BTO Research Report No. 493

A sample survey of the breeding birds at woodland expansion sites of the Scottish Forest Alliance in 2007

A report to Forest Research on behalf of the Scottish Forest Alliance
Ref: CR 2006/07/38

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Abstract

1. This report presents the results of a sample survey of breeding birds at Scottish Forest Alliance (SFA) sites in Scotland in 2007. The SFA is a partnership between BP, Forestry Commission, RSPB Scotland and Woodland Trust Scotland that aims to establish and/or enlarge new native-type woodland at sites throughout Scotland. This is the first of a series of planned periodic surveys that will quantify changes in avifauna as woodland at the sites develops over the next 100 years.

2. Timed point counts were used to survey the breeding bird communities of 11 sites managed under the SFA. Two counts at 169 survey points (8 – 35 per site) were undertaken between April and June 2007.

3. A total of 3,786 registrations of 77 species were recorded within the surveyed areas. A further 430 registrations were of birds flying over the sites and included 10 additional species.

4. Up to five indices of abundance or density estimates were calculated for each species recorded at within each of the SFA sites:

   i) *Occurrence rates* – the number of points at which a given species was recorded;
   ii) *Abundance index* – the mean number of registrations per survey point;
   iii) *Simple bird index* – a summing of all individuals of a species recorded within 50 m of the survey points;
   iv) *Site-level density* – an estimation of bird density that assumes a common detectability function for all species across all sites to adjust for decreased detectability at greater distances from the survey points;
   v) *Distance sampling analysis* – an estimation of bird density that calculates a detectability function from empirical data for the relevant species and sites.

   The required sample size of qualifying registrations for the above indices and estimates increases from (i) to (v) above, therefore occurrence rates are calculated for all species at all sites, while density estimates from distance sampling analyses are only available for the most abundant species.

5. Although some issues associated with the heterogeneity of bird distributions introduced some biases into the estimated densities of some species, there is broad agreement with estimates and indices calculated in different ways and with comparable density estimates from other published studies. This suggests that the approach to field survey and generation of abundance indices and density estimates in the present survey will be appropriate for the long-term monitoring of changes in breeding bird communities at the SFA sites (currently intended to cover a period of 100 years).

6. Recommendations for future monitoring surveys of the SFA sites are:
   i) Repeat surveys should use identical field methodology and as a minimum use the same survey points as the first survey in 2007 to ensure direct comparability;
   ii) The periodicity of repeat surveys at intervals of between 5 and 10 years should be considered;
   iii) Analyses should produce a range of indices of abundance and density estimates (simple and complex as the data permits, as in the present survey) to ensure that fullest range of species can be monitored and to provide a check on the validity of any calculated density estimates;
   iv) Changes in breeding bird populations at the SFA sites should be evaluated against an appropriate reference. We suggest that the BTO/JNCC/RSPB Breeding Bird Survey (potentially sub-sampled to provide regional and habitat-specific trends) would provide a cost-effective source of appropriate reference data.

1. INTRODUCTION

The Scottish Forest Alliance (SFA) is a partnership between BP, Forestry Commission, RSPB Scotland and Woodland Trust Scotland that aims to establish new native-type woodland at sites throughout Scotland (www.scottishforestalliance.org.uk). This is to be achieved through new planting on open ground, natural regeneration and the restructuring of conifer plantations. Amongst the principal aims of the project is to contribute towards the UK targets for forest and woodland biodiversity (www.ukbap.org.uk), the promotion of social and economic gains for local communities and carbon sequestration.

This report presents the results of a sample survey of breeding birds at 11 SFA sites in Scotland in 2007. This is the first of a series of planned periodic surveys that will quantify changes in avifauna as woodland at the sites develops over the next 100 years. Together with concurrent monitoring of vegetation and other taxa (hoverflies and shelled gastropods) plus other assessments of the activity of selected animal groups, the progressive development of woodland ecosystems will be monitored. Co-ordinated by Forest Research on behalf of the SFA, this information will be used to measure the achievements of the SFA in meeting its targets for biodiversity and to influence and inform woodland management practices and associated grant support systems.

2. METHODS

2.1 Study sites

Bird surveys were undertaken at 11 SFA sites in Scotland (Figure 1). To be spatially compatible with surveys of other taxa, breeding birds were sampled at between 8 – 35 survey points per site (Table 1) that were selected by Forest Research. These aimed to be representative of pre-existing ecological units prior to any treatment associated with re-establishment of native-type woodland with the points located centrally within National Vegetation Classification (NVC) polygons that were mapped before any SFA treatment. For the smaller sites (Corrymonnie, Darroch Woods, Inversnaid, Drumbow/Crossrig and Barclye), points included all NVC classes present. For the larger sites, sample squares of 25 ha were selected at random to include 10% of the site area. Within the squares, survey points were selected based on mapped NVC polygons similarly to the smaller sites. In a small number of cases, the separation distance between the original selection of survey points was less than 200 m. In these cases, bird data collected from neighbouring points would likely have low levels of independence (e.g. Bibby & Buckland 1987). To prevent this, alternative points were selected to ensure a minimum separation distance of 200 m between points. A further small number of survey points were considered by the relevant site managers to be close to sensitive and rare breeding birds. Again, alternatives were found that complied with the original sampling strategy but were sufficiently distant from sensitive areas. A full list of the final survey points is given as Appendix 1.

2.2 Bird survey

Timed point counts were used to sample breeding birds at the survey points. Each survey point was sampled twice, the 'early visit' between 11 April and 11 May, and the 'late visit' between 17 May and 15 June (Table 2). Surveys were undertaken in the early mornings when many bird species are most easily detected (Bibby *et al.* 2000); 89% of surveys were completed between first light and 09:00 hours BST and 98% by 10:00 hours. Surveys were not undertaken during persistent or heavy rain or when wind speeds exceeded Beaufort scale force 4, conditions that are likely to reduce the detection rates of many birds. Hand-held GPS were used to locate survey points. On arrival at each point, the surveyor waited for a two-minute settling period, to minimise any influence of walking to the point on the detection rates of birds, then recorded all birds seen or heard for a period of 10-minutes. The sampling interval aimed to maximise the likelihood of registering birds within the immediate vicinity but also reduce the risk of the multiple counting of individuals (Fuller & Langslow 1984, Drapeau *et al.* 1999), which would violate the assumptions of the point count methodology (Bibby *et al.* 2000). The two minute settling period was also used by the surveyors to familiarise themselves with distances to physical features around the points to facilitate accurate distance estimation.

Birds were recorded in five distance classes: within 10 m of the count point; between 10 and 25 m; between 25 and 50 m; between 50 and 100m; and greater than 100 m from the count point. Each registration was assigned to the distance band in which the individual bird was first recorded regardless of any subsequent movements. Birds seen or heard in flight only were also recorded separately. Both Skylarks and Meadow Pipits perform display flights over their breeding territories. Where these or other species were observed displaying in flight, they were recorded as if in the terrestrial distance band above which they were displaying. Juvenile birds (those hatched in the current calendar year) were excluded when they could be reliably aged as such in the field (but see Section 2.3). This aimed to ensure that the calculated density estimates and indices of abundance corresponded to breeding adults as far as is possible, rather than reflecting a contribution made by breeding productivity in the current year.

Any birds that arrived into the 10 m distance band during the 10-minute sampling period were also distinguished to further assess any potential bias introduced by the presence of a surveyor in the area. In the field, care was taken to try and avoid recording individuals more than once at any one survey point. Individuals that were known to have been recorded from more than one survey point were recorded as such to permit future monitoring of change at the survey point scale but to reduce the risk of overestimating site densities of any affected species.

2.3 Analysis

For each of the 11 SFA sites, five levels of analysis were carried out to provide a range of abundance indices and density estimates for each species:

i) *Occurrence rates* - the number of points where a given species was recorded (regardless of abundance) divided by the total number of points surveyed. Note that individual birds that were known to have been recorded from more than one survey point are included for the original point of registration only;

ii) *Abundance index* – the mean number of registrations per survey point. Note (a) that individual birds that are known to have been recorded from more than one survey point are included for the original point of registration only and (b) that registrations of an undetermined number of any species beyond the 100 m distance band are excluded;

iii) *Simple bird density* - a simple summing of all individuals of a species recorded within the 50 m distance band divided by the area sampled within that distance band across the study area (denominator = 0.79 ha * number of survey points; 0.79 ha being the area within a 50 m radius of a survey point). This measure assumes that the majority of individuals within a 50 m radius of the survey points were detected;

iv) *Site-level density* - using a simple formula that assumes a known detectability function that is constant for all sites and species and adjusts for decreased detectability in the outer distance bands (Bibby *et al.* 1985) and using only two distance bands (in this case, 0-50m and 50-100m). The formula used was:

$D = \log_e(n/n_2)*n/(m\pi r^2)$ (after Bibby *et al.* 1985)

Where: D = calculated bird density

n = total number of birds detected (in this case, 0-100 m)

n_2 = the number outside of the distance band r (in this case, 50-100 m)

m = number of survey points

Because this method involves a single calculation of density at the site-level, there are no associated errors (confidence limits) estimated (Bibby *et al.* 1985). The calculation becomes invalid when there are no registrations for the outer distance band (n_2 , above) and returns a density of zero when there are no registrations for the inner distance band even if there are registrations for the outer band. Deviation of the empirical data from the assumed detection function and errors associated with zero counts in either distance band will tend to be greatest when sample sizes are small. Therefore, we present an estimate of site-level density, calculated in this way, only when the number of qualifying registrations is 10 or more. Also, estimates derived from less than 20 qualifying registrations are individually marked so as to highlight the uncertainty associated with such figures and advise caution with their use and interpretation; and

v) *Distance sampling analysis* - estimation of site-level density using the program DISTANCE 5.0 (Thomas *et al.* 2005). This program is similar to, but a more complex version of the simple Bibby *et al.* (1985) formula (iv, above). It is only recommended in cases where there are at least 40 qualifying registrations for a given species, so this was carried out only for the most abundant species. Distance sampling works on the principal that randomly distributed objects (in this instance, birds) become more difficult to detect with increasing distance (in this instance, from the count points). As a result, an increasing proportion of the birds become more difficult to detect in the more distant recording bands. The program DISTANCE 5.0 models this decline in detectability with distance (the detection function) in order to include an estimate of undetected individuals in its calculation of density. In our analyses we consider birds recorded from four distance bands (0-10 m, 10-25 m, 25-50 m and 50-100 m) and assume a half-normal cosine detection function. Birds from the final distance band (>100 m) were excluded from the analyses as counts within an unbounded category are difficult to interpret; truncation of this kind is routinely recommended for accurately estimating density using the distance sampling technique (Buckland *et al.* 2001). This last method estimates density as a mean across points and therefore has the advantage that it allows estimation of associated errors. As with (iv) above, this method includes adjustment for decreases in detectability in the outer distance bands but has the further advantage of calculating specific detectability functions for each sufficiently abundant species from empirical data. Although this method is generally only recommended where there are at least 40 qualifying registrations, we also present the calculated density estimates for cases where the number of registrations is between 30 and 39 inclusive, however these are marked to highlight the uncertainty associated with them.

The measure of occurrence rates, (i) above, includes data from both early and late survey visits, so a registration of a species from a point on just one visit counts equally as if recorded on both visits. For the other four measures of abundance, only data from a single survey visit was incorporated. Ideally, juvenile birds should be excluded from the calculations of indices or estimates of abundance of breeding populations. Although known juvenile birds were excluded during field surveys, in practice the reliable aging of individuals was frequently not possible. Timed sampling surveys such as this, rely on the field identification and initial detection of the majority of birds by call and many birds are either not seen or inadequately seen for them to be reliably aged and therefore excluded if they were juveniles. To minimise the risk of including juveniles in the calculated abundance indices and density estimates, we have taken the pragmatic approach of considering only registrations from the early survey visits for non-migrant species for which juveniles could easily have been recorded but not specifically aged as such (Table 3) as the majority of the breeding adults of these species were expected to have been present at the survey sites by the time of the early survey visits and most juveniles will not yet have fledged. For the remaining species, which were predominantly long-distance migrants or non-passerines (Table 3) we used the maximum counts of the two survey visits summed across all survey points within a site. The arrival times of the longer-distance migrants in the breeding areas varies between species (e.g. Wernham ***et al.*** 2002) and possibly also between sites. Using the maximum counts is likely to give a better representation of breeding density for the species concerned, while the risks associated with the potential inclusion of juvenile birds are likely to be less for migrant species that tend to commence breeding later in the spring than many resident species. For non-passerines, we assume that the field identification of juvenile birds was sufficiently reliable for them to be excluded during field work.

All the above analyses are repeated for each species with sufficient qualifying registrations at each SFA site. In addition, we also present the indices and estimates of density for the 11 sites combined; the latter could ultimately inform the broad influence of the SFA programme across those sites.

3. RESULTS

A total of 3,786 registrations of 77 species were recorded within the 11 surveyed areas during the timed point counts (Table 3) and the number of species encountered at each site ranging from 16 - 40 (Tables 4 - 14). A further 430 registrations were of birds flying over the survey points and included ten species that are excluded from subsequent analyses in that none were recorded as 'using' the areas within sight of the survey points: Western Capercaillie (1 at Glenmore); Golden Eagle (1 at Loch Katrine and 1 at Abernethy); Feral Pigeon (6 at Drumbow); Great Black-backed Gull (6 at Kinloch); Goosander (5 at Abernethy and 2 at Glen Finglas); Herring Gull (4 at Kinloch); Eurasian Jackdaw (1 at Darroch Woods); Common Starling (4 at Drumbow and 12 at Barclye); Barn Swallow (singles at Darroch Woods and Barclye, 3 at Drumbow and 6 at Loch Katrine); and Twite (4 at Loch Katrine). Scientific names for all species are listed as Appendix 2. There was a single recorded instance only of a bird approaching closer than 10 m to the observer during the timed point count surveys (a Chaffinch at Kinloch); therefore we assume that the presence of observers had a minimal influence through the attraction of birds to the count points.

4. DISCUSSION

4.1 Validity of density estimates

Most species were encountered too infrequently for reliable estimation of population densities, using distance sampling analyses and the program DISTANCE (generally recommended where there is a minimum of 40 qualifying registrations; Buckland *et al.* 2001). At the site level, the majority of species were also encountered too infrequently to reliably use a simplified estimation of bird density (Site-level density, (iv) in Section 2.3) that assumes a common detection function for all species and at all sites (for which we have adopted a minimum threshold of 20 qualifying registrations). In all cases where the three methods of density estimation could be employed, the estimates tended to be greatest using distance sampling analyses and lowest for the simplest estimates that were extrapolated from a summation of the number of registrations within a 50 m radius of the survey points. This is to be expected as the latter simplest method has no allowance for correction to account for the more distant birds being missed during field survey. However, in the majority of instances, the two simpler density estimates were within the 95% confidence interval of the estimates derived using the programme DISTANCE where the birds were found to be sufficiently abundant for the more complex method to be used. Hence the low sample sizes for many species within the surveyed areas do not appear to be a barrier for robust long-term monitoring of bird densities.

Where the simpler density estimates were outside of the calculated confidence intervals, or there was a large discrepancy between the two simpler estimates, this was likely to have been a result of (i) relatively low sample sizes that made the use of the distance sampling approaches less reliable (marked as such in Tables 4 – 15), and/or (ii) a heterogeneous distribution of the birds concerned. The detection functions used by both methods that try to estimate the proportion of birds missed during field surveys assume that birds are randomly distributed within the areas covered from the survey points. For some species within the SFA sites surveyed, this is unlikely to have been the case. For example, many survey points were close to remnant woodland or standing trees (an aim of the SFA programme being to permit natural regeneration from these remnants) and trees have already been planted in patches in some areas. This would inevitably lead to a non-random distribution of some birds with woodland birds associated with the patches of trees and species of open habitats avoiding them. A specific example is Chaffinch at Glen Finglas, a woodland specialist within the surveyed areas, where the DISTANCE derived density estimate (951 birds per km^2) is statistically significantly greater (outside of the 95% cls) than the estimated site-level density (376 birds per km^2) which in turn is some 60% greater than the simplest density estimate (233 birds per km^2) (Table 10). Here, the location of the survey points at varying distances from the edges of remnant woodland is likely to violate the assumptions of bird distribution associated with the detection functions that are calculated or assumed to correct for missed birds at the greater distances from the survey points. Conversely, the estimated site-level density of Meadow Pipits, a specialist of open habitats, at Glen Devon (695 birds per km^2) was 34% greater than the simplest density estimate (517 birds per km^2) but was still within the 95% confidence limits estimated using the program DISTANCE (552 – 1343 birds per km^2) (Table 9). Here, the developing planted woodland at the time of the survey had left patches of open habitat suitable for Meadow Pipits. In some cases, heterogeneity of habitats, and therefore bird distributions, may have been a consequence of survey point location within relatively small NVC polygons (Section 2.1) but as this would still likely remain an issue had survey points been selected at random within the chosen survey areas (because of the non-uniformity of the areas in general), most likely there would be negligible benefits from using an alternative sampling strategy for monitoring birds from those adopted for monitoring other taxa.

The densities of birds estimated in this study are, in the most part comparable with published estimates from other studies in the UK of similar habitat types (Table 16) giving further support for the robustness of the current survey methods for the long-term monitoring of the SFA sites. The estimates from the present study for both Sky Lark and Meadow Pipit are very much higher than those and also other published estimates for open habitats however (5 – 7 Sky Lark per km^2; Browne *et al.* 2000: 20 – 100 Meadow Pipits per km^2; Vanhinsbergh & Chamberlain 2001). Those previously published estimates are also much lower than those that have been consistently measured on moorland in south-west Scotland annually from 2002 to 2007 (40 – 90 Sky Lark per km^2 and 100 – 500 Meadow Pipit per km^2; BTO Scotland unpublished data). Considering the constancy of the high estimates across many of the SFA sites and their agreement with data from moorland in south-west Scotland, we see little reason to doubt the density estimates for Sky Lark and Meadow Pipit at the SFA sites in 2007, although there may be some errors associated with heterogeneity of habitats and bird distribution (see above). It is likely that, as many of the sites were of predominantly open habitats where grazing had recently been

reduced (as part of the SFA management programme), excellent conditions for breeding Meadow Pipits (Evans *et al.* 2006, Pearce-Higgins & Grant 2006) had become established at the time of the survey.

4.2 Survey methods and future monitoring

Although there are some issues associated with the heterogeneity of habitats and their associated influence on bird distributions and many species were only recorded in relatively low numbers (Section 4.1), the approaches to field survey and analyses appear to be sufficiently robust and reliable for the long-term monitoring of bird populations at the sampled points within the SFA sites. The precision of density estimates, and also the number of species for which density estimates could be made, would be enhanced with an increased number of sampling points or more intensive surveys of the sampled areas (e.g. a territory mapping approach). Both of these would require additional resources either to sample more points, or for a territory mapping approach, to accommodate the increased number of survey visits (a minimum number of four survey visits would be required; Hewson *et al.* 2007), survey effort and analytical time that would be required. Territory mapping could prove difficult to compare directly with the current survey results. Therefore we suggest that future monitoring adopts an identical field methodology and samples as a minimum the same survey points that were used in 2007. An increase in sample points would permit more precise density estimates and an enhanced power to detect statistically significant changes in abundance. There will, however, always be species that are scarce for which the more elaborate methods of density estimation are not appropriate. The simpler indices of abundance (the proportion of survey points where a species was detected, the 'Occurrence rate', and the mean number of registrations per point, the 'Abundance index') will always be the best that can be achieved for those scarce species by a sampling approach given the likely resources that will be available for future repeat surveys.

Having a range of density estimates and abundance indices, for example the five determined in the present study, is also likely to be of use when assessing the reliability of any apparent changes in a species' abundance. Issues associated with non-random distributions and habitat heterogeneity and their influence on density estimates are likely to remain throughout the development of the SFA sites. Further, the detectability of some species is also likely change as woodland develops. For example, in restocked conifer plantations, it was estimated that 50% of birds were detectable at 57 m when the trees were two years old (essentially an open habitat) but this distance was reduced to 30 m when the trees were 11 years old (essentially a thicket habitat) (Bibby & Buckland 1987). For the most abundant species for which the detectability function can be determined from empirical data, these changes will be accounted for in the density calculations, however for the majority of species this will not be possible. Even when detection functions can be determined from empirical data, there can be complications introduced when birds of both sexes are incorporated as detectability can vary between the sexes (Buckland 2006). Some studies have been selective in that only males were recorded (e.g. Buckland 2006), however this will only be practical where a very restricted number of species are being surveyed and that conditions permit the reliable sexing of all birds recorded, either from behaviour or by plumage. In the present study this would not have been possible. However the influence of variation in the differences between sexes of a species in their detectability as habitats at the SFA sites develop is a potential additional complication in assessing changes in bird population densities. Because of the range of potential complications, it is important that a range of alternative estimates of density and indices of abundance are determined and compared in future surveys, including the simplest indices (e.g. occurrence rates), to provide alternative assessments for any apparent changes.

Over the planned 100 years of monitoring the SFA sites, bird populations in the wider countryside can be expected to vary. Therefore observed changes within the SFA sites may not necessarily be in response to management changes within those sites. It will be important to compare changes with reference data. We suggest that the BTO/JNCC/RSPB Breeding Bird Survey (BBS) (e.g. Raven *et al.* 2007) could provide an appropriate reference. The BBS is an extensive volunteer-based survey and has been the principal UK monitoring scheme for widespread breeding bird populations since 1994. Using a formal sampling design, in which 1-km survey squares are selected at random from the Ordnance Survey's National Grid, BBS squares are stratified regionally and by human population density to allow representative coverage of regions and habitats, whilst making the most of available volunteer resources. In addition to annual monitoring of birds, broad habitat types are also recorded (Crick 1992). Data collected for the BBS can be sub-sampled to provide appropriate regional and habitat-specific indices of general population change for species that are recorded sufficiently frequently. Comparison of data collected at the SFA sites, with concurrent trends derived from the BBS will provide the most realistic measure for SFA achievements in terms of targets for breeding bird populations.

Repeat bird surveys of the SFA sites need not be annual. The periodicity of repeat surveys, however, should not be too infrequent if changes in breeding bird communities are to be representatively monitored. For example, relatively high densities of Willow Warblers in Glen Devon (Table 9), where trees were only planted five years before the current survey indicate the relative speed with which some woodland birds show a response to management changes; this species does not breed in open habitats. Therefore we suggest that although repeat surveys may not be necessary at more frequent than 5-year intervals, a periodicity in excess of 10 years may well not detect some of the important changes as the sites develop to natural-type woodlands.

4.3 Summary of recommendations for future monitoring

1. Repeat surveys should use identical field methodology and as a minimum use the same survey points as the first survey in 2007 to ensure direct comparability.

2. The periodicity of repeat surveys at intervals of between 5 and 10 years should be considered.

3. Analyses should produce a range of indices of abundance and density estimates (simple and complex as the data permits, as in the present survey) to ensure that fullest range of species can be monitored and to provide a check on the validity of any calculated density estimates.

4. Changes in breeding bird populations at the SFA sites should be evaluated against an appropriate reference. We suggest that the BTO/JNCC/RSPB Breeding Bird Survey (potentially sub-sampled to provide regional and habitat-specific trends) would provide a cost-effective source of appropriate reference data.

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TABLES

Table 1 The number of survey points in each SFA site where breeding birds were sampled in 2007

SITE	Total site area (ha)[1]	No. of survey points
Abernethy	1868	25
Glenmore	1440	16
Darroch Woods	500	12
Kinloch Hills	3661	35
Glen Devon	1235	16
Drumbow/Crossrig	195	8
Inversnaid	443	12
Glenfinglas	4400	24
Loch Katrine	9598	24
Corrymonnie	650	16
Barclye	296	8

[1] Areas supplied by Forest Research

Table 2 Dates of bird surveys at the SFA sites in 2007.

SITE	Early visit	Late visit
Abernethy	1-2 May	14-15 June
Glenmore	1 & 11 May	13 June
Darroch Woods	16 April	22-23 May
Kinloch Hills	26-28 April	26-27 May
Glen Devon	13 April	17 May
Drumbow/Crossrig	11 April	13 May
Inversnaid	24 April	8-9 June
Glenfinglas	12-13 April	18 & 21 May
Loch Katrine	25-26 April	24-25 May
Corrymonnie	17-18 April	8-10 June
Barclye	5 May	11 June

Table 3 The survey visits from which registrations were used to calculate indices of abundance and/or density estimates for each species recorded at the SFA sites in 2007.

SPECIES	Count used[1]		SPECIES	Count used[1]
Greylag Goose	Maximum		Stonechat	Early
Greater Canada Goose	Maximum		Northern Wheatear	Maximum
Eurasian Teal	Maximum		Ring Ouzel	Maximum
Mallard	Maximum		Common Blackbird	Early
Tufted Duck	Maximum		Song Thrush	Early
Willow Ptarmigan (Red Grouse)	Maximum		Mistle Thrush	Early
Black Grouse	Maximum		Common Grasshopper Warbler	Maximum
Common Pheasant	Maximum		Sedge Warbler	Maximum
Red-throated Diver	Maximum		Blackcap	Maximum
Grey Heron	Maximum		Common Whitethroat	Maximum
Eurasian Sparrowhawk	Maximum		Wood Warbler	Maximum
Common Buzzard	Maximum		Common Chiffchaff	Maximum
Common Kestrel	Maximum		Willow Warbler	Maximum
Merlin	Maximum		Goldcrest	Early
Common Moorhen	Maximum		Spotted Flycatcher	Maximum
Eurasian Oystercatcher	Maximum		Pied Flycatcher	Maximum
European Golden Plover	Maximum		Long-tailed Tit	Early
Northern Lapwing	Maximum		Crested Tit	Early
Common Snipe	Maximum		Coal Tit	Early
Eurasian Curlew	Maximum		Blue Tit	Early
Common Redshank	Maximum		Great Tit	Early
Common Greenshank	Maximum		Eurasian Treecreeper	Early
Common Sandpiper	Maximum		Eurasian Jay	Early
Black-headed Gull	Maximum		Black-billed Magpie	Early
Mew Gull	Maximum		Rook	Early
Common Wood Pigeon	Early		Carrion Crow	Early
Common Cuckoo	Maximum		Hooded Crow	Early
Tawny Owl	Maximum		Common Raven	Early
Common Swift	Maximum		Chaffinch	Early
Great Spotted Woodpecker	Early		European Goldfinch	Early
Sky Lark	Early		Eurasian Siskin	Early
Tree Pipit	Maximum		Common Linnet	Early
Meadow Pipit	Early		Lesser Redpoll	Early
Grey Wagtail	Early		Common Crossbill	Early
White/Pied Wagtail	Early		Common Bullfinch	Early
White-throated Dipper	Early		Reed Bunting	Early
Winter Wren	Early			
Hedge Accentor	Early			
European Robin	Early			
Common Redstart	Maximum			
Whinchat	Maximum			

[1] The counts used are from either the early survey visit only or the maximum of the two survey visits for each species at each of the sites.

Table 4 The occurrence rate and estimated abundances of birds sampled from 25 survey points at Abernethy in 2007.

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Willow Ptarmigan (Red Grouse)	0.76	1.52	5	7		
Black Grouse	0.16	0.68	5			
Common Pheasant	0.08	0.08				
Red-throated Diver	0.08	0.16				
Eurasian Sparrowhawk	0.04	0.04	5			
Merlin	0.04	0.04				
Eurasian Curlew	0.08	0.04				
Black-headed Gull	0.04					
Common Wood Pigeon	0.16	0.12				
Common Cuckoo	0.12	0.12				
Tree Pipit	0.16	0.16				
Meadow Pipit	0.76	1.08	92	124		
Winter Wren	0.56	0.68	5	6*		
European Robin	0.12	0.08				
Common Redstart	0.16	0.12				
Whinchat	0.04					
Stonechat	0.04					
Song Thrush	0.04					
Mistle Thrush	0.08	0.08				
Willow Warbler	0.6	1.4	25	31		
Goldcrest	0.12	0.04				
Crested Tit	0.08	0.04				
Coal Tit	0.2	0.16	10			
Carrion Crow	0.08	0.04				
Chaffinch	0.6	1.24	51	69		

[1] The proportion of survey points from which the species was recorded.
[2] The mean number of individuals recorded within 50 m of each survey point.
[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.
[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 5 The occurrence rate and estimated abundances of birds sampled from eight survey points at Barclye in 2007.

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Common Pheasant	0.25					
Common Buzzard	0.13					
Common Kestrel	0.13					
Common Snipe	0.13	0.13				
Eurasian Curlew	0.13	0.13				
Common Wood Pigeon	0.25	0.13				
Common Cuckoo	0.25	0.13				
Great Spotted Woodpecker	0.13					
Sky Lark	0.88	1.88	16	18*		
Tree Pipit	0.13	0.13				
Meadow Pipit	0.88	5.88	398	531	710*	408 – 1236*
White/Pied Wagtail	0.13					
Winter Wren	0.88	1.25	16	19*		
European Robin	0.25	0.13				
Common Redstart	0.38	0.38				
Whinchat	0.38	0.38	16			
Stonechat	0.13	0.13				
Northern Wheatear	0.13	0.25				
Common Blackbird	0.38	0.38				
Song Thrush	0.63	0.63	16			
Common Grasshopper Warbler	0.38	0.38				
Willow Warbler	0.63	1.13	32			
Goldcrest	0.13					
Long-tailed Tit	0.13	0.13	16			
Coal Tit	0.25					
Blue Tit	0.38	0.38	16			
Great Tit	0.38	0.25	16			
Eurasian Treecreeper	0.25					
Black-billed Magpie	0.13					
Carrion Crow	0.50	0.63				
Chaffinch	1.00	1.50	48	66*		
Reed Bunting	0.25					

[1] The proportion of survey points from which the species was recorded.
[2] The mean number of individuals recorded within 50 m of each survey point.
[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.
[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 6 The occurrence rate and estimated abundances of birds sampled from 16 survey points at Corrimonnie in 2007.

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Greylag Goose	0.06	0.13				
Willow Ptarmigan (Red Grouse)	0.13	0.13				
Black Grouse	0.19	1.13				
Common Snipe	0.19	0.50	8			
Eurasian Curlew	0.25	0.25				
Common Greenshank	0.06	0.13				
Common Cuckoo	0.19	0.38				
Great Spotted Woodpecker	0.13	0.25				
Sky Lark	0.50	0.63				
Tree Pipit	0.19	0.50				
Meadow Pipit	0.69	4.88	103	127		
Winter Wren	0.81	2.88	72	89		
Hedge Accentor	0.13	0.25	16			
European Robin	0.56	1.38	24	44		
Whinchat	0.06	0.13				
Stonechat	0.13	0.13				
Common Blackbird	0.06					
Song Thrush	0.25	0.38				
Common Grasshopper Warbler	0.06					
Wood Warbler	0.06	0.13				
Willow Warbler	0.69	2.75	64	81		
Goldcrest	0.19	0.13	8			
Coal Tit	0.25	0.25				
Blue Tit	0.19	0.38	24			
Great Tit	0.06	0.13				
Carrion Crow	0.06	0.25				
Chaffinch	0.63	1.38	40	55		
Lesser Redpoll	0.19	0.38				

[1] The proportion of survey points from which the species was recorded.
[2] The mean number of individuals recorded within 50 m of each survey point.
[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.
[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 7 The occurrence rate and estimated abundances of birds sampled from 12 survey points at Darroch Wids in 2007.

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Willow Ptarmigan (Red Grouse)	0.08	0.08				
Black Grouse	0.08	0.08				
Common Pheasant	0.42	0.33				
Eurasian Oystercatcher	0.17	0.17				
Northern Lapwing	0.08	0.33				
Common Snipe	0.08	0.08				
Eurasian Curlew	0.33	0.50				
Common Redshank	0.08	0.08				
Black-headed Gull	0.08	0.25				
Common Wood Pigeon	0.42	0.42	21			
Common Cuckoo	0.25	0.25				
Tawny Owl	0.08	0.08	11			
Great Spotted Woodpecker	0.08					
Sky Lark	1.00	3.08	127	232		
Tree Pipit	0.17	0.17				
Meadow Pipit	0.67	2.17	202	450		
White/Pied Wagtail	0.17	0.08				
Winter Wren	0.67	1.08		23*		
Hedge Accentor	0.08	0.08				
European Robin	0.42	0.25	11			
Whinchat	0.08	0.08	11			
Common Blackbird	0.17	0.17				
Song Thrush	0.42	0.33				
Mistle Thrush	0.17	0.25	11			
Sedge Warbler	0.42	0.50	21			
Common Whitethroat	0.08	0.17				
Common Chiffchaff	0.08	0.08				
Willow Warbler	0.67	0.83				
Goldcrest	0.25	0.17	11			
Coal Tit	0.33	0.25	11			
Great Tit	0.08					
Black-billed Magpie	0.08					
Rook	0.08	0.08				
Carrion Crow	0.17	1.67				
Chaffinch	0.67	1.33	53	125*		
Eurasian Siskin	0.25	0.33	11			
Common Crossbill	0.17	0.17				
Reed Bunting	0.33	0.33	11			

[1] The proportion of survey points from which the species was recorded.

[2] The mean number of individuals recorded within 50 m of each survey point.

[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.

[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 8 The occurrence rate and estimated abundances of birds sampled from eight survey points at Drumbow/Crossrig in 2007

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Greater Canada Goose	0.13	1.13				
Eurasian Teal	0.13	0.25	32			
Mallard	0.13	0.63				
Tufted Duck	0.13	0.50				
Common Pheasant	0.13	0.13	16			
Common Moorhen	0.13	0.13				
European Golden Plover	0.13	0.13				
Common Snipe	0.13	0.25				
Eurasian Curlew	0.50	0.38	16			
Common Redshank	0.13	0.25				
Common Cuckoo	0.13	0.13				
Common Swift	0.13	1.75				
Sky Lark	0.75	1.88	239	342*		
Meadow Pipit	1.00	2.00	255	370*		
Winter Wren	0.88	1.00	127			
European Robin	0.13	0.25	32			
Whinchat	0.25	0.25				
Stonechat	0.13	0.25	32			
Common Blackbird	0.63	0.50	48			
Song Thrush	0.63	0.50	32			
Sedge Warbler	0.38	0.50				
Common Whitethroat	0.13	0.13				
Willow Warbler	0.88	1.75				
Blue Tit	0.25	0.25	32			
Black-billed Magpie	0.13	0.25	32			
Carrion Crow	0.50	0.38	32			
Chaffinch	0.63	0.88	111			
European Goldfinch	0.13					
Common Linnet	0.13	0.38	48			
Lesser Redpoll	0.25	0.13	16			
Reed Bunting	0.88	1.25	159	279*		

[1] The proportion of survey points from which the species was recorded.
[2] The mean number of individuals recorded within 50 m of each survey point.
[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.
[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 9 The occurrence rate and estimated abundances of birds sampled from 16 survey points at Glen Devon in 2007

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Willow Ptarmigan (Red Grouse)	0.13	0.13				
Black Grouse	0.13	0.13	16			
Common Pheasant	0.44	0.44	16			
Eurasian Oystercatcher	0.06	0.06				
Northern Lapwing	0.06	0.06				
Common Snipe	0.31	0.31	40			
Eurasian Curlew	0.38	0.31				
Mew Gull	0.25	2.69				
Common Wood Pigeon	0.19	0.06				
Common Cuckoo	0.19	0.19				
Sky Lark	0.88	3.00	135	169	259	145 - 465
Tree Pipit	0.44	0.56	16			
Meadow Pipit	1.00	6.00	517	695	861	552 – 1343
Winter Wren	0.56	0.69	80	120*		
European Robin	0.13					
Whinchat	0.69	1.00	24	27*		
Stonechat	0.06	0.06				
Song Thrush	0.44	0.06	8			
Mistle Thrush	0.06	0.19	24			
Sedge Warbler	0.06	0.06				
Common Whitethroat	0.13	0.19	16			
Willow Warbler	0.44	1.13	40	49*		
Blue Tit	0.13					
Carrion Crow	0.38					
Chaffinch	0.31	0.25	24			
Reed Bunting	0.38	0.38	32			

[1] The proportion of survey points from which the species was recorded.
[2] The mean number of individuals recorded within 50 m of each survey point.
[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.
[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 10 The occurrence rate and estimated abundances of birds sampled from 24 survey points at Glen Finglas in 2007

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Mallard	0.04	0.08				
Black Grouse	0.13	0.38				
Common Buzzard	0.08	0.04				
Common Snipe	0.08	0.08				
Eurasian Curlew	0.04	0.04				
Common Cuckoo	0.33	0.33				
Sky Lark	0.21	0.25				
Tree Pipit	0.29	0.50				
Meadow Pipit	0.96	3.71	403	571	611	163 – 2286
Winter Wren	0.83	1.67	170	241	373	68 – 2061
European Robin	0.25	0.42	32	44*		
Whinchat	0.21	0.21	5			
Stonechat	0.21	0.17	5			
Northern Wheatear	0.04	0.08				
Ring Ouzel	0.04	0.08				
Song Thrush	0.17	0.25				
Mistle Thrush	0.04	0.17	21			
Willow Warbler	0.79	1.38	11	12	48*	13 – 181*
Coal Tit	0.04	0.04	5			
Blue Tit	0.21	0.50	64	177*		
Great Tit	0.29	0.58	74	156*		
Carrion Crow	0.08	0.08	11			
Hooded Crow	0.04	0.08	11			
Chaffinch	0.71	2.00	233	376	951	481 – 1882
Reed Bunting	0.13	0.17	11			

[1] The proportion of survey points from which the species was recorded.
[2] The mean number of individuals recorded within 50 m of each survey point.
[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.
[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 11 The occurrence rate and estimated abundances of birds sampled from 16 survey points at Glenmore in 2007.

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Willow Ptarmigan (Red Grouse)	0.25	0.25				
Black Grouse	0.06	0.06				
Common Pheasant	0.06	0.06				
Common Buzzard	0.06	0.06				
Merlin	0.06	0.06				
Common Wood Pigeon	0.31	0.38				
Great Spotted Woodpecker	0.31	0.38				
Tree Pipit	0.75	0.94	16	19*		
Meadow Pipit	0.31	0.38	16			
Winter Wren	0.81	1.63	24	28		
Hedge Accentor	0.31	0.44	16			
European Robin	0.38	0.13	8			
Common Redstart	0.50	0.50	8			
Whinchat	0.06	0.06				
Northern Wheatear	0.06	0.06				
Common Blackbird	0.06					
Song Thrush	0.56	0.31				
Mistle Thrush	0.13	0.19				
Willow Warbler	0.75	2.00	40	47	99*	31 – 312*
Goldcrest	0.19	0.13	8			
Crested Tit	0.19	0.44	40			
Coal Tit	0.50	0.44	16			
Blue Tit	0.13	0.06				
Great Tit	0.06	0.06				
Chaffinch	0.88	2.06	80	98	117*	53 – 255*
Eurasian Siskin	0.06					
Common Crossbill	0.06	0.06				

[1] The proportion of survey points from which the species was recorded.
[2] The mean number of individuals recorded within 50 m of each survey point.
[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.
[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 12 The occurrence rate and estimated abundances of birds sampled from 12 survey points at Inversnaid in 2007.

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Black Grouse	0.25	0.17	21			
Eurasian Oystercatcher	0.08	0.08				
Common Snipe	0.25	0.25				
Eurasian Curlew	0.08	0.08				
Common Cuckoo	0.25	0.17				
Sky Lark	0.67	0.67	64			
Meadow Pipit	1.00	3.17	403	606	685*	142 – 3304*
Grey Wagtail	0.08	0.08				
Winter Wren	0.67	0.92	106	151*		
Whinchat	0.25	0.50	11			
Northern Wheatear	0.17	0.08				
Common Grasshopper Warbler	0.08	0.08				
Willow Warbler	0.33	0.50	21			
Common Raven	0.08	0.17	21			
Chaffinch	0.17					
Reed Bunting	0.08	0.08	11			

[1] The proportion of survey points from which the species was recorded.
[2] The mean number of individuals recorded within 50 m of each survey point.
[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.
[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 13 The occurrence rate and estimated abundances of birds sampled from 35 survey points at Kinloch in 2007.

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Grey Heron	0.03	0.03				
Common Snipe	0.03	0.03				
Common Sandpiper	0.06	0.06				
Common Cuckoo	0.43	0.46	11	14*		
Great Spotted Woodpecker	0.03	0.03				
Sky Lark	0.03	0.03				
Tree Pipit	0.20	0.17				
Meadow Pipit	0.51	1.51	142	202	386	140 – 1066
Grey Wagtail	0.03					
White-throated Dipper	0.03	0.03				
Winter Wren	0.94	1.83	51	62	121	64 – 228
Hedge Accentor	0.09	0.03				
European Robin	0.46	0.54	18	22*		
Common Redstart	0.03	0.03				
Whinchat	0.03	0.03	4			
Stonechat	0.11	0.03				
Common Blackbird	0.03	0.03				
Song Thrush	0.46	0.26				
Common Grasshopper Warbler	0.17	0.11	11			
Wood Warbler	0.03	0.03	4			
Willow Warbler	0.94	1.97	36	43	107	50 – 228
Goldcrest	0.09	0.09	4			
Spotted Flycatcher	0.03	0.03	4			
Coal Tit	0.26	0.23	7			
Blue Tit	0.26	0.26	18			
Great Tit	0.17	0.26	4			
Eurasian Treecreeper	0.03					
Hooded Crow	0.06					
Common Raven	0.03	0.03				
Chaffinch	0.74	0.83	25	33		
Eurasian Siskin	0.03					
Lesser Redpoll	0.03					
Common Bullfinch	0.03					

[1] The proportion of survey points from which the species was recorded.
[2] The mean number of individuals recorded within 50 m of each survey point.
[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.
[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 14 The occurrence rate and estimated abundances of birds sampled from 24 survey points at loch Katrine in 2007.

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Willow Ptarmigan (Red Grouse)	0.04	0.04				
Black Grouse	0.08	0.13				
Common Buzzard	0.04	0.04	5			
Common Snipe	0.04	0.04	5			
Eurasian Curlew	0.04	0.04				
Common Wood Pigeon	0.04	0.04				
Common Cuckoo	0.38	0.42				
Sky Lark	0.13	0.04	5			
Tree Pipit	0.58	0.50				
Meadow Pipit	0.88	1.29	149	215	384*	129 – 1144*
Grey Wagtail	0.08	0.08	5			
White-throated Dipper	0.04	0.04	5			
Winter Wren	0.92	1.13	111	154		
Hedge Accentor	0.04	0.04				
European Robin	0.21	0.08	11			
Common Redstart	0.29	0.25	16			
Whinchat	0.25	0.29	5			
Stonechat	0.13	0.08				
Northern Wheatear	0.04	0.08	5			
Common Blackbird	0.04	0.08	5			
Song Thrush	0.13	0.13	5			
Blackcap	0.04	0.04	5			
Wood Warbler	0.08	0.08	5			
Willow Warbler	0.88	1.75	53	71		
Goldcrest	0.04	0.04	5			
Pied Flycatcher	0.04	0.04	5			
Coal Tit	0.04	0.04	5			
Blue Tit	0.25	0.25	27			
Great Tit	0.33	0.17	11			
Eurasian Treecreeper	0.13	0.17	21			
Eurasian Jay	0.04	0.04	5			
Carrion Crow	0.04					
Chaffinch	0.88	0.58	58	83*		
Lesser Redpoll	0.04					
Common Bullfinch	0.04	0.04				
Reed Bunting	0.08	0.08	11			

[1] The proportion of survey points from which the species was recorded.

[2] The mean number of individuals recorded within 50 m of each survey point.

[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.

[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 15 The occurrence rate and estimated abundances of birds sampled from 169 survey points across all the SFA sites in 2007.

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Greylag Goose	0.01	0.01				
Greater Canada Goose	0.01	0.09				
Eurasian Teal	0.01	0.02	3			
Mallard	0.01	0.05				
Tufted Duck	0.01	0.04				
Willow Ptarmigan (Red Grouse)	0.14	0.46	1	2		
Black Grouse	0.08	0.45	6	9		
Common Pheasant	0.08	0.16	4	5		
Red-throated Diver	0.01	0.04				
Grey Heron	0.01	0.01				
Eurasian Sparrowhawk	0.01	0.01	1			
Common Buzzard	0.02	0.04	1			
Common Kestrel	0.01	0.01				
Merlin	0.01	0.02				
Common Moorhen	0.01	0.01				
Eurasian Oystercatcher	0.02	0.06				
European Golden Plover	0.01	0.01				
Northern Lapwing	0.01	0.01				
Common Snipe	0.07	0.14	3	4		
Eurasian Curlew	0.09	0.23	1	2		
Common Redshank	0.01	0.03				
Common Greenshank	0.01	0.01				
Common Sandpiper	0.01	0.02				
Black-headed Gull	0.01	0.04				
Mew Gull	0.02	0.22				
Common Wood Pigeon	0.09	0.19	4	5		
Common Cuckoo	0.22	0.51	4	5		
Tawny Owl	0.01	0.01	1			
Common Swift	0.01	0.14				
Great Spotted Woodpecker	0.05	0.10				
Sky Lark	0.30	1.45	60	75	351	252 – 490
Tree Pipit	0.26	0.66	5	6	66	33 – 134
Meadow Pipit	0.72	5.27	432	587	694	426 – 1130
Grey Wagtail	0.02	0.04	3			
White/Pied Wagtail	0.02	0.02	1			
White-throated Dipper	0.01	0.02	1			
Winter Wren	0.68	2.64	133	175	288	127 – 652
Hedge Accentor	0.06	0.14	6	8		
European Robin	0.22	0.57	25	34	292	195 – 437
Common Redstart	0.09	0.21	5	6		
Whinchat	0.18	0.45	12	14	130	75 – 227
Stonechat	0.08	0.15	8	10		

Table 15 (cont'd) The occurrence rate and estimated abundances of birds sampled from 169 survey points across all the SFA sites in 2007.

SPECIES	Occurrence rate[1]	Abundance index[2]	Simple bird density (km^{-2})	Site-level density[3] (km^{-2})	Distance sampling density estimate[4] (km^{-2})	
					Mean	95% confidence limits
Northern Wheatear	0.03	0.08	1	1*		
Ring Ouzel	0.01	0.02				
Common Blackbird	0.06	0.13	5	7		
Song Thrush	0.29	0.45	6	8		
Mistle Thrush	0.04	0.15	10	15		
Common Grasshopper Warbler	0.05	0.09	4	5		
Sedge Warbler	0.05	0.11	3	3		
Blackcap	0.01	0.01	1			
Common Whitethroat	0.02	0.06	3	4*		
Wood Warbler	0.02	0.04	3			
Common Chiffchaff	0.01	0.01				
Willow Warbler	0.64	2.76	53	64	206	155 – 273
Goldcrest	0.08	0.13	11	19		
Spotted Flycatcher	0.01	0.01	1			
Pied Flycatcher	0.01	0.01	1			
Long-tailed Tit	0.01	0.04	5			
Crested Tit	0.02	0.08	6	9*		
Coal Tit	0.16	0.31	15	19	175	109 – 281
Blue Tit	0.12	0.38	37	55	689	456 – 1043
Great Tit	0.12	0.33	24	37	1017	553 – 1871
Eurasian Treecreeper	0.03	0.06	6	9*		
Eurasian Jay	0.01	0.01	1			
Black-billed Magpie	0.02	0.03	3			
Rook	0.01	0.01				
Carrion Crow	0.09	0.37	5	7		
Hooded Crow	0.02	0.03	3			
Common Raven	0.01	0.03	3			
Chaffinch	0.63	2.33	142	202	508	391 – 661
European Goldfinch	0.01	0.01				
Eurasian Siskin	0.03	0.06	3	3*		
Common Linnet	0.01	0.03	4			
Lesser Redpoll	0.04	0.06	1	1*		
Common Crossbill	0.01	0.01				
Common Bullfinch	0.01	0.02				
Reed Bunting	0.11	0.27	26	38	504	329 – 774

[1] The proportion of survey points from which the species was recorded.

[2] The mean number of individuals recorded within 50 m of each survey point.

[3] Estimated density of birds assuming a common detection function. An asterix denotes species for which the number of qualifying registrations is between 10 and 19 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 20 or more.

[4] Estimated density of birds using the program DISTANCE. An asterix denotes species for which the number of qualifying registrations is between 30 and 39 inclusive, otherwise estimates are only given for species where the number of qualifying registrations is 40 or more.

Table 16 A comparison of some mean density estimates (birds per km2) with other studies from the UK in some comparable habitats

SPECIES	Restocked conifers plantations in Wales[1]	Regenerating scrub in Highlands[2]	Birch-heath mosaics in Highlands[3]	Spruce plantations in North Britain[4]	Woodland & scrub across UK[5]	Conifer plantations in Highlands[6]	This study[7]
Common Wood Pigeon		3 – 12	40		23 – 79	29	5
Sky Lark					0 – 30		75 – 351
Tree Pipit	169	3 – 21	24				6 – 66
Meadow Pipit		7 – 89	12	10 – 20			432 – 694
Winter Wren	283	4 – 25	12	60 – 70		106	133 – 288
Hedge Accentor	40	2 – 6			1 – 14		6 – 8
European Robin	114		18	25 – 103		75	25 – 292
Common Redstart		1 – 28					5 – 6
Whinchat	5						12 – 130
Northern Wheatear		8					1
Common Blackbird	19				1 – 57		5 – 7
Song Thrush	40				1 – 12	8	6 – 8
Willow Warbler	609	20 – 130	230	60 – 110		17	53 – 206
Goldcrest	189	7 – 15		10 – 100		298	11 – 19
Long-tailed Tit		1 – 19	20				5
Coal Tit	41	1 – 47	20	60 – 80		147	15 – 175
Blue Tit	5	2 – 105	40				37 – 689
Great Tit	5	1 – 36	20				24 – 1017
Eurasian Treecreeper		2 – 19					6 – 9
Chaffinch	97	8 – 195	58	100 – 110		169	142 – 508
Eurasian Siskin		2 - 26					3
Common Linnet							4
Lesser Redpoll				10 – 20			1
Reed Bunting					1 – 17		26 – 504

Sources:

[1] Bibby *et al.* (1985)

[2] Fuller *et al.* (1999)

[3] Gillings *et al.* (1998) – the published estimate is converted from 'territories' to 'birds' by multiplying by two. Note also that data is common with some of that reported in Fuller *et al.* 1998.

[4] Patterson *et al.* (1995)

[5] Newson *et al.* (2005)

[6] Calladine *et al.* (2007)

[7] Table 15

FIGURES

Figure 1 The location of the SFA sites where surveys of breeding birds were carried out in 2007

APPENDICES

Appendix 1 The coordinates (British National Grid) of the survey points used for sampling breeding bird abundances at the SFA sites in 2007.

Site	Point	Xcoord	Ycoord
Abernethy	A11	300650	813750
Abernethy	A12	300350	813750
Abernethy	A13	300650	813450
Abernethy	A31	301750	810650
Abernethy	A32	301850	810450
Abernethy	A42	302950	811450
Abernethy	A43	303250	811450
Abernethy	A51	304350	811750
Abernethy	A52	304250	812050
Abernethy	A53	304050	812250
Abernethy	A61	305050	814150
Abernethy	A63	305350	814250
Abernethy	A64	305250	814150
Abernethy	A65	305350	813850
Abernethy	NA1	300577	813533
Abernethy	NA2	301699	810705
Abernethy	NA3	301423	810725
Abernethy	NA4	301201	812217
Abernethy	NA5	301149	811795
Abernethy	NA6	301305	811983
Abernethy	NA7	301536	811884
Abernethy	R41	303268	811628
Abernethy	R62	304943	813793
Abernethy	RAB41	303268	811628
Abernethy	RAB62	304943	813793
Barclye	BC1	240895	570794
Barclye	BC2	240566	570223
Barclye	BC3	241218	570280
Barclye	BC4	240028	570130
Barclye	BC5	240218	569639
Barclye	BC6	238921	569481
Barclye	BC7	239149	568791
Barclye	BC8	239805	568717
Corrimony	CM1	237403	829119
Corrimony	CM11	234669	829930
Corrimony	CM12	233658	829641
Corrimony	CM13	234681	829041

Appendix 1 (cont'd) The coordinates (British National Grid) of the survey points used for sampling breeding bird abundances at the SFA sites in 2007.

Site	Point	Xcoord	Ycoord
Corrimony	CM14	237092	830419
Corrimony	CM15	232713	827241
Corrimony	CM16	234203	827052
Corrimony	CM2	234025	829308
Corrimony	CM3	233691	827830
Corrimony	CM4	235292	828119
Corrimony	CM6	234636	827607
Corrimony	CM7	235003	826274
Corrimony	CM8	235047	830230
Corrimony	CM9	234303	830364
Corrimony	CMNEW1	235827	828113
Corrimony	CMNEW2	233507	828713
Darroch Wids	D1	342450	825950
Darroch Wids	D10	349750	835150
Darroch Wids	D11	347850	833550
Darroch Wids	D12	343050	826250
Darroch Wids	D2	342950	826650
Darroch Wids	D3	342150	826150
Darroch Wids	D4	345950	829750
Darroch Wids	D5	346350	829750
Darroch Wids	D6	346450	829350
Darroch Wids	D7	347350	829350
Darroch Wids	D8	348250	834250
Darroch Wids	D9	347450	834450
Drumbow	DC1	284150	668250
Drumbow	DC2	283550	668750
Drumbow	DC3	284450	669750
Drumbow	DC4	284050	669950
Drumbow	DC5	284050	669550
Drumbow	DC6	283350	669250
Drumbow	DC7	283650	669050
Drumbow	DC8	283950	668250
Glen Devon	GD1	297450	702450
Glen Devon	GD10	294150	703350
Glen Devon	GD11	295850	704450
Glen Devon	GD12	295650	704650
Glen Devon	GD13	295950	704450
Glen Devon	GD14	298350	703750
Glen Devon	GD15	297550	702650
Glen Devon	GD16	295750	704750
Glen Devon	GD2	298150	704150

Appendix 1 (cont'd) The coordinates (British National Grid) of the survey points used for sampling breeding bird abundances at the SFA sites in 2007.

Site	Point	Xcoord	Ycoord
Glen Devon	GD3	298250	703950
Glen Devon	GD4	298450	704050
Glen Devon	GD5	297350	702750
Glen Devon	GD6	297150	702650
Glen Devon	GD7	294550	703350
Glen Devon	GD8	294350	703250
Glen Devon	GD9	294350	703550
Glen Finglas	GF11	248869	711876
Glen Finglas	GF12	248588	711800
Glen Finglas	GF13	248874	711653
Glen Finglas	GF14	248720	711538
Glen Finglas	GF31	250080	711652
Glen Finglas	GF32	250210	711740
Glen Finglas	GF33	249839	711675
Glen Finglas	GF34	249868	711514
Glen Finglas	GF41	250441	710913
Glen Finglas	GF42	250263	710670
Glen Finglas	GF43	250130	710566
Glen Finglas	GF44	250251	710937
Glen Finglas	GF61	252068	711806
Glen Finglas	GF62	252235	711602
Glen Finglas	GF63	252378	711765
Glen Finglas	GF64	252025	711570
Glen Finglas	GF71	253685	710415
Glen Finglas	GF72	253821	710174
Glen Finglas	GF73	253541	710107
Glen Finglas	GF74	253965	710048
Glen Finglas	GF81	253630	708614
Glen Finglas	GF82	253776	708579
Glen Finglas	GF83	253653	708845
Glen Finglas	GF84	253973	708887
Glenmore	GM10	296600	808200
Glenmore	GM11	297900	807800
Glenmore	GM12	298100	808700
Glenmore	GM13/14	298800	808700
Glenmore	GM15	297100	805200
Glenmore	GM16	299600	807600
Glenmore	GM17	298300	809000
Glenmore	GM18	296700	806100
Glenmore	GM2	299100	809500
Glenmore	GM3	299100	808800
Glenmore	GM4	299100	809100

Appendix 1 (cont'd) The coordinates (British National Grid) of the survey points used for sampling breeding bird abundances at the SFA sites in 2007.

Site	Point	Xcoord	Ycoord
Glenmore	GM5	300300	809600
Glenmore	GM6	299200	810200
Glenmore	GM7	299500	810400
Glenmore	GM8	299100	810500
Glenmore	GM9	295700	810400
Inversnaid	IS10	235251	712138
Inversnaid	IS11	234794	710561
Inversnaid	IS12	235022	711751
Inversnaid	IS2	235183	710886
Inversnaid	IS3	235630	711407
Inversnaid	IS4	234777	711908
Inversnaid	IS5	235691	710791
Inversnaid	IS6	234432	712490
Inversnaid	IS7	235014	712626
Inversnaid	IS8	234730	711292
Inversnaid	ISNEW1	235494	710366
Inversnaid	ISNEW2	234325	712010
Kinloch	K101	172850	822050
Kinloch	K102R	172782	822553
Kinloch	K103	172650	822350
Kinloch	K11	170350	818050
Kinloch	K12	170650	817850
Kinloch	K13	170450	817750
Kinloch	K21	170950	816250
Kinloch	K23	171150	816150
Kinloch	K24	170850	815950
Kinloch	K31	174750	816250
Kinloch	K32	174550	816250
Kinloch	K33	174450	816550
Kinloch	K41	177150	818150
Kinloch	K42	176850	818250
Kinloch	K43	177150	818550
Kinloch	K51	174750	820750
Kinloch	K52	174550	820650
Kinloch	K53	174650	820450
Kinloch	K61	178550	822450
Kinloch	K63	178350	822650
Kinloch	K64	178450	822350
Kinloch	K71	178950	825050
Kinloch	K72	179150	824850
Kinloch	K74	178850	824950
Kinloch	K81	176950	825050

Appendix 1 (cont'd) The coordinates (British National Grid) of the survey points used for sampling breeding bird abundances at the SFA sites in 2007.

Site	Point	Xcoord	Ycoord
Kinloch	K82	177350	824850
Kinloch	K83	177150	824750
Kinloch	K84	177150	824950
Kinloch	K91	174950	824850
Kinloch	K92	174650	824550
Kinloch	K93	174950	824450
Kinloch	RK22	171015	815885
Kinloch	RK25	171224	815970
Kinloch	RK62	178598	822845
Kinloch	RK73	178983	824674
Loch Katrine	KA1	242612	708007
Loch Katrine	KA10	244425	710585
Loch Katrine	KA11	244014	710660
Loch Katrine	KA12	240649	712735
Loch Katrine	KA13	240391	712399
Loch Katrine	KA14	240617	712438
Loch Katrine	KA15	240852	712560
Loch Katrine	KA16	237400	714286
Loch Katrine	KA17	237742	713849
Loch Katrine	KA18	237493	714104
Loch Katrine	KA19	237383	713976
Loch Katrine	KA2	242491	708213
Loch Katrine	KA20	237785	714002
Loch Katrine	KA21	237888	712980
Loch Katrine	KA22	237465	713295
Loch Katrine	KA23	237796	713236
Loch Katrine	KA24	237618	712889
Loch Katrine	KA3	242887	708220
Loch Katrine	KA4	242883	707791
Loch Katrine	KA5	245245	708208
Loch Katrine	KA6	245633	708311
Loch Katrine	KA7	245228	708525
Loch Katrine	KA8	244288	710795
Loch Katrine	KA9	244029	710743

Appendix 2 The scientific names of species referred to in this report

English name	Scientific name		English name	Scientific name
Greylag Goose	*Anser anser*		Hedge Accentor	*Prunella modularis*
Greater Canada Goose	*Branta canadensis*		European Robin	*Erithacus rubecula*
Eurasian Teal	*Anas crecca*		Common Redstart	*Phoenicurus phoenicurus*
Mallard	*Anas platyrhynchos*		Whinchat	*Saxicola rubetra*
Tufted Duck	*Aythya fuligula*		Stonechat	*Saxicola torquatus*
Goosander	*Mergus merganser*		Northern Wheatear	*Oenanthe oenanthe*
Willow Ptarmigan (Red Grouse)	*Lagopus lagopus scotica*		Ring Ouzel	*Turdus torquatus*
Black Grouse	*Tetrao tetrix*		Common Blackbird	*Turdus merula*
Western Capercaillie	*Tetrao urogallus*		Song Thrush	*Turdus philomelos*
Common Pheasant	*Phasianus colchicus*		Mistle Thrush	*Turdus viscivorus*
Red-throated Diver	*Gavia stellata*		Common Grasshopper Warbler	*Locustella naevia*
Grey Heron	*Ardea cinerea*		Sedge Warbler	*Acrocephalus schoenobaenus*
Eurasian Sparrowhawk	*Accipiter nisus*		Blackcap	*Sylvia atricapilla*
Common Buzzard	*Buteo buteo*		Common Whitethroat	*Sylvia communis*
Golden Eagle	*Aquila chrysaetos*		Wood Warbler	*Phylloscopus sibilatrix*
Common Kestrel	*Falco tinnunculus*		Common Chiffchaff	*Phylloscopus collybita*
Merlin	*Falco columbarius*		Willow Warbler	*Phylloscopus trochilus*
Common Moorhen	*Gallinula chloropus*		Goldcrest	*Regulus regulus*
Eurasian Oystercatcher	*Haematopus ostralegus*		Spotted Flycatcher	*Muscicapa striata*
European Golden Plover	*Pluvialis apricaria*		Pied Flycatcher	*Ficedula hypoleuca*
Northern Lapwing	*Vanellus vanellus*		Long-tailed Tit	*Aegithalos caudatus*
Common Snipe	*Gallinago gallinago*		Crested Tit	*Lophophanes cristatus*
Eurasian Curlew	*Numenius arquata*		Coal Tit	*Periparus ater*
Common Redshank	*Tringa totanus*		Blue Tit	*Cyanistes caeruleus*
Common Greenshank	*Tringa nebularia*		Great Tit	*Parus major*
Common Sandpiper	*Actitis hypoleucos*		Eurasian Treecreeper	*Certhia familiaris*
Black-headed Gull	*Larus ridibundus*		Eurasian Jay	*Garrulus glandarius*
Mew Gull	*Larus canus*		Black-billed Magpie	*Pica pica*
Herring Gull	*Larus argentatus*		Eurasian Jackdaw	*Corvus monedula*
Great Black-backed Gull	*Larus marinus*		Rook	*Corvus frugilegus*
Feral Pigeon/Rock Dove	*Columba livia*		Carrion Crow	*Corvus corone*
Common Wood Pigeon	*Columba palumbus*		Hooded Crow	*Corvus cornix*
Common Cuckoo	*Cuculus canorus*		Common Raven	*Corvus corax*
Tawny Owl	*Strix aluco*		Common Starling	*Sturnus vulgaris*
Common Swift	*Apus apus*		Chaffinch	*Fringilla coelebs*
Great Spotted Woodpecker	*Dendrocopos major*		European Goldfinch	*Carduelis carduelis*
Sky Lark	*Alauda arvensis*		Eurasian Siskin	*Carduelis spinus*
Barn Swallow	*Hirundo rustica*		Common Linnet	*Carduelis cannabina*
Tree Pipit	*Anthus trivialis*		Twite	*Carduelis flavirostris*
Meadow Pipit	*Anthus pratensis*		Lesser Redpoll	*Carduelis cabaret*
Grey Wagtail	*Motacilla cinerea*		Common Crossbill	*Loxia curvirostra*
White/Pied Wagtail	*Motacilla alba*		Common Bullfinch	*Pyrrhula pyrrhula*
White-throated Dipper	*Cinclus cinclus*		Reed Bunting	*Emberiza schoeniclus*
Winter Wren	*Troglodytes troglodytes*			