely to vary between and within field habitat types. For this reason, where comparisons between fields are required, whole-area searches or standardized within-field transects will be necessary.

Most of the species that were under-recorded are farmland birds that have undergone serious population declines in the last 25 years and are thus of high conservation concern. Skylark and Grey Partridge are both UK Biodiversity Action Plan species (Anon 1995a, 1995b). The population decline of Yellowhammer is more recent (from around the late 1980s; Baillie et al. 2005) and the species has recently been red-listed, having exhibited a population decline in excess of 50%. These three species are also part of the farmland bird index (Vickery et al. 2004). Meadow Pipit has also exhibited a population decline and has been afforded Medium BTO Alert.

The population declines of many granivorous farmland birds have been linked with declines in survival outside the breeding season, probably caused by a lack of food in winter (Siriwardena et al. 2000, Moorcroft et al. 2002). There is, therefore, a real need to gain a better understanding of the winter ecology, habitat preferences and foraging behaviour of many of these species. The results here suggest that, for some key species, field studies designed to provide an accurate count of numbers of birds, or compare the use made by birds of different fields and habitat types, require the use of the whole-area search methodology (although distance between transects will vary with habitat type; Hancock & Wilson 2003). We recommend this method particularly for Grey Partridge, Snipe, Skylark and Meadow Pipit. However, for a large number of species, including thrushes, sparrows, finches and buntings in most field types, over 90% of individuals

Table 4. Percentage of all individuals recorded from the field transect in the Winter Farmland Bird Survey classified by three broad habitat types.

<table>
<thead>
<tr>
<th>Species</th>
<th>Crop</th>
<th>Grass</th>
<th>Stubble</th>
<th>LR $\chi^2_1$</th>
<th>LR $\chi^2_2$</th>
<th>LR $\chi^2_2$</th>
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<tbody>
<tr>
<td>Grey Partridge</td>
<td>11</td>
<td>13</td>
<td>17</td>
<td>3.0</td>
<td>4.5</td>
<td>5.4</td>
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<tr>
<td>Golden Plover</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>9.1**</td>
<td>7.0*</td>
<td>0.9</td>
</tr>
<tr>
<td>Lapwing</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>1.8</td>
<td>1.7</td>
<td>5.1</td>
</tr>
<tr>
<td>Curlew</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>5.9*</td>
<td>11.6**</td>
<td>5.5</td>
</tr>
<tr>
<td>Snipe</td>
<td>20</td>
<td>33</td>
<td>39</td>
<td>2.3</td>
<td>1.6</td>
<td>6.9*</td>
</tr>
<tr>
<td>Stock Dove</td>
<td>4</td>
<td>2</td>
<td>19</td>
<td>0.5</td>
<td>40.2**</td>
<td>34.8***</td>
</tr>
<tr>
<td>Skylark</td>
<td>25</td>
<td>27</td>
<td>40</td>
<td>7.5**</td>
<td>34.3***</td>
<td>59.9***</td>
</tr>
<tr>
<td>Meadow Pipit</td>
<td>31</td>
<td>20</td>
<td>32</td>
<td>8.2**</td>
<td>6.1*</td>
<td>27.6***</td>
</tr>
<tr>
<td>Pied Wagtail</td>
<td>8</td>
<td>4</td>
<td>9</td>
<td>19.8***</td>
<td>4.0</td>
<td>30.7***</td>
</tr>
<tr>
<td>Stonechat</td>
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<td>2</td>
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<td>3.7</td>
<td>3.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Fieldfare</td>
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<td>4</td>
<td>4</td>
<td>31.9***</td>
<td>96.0***</td>
<td>14.9***</td>
</tr>
<tr>
<td>Song Thrush</td>
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<td>1</td>
<td>1</td>
<td>262.9***</td>
<td>61.9***</td>
<td>41.8***</td>
</tr>
<tr>
<td>Redwing</td>
<td>5</td>
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<td>5</td>
<td>27.0***</td>
<td>7.8</td>
<td>41.7***</td>
</tr>
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<td>5</td>
<td>5</td>
<td>10.7***</td>
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<tr>
<td>Starling</td>
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<td>4</td>
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<td>2.3</td>
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<tr>
<td>House Sparrow</td>
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<td>0</td>
<td>2</td>
<td>71.9***</td>
<td>42.2***</td>
<td>59.5***</td>
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<tr>
<td>Tree Sparrow</td>
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<tr>
<td>Chaffinch</td>
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<td>2</td>
<td>1</td>
<td>19.8***</td>
<td>244.0***</td>
<td>4.5</td>
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<tr>
<td>Brambling</td>
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<td>0</td>
<td>9.1**</td>
<td>12.8**</td>
<td>0.0</td>
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<tr>
<td>Greenfinch</td>
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<td>2</td>
<td>1</td>
<td>2.7</td>
<td>7.4</td>
<td>32.1***</td>
</tr>
<tr>
<td>Goldfinch</td>
<td>6</td>
<td>5</td>
<td>15</td>
<td>73.1***</td>
<td>12.8***</td>
<td>107.3***</td>
</tr>
<tr>
<td>Linnet</td>
<td>11</td>
<td>7</td>
<td>5</td>
<td>0.6</td>
<td>13.9**</td>
<td>8.7**</td>
</tr>
<tr>
<td>Redpoll</td>
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<td>0</td>
<td>0</td>
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<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
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<td>1</td>
<td>1</td>
<td>0</td>
<td>42.2***</td>
<td>26.7***</td>
<td>34.5***</td>
</tr>
<tr>
<td>Yellowhammer</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>10.4**</td>
<td>6.8*</td>
<td>50.8***</td>
</tr>
<tr>
<td>Reed Bunting</td>
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<td>1</td>
<td>18</td>
<td>0.2</td>
<td>46.5***</td>
<td>46.4***</td>
</tr>
<tr>
<td>Corn Bunting</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>1.8</td>
<td>1.9</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Significance: *$P < 0.05$, **$P < 0.01$; ***$P < 0.001$. 

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can be recorded using the much less time-consuming perimeter count method.

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REFERENCES


