



BTO Research Report No 345

**Comparison of population trends,
abundance and species richness
on land affected by
SRDP agri-environment schemes
with non-agreement land**

Authors

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A report by the British Trust for Ornithology

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1. INTRODUCTION

The Scottish Rural Development Plan (SRDP), which is aimed at improving the economic, environmental and social conditions of rural communities in Scotland, was announced by the government in 2000. One of its components is an agri-environment scheme programme, including the Rural Stewardship Scheme, the Organic Aid Scheme, the continuation of the Woodland Grant Scheme and the Farm Woodland Premium Scheme. The purpose of this preliminary study is to investigate the use of existing bird survey data to evaluate the effectiveness of the Scottish Rural Development Plan (SRDP) agri-environment scheme in Scotland. As holders of many large-scale datasets of counts of birds across the UK, the BTO was contracted to extract and analyse data from the BTO/JNCC/RSPB Breeding Bird Survey (BBS) in relation to their participation in the SRDP agri-environment programme

1.1 Data extraction

The BTO/JNCC/RSPB Breeding Bird Survey (BBS) was introduced in 1994 to monitor population trends of a broad range of breeding birds across the UK. The BBS, which uses a line transect method for recording birds, calculates annual population indices for all species where there is sufficient coverage, and population trends are reported annually (e.g. Noble *et al.* 2001). The use of volunteers is maximised through a stratified random sampling design. BBS survey squares are randomly selected from a list of all 1-km squares in the National Grid, excluding coastal squares with less than 50% land. Within each region, squares are selected randomly, and allocated to volunteers through a network of voluntary regional organisers.

Fieldwork involves two counting visits by a volunteer observer to each survey square. These line transects should follow the ideal, a straight line through the square as closely as possible, but allow for minor deviation due to impracticalities for the observer caused by land features. The habitats of each 200-m section along line transects are recorded using a hierarchical coding system formulated from Crick (1992). Early morning bird counts are carried out between early April and mid-May and between mid-May and late June respectively. Observers record all birds that they see or hear as they walk along their transect routes within each 200m section in one of three distance categories from the line (0-25-m, 25-100-m, 100-m or more) or in flight. The flight category, excludes birds obviously associated with the square (e.g. display flight of Skylark *Alauda arvensis*), which is recorded in the appropriate distance band. Distances are estimated at right angles to the transect line. Juvenile and immature birds are recorded in the field, but are excluded from the computerised data and subsequent analyses. Thus, it is assumed that sightings relate to breeding, or potentially breeding adults only.

A list of the locations of all BBS squares surveyed in Scotland between 1994 and 2002 was provided to the partnership. Squares that coincided with land under SRDP agreement were matched with squares that were not under SRDP agreement, based on a suite of characteristics including geographical location (Ordnance Survey easting and northing), mean annual rainfall, average temperature, distance of the square from the sea, and the mix of land cover types in the square (J Wright, pers comm.).

1.2 Estimating population trends

Examination of species coverage in the matched squares revealed that 17 species were recorded on a mean of at least eight squares for both SRDP and control land (Table 1). Count data were analysed using log-linear Poisson regression models fitted in SAS (SAS 1996). Annual indices were generated by modelling a matrix of annual site counts, with site and year effects (ter Braak *et al.* 1994). The year effect is an annual index of total numbers, whilst the site effect describes how species abundance at sites differ from one another. The first index of a run of years is set to an arbitrary value 1 and other indices are measured relative to this.

A second set of analyses examines the significance of the underlying trend by removing the year effect from the model and formally testing whether the trend is significantly different from zero. We then determine whether linear trends on SRDP land and non-SRDP control squares are significantly different from another. For these analyses, an additional variable ‘type’ was employed where ‘type’= 1 for a site on land affected by SRDP schemes and 2 on non-agri-environment scheme land. Adding to the model a year*type interaction enables a formal assessment of the significance of the difference in linear trends, between two geographic areas for the time period 1994 to 2002.

1.3 Estimating mean densities

Although bird counts using standardised protocols can be used to monitor trends over time, estimates of absolute abundance encounter the problem that raw counts represent only observed individuals. It is extremely unlikely that all individuals in the sampled population will be detected, and hence the undetected proportion must be estimated. Distance sampling provides a method for estimating this proportion (Buckland *et al.* 2001). This problem is further complicated by the fact that detectability varies between habitats. For example a species in open country is likely to be detectable at a greater distance from the transect line than in woodland or scrub. For an unbiased comparison of species abundance on and outside SRDP agreement land, it is necessary to take detectability in different habitats into account. Using distance sampling the distribution of detected individuals in relation to their distance from the transect line allows the probability of detection of this species to be modelled in relation to distance from the line. Assuming that all individuals near the transect line are detected, the proportion of individuals missed can be estimated, and the true number of individuals estimated.

As recommended by Buckland *et al.* (2001), birds recorded in the final distance band (100-m or more) were excluded from the analyses. Birds in flight were also excluded, leaving the count data from the two remaining bands (0-25-m, 25-100-m). We modelled the detectability of each species in each of seven broad habitat classes (Table 2). To take these habitat-specific detectabilities into account, we included habitat as a covariate in the analyses using the distance sampling software; Distance 4 (Thomas *et al.* 2002). Exploratory analysis suggested that detection functions based on half-normal models gave the best fit of the model to the data. Comparison of model fit were based on Akaike’s Information Criterion (AIC), which assesses the most parsimonious model based on maximising fit and minimizing the number of model parameters used. In all analyses we assume that whilst encounter rate (‘occurrence’) varied between squares, detectability is species-specific and varies by habitat, but not between years or between agri-environment and non agri-environment scheme land. Using this methodology we estimated mean abundance on 1-km BBS squares for each year (1994 to 2002) in each land category. To generate estimates of variance we used bootstrapping, resampling from BBS squares within years for agri-environment and non agri-environment scheme land separately. We restricted density estimates to the same 17 species included in the trend analyses.

For the same 17 species we also perform paired t-tests on the raw count data to examine whether there was a significant difference between SRDP agreement squares and their corresponding matched control squares. For an additional suite of 24 species occurring on five to eight BBS squares, a simple comparison of the raw counts on land affected by SRDP agri-environment schemes and non-agreement land was made using a Wilcoxon Rank Sum test (Zar 1999).

1.4 Species richness

A simple comparison of species diversity on land affected by SRDP agri-environment schemes and non agreement land was made by determining the number of species recorded on each BBS square within these two groups for each year (1994 to 2002) using Mann-Whitney U to test whether the medians differed significantly.

2. RESULTS

2.1 Population trends

Population trends and summary measures of change are provided in Figure 1 and Tables 3 to 6. The relatively small number of sites in this study means that the variance associated with trends was large and hence the power to detect a significant change in abundance over time, or differences between the two groups, was small. Foot-and-mouth disease restrictions severely reduced survey coverage in 2001, and a reduced sample size in that year increased the variance associated with the estimates. Nevertheless, examination of both the annual indices, and the linear trends revealed some significant and consistent trends. Curlew numbers declined significantly on non-agreement land, but remained stable on land in the SRDP scheme. This is illustrated by a significant linear decline on non-SRDP agreement land over the period 1994-2002 and declining annual indices over the period. Woodpigeons declined significantly on agreement land, Meadow Pipits increased significantly on non-agreement land and Wren numbers increased significantly on agreement land, although there was large fluctuations in Wren abundance between years. Two species (Willow Warbler and Crow) increased significantly on both land types, as revealed by the linear and the annual trend analyses. A significant linear increase was found for Song Thrush and Buzzard on non-agreement land, as suggested by the annual trend analysis, albeit not significantly. The change in abundance between 1994 and 2002, based on the annual model, is shown for each species in Table 6. These should be interpreted with caution because the confidence limits are large. Three species (Robin, Swallow and Wood Pigeon) exhibited a significant difference in the slope of the linear trend between agreement land and non-agreement land (Table 5; last 2 columns). The first two species exhibited increases that were significantly steeper on non-agreement land and Wood Pigeon declined more steeply on land under agreement than on land outside of the agreement.

2.2 Measures of abundance using distance sampling

Estimates of mean abundance for each year, with confidence intervals, on 1-km BBS squares on land affected by SRDP schemes and non-agreement land are shown in Tables 7 & 8. This allows comparison of relative density measures between the two types of land within years, as well as changes in density within species between years. We use the term relative density because the units of densities derived from BBS counts cannot always be easily converted to numbers of breeding pairs for all species (Newson *et al.* in prep). In the case of Skylarks, it is mainly singing males that are counted, but for other species such as Starling, counts include an unknown ratio of males and females. Although confidence limits on 1-km BBS squares within the two land categories overlap for all species in any particular year, it can be seen that the two most widespread species, Meadow Pipit and Skylark are generally more abundant on land affected by SRDP schemes than outside it. Meadow Pipit densities on land in the scheme are between 68 and 100 birds, whereas values for outside the scheme range from 45 to 60.

For the same 17 species paired t-tests were carried out on the raw count data to examine whether there was a significant difference between SRDP agreement squares and their corresponding matched control squares in each year of the survey. A significant difference between matched squares was found for the Robin in 1997 ($t_{32} = -2.74$, $P=0.010$), Chaffinch in 1998 and 2000 (1998: $t_{32} = -2.17$, $P=0.038$; 2000: $t_{32} = -2.34$, $P=0.026$), Blackbird in 2002 ($t_{32} = -2.09$, $P=0.045$), Buzzard in 2002 ($t_{32} = -2.39$, $P=0.023$), Swallow in 2002 ($t_{32} = 3.38$, $P=0.002$) and Woodpigeon in 2002 ($t_{32} = 2.59$, $P=0.014$).

In the simple comparison of raw counts for the 24 scarcer species, we found no significant difference in abundance within years for any species.

2.3 Species richness

The mean number of species recorded on BBS squares in each year between 1994 and 2002 on land affected by SRDP schemes and non-agreement land is shown in Table 9. There was no significant difference in species richness between these two groups, in any year.

3. CONCLUSIONS

Population trends of relative abundance were generated for 17 reasonably common bird species, on land under agreement in the SRDP scheme and on land outside the agreement. It should be emphasized that the relatively small number of sites where each species occurred on either category of land means that the power to detect changes is small. The period 1994 to 2002 is also a relatively short period to detect change. Nevertheless, a number of significant changes in abundance were identified. Results suggest that the scheme may have a positive effect on some bird populations. Curlew declined significantly on non-agreement land, while remaining stable on SRDP agreement land, and Wrens increased significantly on agreement land. However, not all differences suggested positive effects: Meadow Pipits increased significantly on non-agreement land but not on land in the SRDP scheme.

Estimates of the mean densities of seventeen species were calculated using distance sampling, and habitat-specific detectability functions. The reason for this approach is that it provides estimates of abundance that are corrected for differences in detectability, for comparison across the two categories of land agreement (within and outside the SRDP scheme). However, another advantage of the distance estimate method is that it is the number of observations used to determine detectability, rather than the number of squares in which the species occurs, that determines the precision of the estimate, although the number of observations will increase with the number of squares surveyed. Confidence intervals were nevertheless quite large. However, there is evidence that the two most widespread species, Meadow Pipit and Skylark are more abundant on land in the SRDP schemes. This method has considerable potential in comparisons of abundance, where the number of sites is small.

Analyses examining matched comparisons between SRDP agreement squares and their corresponding matched squares for the 17 most abundant species, found a significant difference in the raw counts for 6 of these species in one or more year.

There was no evidence that bird species richness differed between land in the scheme and land outside it, during any year.

Although this study provides some evidence of differences in the abundance of wild birds related to participation in the SRDP scheme, the main limitation of these analyses is the relatively small number of BBS squares included. Work by Joys *et al.* (2003) to investigate the power of BBS data to detect biologically important trends suggests that occurrence on 30 to 40 BBS squares is required to detect a significant 50% decline. Where the area of interest is smaller or more homogeneous, a smaller number of squares may have equivalent power to detect change. For reliable long-term monitoring of wild bird populations on land participating in agri-environment schemes of this type, considerable effort should be focused on increasing the number of survey sites.

ACKNOWLEDGEMENTS

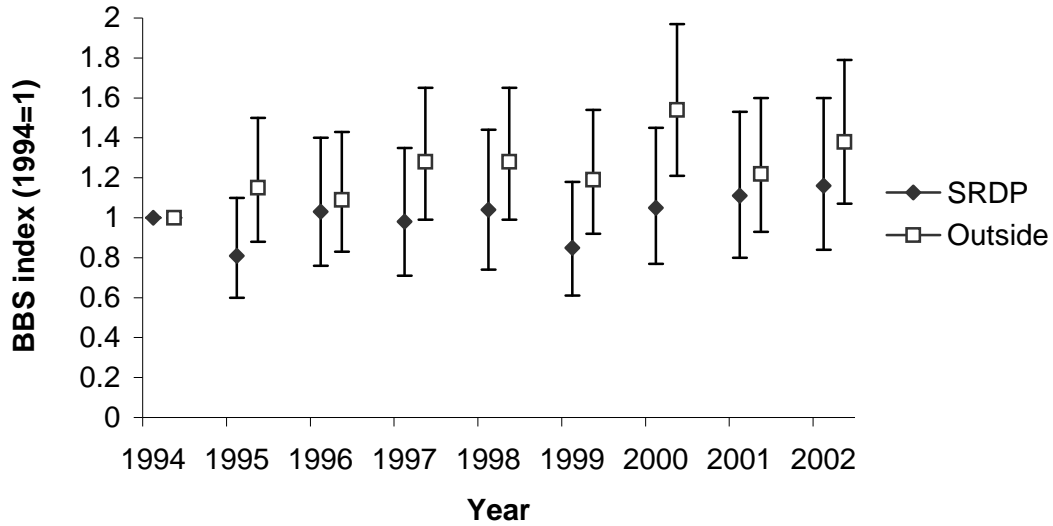
The BBS is organised by the British Trust for Ornithology (BTO) and jointly funded by BTO, the Joint Nature Conservation Committee (JNCC, on behalf of English Nature, Scottish Natural Heritage, Countryside Council for Wales and the Environment and Heritage Service in Northern Ireland) and the Royal Society for the Protection of Birds (RSPB). The success of the BBS is dependent on the huge effort, every year, of more than 200 volunteer participants and regional organizers across the UK.

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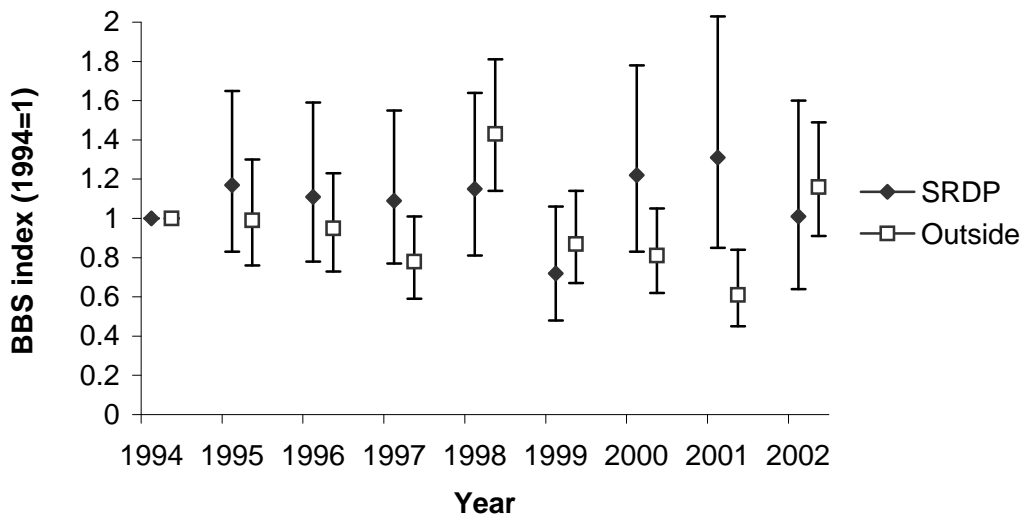
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Figure 1 Comparison between annual BBS indices on land affected by SRDP agri-environment schemes and non agri-environment land over the period 1994-2002 for the 17 most widespread species. The error bars represent 95% confidence intervals of the BBS indices. Indices are measured relative to the year 1994, which is set to 1. Indices are staggered for visual purposes.

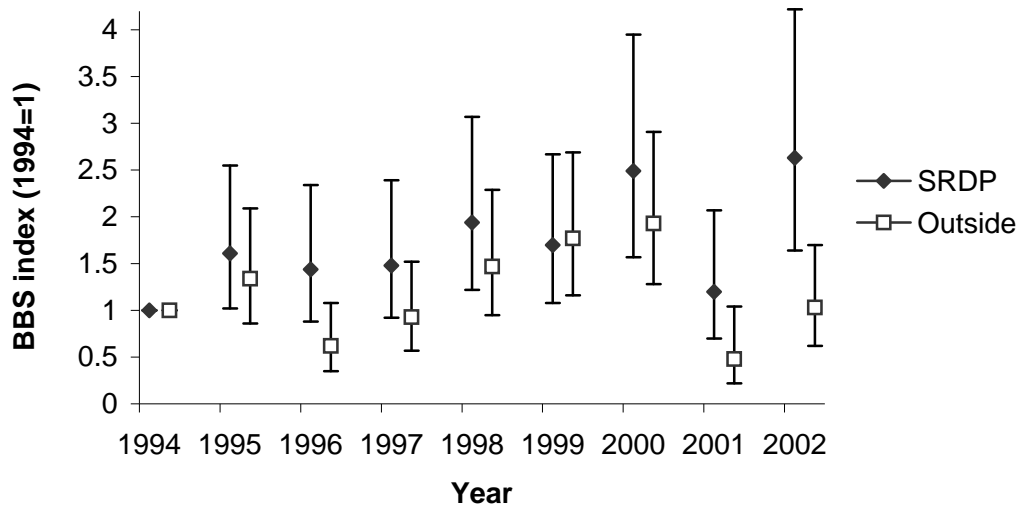
a) Meadow Pipit



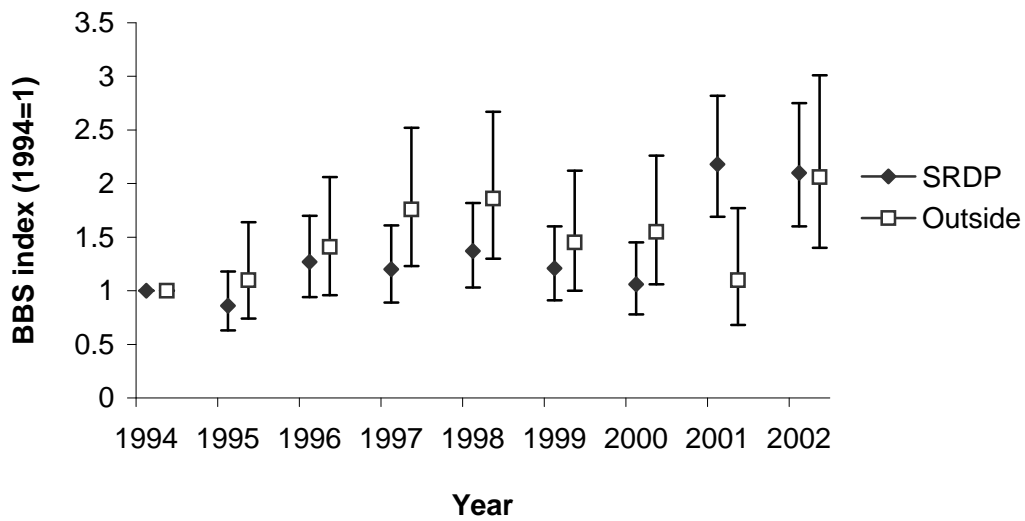
b) Skylark



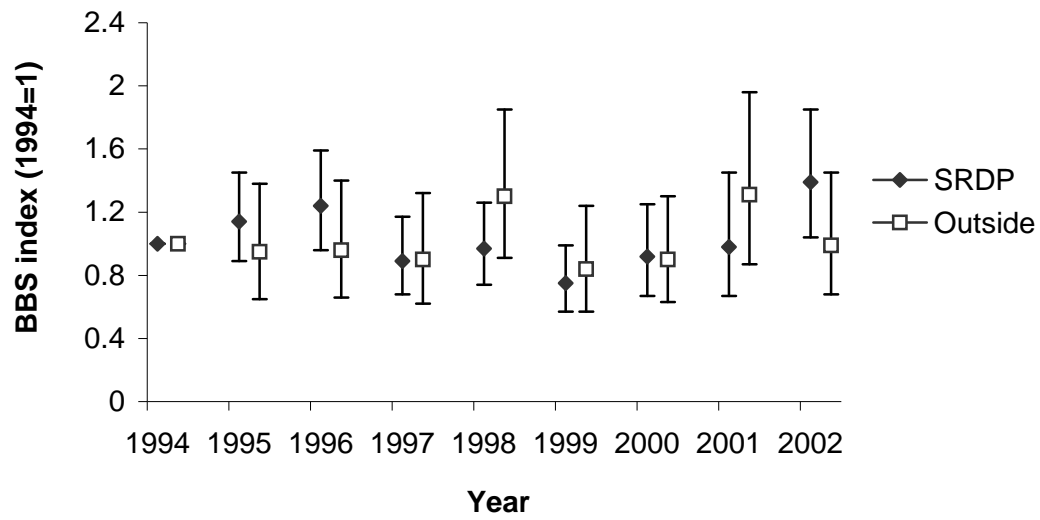
c) Wren



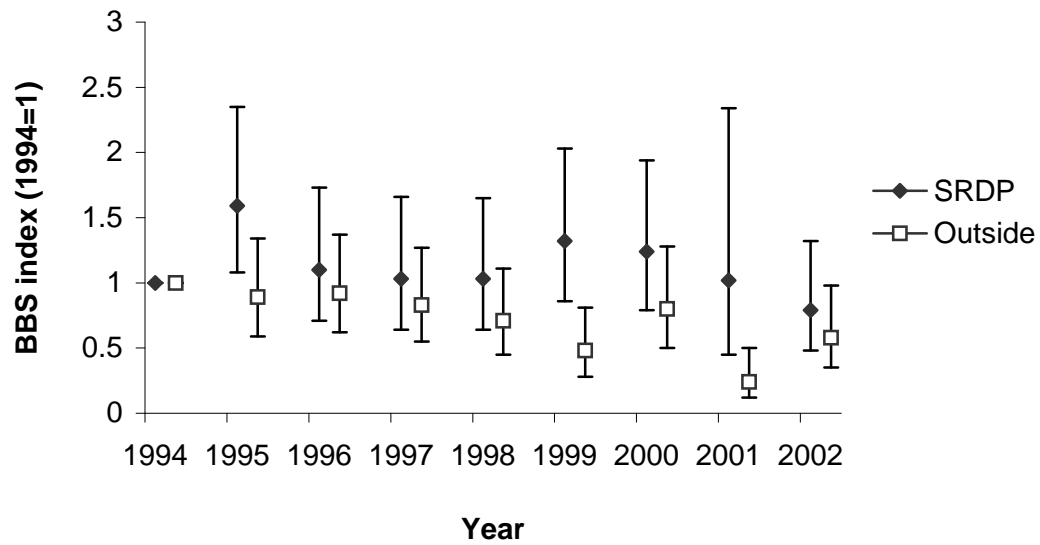
d) Willow Warbler



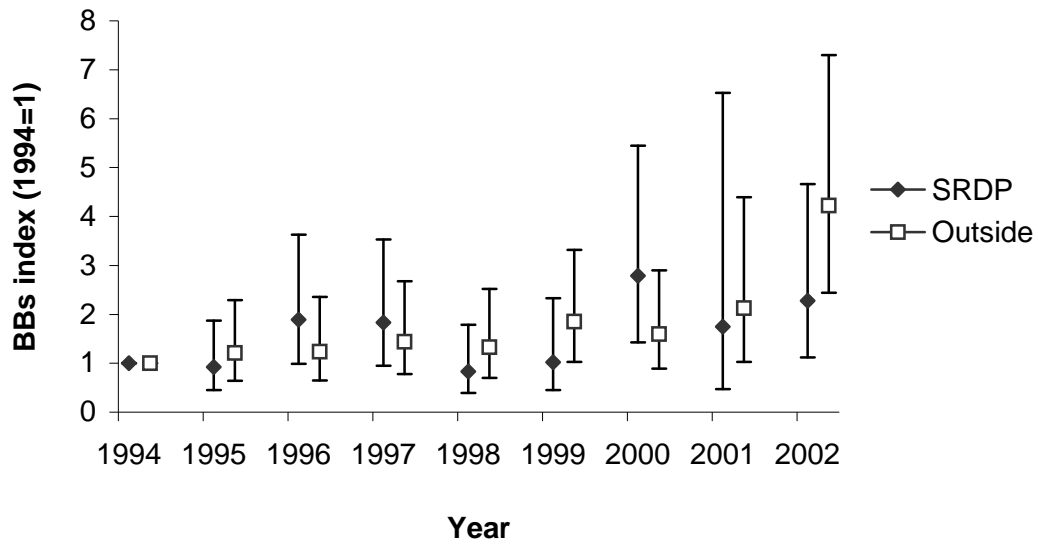
e) Chaffinch



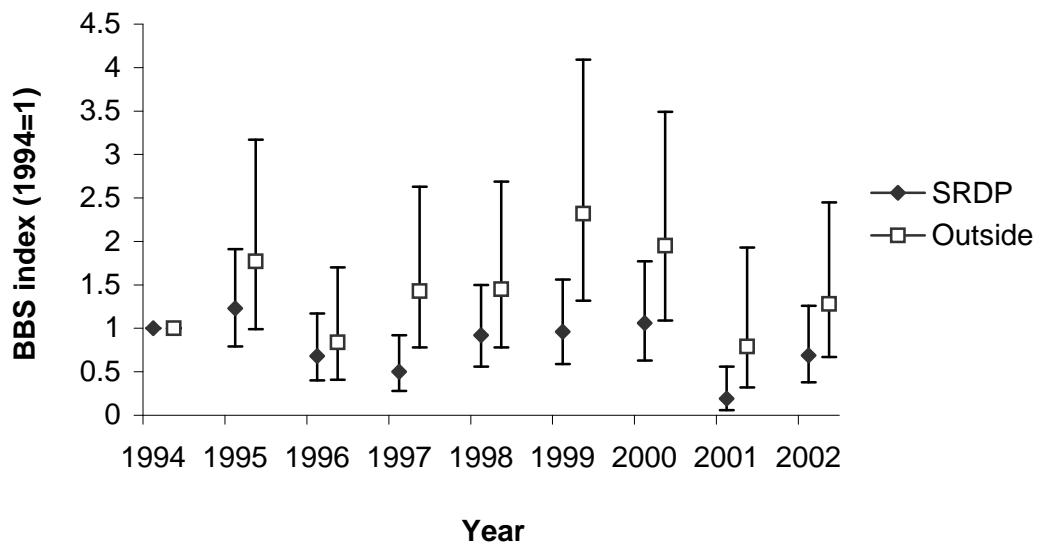
f) Curlew



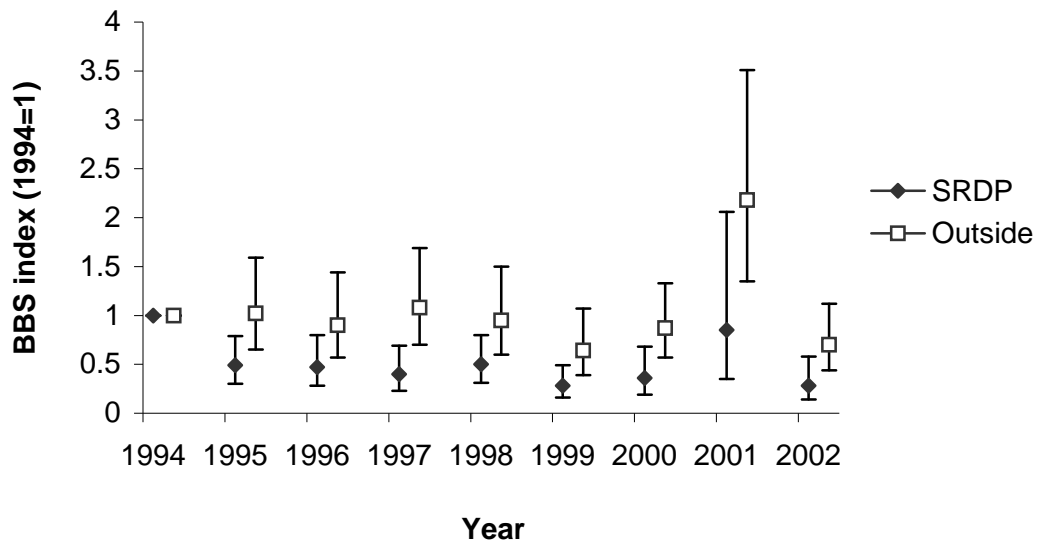
g) Carrion Crow



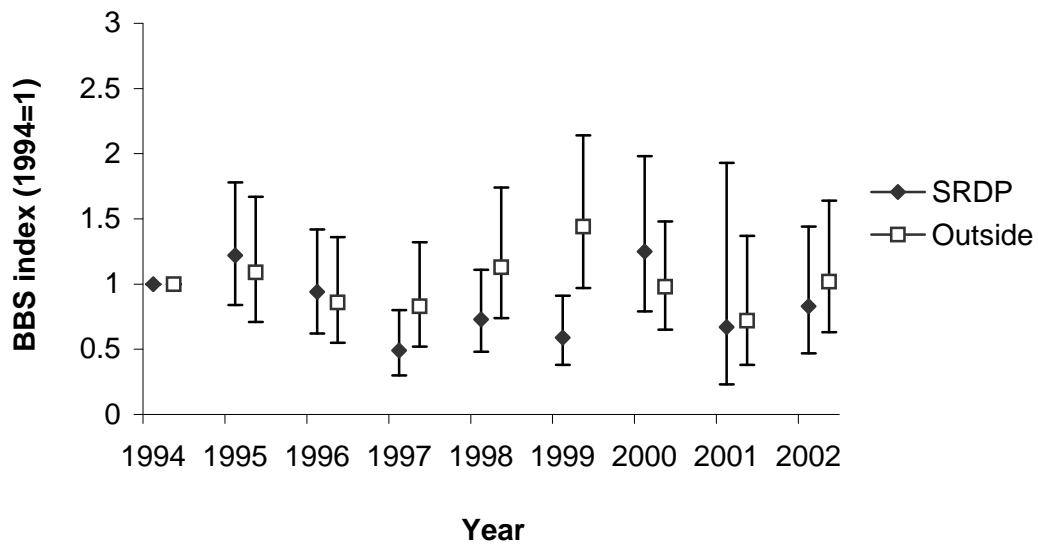
h) Robin



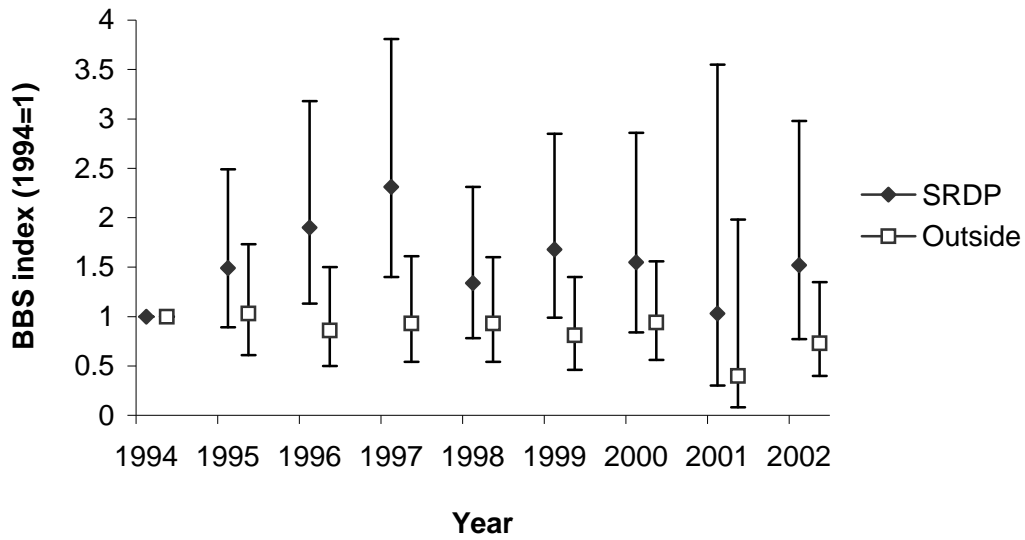
i) Woodpigeon



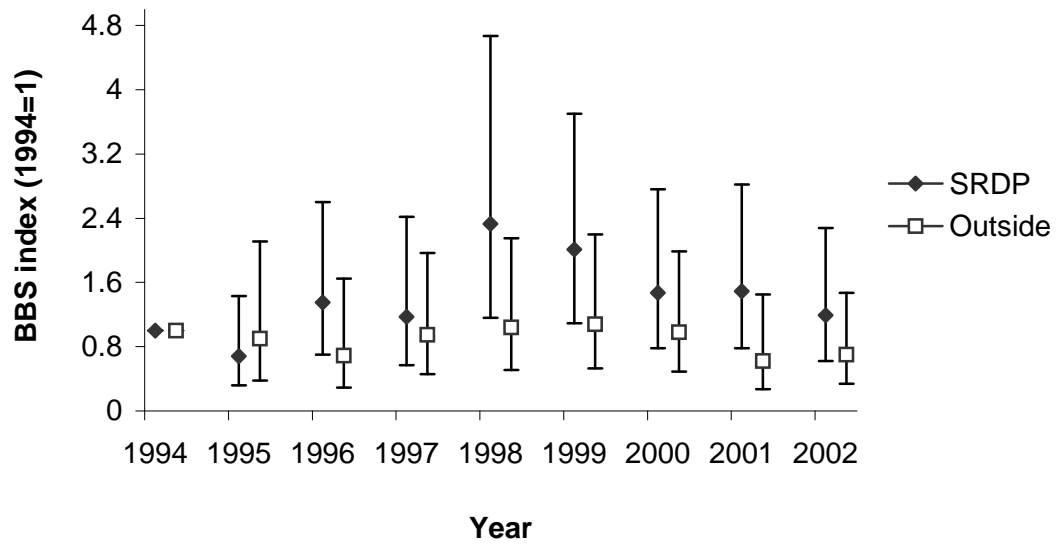
j) Blackbird



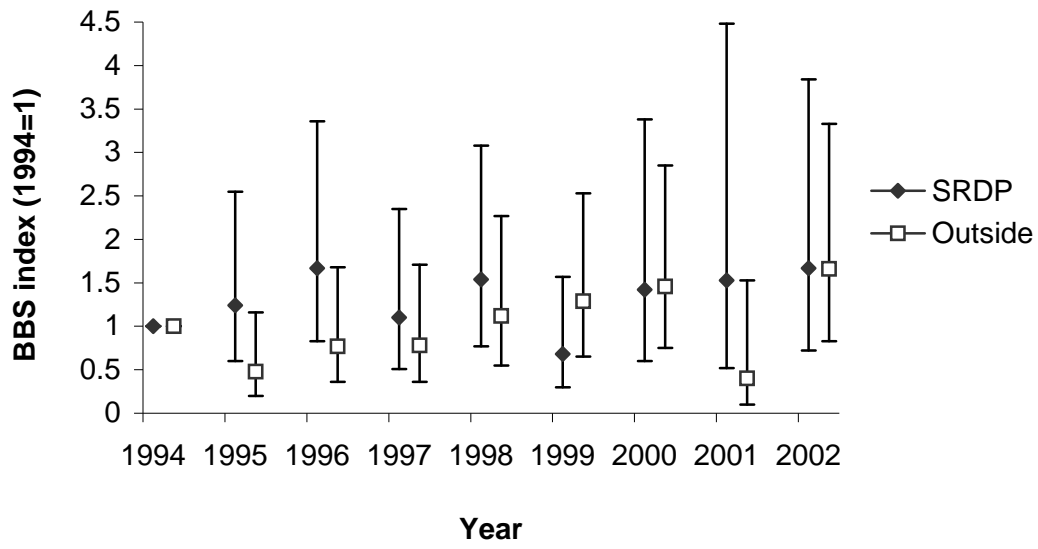
k) Blue Tit



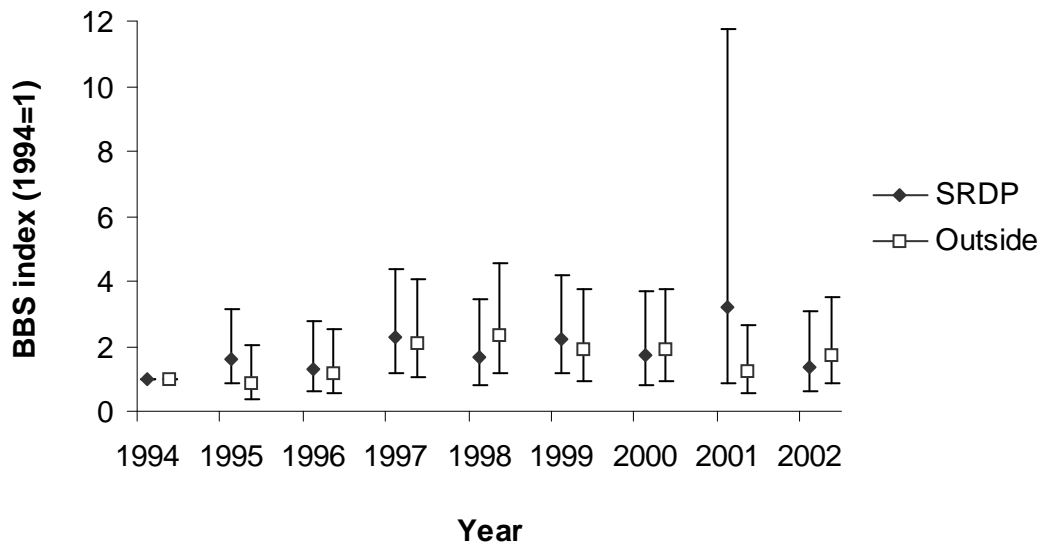
l) Red Grouse



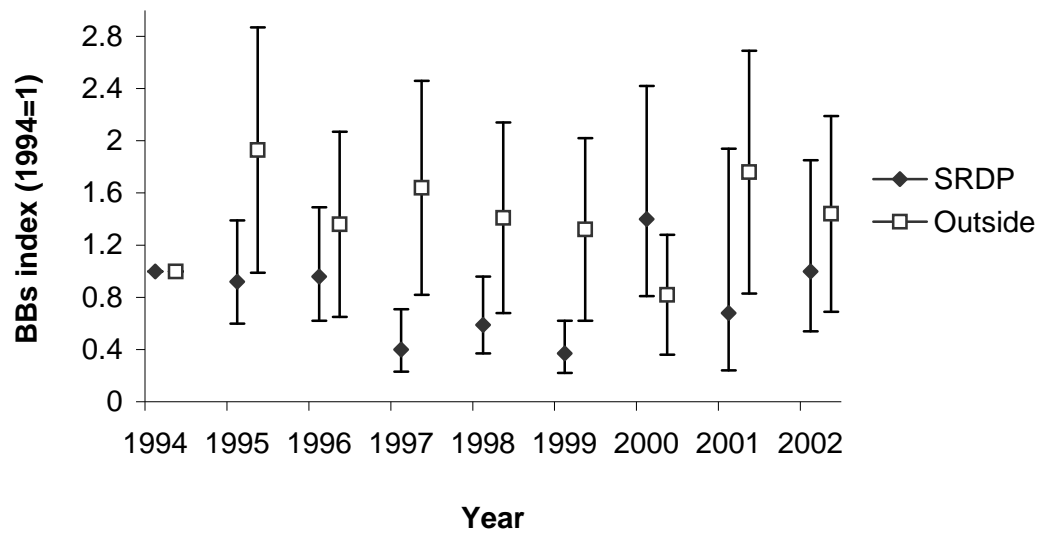
m) Song Thrush



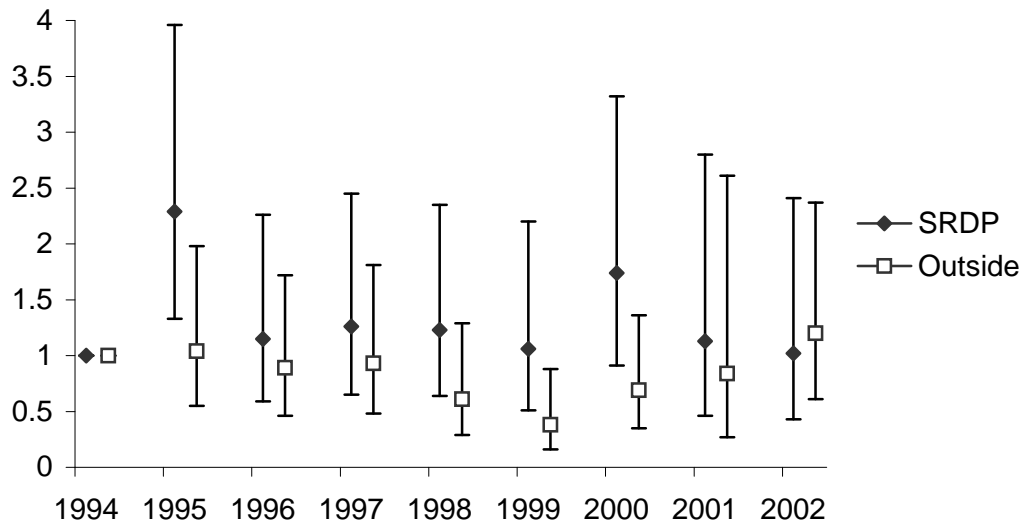
n) Buzzard



o) Pheasant



p) Pied Wagtail



q) Swallow

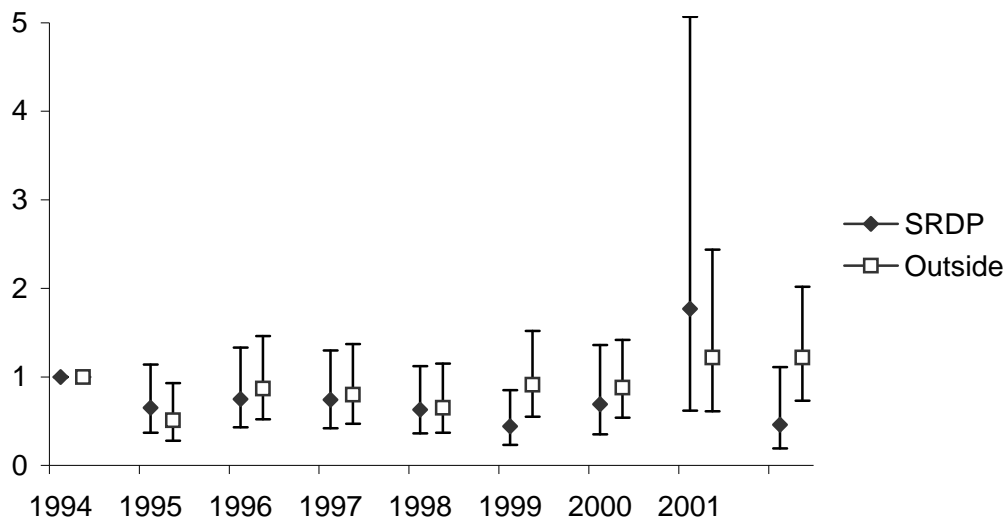


Table 1 Mean number of BBS squares occupied each year by each bird species over the period 1994-2002 on land affected by SRDP schemes and on matched control squares not affected by these schemes.

Species	SRDP	Control		SRDP	Control
Meadow Pipit	18	16	Woodcock	1	0
Skylark	16	15	Scottish Crossbill	0	1
Wren	16	14	Oystercatcher	0	1
Willow Warbler	15	15	Black Grouse	0	1
Chaffinch	14	14	Siskin	3	3
Curlew	12	9	Tree Pipit	3	1
Carrion Crow	11	12	Whinchat	3	3
Robin	11	11	Great B-b Gull	2	1
Woodpigeon	10	12	Greylag Goose	2	1
Blackbird	9	10	Grey Wagtail	2	2
Blue Tit	9	8	Grey Heron	2	2
Red Grouse	9	8	Grey Partridge	2	1
Song Thrush	9	9	Red-throated Diver	2	1
Buzzard	8	11	Redshank	2	1
Great Tit	8	7	Red-b. Merganser	2	1
Pheasant	8	9	Redstart	2	0
Pied Wagtail	8	8	Spotted Flycatcher	2	2
Rook	8	7	Swift	2	4
Starling	8	7	Treecreeper	2	2
Swallow	8	10	Twite	2	1
Wheatear	8	4	Arctic Squa	1	0
Jackdaw	7	7	Blackcap	1	2
Lapwing	7	7	Bullfinch	1	1
Oystercatcher	7	9	Black-throated Diver	1	0
Yellowhammer	7	8	Cormorant	1	0
Black-h. Gull	6	6	Corn Bunting	1	0
Cuckoo	6	7	Chiffchaff	1	1
Duncock	6	8	Collared Dove	1	2
Herring Gull	6	7	Canada Goose	1	0
Linnet	6	7	Coot	1	0
Mallard	6	5	Common Crossbill	1	1
Coal Tit	5	7	Dipper	1	4
Snipe	5	4	Dunlin	1	1
Whitethroat	5	5	Fulmar	1	0
Common Gull	4	5	Green Woodpecker	1	1
Feral Pigeon	4	3	Goosander	1	1
Goldfinch	4	5	Greenshank	1	1
Golden Plover	4	5	Great S. Woodpecker	1	1
Greenfinch	4	6	Garden Warbler	1	2
Hooded Crow	4	2	Hen Harrier	1	0
Kestrel	4	4	Jay	1	1
Lesser B.b Gull	4	3	Long-tailed Tit	1	1
Mistle Thrush	4	6	Magpie	1	2
Sedge Warbler	4	4	Moorhen	1	1
C. Sandpiper	3	5	Merlin	1	1
Goldcrest	3	5	Mute Swan	1	0
House Martin	3	3	Peregrine	1	0
House Sparrow	3	4	Ringed Plover	1	0
Lesser Redpoll	3	3	Ring Ousel	1	1
Reed Bunting	3	2	Stock Dove	1	3
Raven	3	3	Short-eared Owl	1	0
Teal	1	1	Sparrowhawk	1	1
Tree Sparrow	1	1	Sand Martin	1	2
Tufted Duck	1	0			

Table 2 Habitat classes used in distance-sampling analyses.

Name	Description
Woodland	Broadleaved, coniferous and mixed woodland
Scrubland	Young regenerated woodland, downland scrub, heath scrub, young coppice, young plantation and clear-felled woodland (< 5m in height)
Semi-natural grassland/marsh	Chalk downland, grass moor (unenclosed), grass moor mixed with Heather and other dry grassland, machair, water meadow, grazing marsh, reed swamp, saltmarsh and other open marsh
Heath and bog	Dry heath, wet heath, mixed heath and breckland, bog, drained bog and bare peat
Farmland	Improved and unimproved grass farmland, mixed grass/tilled land, tilled land, orchard, other farming
Human sites	Urban, suburban and rural human
Freshwater bodies	Freshwater pond, lake, reservoir, stream, river, canal and ditch

Table 3 Annual BBS indices (+95% confidence intervals) on land under SRDP agri-environment scheme agreement over the period 1994-2002 for the 17 most widespread bird species. Indices are measured relative to the year 1994, which is set to 1. A visual comparison of indices within and outside SRDP land for these species is shown in Figure 1.

Species	1994	1995	1996	1997	1998	1999	2000	2001	2002
Meadow Pipit	1	0.81 (0.60-1.10)	1.03 (0.76-1.4)	0.98 (0.71-1.35)	1.04 (0.74-1.44)	0.85 (0.61-1.18)	1.05 (0.77-1.45)	1.11 (0.80-1.53)	1.16 (0.84-1.60)
Skylark	1	1.17 (0.83-1.65)	1.11 (0.78-1.59)	1.09 (0.77-1.55)	1.15 (0.81-1.64)	0.72 (0.48-1.06)	1.22 (0.83-1.78)	1.31 (0.85-2.03)	1.01 (0.64-1.60)
Wren	1	1.61 (1.02-2.55)	1.44 (0.88-2.34)	1.48 (0.92-2.39)	1.94 (1.22-3.07)	1.70 (1.08-2.67)	2.49 (1.57-3.95)	1.20 (0.70-2.07)	2.63 (1.64-4.22)
Willow Warbler	1	0.86 (0.63-1.18)	1.27 (0.94-1.70)	1.20 (0.89-1.61)	1.37 (1.03-1.82)	1.21 (0.91-1.6)	1.06 (0.78-1.45)	2.18 (1.69-2.82)	2.10 (1.60-2.75)
Chaffinch	1	1.14 (0.89-1.45)	1.24 (0.96-1.59)	0.89 (0.68-1.17)	0.97 (0.74-1.26)	0.75 (0.57-0.99)	0.92 (0.67-1.25)	0.98 (0.67-1.45)	1.39 (1.04-1.85)
Curlew	1	1.59 (1.08-2.35)	1.10 (0.71-1.73)	1.03 (0.64-1.66)	1.03 (0.64-1.65)	1.32 (0.86-2.03)	1.24 (0.79-1.94)	1.02 (0.45-2.34)	0.79 (0.48-1.32)
Carrion Crow	1	0.92 (0.45-1.87)	1.89 (0.99-3.63)	1.83 (0.95-3.53)	0.83 (0.39-1.79)	1.02 (0.45-2.33)	2.79 (1.43-5.45)	1.75 (0.47-6.53)	2.28 (1.12-4.66)
Robin	1	1.23 (0.79-1.91)	0.68 (0.40-1.17)	0.50 (0.28-0.92)	0.92 (0.56-1.50)	0.96 (0.59-1.56)	1.06 (0.63-1.77)	0.19 (0.06-0.56)	0.69 (0.38-1.26)
Woodpigeon	1	0.49 (0.30-0.79)	0.47 (0.28-0.80)	0.40 (0.23-0.69)	0.50 (0.31-0.80)	0.28 (0.16-0.49)	0.36 (0.19-0.68)	0.85 (0.35-2.06)	0.28 (0.14-0.58)
Blackbird	1	1.22 (0.84-1.78)	0.94 (0.62-1.42)	0.49 (0.30-0.80)	0.73 (0.48-1.11)	0.59 (0.38-0.91)	1.25 (0.79-1.98)	0.67 (0.23-1.93)	0.83 (0.47-1.44)
Blue Tit	1	1.49 (0.89-2.49)	1.90 (1.13-3.18)	2.31 (1.40-3.81)	1.34 (0.78-2.31)	1.68 (0.99-2.85)	1.55 (0.84-2.86)	1.03 (0.30-3.55)	1.52 (0.77-2.98)
Red Grouse	1	0.68 (0.32-1.43)	1.35 (0.70-2.60)	1.17 (0.57-2.42)	2.33 (1.16-4.67)	2.01 (1.09-3.70)	1.47 (0.78-2.76)	1.49 (0.78-2.82)	1.19 (0.62-2.28)
Song Thrush	1	1.24 (0.60-2.55)	1.67 (0.83-3.36)	1.10 (0.51-2.35)	1.54 (0.77-3.08)	0.68 (0.30-1.57)	1.42 (0.60-3.38)	1.53 (0.52-4.48)	1.67 (0.72-3.84)
Buzzard	1	1.63 (0.85-3.12)	1.31 (0.62-2.77)	2.25 (1.16-4.34)	1.67 (0.81-3.42)	2.20 (1.16-4.17)	1.72 (0.80-3.72)	3.21 (0.88-11.75)	1.36 (0.59-3.10)
Pheasant	1	0.92 (0.60-1.39)	0.96 (0.62-1.49)	0.40 (0.23-0.71)	0.59 (0.37-0.96)	0.37 (0.22-0.62)	1.40 (0.81-2.42)	0.68 (0.24-1.94)	1.00 (0.54-1.85)
Pied Wagtail	1	2.29 (1.33-3.96)	1.15 (0.59-2.26)	1.26 (0.65-2.45)	1.23 (0.64-2.35)	1.06 (0.51-2.20)	1.74 (0.91-3.32)	1.13 (0.46-2.80)	1.02 (0.43-2.41)
Swallow	1	0.65 (0.37-1.14)	0.75 (0.43-1.33)	0.74 (0.42-1.30)	0.63 (0.36-1.12)	0.44 (0.23-0.85)	0.69 (0.35-1.36)	1.77 (0.62-5.07)	0.46 (0.19-1.11)

Table 4 Annual BBS indices (+95% confidence intervals) on land not under SRDP agri-environment scheme agreement over the period 1994-2002 for the 17 most widespread bird species. Indices are measured relative to the year 1994, which is set to 1. A visual comparison of indices within and outside SRDP land for these species is shown in Figure 1.

Species	1994	1995	1996	1997	1998	1999	2000	2001	2002
Meadow Pipit	1	1.15 (0.88-1.50)	1.09 (0.83-1.43)	1.28 (0.99-1.65)	1.28 (0.99-1.65)	1.19 (0.92-1.54)	1.54 (1.21-1.97)	1.22 (0.93-1.60)	1.38 (1.07-1.79)
Skylark	1	0.99 (0.76-1.30)	0.95 (0.73-1.23)	0.78 (0.59-1.01)	1.43 (1.14-1.81)	0.87 (0.67-1.14)	0.81 (0.62-1.05)	0.61 (0.45-0.84)	1.16 (0.91-1.49)
Wren	1	1.34 (0.86-2.09)	0.62 (0.35-1.08)	0.93 (0.57-1.52)	1.47 (0.95-2.29)	1.77 (1.16-2.69)	1.93 (1.28-2.91)	0.48 (0.22-1.04)	1.03 (0.62-1.70)
Willow Warbler	1	1.1 (0.74-1.64)	1.41 (0.96-2.06)	1.76 (1.23-2.52)	1.86 (1.3-2.67)	1.45 (1.00-2.12)	1.55 (1.06-2.26)	1.10 (0.68-1.77)	2.06 (1.40-3.01)
Chaffinch	1	0.95 (0.65-1.38)	0.96 (0.66-1.40)	0.90 (0.62-1.32)	1.3 (0.91-1.85)	0.84 (0.57-1.24)	0.90 (0.63-1.30)	1.31 (0.87-1.96)	0.99 (0.68-1.45)
Curlew	1	0.89 (0.59-1.34)	0.92 (0.62-1.37)	0.83 (0.55-1.27)	0.71 (0.45-1.11)	0.48 (0.28-0.81)	0.80 (0.5-1.28)	0.24 (0.12-0.50)	0.58 (0.35-0.98)
Carrion Crow	1	1.21 (0.64-2.29)	1.24 (0.65-2.36)	1.44 (0.78-2.68)	1.33 (0.70-2.52)	1.85 (1.03-3.32)	1.60 (0.89-2.90)	2.13 (1.03-4.39)	4.22 (2.44-7.30)
Robin	1	1.77 (0.99-3.17)	0.84 (0.41-1.70)	1.43 (0.78-2.63)	1.45 (0.78-2.69)	2.32 (1.32-4.09)	1.95 (1.09-3.49)	0.79 (0.32-1.93)	1.28 (0.67-2.45)
Woodpigeon	1	1.02 (0.65-1.59)	0.90 (0.57-1.44)	1.08 (0.70-1.69)	0.95 (0.60-1.5)	0.64 (0.39-1.07)	0.87 (0.57-1.33)	2.18 (1.35-3.51)	0.70 (0.44-1.12)
Blackbird	1	1.09 (0.71-1.67)	0.86 (0.55-1.36)	0.83 (0.52-1.32)	1.13 (0.74-1.74)	1.44 (0.97-2.14)	0.98 (0.65-1.48)	0.72 (0.38-1.37)	1.02 (0.63-1.64)
Blue Tit	1	1.03 (0.61-1.73)	0.86 (0.50-1.50)	0.93 (0.54-1.61)	0.93 (0.54-1.60)	0.81 (0.46-1.40)	0.94 (0.56-1.56)	0.40 (0.08-1.98)	0.73 (0.40-1.35)
Red Grouse	1	0.90 (0.38-2.11)	0.69 (0.29-1.65)	0.95 (0.46-1.97)	1.04 (0.51-2.15)	1.08 (0.53-2.20)	0.98 (0.49-1.99)	0.62 (0.27-1.45)	0.70 (0.34-1.47)
Song Thrush	1	0.48 (0.20-1.16)	0.77 (0.36-1.68)	0.78 (0.36-1.71)	1.12 (0.55-2.27)	1.29 (0.65-2.53)	1.46 (0.75-2.85)	0.40 (0.1-1.53)	1.66 (0.83-3.33)
Buzzard	1	0.88 (0.37-2.05)	1.15 (0.53-2.52)	2.07 (1.05-4.08)	2.32 (1.18-4.55)	1.88 (0.93-3.77)	1.88 (0.94-3.74)	1.22 (0.56-2.64)	1.75 (0.87-3.52)
Pheasant	1	1.93 (0.99-3.78)	1.36 (0.65-2.82)	1.64 (0.82-3.25)	1.41 (0.68-2.94)	1.32 (0.62-2.78)	0.82 (0.36-1.88)	1.76 (0.83-3.73)	1.44 (0.69-3.03)
Pied Wagtail	1	1.04 (0.55-1.98)	0.89 (0.46-1.72)	0.93 (0.48-1.81)	0.61 (0.29-1.29)	0.38 (0.16-0.88)	0.69 (0.35-1.36)	0.84 (0.27-2.61)	1.20 (0.61-2.37)
Swallow	1	0.51 (0.28-0.93)	0.87 (0.52-1.46)	0.80 (0.47-1.37)	0.65 (0.37-1.15)	0.91 (0.55-1.52)	0.88 (0.54-1.42)	1.22 (0.61-2.44)	1.22 (0.73-2.02)

Table 5 Results from the fitting of a linear trend across years on land affected by SRDP agri-environment schemes and matched land not affected by these schemes over the period 1994-2002 for the 17 the most widespread bird species. We present the annual rate of change and a test to examine whether change over time is significantly difference from zero. We also provide a test of the interaction between the trend in and outside SRDP agreement land.

Species	Within SRDP			Outside SRDP			Test of interaction	
	Annual rate of change (%)	χ^2	<i>P</i>	Annual rate of change (%)	χ^2	<i>P</i>	χ^2	<i>P</i>
Meadow Pipit	2.64	3.08	0.0793	3.76	7.87	0.0050	0.28	0.5948
Skylark	-0.77	0.14	0.7051	0.42	0.07	0.7909	0.22	0.6425
Wren	8.10	11.23	0.0008	4.53	3.02	0.0822	0.91	0.3401
Willow Warbler	10.68	47.76	<0.0001	6.35	9.71	0.0018	2.55	0.1102
Chaffinch	-0.75	0.21	0.6473	0.54	0.08	0.7795	0.26	0.6116
Curlew	-2.80	1.47	0.2251	-8.84	11.86	0.0006	3.08	0.0795
Carrion Crow	9.94	6.48	0.0109	17.69	30.66	<0.0001	1.94	0.1639
Robin	-5.42	3.20	0.0736	3.76	1.45	0.2292	4.22	0.0399
Woodpigeon	-13.45	17.05	<0.0001	-2.33	0.83	0.3626	7.72	0.0055
Blackbird	-5.21	3.38	0.0652	1.45	0.39	0.5301	3.38	0.0661
Blue Tit	3.10	1.00	0.3183	-3.34	1.51	0.2191	2.22	0.1362
Red Grouse	5.26	3.24	0.0717	-3.00	0.73	0.3928	3.19	0.0741
Song Thrush	1.92	0.21	0.6502	10.51	6.55	0.0105	2.00	0.1578
Buzzard	5.85	2.48	0.1153	6.77	3.84	0.0499	0.03	0.8602
Pheasant	-6.34	3.45	0.0631	-0.24	0.01	0.9430	1.68	0.1955
Pied Wagtail	-2.54	0.47	0.4914	-3.22	0.76	0.3830	0.02	0.8959
Swallow	-6.23	2.98	0.0845	4.57	2.56	0.1093	5.62	0.0177

Table 6 Summary of changes in abundance for 17 species on SRDP agreement land and on non agreement land, as determined by fitting an annual trend model. The index value for 2002 is presented (with associated 95% confidence intervals) relative to year 1994. Indices marked with an (*) show a significant change at the $P < 0.05$ level since 1994.

Species	Within SRDP		Outside SRDP	
	Index in 2002	95% CI	Index in 2002	95% CI
Meadow Pipit	1.16	(0.84-1.60)	1.38 *	(1.07-1.79)
Skylark	1.01	(0.64-1.60)	1.16	(0.91-1.49)
Wren	2.63 *	(1.64-4.22)	1.03	(0.62-1.70)
Willow Warbler	2.10 *	(1.60-2.75)	2.06 *	(1.40-3.01)
Chaffinch	1.39 *	(1.04-1.85)	0.99	(0.68-1.45)
Curlew	0.79	(0.48-1.32)	0.58 *	(0.35-0.98)
Carrion Crow	2.28 *	(1.12-4.66)	4.22 *	(2.44-7.30)
Robin	0.69	(0.38-1.26)	1.28	(0.67-2.45)
Woodpigeon	0.28 *	(0.14-0.58)	0.70	(0.44-1.12)
Blackbird	0.83	(0.47-1.44)	1.02	(0.63-1.64)
Blue Tit	1.52	(0.77-2.98)	0.73	(0.40-1.35)
Red Grouse	1.19	(0.62-2.28)	0.70	(0.34-1.47)
Song Thrush	1.67	(0.72-3.84)	1.66	(0.83-3.33)
Buzzard	1.36	(0.59-3.10)	1.75	(0.87-3.52)
Pheasant	1.00	(0.54-1.85)	1.44	(0.69-3.03)
Pied Wagtail	1.02	(0.43-2.41)	1.20	(0.61-2.37)
Swallow	0.46	(0.19-1.11)	1.22	(0.73-2.02)

Table 7 Mean density estimates calculated using distance sampling on land affected by SRDP schemes for the 17 most widespread species over the period 1994-2002. Bootstrapped 95% confidence intervals are shown in brackets.

Species	1994	1995	1996	1997	1998	1999	2000	2001	2002
Meadow Pipit	77.1 (50.9-116.8)	94.2 (68-130.3)	93.0 (63.7-135.9)	74.8 (52.4-106.9)	68.1 (44-105.5)	67.9 (38.6-119.3)	77.5 (47.5-126.5)	87.1 (43.6-174.1)	99.8 (57.1-174.7)
Skylark	11.5 (6.3-21)	13.7 (7.8-24)	10.0 (5.5-18.2)	12.8 (7.2-22.7)	15.8 (8.6-29.2)	11.1 (6.5-18.8)	13.2 (7.4-23.7)	10.3 (4.2-25.2)	12.2 (6.4-23.2)
Wren	9.8 (4.3-22.5)	12.6 (6.2-25.5)	9.5 (3.4-26.5)	9.3 (5-17.3)	14.1 (8.9-22.1)	14.1 (8.6-23.2)	13.9 (8.2-23.6)	9.7 (4.5-21)	14.1 (8.9-22.5)
Willow Warbler	16.0 (8.1-31.8)	14.2 (6.9-29.1)	15.8 (7.7-32.3)	17 (8.6-33.3)	20.9 (11.5-37.9)	17.3 (9.1-32.8)	11.8 (5.8-24)	29.4 (8.5-101.3)	21.2 (7.1-63.3)
Chaffinch	43.4 (18.0-104.2)	33.3 (15.1-73.6)	36.4 (14.0-94.7)	24.0 (13.3-43.5)	38.9 (22.2-68.1)	30.4 (14.8-62.3)	25.4 (14.4-44.6)	20.1 (7.4-54.1)	32.3 (18.4-56.7)
Curlew	2.8 (1.3-6.2)	3.2 (1.1-9.2)	2.3 (0.7-7.8)	1.3 (0.5-3)	2.4 (0.8-7.1)	2.2 (0.9-5.3)	1.7 (0.5-6)	0.2 (0-1)	0.6 (0.2-1.8)
Carrion Crow	2.9 (1.5-5.6)	4.2 (1.9-9.2)	10.1 (3.1-32.4)	6.5 (2.4-17.9)	2.9 (1.6-5.4)	3.7 (1.4-9.7)	3.5 (1.7-7.2)	0.5 (0.1-2.2)	6.4 (3-13.4)
Robin	8.5 (3.5-20.7)	6.9 (3.6-13.1)	5.6 (2.7-11.8)	2.8 (0.4-14.8)	7.7 (4-14.8)	10.2 (4.9-21.2)	7.3 (3.2-16.5)	2.5 (0.8-7.9)	7 (3.1-15.9)
Woodpigeon	31.2 (8.1-120.4)	9 (3.6-22.6)	6.3 (2.1-18.8)	6.3 (2.3-17.2)	10.4 (4.8-22.4)	9.8 (4.4-21.7)	6.5 (2.5-16.6)	16.7 (4.6-61.2)	11 (4.4-27.6)
Blackbird	9.1 (3.6-23.1)	10.2 (3.3-31.4)	7.6 (2.7-21.5)	4.6 (1.9-11.4)	8.2 (4.1-16.1)	8.4 (3.5-20.3)	7.6 (3.7-15.7)	6.5 (1.7-25.4)	6.3 (3.1-12.8)
Blue Tit	8.5 (3-24.1)	8.5 (3.7-19.5)	13.2 (4.4-39.9)	10.5 (4.4-24.7)	12.1 (6.1-28.9)	13.2 (6.2-28.4)	7.4 (3.8-14.3)	5.2 (1.5-18.1)	9.8 (4.6-21)
Red Grouse	6.4 (3.4-12.3)	5.2 (2.5-10.9)	6.7 (2.9-15.5)	4.5 (2-10)	6.3 (2.7-14.5)	8.9 (4.1-19.2)	6.5 (3-14.2)	5.9 (2.2-15.5)	6.5 (3.5-11.8)
Song Thrush	7.2 (3.7-14)	10.6 (2.7-40.8)	10.2 (4.1-25.3)	8.4 (3.3-21)	5.8 (3.3-10.2)	8.9 (3.3-24.2)	12.5 (2.8-56.8)	5.3 (0.1-411.6)	8.9 (3.7-21.1)
Buzzard	5.9 (0.4-83.3)	9.9 (6.8-14.4)	2 (1.4-2.9)	6.9 (0-1955.7)	2.8 (1.2-6.3)	3.6 (1.9-6.6)	2.8 (1.5-5.3)	2 (1.4-2.9)	4 (1-16.1)
Pheasant	3.8 (1.1-13.5)	3.7 (1.2-11.8)	3.5 (1-12)	2.3 (0.9-6.1)	2.8 (1.3-5.8)	2.2 (0.9-5.5)	2.8 (1.1-7)	3.7 (0.9-15.4)	4.6 (1.7-12.4)
Pied Wagtail	17.1 (8.4-34.7)	23.2 (13.6-39.6)	9.9 (6.3-15.7)	12.4 (9-17)	8.3 (4.5-15.4)	8.1 (5.6-11.7)	11.6 (5.5-24.6)	9.7 (1.2-79.8)	16.8 (3.4-81.8)
Swallow	4.4 (1.5-12.8)	0.7 (0.3-1.9)	1.2 (0.4-3.9)	1.6 (0.4-6.6)	0.6 (0.2-1.7)	1 (0.4-2.5)	0.8 (0.3-2.2)	0.5 (0.1-3.2)	0 (0-0)

Table 8 Mean density estimates calculated using distance sampling on land not affected by SRDP schemes for the 17 most widespread species over the period 1994-2002. Bootstrapped 95% confidence intervals are shown in brackets.

Species	1994	1995	1996	1997	1998	1999	2000	2001	2002
Meadow Pipit	55.9 (33.5-93.4)	52.1 (31.8-93.4)	55.9 (34.3-91)	60.3 (39.3-92.6)	57 (36.4-89.5)	52.2 (32.9-84.4)	56.1 (34.9-90)	45.4 (25.1-81.9)	52.4 (33-83.3)
Skylark	10.2 (6.1-17.3)	10.2 (5.5-18.9)	9 (4.6-17.4)	7.9 (4.4-14)	11.8 (7.1-19.9)	8.7 (5-15)	7.9 (4.6-13.4)	6.8 (3.1-14.9)	11.0 (6.2-19.3)
Wren	10.8 (5.3-21.7)	14.5 (8.3-25.2)	8 (4.7-13.6)	10 (5.7-17.6)	16.2 (9.8-26.7)	16.5 (10.6-25.6)	21.9 (13.3-35.9)	2.7 (0.8-8.9)	11.9 (6.6-21.7)
Willow Warbler	12.4 (6.9-22.3)	11.7 (6.9-19.9)	14.7 (8-26.9)	18.6 (10.8-32.2)	15.8 (9.4-26.7)	13.3 (8.1-21.7)	15.4 (9.3-25.8)	10.5 (3.6-30.8)	14.2 (8.7-23.3)
Chaffinch	31.4 (16.5-59.6)	33.8 (21.1-54.2)	33.3 (19.8-56.1)	28.7 (17.3-47.8)	38.3 (24.1-60.8)	30.5 (19.9-46.8)	33.9 (21.2-54.1)	22.3 (9.7-51.1)	34.4 (21.3-55.7)
Curlew	1.8 (0.5-6.3)	1.6 (0.6-4.3)	1.5 (0.6-3.6)	1.4 (0.5-3.8)	0.9 (0.3-2.7)	0.6 (0.2-1.3)	0.6 (0.2-1.8)	0.3 (0.1-2.3)	0.4 (0.2-1)
Carrion Crow	3.4 (1.6-7.2)	3.5 (2-6.4)	3.9 (1.8-8.4)	4.7 (1.8-11.9)	3.5 (1.6-7.6)	6.9 (2.4-20.1)	14.2 (4.3-47)	3.5 (1.8-6.8)	2.9 (0.9-8.9)
Robin	5 (2.3-10.5)	8.5 (4.8-15)	4.1 (2.2-7.9)	4.8 (2.8-8.3)	7.1 (4-12.7)	11.5 (6.8-19.5)	9.7 (5.8-16.3)	3.1 (1.2-8.1)	7.3 (4.1-12.9)
Woodpigeon	15.7 (5.4-45.7)	16.6 (6.9-39.7)	10.9 (5-23.4)	13.8 (4.5-42.1)	18.7 (8.6-40.8)	11.5 (5.7-23.2)	15.4 (7.2-32.7)	25 (7-88.9)	12.9 (5.9-27.9)
Blackbird	6.9 (3.1-15.4)	11.1 (6-20.4)	9.1 (4.7-17.8)	7.3 (3.9-13.9)	9.9 (5.4-17.9)	10.7 (5.8-19.8)	9 (4.5-17.8)	5.8 (1.4-23.9)	10.3 (5.1-20.6)
Blue Tit	13.5 (5.2-34.6)	15 (6.8-33.4)	12.7 (5.7-27.9)	12.5 (5.9-26.5)	13 (6.2-27.5)	9.6 (4.6-19.9)	9.6 (4.4-21.2)	1 (0.2-3.9)	10.4 (4.9-21.9)
Red Grouse	3.5 (1.3-9.6)	2.7 (1.1-6.4)	3.1 (1.3-7.3)	4.9 (2.5-9.7)	5 (2.6-9.6)	6.4 (2.7-15.5)	4.4 (2-9.6)	3.5 (1-12.8)	2.6 (5.6-5.6)
Song Thrush	5.8 (2.9-11.5)	4.4 (3.2-6.1)	5.3 (3.6-7.6)	5.7 (3.4-9.8)	7.6 (4.7-12.2)	7 (4.4-11.2)	8.2 (4.5-14.9)	6.2 (1-40.1)	5.1 (3.2-10.4)
Buzzard	2 (1.4-2.9)	2 (1.4-2.9)	2.8 (1.6-5)	3 (1.1-7.8)	2 (1.4-2.9)	5.9 (0-2725.9)	3.2 (1.3-7.7)	3 (0.1-73.9)	4 (1.1-14)
Pheasant	2.5 (0.9-7)	5.2 (2.2-12.3)	2.8 (1.1-6.7)	3.2 (1.4-7.1)	3.6 (1.5-8.9)	4 (1.1-14.4)	4.1 (0.9-18)	1.5 (0.7-3.7)	5.4 (1.8-16.1)
Pied Wagtail	12.2 (6.4-22.9)	13.1 (9-19)	8.5 (5.4-13.4)	12.6 (7.7-20.5)	14 (4.5-43.3)	7.2 (4-13)	11.1 (7.2-17)	7.7 (0-2610.8)	20.6 (10-42.7)
Swallow	0.5 (0.1-2.6)	2.6 (0.7-9.6)	2 (1-4.2)	3.9 (1.2-12.2)	4.7 (1.1-20.5)	4.6 (1.6-13)	7.9 (2.6-23.8)	3.5 (0.5-24)	4.9 (1.4-17.1)

Table 9 Comparison of bird richness (mean number of BBS species reported per BBS square) on land affected by SRDP agri-environment schemes with matched control square not affected by SRDP agricultural schemes. We also test the significance of the difference in median number of species recorded between these two land types using a Wilcoxon Rank Sum test.

Year	SRDP agreement land		Non-agreement land		Statistical comparison	
	Mean number of species (95% Confidence Interval)	N_1	Mean number of species (95% Confidence Interval)	N_2	W	P
1994	22.0 (16.7-27.3)	22	19.2 (13.5-24.9)	21	515.5	0.45
1995	19.2 (14.4-24.1)	25	21.4 (16.0-26.8)	22	573.0	0.57
1996	20.0 (14.9-25.2)	24	21.9 (16.5-27.3)	23	546.0	0.53
1997	21.0 (16.5-25.4)	22	21.3 (15.9-26.6)	24	510.0	0.89
1998	23.2 (18.7-27.8)	23	20.4 (16.3-24.4)	25	611.5	0.33
1999	20.3 (15.9-24.6)	24	19.6 (15.0-24.2)	24	594.5	0.90
2000	19.5 (15.3-23.7)	24	21.1 (16.8-25.5)	24	565.5	0.65
2001	20.1 (12.2-28.0)	10	16.0 (9.7-22.3)	9	109.5	0.46
2002	21.2 (16.4-26.0)	19	19.9 (15.1-52.7)	21	403.5	0.71

