



BTO Research Report No. 376

**Scoping Study on Integrating Countryside
Bird Survey and Breeding Bird Survey
Data to Generate All-Ireland Trends**

Newson, S.E., Crowe, O. & Noble D.G.

A report produced by British Trust for Ornithology and BirdWatch Ireland for
Environment & Heritage Service of Northern Ireland

May 2005

© **British Trust for Ornithology**

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

Newson, S.E., Crowe, O. & Noble D.G.

**Scoping Study on Integrating Countryside
Bird Survey and Breeding Bird Survey
Data to Generate All-Ireland Trends**

BTO Research Report No. 376

Published in May 2005 by the British Trust for Ornithology
The Nunnery, Thetford, Norfolk IP24 2PU, UK

ISBN 1-904870-47-3

© British Trust for Ornithology

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form, or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the publishers.

CONTENTS

	Page No.
1. EXECUTIVE SUMMARY.....	3
2. INTRODUCTION.....	5
2.1 Background to BBS and CBS	5
2.2 Rationale for this work.....	5
2.3 Objectives.....	5
3. METHODS	7
3.1 Survey organisation and field methods	7
3.2 Analytical techniques	8
3.2.1 Compilation of data	8
3.2.2 Analytical procedures.....	8
3.2.3 Analyses	8
3.3 Sensitivity analyses: implications of a cessation in professional coverage and expansion in volunteer recruitment	10
4. RESULTS	11
4.1 Survey coverage	11
4.2 Species coverage	12
4.3 Proc GENMOD versus TRIM.....	15
4.4 Trend analyses.....	16
4.4.1 Implications of a hypothetical cessation in professional coverage.....	22
4.4.2 Implications of an expansion in volunteer recruitment	22
5. CONCLUSIONS AND RECOMMENDATIONS.....	29
ACKNOWLEDGEMENTS	32
REFERENCES.....	34

1. EXECUTIVE SUMMARY

1. Breeding bird populations are used as indicators of sustainability throughout many parts of Europe. In the UK and Republic of Ireland, breeding bird populations have been monitored using line transect methodology since 1994 and 1998 respectively. The first collaborative analyses of breeding bird populations across the entire island of Ireland was initiated in January 2004. The project is funded the Environment and Heritage Service in Northern Ireland, and carried out by the two key organisations responsible for the coordination of the respective schemes in Britain and Ireland, the British Trust for Ornithology and BirdWatch Ireland.
2. Data were compiled for all species recorded between 1998 and 2003, in Northern Ireland and the Republic of Ireland (the latter subdivided into three regions – east, south and west).
3. Two similar log-linear regression modelling approaches, using the SAS procedure GENMOD and the computer program TRIM were used to produce trends in relative abundance in the UK and Republic of Ireland respectively. An assessment is made to ensure that these techniques produced similar results. Thereafter analyses for all-Ireland and Northern Ireland were produced using SAS, while those for the Republic of Ireland and regions were produced using TRIM. Trends were produced for all species that were present in at least 30 1-km squares.
4. A total of 151 species were recorded across the island, including 142 species in the Republic of Ireland and 125 in Northern Ireland. Wren, Robin and Blackbird were the most widespread, while Rook, Starling, Wren and Blackbird were the most abundant.
5. In total, trends were produced at an all-Ireland level for 61 species, for 55 species in the Republic and for 28 species in Northern Ireland. These included 27 species of conservation concern in the UK and 13 species of conservation concern in Ireland. Twelve species exhibited significant changes in abundance between 1998 and 2003. Trends were produced For 26 species, it was possible to produce trends for all four regions (NI and three regions in the Republic of Ireland). Increases in Pheasant, Woodpigeon and Wren and declines in Skylark, Swallow and Robin were consistent across regions, but trends for Mistle Thrush and Coal Tit varied between regions.
6. An assessment was made to examine the implications of a hypothetical cessation in professional coverage, and, conversely of an expansion in survey effort. Loss of professional coverage across Ireland could prevent the production of trends for eight species.
7. While an increase in survey coverage (overall or targeted to particular regions) is not predicted to substantially increase the number of species for which trends can be routinely reported, increasing sample size is likely to substantially increase the power to detect population changes, and the number of significant increases or declines that could be reported.
8. Production of all-Ireland population trends should be continued on an annual basis, and reported in a variety of media. Improved coverage, particularly around the border regions may result from workshops and meetings carried out at regular intervals. It is recommended that there be increased liaison between BBS and CBS coordinators.

2. INTRODUCTION

2.1 Background to BBS and CBS

The status of wild bird populations has been recognised as an indicator of the health of the environment. Their status in Northern Ireland and in the Republic of Ireland are monitored in each country by volunteer-based national schemes. In the UK, including Northern Ireland, the Breeding Bird Survey (BBS), a joint project of the British Trust for Ornithology (BTO), Joint Nature Conservancy Committee (JNCC) and Royal Society for the Protection of Birds (RSPB), was introduced in 1994 to monitor population trends of a broad range of breeding birds. 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. Raven *et al.* 2004).

The Countryside Bird Survey (CBS) was initiated in 1998. It is a joint project of BirdWatch Ireland (BWI), the National Parks and Wildlife Service (NPWS) and the Heritage Council. Its design closely resembles that of the BBS.

2.2 Rationale for this work

Ornithologists have long been interested in assessing bird populations on the island of Ireland as a whole. As well as the obvious conservation value of producing all-Ireland trends and the potential of these for producing Irish indicators similar to those in Pan-European Common Bird Monitoring project based on broad habitat categorizations, both parties would undoubtedly benefit from the sharing of ideas and expertise. Statutory Governments and Bird organisations in the UK and the Republic of Ireland realise the importance of such collaborative work and continue to work together on many bird related surveys. Further, population sizes and trends have also been assessed at an all-Ireland level for many bird groups (e.g. breeding seabird populations (Mitchell *et al.* 2004) and wintering waterbirds (data in prep).

The similarity in field methodology and recording between the BBS and CBS, greatly facilitates collaborative work, and ultimately the production of all-Ireland population trends. In 2002, BirdWatch Ireland collaborated with the BTO to produce annual CBS population indices using BBS analytical methods (Coombes *et al.* 2002). Although no formal comparisons were made in this report, reference was made to population trends for both Northern Ireland and all-Ireland produced for the same period, under the BBS program.

The six counties of Northern Ireland are part of a separate jurisdiction to those of the Republic, and have been subject to different laws. Differences in both landscape and farming practices both between the two countries as well as throughout the Republic largely determine the abundance and distribution of breeding bird populations throughout the island. Until now, collaborative work in this survey has been limited mostly by funding, with most allocated to suit the requirements of the respective governments. Additionally, the relative short-term life span of the project, particularly the CBS, would have greatly limited any conclusions and confidence in population trends produced.

A meeting to discuss the feasibility of an all-Ireland project was held in Dublin in February 2003. Representatives of both Statutory Governments, as well as the key organisations involved in both projects, were present. In January 2004, The Environment and Heritage Service of Northern Ireland provided funding for the collaborative project. It was agreed that the BTO would take a leading role, and that the bulk of the work would be divided more or less evenly between the BTO and BWI.

2.3 Objectives

This scoping study aims to further develop the comparisons between CBS and BBS trends, and assess the feasibility of producing population trends (trends in relative abundance) for as many species as possible at different spatial scales, including all-Ireland and smaller regions.

The primary objectives of this project were to:

- Assess data compatibility and produce a standardised combined CBS and BBS database.
- Assess analytical methods for producing population trends.
- Identify species for which all-Ireland trends could be consistently developed, considering both the long-term commitment to professional coverage, and opportunities for further volunteer recruitment.
- Identify species for which regional trends could be consistently developed, including an assessment of different approaches to regionalisation.
- Assess the costs and delivery mechanisms of the above as a long term BTO/BWI programme.

3. METHODS

3.1 Survey organisation and field methods

In the case of the Breeding Bird Survey, survey squares are selected randomly from a list of all 1 km squares that comprise Northern Ireland, excluding coastal squares with less than 50% land. The use of volunteers is maximised through a stratified random sampling design in which the number of squares allocated to each of the BTO's six regions (roughly counties), hereafter referred to as sampling regions, in Northern Ireland is a fixed proportion of the number of potential volunteers in the sampling region, estimated using BTO membership information. Sampling regions with relatively few potential volunteers are set a minimum level of coverage. Within each sampling region, squares are selected randomly, and allocated to volunteers by voluntary regional organisers. Organisers receive a list of target squares for their sampling region, and to maintain the random design of the survey, are asked to allocate them in the order generated.

The CBS uses a similar approach. However, the sampling design of the CBS is based on that used in *The Badger & Habitat Survey* (Smal 1995) using pre-selected 1 km squares throughout the country, each square being that at the extreme southwest corner of every 10 km square of the National Grid (which is roughly 1% of the total land area). In total, the Republic of Ireland comprises 729 such squares. Like the BBS, those with less than 50% land, e.g., coastal areas or lake shores, are excluded, leaving some 700 possible survey squares. The CBS is also based on a random and stratified design. The Republic of Ireland has been divided into eight sampling regions (each containing approximately three to four counties) and squares have been randomly selected within each, and allocated in sequence. An initial target of 330 squares was considered the minimum number of squares sufficient for a representative sample across the country. Both surveys aim to survey as many of the same 1 km squares every year, ideally by the same observer, although there is likely to be some changeover of volunteers. If a square cannot be surveyed, for example if a landowner refuses access permission, these squares are reported as being uncoverable and are subsequently removed from the active list.

BBS and CBS fieldwork involves three visits to each survey square per year, including a reconnaissance visit and two bird recording visits. During the reconnaissance visit, the transect routes are planned out and habitat information recorded. The ideal survey route comprises two parallel lines, each 1 km in length about 500 m apart and about 250 m from the edge of the square. Transects are divided into ten sections, making a total of ten 200 m sections. For practical reasons there is often substantial deviation from the ideal route, and for this reason, habitat data is collected periodically from both the ideal and the actual transects to allow correction for observer bias. Habitat information is recorded using codes from an established hierarchical system common to a range of BTO schemes (Crick 1992). Observers record the primary (dominant) and secondary habitat for each transect section in up to four levels of detail.

Bird counts are carried out on the second and third visits. Visits are timed so that the first is in the early part of the breeding season (April to mid-May) and the second at least four weeks later (from mid-May to the end of June). Volunteers are asked to begin their counts between 0600 and 0700 hours so that they coincide with maximum bird activity, but avoid concentrated song activity at dawn (Bibby *et al.* 1992). Volunteers record all the birds they see or hear as they walk methodically along their transect routes. However, only adult birds are used in the analysis of the population trends. Observers record the starting and finishing times for each of the two halves of the transect and weather conditions using three-level weather codes to describe cloud cover, rain, wind and visibility, although bird counts in heavy rain, poor visibility, or strong winds are discouraged.

3.2 Analytical techniques

3.2.1 Compilation of data

The total numbers of adult birds of each species detected in each 1 km square, i.e. summed over all distance categories and transect sections, are calculated for each year for both the BBS and CBS surveys. The current models use the maximum of the two counts (early and late) as the annual measure of relative abundance. The maximum was chosen as a simple means of simultaneously reflecting the abundance of residents and early migrants, which tend to be most abundant on the first visit, and later migrants, which tend to be most abundant in the second visit. Species not recorded in a particular survey year are assigned a count value of zero. Field and Gregory (1999) investigating the possibility that trends for gulls, waterfowl and waders might be influenced by the presence of non-breeders found that exclusion of counts greater than 5, 10 or 20 within single transect sections had no effect on trends for waterfowl or gulls, however, elevated counts did influence trends in some waders, so counts of greater than ten for a single transect section are excluded in the current models for wader species (see Noble *et al.* 1999). Golden Plover indices were additionally corrected to exclude all counts in non-upland habitat.

3.2.2 Analytical procedures

Annual population indices are routinely calculated for the BBS in SAS (SAS 1996) and for the CBS using TRIM (Trends & Indices for Monitoring Data). Both techniques use log-linear regression models with Poisson error terms. The SAS program is a modification of TRIM, and both are used for the analysis of time series of counts with missing observations (Pannekoek & van Strien 1996). Counts are modelled as a function of square (site) and year effects, with interpolated estimates for site-year combinations with missing data. Both procedures use the maximum likelihood method to fit the model. The SAS GENMOD corrects for over-dispersion by using the *dscale* option. Calculation of standard errors and test statistics differ from the standard maximum-likelihood method because of the need to take into account over-dispersion and serial correlation. While these usually have only a small effect on the estimates of parameters, they can have important effects on standard errors. TRIM uses Generalised Estimating Equations (GEE) procedures (McCullagh and Nelder 1989) to assess and test overdispersion and serial correlation.

The change in species populations is estimated by comparison between the start and end years in the series. Like most monitoring projects that involve the annual surveying of a large number of sites, both BBS and CBS data include many missing values, where a particular site was not monitored. The model is estimated using the observed counts and then used to predict the missing counts and calculate the indices from a full data set including observed and predicted counts. The model requires at least two points in the time series to estimate parameters and hence squares counted in only one year are excluded. Moreover, if the data are too sparse, i.e. contain too many missing values, the model parameters cannot be estimated. Because the stratified sampling design results in unequal representation of regions across Ireland, annual counts are weighted by the inverse of the proportion of the area of each region that is surveyed that year.

Whilst the SAS and TRIM analyses use slightly approaches to take observer coverage into account, both are effectively doing the same thing although trends will not be exactly identical through rounding differences. To examine how trends produced using PROC GENMOD and TRIM compare, we examine and report trends produced using these methods for 10 example species for the whole of Ireland (BBS + CBS) for the period 1998-2003.

3.2.3 Analyses

All trends were calculated across all habitats. Survey work was prevented due to foot-and-mouth disease restrictions in 2001, and hence modelling excludes 2001. Only results for species occurring on a mean of 20 or more squares over the six years of the survey are presented, though caution is urged because of the low precision associated with sample sizes smaller than 30 (Joys *et al.* 2003). The significance of the trends was examined by making a comparison between the first and last years of the survey. Because

non-overlapping of 95% confidence intervals highlight significance at the $\geq 5\%$ level, separate formal analyses to examine differences between indices were not performed.

For this project, bird data were analysed, and population trends produced, at three spatial levels:

1. All-Ireland, also referred to as Ireland (abbreviated to Irl in tables).
2. Northern Ireland (NI in tables) and Republic of Ireland, the latter hereafter referred to as the Republic (RoI).
3. Regional. Ireland has been divided into four study regions, based on broad habitat and land management practices (Fig. 1). Northern Ireland forms one study region and the Republic has been divided into three. The western study region (RoI-W) includes all remaining counties between Clare and Donegal inclusive. The southern study region (RoI-S) includes all counties south of the Shannon Estuary (including Counties Limerick and Tipperary) east to and including Counties Waterford, Kilkenny and Laois, while the eastern study region (RoI-E) encompasses all east coast counties, south of and including county Louth, and also including Cavan, Monaghan, Kildare and Carlow.

Any differences in the analytical techniques were resolved (see 3.2.2 *Analytical procedures*), and trends were produced for all-Ireland and Northern Ireland using PROC GENMOD, while those for the Republic and the regions thereof were produced using TRIM.

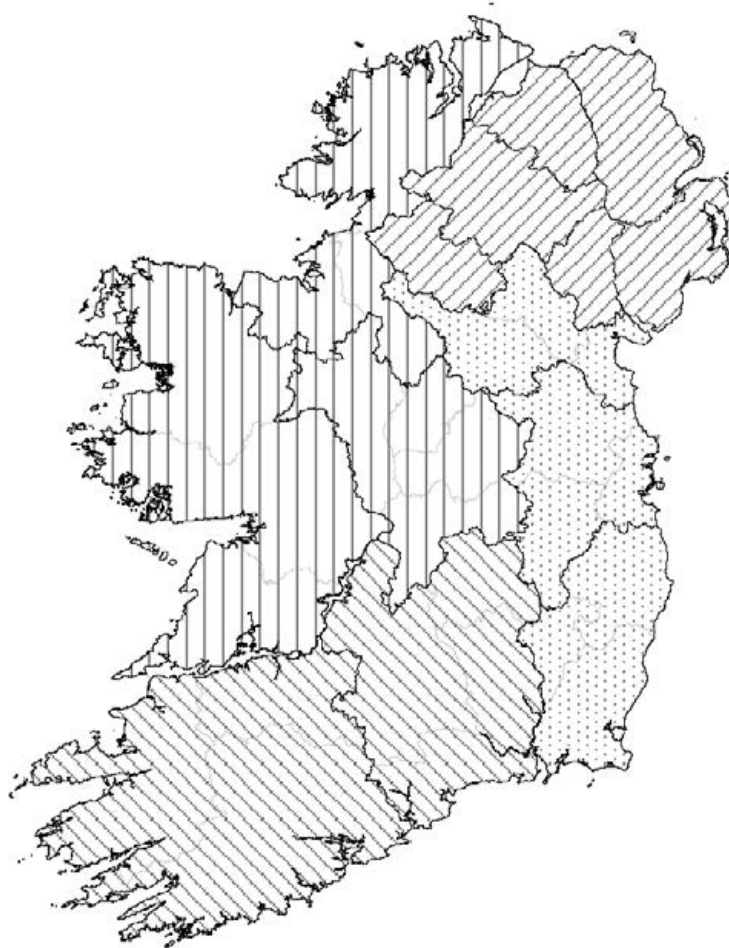


Figure 1. Map illustrating BBS and CBS sampling regions (black). Stripes and stipling represent the four study regions used in this project (clockwise from the top, NI, RoI-E, RoI-S & RoI-W).

3.3 Sensitivity analyses: implications of a cessation in professional coverage and expansion in volunteer recruitment

We examine the implications of a hypothetical cessation in professional coverage in the Republic of Ireland (RoI) and Northern Ireland (NI) and expansion of volunteer recruitment on the number of species that can be monitored by the CBS and BBS at the respective country and the combined all-Ireland level. It is important to note that in this report we examine simply the predicted loss and gain of species that can be monitored under different scenarios and do not explicitly model the changes in power to detect population change. Obviously, with increasing survey coverage, the power to detect a specified level of decline will increase and conversely the power will decline with reduced coverage, so a change in survey coverage has greater importance than simply the number of species which we can monitor.

To examine the implications of a cessation in professional coverage, we know which 1-km squares have been surveyed by professionals, so it is a simple task to re-run the analyses excluding these squares and examine the implications on the sample sizes, assuming a species needs to be recorded on a mean of 30 or more squares over the survey to produce reliable trends. We examine the influence of a cessation of professional coverage in Northern Ireland on Northern Irish trends, Northern Ireland on all-Ireland trends, the Republic on Republic of Ireland trends, the Republic on all-Ireland trends and the loss of all professional coverage on all-Ireland trends. We also examine the influence of a loss of BirdWatch Ireland and NPWS professional coverage separately on Republic of Ireland trends and on all-Ireland trends.

To examine the implications of an increase in survey coverage through volunteer recruitment, we make the assumption that whilst the number of 1-km squares surveyed may change, the proportion of squares reporting a specified species will remain constant. For example, for a species recorded on a mean of 25 of 200 squares surveyed (12.5% of squares), if an additional 100 squares were to be surveyed, we assume that this species would now be recorded on a 37.5 squares of the 300 squares surveyed. If this mean number of squares increases to 30 or more, we assume that the sample size is now adequate to produce a reliable trend in relative abundance for this species. It is important to note that these simulations examine the change in the mean number of squares reporting each species of the survey period and not the influence of a single additional survey year with different coverage.

4. RESULTS

4.1 Survey coverage

Overall, 488 squares were used in these analyses (Fig. 2). This includes 362 squares in the Republic of Ireland and 126 in Northern Ireland. The number of squares covered in Northern Ireland has ranged between 81 in 2000 and 101 in 2003, and in the Republic of Ireland between 259 in 1998 and 316 in 2002. Coverage in Northern Ireland was highest in Down and Fermanagh and lowest in Tyrone (Table 1), while coverage in the Republic of Ireland has generally been highest in the east and southeast regions (Table 1), and has been relatively low in the south and midlands. The proportion of squares that received two visits has ranged between 83% in 2003 and 91% in 2000 in the Republic and between 87% in 1998 and 97% in 2003 in Northern Ireland.

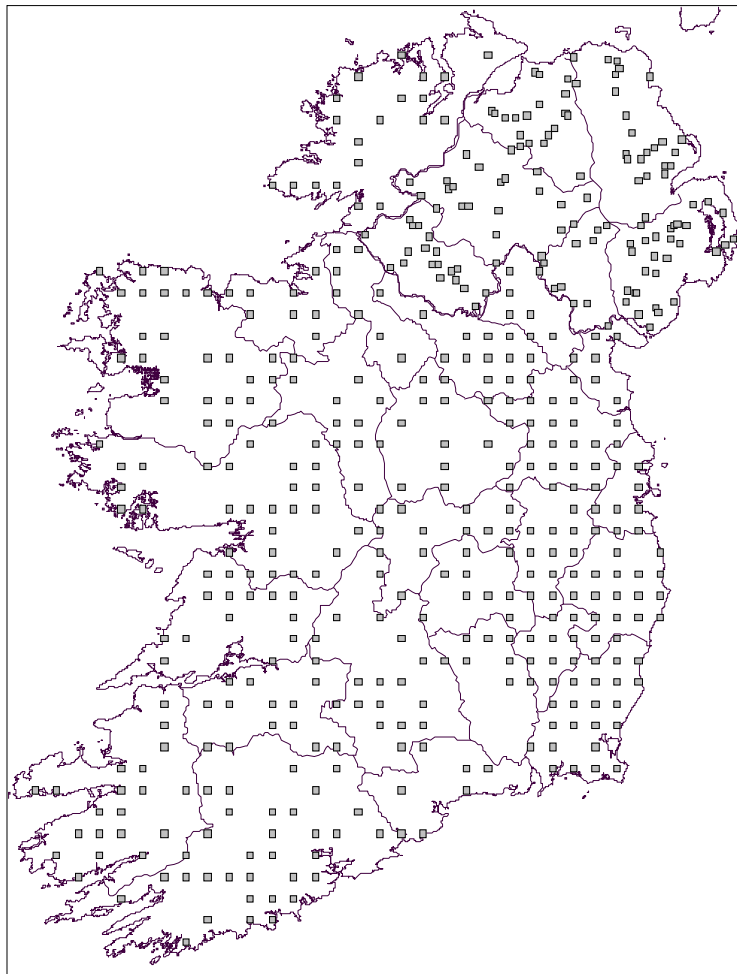


Figure 2. Squares covered in at least two seasons and used in analyses.

Table 1. Percentage of land area covered within each of the sampling regions between 1998 and 2003.

Sampling region		1998	1999	2000	2002	2003	Overall
NE	RoI	0.42	0.44	0.49	0.47	0.57	0.67
E	RoI	0.79	0.87	0.89	0.77	0.73	1.05
SE	RoI	0.74	0.81	0.81	0.76	0.79	0.93
S	RoI	0.25	0.29	0.38	0.39	0.37	0.42
SW	RoI	0.26	0.40	0.37	0.40	0.35	0.49
M	RoI	0.29	0.27	0.40	0.33	0.33	0.43
W	RoI	0.34	0.40	0.40	0.40	0.38	0.46
NW	RoI	0.31	0.41	0.40	0.39	0.34	0.47
ANTR	NI	0.47	0.57	0.60	0.63	0.69	0.79
ARMA	NI	0.37	0.56	0.25	0.50	0.50	0.87
DOWN	NI	0.86	0.99	0.78	0.95	0.91	1.19
FERM	NI	0.73	0.85	0.56	0.79	1.02	1.13
LDRY	NI	0.59	0.59	0.59	0.44	0.69	0.84
TYRO	NI	0.54	0.57	0.57	0.50	0.57	0.70

4.2 Species recorded

A total of 151 species were recorded during the CBS/BBS in Ireland. This includes 142 species in the Republic of Ireland and 125 species in Northern Ireland. The total recorded in any given season ranged between 120 (1999) and 128 (2000 & 2002). Occasional records (one or two records) were made of 31 species, including Turtle Dove, Short-eared Owl, Barn Owl, Ring Ouzel, Tree Pipit, Lesser Whitethroat, Reed Warbler, Pied Flycatcher and Brambling. The remaining scarce species mostly comprised waterbird species.

Wren, Robin and Blackbird were the most widespread species, all occurring in over 90% of squares overall in Ireland and in most of the regions. Chaffinch, Swallow, Wood Pigeon, Magpie, Song Thrush and Rook all occurred in greater than 80% of squares in Ireland, and in most regions. Rook, Starling, Wren and Blackbird were the most abundant species at both an all Ireland and regional level (Table 2a).

There were differences in geographical distribution of several species (Table 2a). The greater abundance and wider distribution of Meadow Pipit in Northern Ireland and in the western region is particularly noteworthy (Tables 2a & b). Skylark was also more widespread and numerous in the western region, and abundant in Northern Ireland. Yellowhammer was scarcer in the west and Northern Ireland while Stonechat was rarer in the eastern region and Northern Ireland. Pheasant was less numerous and was present in a much lower proportion of squares in Northern Ireland (Tables 2a & b).

Table 2a Top 50 most widespread species occurring in Ireland and in each of the regions. The proportion of squares in which each species has been recorded at least once is presented.

species	All	NI	RoI-W	RoI-S	RoI-E	species	All	NI	RoI-W	RoI-S	RoI-E
Wren	94.7	93.1	93.6	95.6	96.8	Linnet	36.8	35.2	33.7	39.3	39.6
Robin	92.5	89.8	90.0	94.4	96.2	Chiffchaff	35.7	27.6	24.7	47.0	45.7
Blackbird	92.3	89.5	89.1	94.4	96.6	Goldfinch	35.6	35.9	25.3	33.4	48.9
Chaffinch	89.6	90.9	83.7	90.7	94.3	Bullfinch	32.9	24.1	28.3	43.5	37.0
Swallow	86.6	86.9	79.4	89.3	92.3	House Martin	29.2	38.5	16.5	24.5	39.2
Wood Pigeon	86.3	84.0	75.5	90.7	96.8	Reed Bunting	28.0	30.3	33.0	21.5	25.9
Magpie	84.7	84.2	76.2	89.0	90.9	Mallard	27.2	23.4	33.9	20.6	28.9
Song Thrush	82.0	76.8	76.7	84.8	90.3	Cuckoo	24.4	22.5	43.0	16.6	11.9
Rook	81.1	78.2	70.3	85.3	92.3	Raven	23.2	23.8	25.8	23.4	19.6
Hooded Crow	76.6	82.0	75.8	74.1	75.0	Sedge Warbler	23.1	31.4	28.3	11.0	20.2
Blue Tit	76.3	76.2	67.0	79.4	84.0	Grey Heron	22.5	23.8	21.2	16.6	27.9
Jackdaw	73.2	76.2	59.9	75.0	83.8	Yellowhammer	21.8	7.8	7.4	26.6	46.5
Starling	72.0	79.5	65.4	71.5	73.1	Stonechat	19.6	14.7	29.4	25.9	7.7
Dunnock	70.5	71.7	55.4	75.7	82.0	Collared Dove	18.9	24.9	10.9	18.0	23.0
Willow Warbler	67.9	82.2	68.5	57.2	63.6	Curlew	18.1	31.0	21.5	9.4	10.3
Great Tit	64.8	67.0	55.0	64.3	74.3	Blackcap	17.7	23.6	10.4	11.5	26.1
Meadow Pipit	63.9	72.2	80.5	56.5	44.2	Grey Wagtail	17.6	20.3	17.7	15.7	16.8
Pheasant	63.6	33.4	62.5	77.3	80.4	Redpoll	16.9	27.8	14.9	10.1	15.2
Coal Tit	56.2	62.6	42.1	54.0	68.3	Whitethroat	16.2	12.7	16.5	16.4	19.0
Greenfinch	54.7	49.2	41.6	63.6	66.9	Swift	16.2	20.5	9.7	12.9	22.4
Mistle Thrush	49.9	61.5	44.3	39.5	54.8	Herring Gull	15.4	19.8	15.4	10.3	16.0
Skylark	47.0	39.2	67.2	38.8	38.4	Snipe	15.2	13.4	27.2	9.4	8.5
Goldcrest	44.7	43.0	35.5	46.5	55.2	Long-tailed Tit	14.9	14.5	9.3	18.9	18.0
Pied Wagtail	44.7	42.5	41.6	45.1	49.9	Kestrel	14.4	10.9	16.9	19.4	10.5
House Sparrow	43.5	50.6	31.9	43.9	49.7	Black-headed Gull	13.9	24.7	15.6	3.3	11.5
Total Species Recorded							151	125	123	108	115

Table 2b. Top 50 most abundant species occurring in Ireland and in each of the regions. The figure indicates the total number of each species recorded across all years.

species	Irl	NI	RoI-W	RoI-S	RoI-E	species	Irl	NI	RoI-W	RoI-S	RoI-E
Rook	61,325	11,883	9,745	15,013	24,684	Goldcrest	3,007	749	505	834	919
Starling	28,005	9,769	7,370	5,014	5,852	Mistle Thrush	2,708	822	702	482	702
Wren	26,354	5,769	6,339	6,032	8,214	Herring Gull	2,504	693	589	346	876
Blackbird	20,932	3,882	5,380	5,208	6,462	Mallard	2,058	434	881	252	491
Swallow	20,117	4,710	5,005	4,431	5,971	Goldfinch	2,043	416	387	453	787
Wood Pigeon	19,376	3,470	3,253	4,494	8,159	Chiffchaff	1,888	337	343	603	605
Robin	18,831	3,565	4,627	4,966	5,673	Pied Wagtail	1,865	348	518	466	533
Jackdaw	18,707	4,863	4,079	3,530	6,235	Yellowhammer	1,782	130	102	380	1,170
Chaffinch	17,362	5,165	3,788	3,706	4,703	Feral Pigeon	1,535	273	11	402	849
Meadow Pipit	13,365	4,344	5,390	2,032	1,599	Sedge Warbler	1,519	480	560	140	339
Magpie	9,280	2,502	2,102	2,075	2,601	Sand Martin	1,504	129	610	102	663
Willow Warbler	8,910	3,043	2,802	1,247	1,818	Bullfinch	1,414	213	347	468	386
Song Thrush	8,389	1,386	1,988	2,130	2,885	Swift	1,345	480	142	185	538
Blue Tit	6,929	1,747	1,651	1,491	2,040	Reed Bunting	1,299	396	454	193	256
Hooded Crow	6,474	1,828	1,956	1,239	1,451	Lesser B-b Gull	1,225	438	258	135	394
House Sparrow	6,237	1,906	1,037	1,266	2,028	Curlew	1,106	419	442	146	99
Skylark	5,866	1,810	2,415	888	753	Redpoll	1,081	419	282	181	199
Duncock	5,841	1,248	1,065	1,713	1,815	Long-tailed Tit	1,034	239	181	312	302
Greenfinch	4,965	910	835	1,324	1,896	Raven	981	245	305	246	185
Great Tit	4,163	1,142	914	932	1,175	Common Gull	934	86	636	3	209
Pheasant	4,068	308	1,109	1,084	1,567	Collared Dove	931	322	122	194	293
Linnet	3,623	738	745	886	1,254	Stonechat	922	142	432	268	80
Coal Tit	3,445	1,001	717	649	1,078	Grey Heron	831	227	216	133	255
House Martin	3,199	1,061	533	543	1,062	Cuckoo	792	161	447	104	80
Black-headed Gull	3,104	1,542	612	51	899	Blackcap	736	282	120	88	246

4.3 Proc GENMOD versus TRIM

There was generally good agreement between the two analytical packages used in the production of all trends for 10 species (Fig. 3). Therefore, it is assumed that the use of different analytical procedures did not bear any important effects on the trends produced.

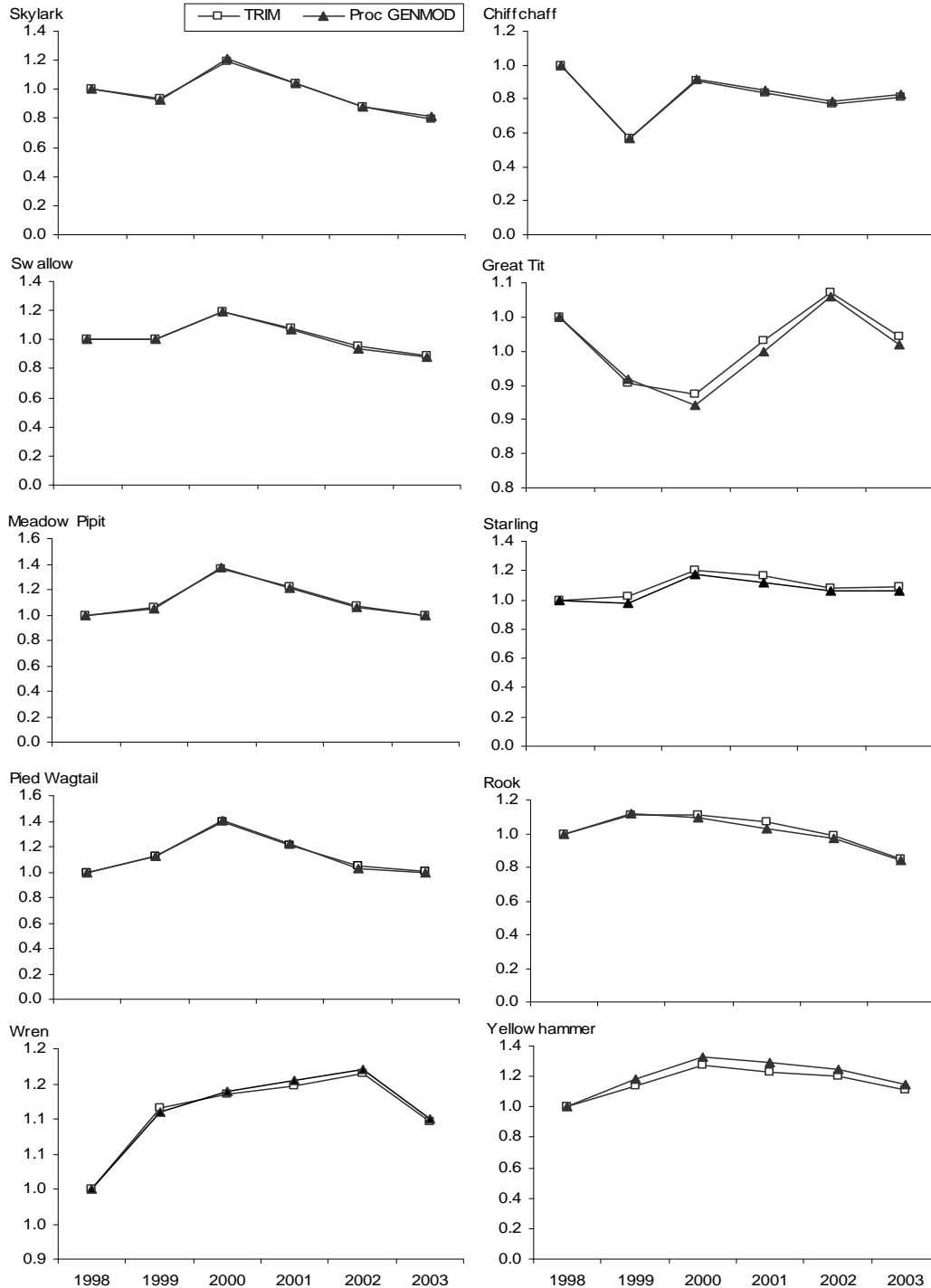


Figure 3. Comparison of the analytical techniques used on ten common species. Open squares represent TRIM, while closed triangles represent SAS PROC GENMOD.

4.4. Trend analyses

Of the 61 species recorded in 30 or more squares in Ireland, there were significant increases in 12 species and declines in a further 12 species between 1998 and 2003 (Table 3). Significant increases included Pheasant, Curlew, Feral Pigeon, Woodpigeon, Wren, Dunnock, Stonechat, Jackdaw, Goldfinch, Linnet, Redpoll and Bullfinch. There was also an increase in Buzzard over this time period, which is coincident with an apparent expansion in range of this species, particularly throughout the northeast. However, the low sample size reduces the precision of this trend. There were particularly large and significant declines in Lesser Black-backed, Herring and Great Black-backed Gull, Stock Dove, Swift, Skylark, Swallow, Robin, Wheatear, Grasshopper Warbler Chiffchaff and Rook.

A total of 28 species were included in trend analyses for Northern Ireland (Table 3). There were significant increases in Woodpigeon, Mistle Thrush, Greenfinch and Goldfinch. This shows partial agreement with NI generated using the full data set from 1994-2003 (Raven *et al.* 2004). Of these four increasing species, the small number of sites surveyed in the early years of the BBS (1994 and 1995 in particular), meant that a trend was not produced for Goldfinch, whilst Woodpigeon and Greenfinch also increased significantly over the longer time period from 1994. In contrast, the trend of Mistle Thrush fluctuated in abundance between 1994-1999, following by an increase from 1999-2003, such that a significant increase was observed in this study from 1998-2003, but no significant change was detected between 1994 and 2003. Other species to show a significant increase from 1994-2003, but no significant change in abundance from 1998 includes Meadow Pipit, Wren, Dunnock, Blackbird, Willow Warbler, Coal Tit, Blue Tit, Great Tit, Rook, Hooded Crow and Chaffinch.

Significant declines for the period 1998-2003 were observed in Skylark, Robin, Sedge Warbler and Willow Warbler. Whilst the sample was not adequate to produce a trend for Sedge Warbler for the longer period from 1994, Skylark and Robin showed not significant change in abundance from 1994-2003. The trend for Willow Warbler is interesting in that it increased from 1994 to 1998, followed by a decline to 2003 although remaining at a higher level than in 1994. This means that whilst the change in abundance from 1998-2003 shows a significant decline, the change in abundance from 1994-2003 is a significant increase.

Of the 55 species eligible for trend analyses for the Republic of Ireland, there were seven significant increases and 14 declines. Increases included Pheasant, Curlew, Wren, Dunnock, Stonechat, Goldfinch and Linnet, all of which were shown to increase, though only some significantly, between 1998 and 2000 (Coombes *et al.* 2002). Of the declines, nine species had shown to be in decline during the 1998 to 2000 period, and two of these (Black-headed and Herring Gull) were significant. The remaining five species all showed reverse trend during the previous three-year interval, with Swallow significantly increasing.

At a regional level, and with Northern Ireland already discussed above, most of the species increases were from the eastern region, most declines were evident in the west, and there were few significant changes in the southern region (Table 3). Increases in the eastern region included Pheasant, Wren, Dunnock, Jackdaw and Linnet, while there were declines in just two species, Pied Wagtail and Mistle Thrush. There were significant increases in Goldfinch in all other than the eastern region. It was the only species shown to increase in both the western and southern regions, though low sample sizes in both limit this conclusion. There were declines in a further eight species in the western region, including Cuckoo, Swallow, Robin, Mistle Thrush, Goldcrest, Coal Tit, Blue Tit and Great Tit.

Comparison across regions- the potential for indicators

A total of 26 species were analysed across all regions (Table 3). The sample sizes of a further three species, Chiffchaff, Goldfinch and Bullfinch, were just below 30 in one or more regions, thereby limiting any conclusions based on the comparisons in their trends at a regional level. However, Goldfinch has significantly increased across all regions between 1998 and 2003, and it is likely that this species will be sufficiently widespread in future seasons to permit valid analyses.

Trends were consistent across regions for most species (Table 3), with increases in Pheasant, Woodpigeon, Wren, Dunnock and Linnet and declines in Skylark, Swallow and Robin quite prominent. However, there were several cases where regional trends did not corroborate. For example, Mistle Thrush increased in Northern Ireland and declined across the Republic, while Coal Tit declined in the west and increase in the east.

Effectiveness of the BBS/CBS for monitoring PSOB/BoCCI/Pan-EU species

In total, 10 Red-listed and 17 Amber-listed species on the PSOB list and three Red and 10 Amber-listed species from the BoCCI list have been included in analyses, at least at an all-Ireland level (Table 4). Of these, Skylark, Meadow Pipit, Dunnock, Song Thrush, Mistle Thrush, Starling and House Sparrow in particular, despite their previous declines in Ireland and/or Britain, remain widespread enough for analyses at all regional levels. Additionally, 22 out of the 41 species analysed as part of the pan-EU project were analysed across all regions (Table 4). Of these, just two are used in those analyses as farmland and six as woodland indicators, with remaining species classified as from all other habitat types. However, as only a very small proportion of Ireland is forested, almost all of those listed woodland indicators as well as those in the 'other habitats' category are typical of farmland in Ireland.

Table 3. Population change in Irish bird populations at different geographic levels. The sample size (n) shown for each species is the mean number of squares in which the species was recorded over the six-year period (excluding squares surveyed in only one year). The species listed occurred in 20 squares or more, although the power to detect change in species occurring on fewer than about 30 squares is likely to be small and population change estimates should be treated with caution. The percentage change in relative abundance from 1998-2003 is presented and 95% confidence intervals shown in parentheses. Significant population change at the 5% level is highlighted in bold. Shaded rows illustrate species which were analysed across all regions.

Species	Irl		NI		RoI		RoI-W		RoI-S		RoI-E	
	n	Change98-03	n	Change98-03	n	Change98-03	n	Change98-03	n	Change98-03	n	Change98-03
Cormorant	(28)	17 (-26 - 86)	-	-	(21)	32 (-28 - 92)	(24)	27 (-32 - 86)	-	-	(28)	28 (-30 - 87)
Grey Heron	87	11 (-13 - 41)	(21)	15 (-25-78)	65	13 (-20 - 46)	-	-	-	-	-	-
Mute Swan	(26)	12 (-37 - 100)	-	-	-	-	-	-	-	-	(29)	129 (1 - 258)
Mallard	105	28 (0 - 63)	(21)	60 (-17-207)	84	25 (-8 - 59)	38	5 (-34 - 44)	-	-	-	-
Sparrowhawk	40	0 (-33 - 50)	-	-	(29)	-13 (-60 - 34)	-	-	-	-	-	-
Buzzard	(24)	204 (69 - 447)	-	-	-	-	-	-	-	-	-	-
Kestrel	56	-19 (-42 - 13)	-	-	46	-22 (-53 - 10)	-	-	-	-	-	-
Pheasant	246	16 (3 - 30)	30	-12 (-45-40)	216	20 (5 - 34)	70	-2 (-22 - 18)	66	22 (-5 - 49)	80	48 (20 - 77)
Moorhen	49	31 (-8 - 87)	-	-	38	50 (-15 - 115)	-	-	-	-	(21)	15 (-43 - 74)
Lapwing	29	25 (-18 - 91)	-	-	(20)	26 (-40 - 92)	-	-	-	-	-	-
Snipe	59	24 (-7 - 67)	-	-	47	23 (-21 - 66)	30	-3 (-43 - 36)	-	-	-	-
Curlew	70	49 (2 - 99)	(28)	-39 (-66-8)	42	68 (5 - 131)	(24)	44 (-22 - 110)	-	-	-	-
Black-headed Gull	54	-18 (-42 - 15)	(22)	64 (-10-202)	32	-43 (-68 - -17)	-	-	-	-	-	-
Common Gull	(21)	0 (-41 - 71)	-	-	-	-	-	-	-	-	-	-
Lesser Black-backed Gull	40	-46 (-65 - -19)	-	-	-	-	-	-	-	-	-	-
Herring Gull	60	-67 (-77 - -52)	-	-	42	-68 (-85 - -52)	-	-	-	-	-	-
Great Black-backed Gull	(21)	-66 (-81 - -40)	-	-	20	-69 (-92 - -46)	-	-	-	-	-	-
Feral Pigeon	41	80 (19 - 175)	-	-	33	121 (6 - 236)	-	-	-	-	(22)	56 (-21 - 134)
Stock Dove	33	-41 (-61 - -11)	-	-	32	-34 (-64 - -5)	-	-	-	-	-	-
Woodpigeon	333	12 (3 - 21)	75	41 (17-70)	258	10 (0 - 20)	84	-3 (-21 - 16)	78	-2 (-17 - 13)	96	30 (14 - 46)
Collared Dove	73	4 (-21 - 37)	(22)	36 (-17-125)	50	-11 (-40 - 19)	-	-	-	-	(23)	-36 (-67 - -5)
Cuckoo	94	-21 (-39 - 2)	(20)	30 (-33-152)	74	-25 (-46 - -4)	48	-31 (-54 - -8)	-	-	-	-
Swift	62	-29 (-48 - -1)	-	-	44	-47 (-71 - -22)	-	-	-	-	(22)	-69 (-88 - -49)
Sky lark	181	-19 (-29 - -8)	35	-39 (-54--20)	146	-14 (-27 - -1)	75	-10 (-27 - 8)	70	-19 (-49 - 11)	38	-21 (-45 - 3)
Sand Martin	33	24 (-22 - 97)	-	-	-	-	-	-	-	-	-	-
Swallow	334	-12 (-20 - -4)	78	5 (-16-31)	256	-14 (-23 - -6)	89	-25 (-37 - -12)	76	-9 (-25 - 7)	91	-3 (-19 - 14)
House Martin	113	-5 (-25 - 20)	35	-31 (-57-11)	78	-1 (-28 - 27)	-	-	(21)	7 (-48 - 62)	39	-24 (-54 - 6)
Meadow Pipit	247	-1 (-11 - 10)	65	10 (-11-36)	182	-4 (-16 - 8)	90	-7 (-23 - 8)	48	7 (-23 - 38)	44	11 (-16 - 38)

Species	Irl		NI		RoI		RoI-W		RoI-S		RoI-E	
	n	Change98-03	n	Change98-03	n	Change98-03	n	Change98-03	n	Change98-03	n	Change98-03
Pied Wagtail	173	0 (-17 - 20)	38	27 (-16-93)	134	-4 (-24 - 16)	46	8 (-31 - 47)	39	-1 (-40 - 38)	49	-26 (-51 - -1)
Wren	366	10 (3 - 17)	84	-5 (-18-11)	282	13 (5 - 20)	104	2 (-10 - 13)	82	15 (0 - 31)	96	23 (11 - 35)
Duncock	272	17 (5 - 31)	64	12 (-13-44)	208	18 (3 - 32)	62	8 (-18 - 35)	65	20 (-5 - 45)	81	25 (1 - 49)
Robin	357	-10 (-15 - -4)	81	-16 (-29--2)	276	-8 (-15 - -2)	100	-20 (-30 - -10)	81	-5 (-18 - 8)	95	2 (-9 - 13)
Stonechat	76	113 (55 - 194)		-	63	111 (32 - 190)	33	47 (-24 - 118)	(22)	315 (-9 - 638)		-
Wheatear	47	-32 (-53 - -1)		-	34	-34 (-64 - -5)	(24)	-28 (-62 - 6)				-
Blackbird	356	-1 (-7 - 5)	80	-8 (-21-7)	276	0 (-7 - 6)	99	-5 (-16 - 6)	81	-2 (-14 - 11)	96	8 (-3 - 19)
Song Thrush	317	9 (-1 - 19)	69	-6 (-25-17)	248	11 (-1 - 22)	86	-3 (-21 - 15)	73	17 (-6 - 41)	89	20 (2 - 37)
Mistle Thrush	193	-10 (-25 - 9)	55	43 (2-102)	137	-22 (-40 - -5)	49	-43 (-66 - -21)	34	37 (-26 - 100)	54	-32 (-55 - -9)
Grasshopper warbler	47	-47 (-63 - -25)		-	31	-48 (-72 - -24)	(22)	-42 (-72 - -12)				-
Sedge Warbler	89	20 (-8 - 55)	(28)	-43 (-63--13)	61	50 (0 - 99)	32	48 (-16 - 111)			(20)	110 (-2 - 223)
Whitethroat	63	-2 (-29 - 35)		-	51	0 (-36 - 36)		-				-
Blackcap	68	30 (-1 - 70)	(21)	8 (-29-67)	47	41 (-7 - 89)		-			(26)	22 (-31 - 75)
Chiffchaff	138	-17 (-30 - -1)	(25)	-28 (-54-13)	113	-16 (-32 - -1)	(28)	-42 (-66 - -17)	40	-1 (-32 - 29)	45	-10 (-36 - 15)
Willow Warbler	262	-10 (-19 - 0)	74	-34 (-44--21)	188	-1 (-13 - 12)	76	-4 (-23 - 15)	49	-4 (-31 - 22)	63	9 (-13 - 32)
Goldcrest	173	-4 (-19 - 13)	39	30 (-8-85)	134	-11 (-27 - 6)	40	-36 (-60 - -12)	40	-6 (-41 - 29)	55	15 (-13 - 43)
Spotted Flycatcher	36	-10 (-41 - 38)		-	(28)	-9 (-56 - 38)		-				-
Long-tailed Tit	57	38 (-4 - 99)		-	44	23 (-30 - 76)		-				-
Coal Tit	217	-6 (-20 - 10)	56	16 (-14-58)	161	-8 (-24 - 9)	47	-45 (-63 - -28)	46	-6 (-40 - 28)	68	60 (18 - 102)
Blue Tit	294	-2 (-12 - 9)	68	23 (-1-51)	226	-8 (-20 - 3)	75	-24 (-40 - -8)	68	19 (-9 - 47)	83	-11 (-28 - 6)
Great Tit	250	-4 (-16 - 10)	60	12 (-14-47)	190	-8 (-22 - 6)	61	-25 (-45 - -5)	55	3 (-28 - 34)	74	4 (-21 - 30)
Treecreeper	32	12 (-31 - 81)		-	(21)	-23 (-71 - 25)		-				-
Maggpie	327	-6 (-15 - 3)	76	2 (-17-26)	251	-6 (-16 - 5)	85	-16 (-32 - 0)	76	-10 (-28 - 8)	90	15 (-6 - 36)
Jackdaw	282	20 (7 - 35)	68	21 (-7-56)	214	20 (2 - 37)	67	8 (-21 - 36)	64	23 (-7 - 53)	83	33 (3 - 63)
Rook	313	-16 (-26 - -4)	70	-15 (-37-14)	243	-15 (-28 - -2)	78	-10 (-34 - 14)	73	-21 (-41 - 0)	91	-15 (-35 - 6)
Hooded Crow	296	7 (-6 - 22)	74	23 (-4-56)	222	5 (-13 - 22)	85	-4 (-29 - 21)	63	1 (-28 - 31)	74	25 (-9 - 59)
Raven	90	27 (-4 - 69)	(21)	132 (30-313)	68	13 (-26 - 52)	(29)	-3 (-51 - 45)	(20)	33 (-58 - 124)		-
Starling	278	6 (-8 - 23)	71	1 (-26-39)	207	7 (-12 - 26)	73	24 (-12 - 60)	61	1 (-31 - 33)	72	-17 (-43 - 8)
House Sparrow	168	8 (-8 - 28)	45	12 (-18-53)	122	7 (-15 - 29)	36	5 (-38 - 47)	38	9 (-31 - 49)	49	8 (-23 - 38)
Chaffinch	346	6 (-2 - 15)	82	-4 (-21-18)	264	10 (0 - 19)	93	9 (-8 - 27)	78	-2 (-18 - 13)	93	27 (10 - 43)
Greenfinch	211	13 (-3 - 32)	44	67 (14-145)	167	6 (-12 - 24)	46	-15 (-45 - 15)	54	45 (-3 - 92)	66	-8 (-29 - 12)
Goldfinch	137	127 (81 - 185)	32	74 (6-186)	105	116 (58 - 174)	(28)	143 (13 - 272)	(29)	227 (47 - 406)	48	39 (-9 - 87)
Siskin	(21)	-17 (-53 - 47)		-		-		-				-
Linnet	142	63 (30 - 105)	32	48 (-9-141)	110	67 (23 - 111)	38	66 (-18 - 150)	34	36 (-32 - 105)	39	101 (24 - 177)

Species	Irl		NI		RoI		RoI-W		RoI-S		RoI-E	
	n	Change98-03	n	Change98-03	n	Change98-03	n	Change98-03	n	Change98-03	n	Change98-03
Bullfinch	127	27 (4 - 56)	(22)	28 (-22-111)	105	29 (-2 - 60)	32	39 (-28 - 106)	37	8 (-30 - 46)	37	65 (0 - 131)
Yellowhammer	84	15 (-6 - 46)		-	77	12 (-12 - 35)		-	(23)	57 (-19 - 133)	46	3 (-21 - 27)
Reed Bunting	108	10 (-12 - 36)	(27)	8 (-27-60)	81	10 (-21 - 41)	37	7 (-33 - 48)	(26)	-	(26)	39 (-32 - 110)

Table 4. BoCCI or PSOB red or amber listed species, which can be monitored at an all-Ireland level. Species included in pan-EU analyses have been assigned F, W or O in accordance with the farmland, woodland or other habitat type which they best represent across Europe. Those species that were analysed across all regions are shaded in grey.

Species	BoCCI	PSOB	Pan-EU
Cormorant			
Grey Heron			
Mute Swan			
Mallard			
Sparrowhawk			W
Buzzard			O
Kestrel			O
Pheasant			
Moorhen			
Lapwing	R	A	F
Snipe	A	A	
Curlew	R	A	
Black-headed Gull	A	A	
Common Gull			
Lesser Black-backed Gull		A	
Herring Gull		A	
Great Black-backed Gull			
Feral Pigeon			
Stock Dove	A	A	
Woodpigeon			F
Collared Dove			
Cuckoo	A	A	O
Swift			
Skylark	A	R	F
Sand Martin	A	A	
Swallow		A	W
House Martin		A	
Meadow Pipit		A	
Grey Wagtail		A	
Pied Wagtail			O
Wren			O
Dunnock		A	W
Robin			O
Stonechat	A	A	
Wheatear			
Blackbird			O
Song Thrush		R	O
Mistle Thrush		A	O
Grasshopper warbler	A	R	
Sedge Warbler			
Whitethroat			
Blackcap			O
Chiffchaff			W
Willow Warbler			O
Goldcrest			W
Spotted Flycatcher	A	R	W
Long-tailed Tit			W
Coal Tit			W
Blue Tit			W
Great Tit			O

Species	BoCCI	PSOB	Pan-EU
Treecreeper			W
Magpie			O
Jackdaw			O
Rook			
Hooded Crow			O
Raven			
Starling		R	W
House Sparrow		R	
Chaffinch			O
Greenfinch			O
Goldfinch			W
Siskin			
Linnet		R	O
Lesser Redpoll	A	A	
Bullfinch		R	W
Yellowhammer	R	R	F
Reed Bunting		R	O

4.4.1 Implications of a hypothetical cessation in professional coverage

The number (and percentage) of squares surveyed by professionals in each year is shown in Table 5. This highlights the fact that both the CBS and BBS rely very heavily on professional field workers. Removing this coverage would result in a number of species being no longer monitored (Table 6). Removing professional coverage in the Republic of Ireland would prevent reliable trends being produced for 10 species in that country, of which five species (Curlew, Kestrel, Lesser Redpoll, Grasshopper Warbler, Stock Dove) are Red or Amber listed in the BoCCI and/or PSOB lists. Removing professional coverage in Northern Ireland is likely to remove 8 species from species that can currently be monitored there. This includes three species that are listed as being of conservation concern (Skylark, Goldcrest and Linnet) in BoCCI or PSOB. If professional coverage were to cease in both Northern Ireland and the Republic of Ireland the overall effect on the all-Ireland trends would be to prevent reliable trends being produced for eight species, comprising Lapwing, Feral Pigeon, Lesser Black-backed Gull, Sparrowhawk, Spotted Flycatcher, Sand Martin, Treecreeper and Stock Dove. Of these species, all except three are listed as being of conservation concern.

4.4.2 Implications of an expansion in volunteer recruitment

Implications for trends within the Republic of Ireland

With the current level of coverage, the CBS can produce reliable trends in relative abundance for 55 species in the Republic of Ireland. Assuming that the relative coverage in different regions remains constant, increasing survey coverage in the Republic of Ireland by 25 squares per year would allow an additional three species to be monitored (Sparrowhawk, Sand Martin and Spotted Flycatcher). Although breeding gulls and other seabirds are likely to be better monitored by targeted colony surveys and for this reason will not be presented in the forthcoming BBS annual report (Raven pers. comm.), with an additional 100 survey squares, Lesser Black-backed Gull could be monitored, in terms of sample size at least. An additional 200 survey squares would add Mute Swan, Great Black-backed Gull and Lapwing, whilst 300 squares would add Common Gull and 400 squares Tree Sparrow and Siskin. Whilst several of these species are Red or Amber listed BoCCI or PSOB species, this suggests that an increase in coverage would add relative few species to those for which trends are currently presented. However, it is again important to stress that we do not examine here the power to detect a specified level of population change, which will increase for all species with increased survey coverage.

In the above scenarios, we assume that the relative coverage in different regions within the Republic remains constant, with an absolute increase in coverage. However, in practice a better strategy would be to target regions of poorer coverage, to enable as much as possible the trends to be representative of the Republic as a whole. Table 7 examines the mean proportion of total squares surveyed in each sampling region in the Republic over the period 1998-2003. This suggests that increased survey effort should perhaps be concentrated in five of the eight regions: M, NW, S, SW & W. In Table 8 we examine the influence of increasing survey coverage in each region in turn by an additional 25 and 50 survey squares per year. Interestingly, Table 7 suggests that an increase in survey effort in E, M, NW and SE would result in the greatest number of additional species being monitored. Apart from M and NW, these regions currently have the best coverage. This suggests that borderline species, which may be brought in and monitored with a realistic increase in coverage, occur on a higher proportion of survey squares within these regions. Investigating this point further, it appeared that in sampling regions M, NE, E and SE, there are more species, and these species are more abundant. We measured this crudely by compiling the percent occurrence of each species in each sampling region, excluding species occurring on less than a mean of 10% of squares. These scarce species were excluded to minimize the effect of more species in regions with a more survey sites. The sum of the percent occurrence of each species in each region, was used as a measure of overall abundance of birds in that region. Figure 4 shows a comparison of 'bird abundance' suggesting that abundance is highest in sampling region M, followed NE, E, S and SE.

Implications for trends within Northern Ireland

Currently the BBS is able to produce trends in relative abundance for 28 species in Northern Ireland. Compared with The Republic of Ireland, the smaller number of species monitored by the BBS, is a reflection of the smaller number of squares surveyed. Consequently, an increase in survey coverage in Northern Ireland brings in a larger number of species to be monitored than a similar increase in survey effort in the Republic of Ireland.

To illustrate, assuming that the relative coverage in different regions remains constant, increasing coverage by 25 squares per year in Northern Ireland would increase the species for which we can monitor to 32, with the addition of Sedge Warbler, Chiffchaff, Lesser Redpoll and Reed Bunting. Increasing the number of squares surveyed by 50 would add Grey Heron, Mallard, Black-headed Gull, Coot, Cuckoo, Blackcap, Raven and Bullfinch, whilst an additional 100 squares would allow trends to be produced for Buzzard, Lesser Black-backed Gull, Herring Gull, Lapwing, Swift, Grey Wagtail, Grasshopper Warbler. Increasing survey coverage further by 200 squares would add Sparrowhawk, Kestrel, Moorhen, Stonechat, Wheatear, Whitethroat, Treecreeper and Long-tailed Tit, with an additional 300 squares Spotted Flycatcher and Feral Pigeon may be monitored and with 400 additional squares the list would add Cormorant, Mute Swan, Siskin, Tree Sparrow and Yellowhammer.

The above scenarios assume that the relative coverage in different regions within Northern Ireland remains constant, with an absolute increase in coverage. However, in practice a better strategy might be to target regions of poorer coverage, to enable as much as possible the trends to be representative of Northern Ireland as a whole. Table 9 examines the mean proportion of total squares surveyed in each sampling region in Northern Ireland over the period 1998-2003. This suggests that increased survey effort should be concentrated in Armagh and to a lesser extent, Tyrone, Londonderry and Antrim. In Table 10 we examine the influence of increasing survey coverage in each region in turn by an additional 25 and 50 survey squares per year. This suggests that an increase in survey effort in Fermanagh, Armagh and Londonderry would result in the greatest number of additional species being monitored. This suggests that these borderline species at least occur on a higher proportion of survey squares within these regions. Calculating a 'bird abundance' value as above for each region, suggests that abundance is highest in Fermanagh, Armagh and Londonderry (Figure 5). Armagh and Londonderry currently both have relatively poorer coverage.

Implications for all-Ireland trends

Currently the combined BBS and CBS survey can produce trends in relative abundance for 61 species at the all-Ireland level. Assuming that the relative coverage across regions in Northern Ireland and the Republic of Ireland remain constant, we examine the effect of increasing survey coverage in the Republic, Northern Ireland and all-Ireland.

Increasing coverage in the Republic or Northern Ireland by 25 squares would add Cormorant to the list of species that can be monitored at an all-Ireland level, although this species is probably better monitored through colony counts. With an additional 50 squares in either the Republic or Northern Ireland, Mute Swan could be monitored, whilst Great Black-backed Gull and Siskin could be monitored with an additional 200 survey squares. With an additional 200 squares surveyed in Northern Ireland and 300 squares in the Republic, trends could be produced for Tree Sparrow. Other species that could be monitored with a further increase in coverage includes Common Gull (Republic +300 squares, Northern Ireland + 200 squares), Coot (Republic + 400 squares, 300 squares Northern Ireland), Great B-b Gull (Republic & Northern Ireland +400 squares), Lesser B-b Gull (Republic & Northern Ireland + 400 squares), Oystercatcher (Republic & Northern Ireland + 400 squares) and Buzzard (Republic + 400 squares).

The above scenarios assume that the relative coverage in different regions across Ireland remain constant, with an absolute increase in coverage. In practice we might want to target regions of poorer coverage, to enable as much as possible the trends to be representative of Ireland as a whole. Tables 7 & 8 show how coverage varies between regions. This suggests that survey coverage should perhaps be concentrated in some of the poorer covered regions in the Republic of Ireland (M, NW, SW, W) and Armagh in Northern Ireland. In Table 11 we examine the influence of increasing survey coverage in each sampling region in Ireland in turn by an additional 25 and 50 survey squares per year. This suggests that an increase in survey effort in different regions will make very little difference to the number of additional species that could be monitored at an all-Ireland level.

In the above, we examine the influence of increasing survey coverage in the Republic or Northern Ireland on all-Ireland trends. However, if we were to increase coverage in both the Republic and Northern Ireland what would the influence now be on the number of species that can be monitored at an all-Ireland level? We examine this question by simultaneously adding 25 and 50 survey squares to both surveys and examine which additional species may now be monitored. An increase of 25 survey squares in both the Republic of Ireland and Northern Ireland would allow trends to be produced for the Cormorant and Mute Swan, whilst Buzzard would be added with an additional 50 squares surveyed by both surveys. With an extra 100 squares in both countries, it would be possible to monitor Common Gull, Great Black-backed Gull, Siskin and Tree Sparrow. Coot would be added to the list with an additional 200 survey squares in both surveys, Greylag Goose, Oystercatcher and Jay would be added with an additional 300 survey squares added to both surveys and Lesser Black-backed Gull added with an additional 400 squares surveyed in both the Republic of Ireland and Northern Ireland.

Increases in the power to detect significant changes in abundance

The results of the above analyses suggest that increasing survey effort would allow few additional species to be monitored. However, it is important to stress that whilst the number of species monitored may not increase substantially, increasing coverage would increase the power to detect population change in those species for which trends are already produced. Whilst formal power analyses would be required to determine the quantitative influence of increasing coverage on the power to detect population change, the importance of larger sample sizes can be shown in a simple plot of sample size against population change for species that show a significant increase in relative abundance between 1998 and 2003 in this study (Figure 6) and for species showing a significant decline during this period (Figure 7). For increasing species, there appears to be adequate power to detect at least a 25% decline where the number of 1-km squares is 100 or more. However, as the mean number of occupied squares falls downwards from 100 squares, only larger increases will be detected such as greater than 100% (doubling) with 30 sites. There is a similar pattern for declining species. To detect a significant decline of 25%, a mean of 80-100 squares are needed. However, as the number of occupied squares falls below this number, only large declines are detected, such as 50% declines with sample sizes of 30 1-km squares.

Table 5. Number (and percentage) of squares surveyed by professionals

Year	NI	RoI	RoI - NPWS only	RoI - BWI only	RoI - Contract
1998	19 (22)	64 (25)	36 (14)	26 (10)	2 (1)
1999	26 (27)	81 (26)	52 (17)	27 (9)	2 (1)
2000	27 (32)	101 (31)	75 (23)	24 (7)	2 (1)
2002	39 (40)	98 (31)	65 (21)	23 (7)	10 (3)
2003	52 (50)	84 (28)	53 (18)	24 (8)	7 (2)

Table 6. Influence of removing professional survey coverage on the number of species that can be monitored by the CBS and BBS at a country and all-Ireland scale.

Trend	Action	Species lost (number of species)
RoI	Minus NPW pros	(5) Black-h Gull, Wheatear, Grasshopper Warbler, Feral Pigeon, Stock Dove
RoI	Minus BWI pros	(5) Black-h Gull, Wheatear, Grasshopper Warbler, Feral Pigeon, Stock Dove
RoI	Minus all RoI pros	(10) Moorhen, Curlew, Kestrel, Long-tailed Tit, Wheatear, Black-h Gull, Lesser Redpoll, Grasshopper Warbler, Feral Pigeon, Stock Dove
NI	Minus NI pros	(8) Pheasant, Skylark, House Martin, Pied Wagtail, Goldcrest, Greenfinch, Goldfinch, Linnet
Irl	Minus NPW pros	(3) Sand Martin, Treecreeper, Stock Dove
Irl	Minus BWI pros	(3) Sand Martin, Treecreeper, Stock Dove
Irl	Minus all RoI pros	(5) Sparrowhawk, Spotted Flycatcher, Treecreeper, Sand Martin, Stock Dove
Irl	Minus all NI pros	(1) Treecreeper
Irl	Minus all pros	(8) Lapwing, Feral Pigeon, Lesser B-b Gull, Sparrowhawk, Spotted Flycatcher, Sand Martin, Treecreeper, Stock Dove

Table 7. Mean proportion of total squares surveyed in each sampling region in the Republic over the period 1998-2003. The regions are shown graphically in Figure 4.

Region	E	M	NE	NW	S	SE	SW	W
% Coverage	0.74	0.35	0.51	0.35	0.32	0.80	0.36	0.38

Table 8. Influence of increasing survey coverage in each sampling region of the Republic of Ireland in turn by an additional 25 and 50 squares per year.

Squares	Region	Additional species (number of species)
+25	Random	(3) Sparrowhawk, Sand Martin, Spotted Flycatcher
+25	E	(5) Lesser B-b Gull, Mute Swan, Jay, Siskin, Sand Martin
+25	M	(1) Sand Martin
+25	NE	(1) Sand Martin
+25	NW	(1) Sand Martin
+25	S	
+25	SE	(1) Siskin
+25	SW	
+25	W	(1) Sand Martin
+50	Random	(3) Sparrowhawk, Sand Martin, Spotted Flycatcher
+50	E	(6) Lesser B-b Gull, Mute Swan, Spotted Flycatcher, Sparrowhawk, Siskin, Sand Martin
+50	M	(6) Lesser B-b Gull, Lapwing, Spotted Flycatcher, Sparrowhawk, Woodcock, Sand Martin
+50	NE	(4) Mute Swan, Spotted Flycatcher, Sparrowhawk, Sand Martin
+50	NW	(3) Spotted Flycatcher, Sparrowhawk, Sand Martin
+50	S	(2) Spotted Flycatcher, Sparrowhawk
+50	SE	(5) Peregrine, Spotted Flycatcher, Sparrowhawk, Siskin, Sand Martin
+50	SW	(3) Spotted Flycatcher, Sparrowhawk, Sand Martin
+50	W	(3) Spotted Flycatcher, Sparrowhawk, Sand Martin

Table 9. Mean proportion of total squares surveyed in each sampling region in Northern Ireland over the period 1998-2003. The regions are shown graphically in Figure 5.

Region	ANTR	ARMA	DOWN	FERM	LDRY	TYRO
% Coverage	0.64	0.45	0.91	0.79	0.59	0.58

Table 10. Influence of increasing survey coverage in each sampling region of Northern Ireland in turn by an additional 25 and 50 squares per year.

Squares	Region	Additional species (number of species)
+25	Random	(4) Sedge Warbler, Chiffchaff, Lesser Redpoll, Reed Bunting
+25	LDRY	(7) Sedge Warbler, Chiffchaff, Cuckoo, Lesser Redpoll, Reed Bunting, Sand Martin, Raven
+25	FERM	(9) Blackcap, Bullfinch, Black-headed Gull, Chiffchaff, Lesser Redpoll, Mallard, Reed Bunting, Sand Martin, Sedge Warbler
+25	TYRO	(4) Lesser Redpoll, Reed Bunting, Sand Martin, Sedge Warbler
+25	DOWN	(3) Chiffchaff, Reed Bunting, Sedge Warbler
+25	ANTR	(3) Lesser Redpoll, Reed Bunting, Sedge Warbler
+25	ARMA	(7) Lesser Redpoll, Reed Bunting, Sedge Warbler
+50	Random	(12) Grey Heron, Mallard, Black-headed Gull, Cuckoo, Collared Dove, Blackcap, Raven, Bullfinch, Sedge Warbler, Reed Bunting, Chiffchaff, Lesser Redpoll
+50	LDRY	(16) Blackcap, Bullfinch, Buzzard, Chiffchaff, Collared Dove, Cuckoo, Grasshopper Warbler, Grey Heron, Grey Wagtail, Hooded Crow, Lesser Redpoll, Mistle Thrush, Mallard, Reed Bunting, Raven, Sedge Warbler
+50	FERM	(13) Blackcap, Bullfinch, Black-headed Gull, Chiffchaff, Cuckoo, Grey Heron, Hooded Crow, Herring Gull, Lesser Redpoll, Mistle Thrush, Mallard, Reed Bunting, Sedge Warbler
+50	TYRO	(12) Blackcap, Chiffchaff, Collared Dove, Cuckoo, Grey Heron, Hooded Crow, Lesser Redpoll, Mistle Thrush, Reed Bunting, Raven, Snipe, Sedge Warbler
+50	DOWN	(11) Black-headed Gull, Chiffchaff, Collared Dove, Grey Heron, Hooded Crow, Herring Gull, Mistle Thrush, Mallard, Reed Bunting, Raven, Sedge Warbler
+50	ANTR	(15) Black-headed Gull, Buzzard, Chiffchaff, Collared Dove, Grey Wagtail, Grey Heron, Hooded Crow, Herring Gull, Lesser Redpoll, Mistle Thrush, Mallard, Reed Bunting, Raven, Swift, Sedge Warbler
+50	ARMA	(17) Blackcap, Bullfinch, Black-headed Gull, Chiffchaff, Collared Dove, Cuckoo, Grey Wagtail, Grey Heron, Hooded Crow, Lapwing, Lesser Black-backed Gull, Lesser Redpoll, Mistle Thrush, Mallard, Reed Bunting, Swift, Sedge Warbler

Table 11. Influence of increasing survey coverage in each sampling region of Ireland in turn by an additional 25 and 50 squares per year.

Squares	Region	Additional species (number of species)
+25	Random	(1) Cormorant
+25	E	(3) Cormorant, Mute Swan, Jay, Siskin
+25	M	(0)
+25	NE	(2) Cormorant, Mute Swan
+25	NW	(1) Cormorant
+25	S	(0)
+25	SE	(1) Cormorant, Siskin
+25	SW	(0)
+25	W	(1) Cormorant
+25	LDRY	(2) Cormorant, Buzzard
+25	FERM	(1) Mute Swan
+25	TYRO	(0)
+25	DOWN	(0)
+25	ANTR	(2) Cormorant, Buzzard
+25	ARMA	(2) Cormorant, Mute Swan
+50	Random	(2) Cormorant, Mute Swan
+50	E	(4) Cormorant, Mute Swan, Jay, Siskin
+50	M	(2) Cormorant, Mute Swan

Squares	Region	Additional species (number of species)
+50	NE	(2) Cormorant, Mute Swan
+50	NW	(2) Cormorant
+50	S	(0)
+50	SE	(2) Cormorant, Siskin
+50	SW	(2) Cormorant
+50	W	(2) Cormorant, Mute Swan
50	E	(2) Cormorant, Buzzard
50	M	(2) Buzzard, Mute Swan
50	NE	(2) Cormorant, Buzzard
50	NW	(2) Cormorant, Buzzard
50	S	(2) Cormorant, Buzzard
50	SE	(2) Cormorant, Buzzard, Mute Swan

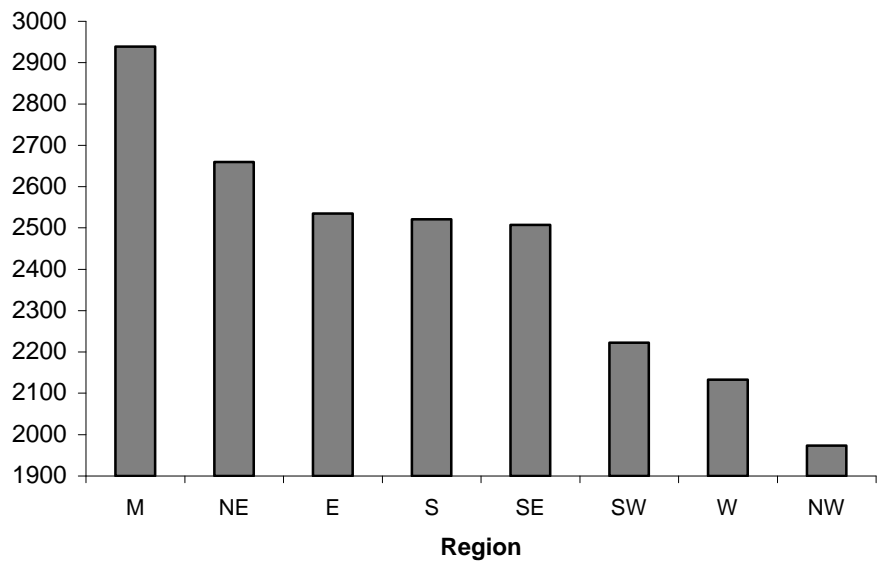


Figure 4. A comparison of 'bird abundance' between sampling regions in the Republic of Ireland.

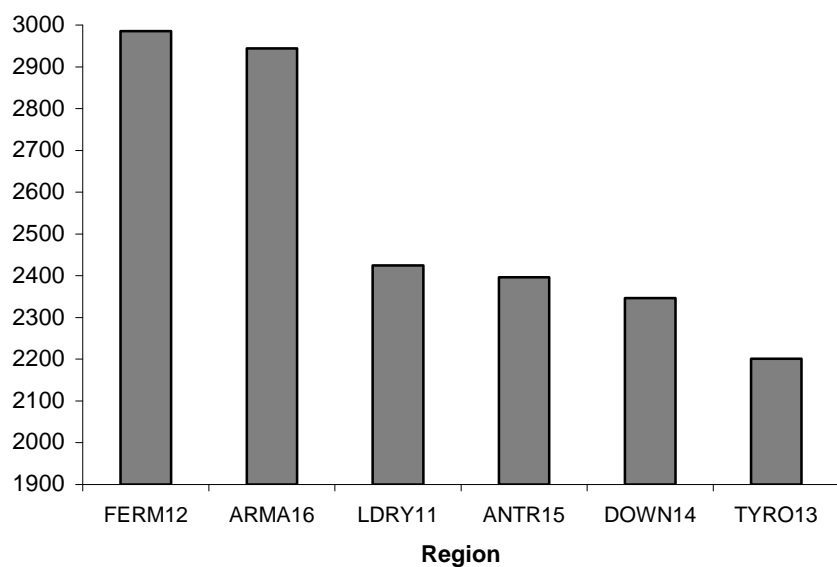


Figure 5. A comparison of 'bird abundance' between sampling regions in Northern Ireland.

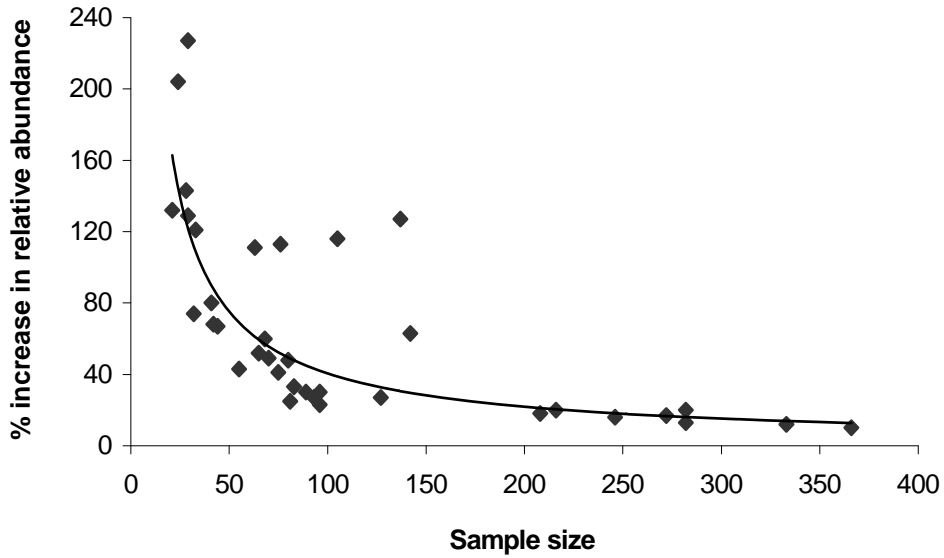


Figure 6. Plot of sample size (mean number of surveyed 1-km squares) against population growth (% increase) between 1998 and 2003. All species/geographical areas for which a significant increase was detected were included.

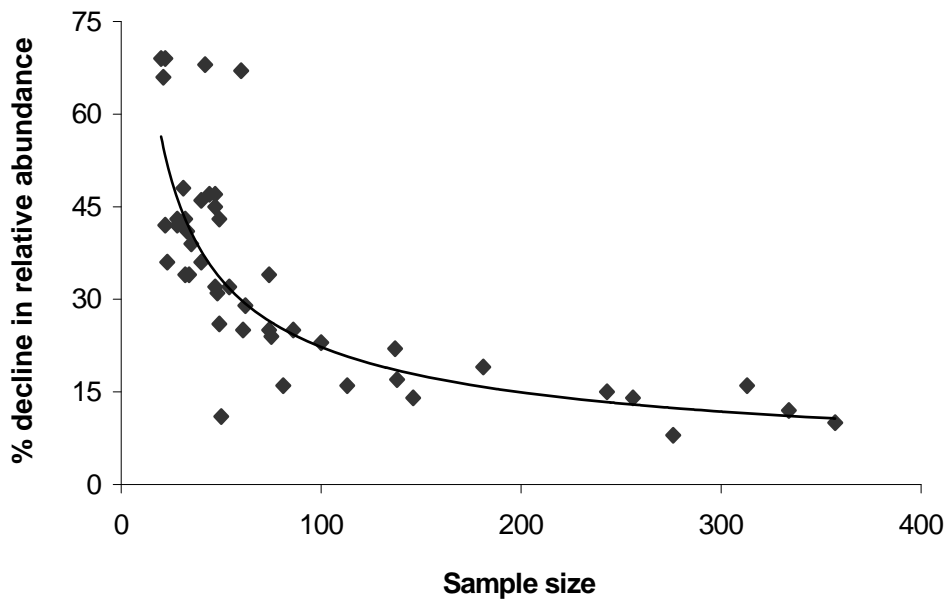


Figure 7. Plot of sample size (mean number of surveyed 1-km squares) against population decline (% decline) between 1998 and 2003. All species/geographical areas for which a significant decline was detected are included.

5. CONCLUSIONS & RECOMMENDATIONS

This joint BBS/CBS project has proven to be a worthwhile exercise. Aside from the specific species comparisons within Ireland and between regions, it has indirectly facilitated an in-depth comparison of analytical techniques used in Britain with those used in Ireland and throughout most of Europe. Further, the implications of increased or decreased coverage in both countries on the reporting of species trends has been quantified.

Future analyses

With current levels of coverage in the Republic and Northern Ireland, trend analyses are possible for a total of 61 species, at least at an all-Ireland level. This includes 27 species listed on PSOB and 13 on BoCCI. However, the CBS in particular is still in early stages, thus a certain degree of caution remains in relation to the interpretation of the trends presented. Nonetheless, a number of significant trends have been highlighted, and it is likely that continued analyses in the future will increase our confidence in these trends and may in some cases strengthen our rationale for conservation action.

Future analyses ought to focus on the 26 species for which trends can be produced across all regions. The majority of these species are typical, and ought to be deemed appropriate indicators, of the farmland environment in Ireland. However, other species such as Meadow Pipit are more typical of scrub vegetation and bogland, the latter which is a valuable and unique habitat in northwest Europe. A small proportion (approximately 5%) of Ireland remains forested. Nonetheless, both Coal and Blue Tits are potential indicators for woodland environment in Ireland. Further, there are a number of extra species that ought to be included as suitable candidates for indicators of certain habitat types, such as Yellowhammer for cereals.

Producing joint publication of results

Apart from its contribution to the UK trends and reporting, BBS data from Northern Ireland are reported by BTO in a number of popular media, including the Harrier (NI Ornithological Club) and the NI Birdwatchers Association newsletter.. The production of joint Irish-Northern Ireland trends provides a valuable opportunity to jointly publish the results in media ranging from local bird club newsletters to papers in scientific journals. Publishing in the latter will be aided by the greater amount of data and time period elapsed by incorporating both data sets in the analyses, giving greater reliability and more scope for interpretation.

Timetable for providing all Irish trends

Currently, BBS-NI data and CBS data are available in April in the year following data collection. The reporting of all-Irish trends and separate NI & Republic of Ireland trends is constrained by the reporting dates currently agreed for the respective surveys. The BBS NI trends are published in the annual BBS report in the calendar year following data collection. The most recent report, for the 2003 season (Raven *et al.* 2004), was published in July 2004, but the next is planned for May/June in 2005. All Irish trends could be included in this report, but this would require the agreement of all partners and would increase the number of tables in an already lengthy report. The CBS trends are currently published in reports produced at irregular intervals. All-Ireland trends could be produced at the same time as the national trends, with reporting to follow. However, these trends will be from 1998, not from 1994 as for the BBS in NI. To achieve most impact, it might be preferable to publicize these separately from those of the BBS and CBS – although the trends are unlikely to be very different. Plans for publicizing the trends will need to take into account media timing issues and high priority of the national trends. Annual population indices and covariance matrices are requested in autumn of each calendar year following data collection for the Pan European Common Bird Monitoring project, described below.

BBS trends (for the UK including NI) and CBS trends are both used in a European Bird Census Council (EBCC)/RSPB/Birdlife International initiative (Pan European Common Bird Monitoring (PECBM) to produce Pan-European species indices and multi-species indicators. To date, annual population indices and covariance matrices have been requested in autumn of the calendar year

following data collection. Trends for this purpose are calculated using TRIM, a software package designed by Statistic Netherlands, and widely used by organisations responsible for bird monitoring across Europe.

Measures to improve coverage

It is evident that any expansion of volunteer effort should be targeted towards areas of poorer coverage. In particular, greater coverage is required for five out of the eight sampling regions in the Republic and for Armagh in Northern Ireland. While this effort would not necessarily increase the total number of species for which we could provide trends, it would increase the robustness of the analyses.

It has been implied that the removal of professional effort could prevent the ability to monitor four species on Red or Amber BoCCI list, five on PSOB and four species monitored as part of the pan-EU project. It is therefore imperative that professional effort continues, at least in the short to medium term, in order to maintain the current coverage levels in both countries.

Recommendations for cross-border recruitment and promotion

Following are a number of recommendations for cross-border recruitment, promotion and reporting of results. It is recommended that there be regular liaison between the CBS and BBS Coordinators, particularly before the field season commences.

Joint Training Workshops

Training workshops conducted in the Republic of Ireland during the first few seasons of the project proved highly successful at encouraging new volunteers to take part. The BTO currently runs a series of training courses on bird surveying, field recording, analyses and bird identification, and in the past, BTO has organised special practical workshops on the BBS in Northern Ireland, incurring minimum cost to participants, in order to attract potential recruits to the BBS and provide feedback on results to existing volunteers. Held in the spring, ideally just before the field season, these include practical sessions in the field as well as practice in filling out forms and using BBS Online. The BTO also runs a number of small workshops on BBS Online at its annual and regional conferences. Similar practical CBS workshops are also conducted. It would be worth revisiting this task jointly on a regular basis. In particular, cross-border workshops may facilitate exchange of observers, and improvement in coverage in at least the border areas.

Annual meeting

One of the most important ways of promoting both the CBS and the BBS is to increase communication at all levels. We envisage two types of meetings that could be held in alternate years, although perhaps in the first year a single meeting could cover both aspects.

The first type of meeting would be aimed at the regional representatives and volunteers, in order to give those 'on the ground' the opportunity to discuss successes and problems, raise issues to the national organisers and for general discussion, and possibly cross-border exchange of potential volunteers that are closer to BBS or CBS squares. Most importantly, it should be enjoyable – ideally something that could be considered a reward for all their efforts rather than another job to do. In that respect, participation in this workshop would have to be free or at absolute minimal cost to participants.

The second type of meeting would be a joint CBS-BBS workshop to discuss volunteer coverage, recruitment issues, population trends and the publication and use of all Ireland trends. Those invited would include volunteer regional organisers, and other interested parties (stakeholders, government departments, county bird recorders, bird clubs, ornithological societies, RSPB and WWT personnel, and interested members of the public). This would be a combination of presentations on recent trends in numbers or distribution, perhaps linked to other surveys of particular species for comparison, and discussion of possibilities for using these data in conservation assessments (red-listing, BAPs) and wild bird indicators. There could be a charge for this meeting, to cover most of the organizational costs.

Proposed tasks for ongoing all-Ireland analyses

In summary, we recommend that the following be carried out on an annual basis:

- 1) Collation of new data from both schemes (CBS & BBS), updating the database & generation of population trends, with confidence limits, for ca. 60 species
- 2) Preparation of a summary table of population trends in all-Ireland, Northern Ireland, and in the Republic of Ireland (and three regions of the Republic)
- 3) Interpret the main findings (significant positive or negative changes) including relating population trends to those in UK, England, Scotland & Wales where appropriate
- 4) Publish the results in appropriate media, ranging from a bespoke annual report, on BTO and BWI websites, in regional bird club newsletters and reports, and in press releases.
- 5) Publicize the survey jointly in the period prior to the field season, in order to recruit new volunteers, using websites and other for a, emphasizing the similarity between the two surveys and that joint trends as well as separate country trends will be produced.
- 6) Organize annually (or at other, longer, intervals) joint CBS-BBS workshops to discuss volunteer coverage, promotion and recruitment issues, population trends and the publication and use of all Ireland trends. In alternate years, these could be aimed at: i) volunteers and regional organizers, and ii) government and non-government institutions.

ACKNOWLEDGEMENTS

We are extremely grateful to the Environment and Heritage Service for funding this project, and in particular to Ian Enlander for taking interest in this work.

The BBS is coordinated by Mike Raven at British Trust for Ornithology (BTO) headquarters, and funded jointly by the BTO, the Joint Nature Conservancy Committee and Royal Society for the Protection of Birds. The BBS Steering Group comprises Dr. Helen Baker (JNCC), Dr. Richard Gregory (RSPB), Dr. Stephen Baillie (BTO) and Dr. David Noble (BTO).

The Countryside Bird Survey is coordinated by Richard Coombes (BirdWatch Ireland), and funded by the National Parks and Wildlife Service (NPWS) and the Heritage Council. The CBS Steering Group includes John Wilson and David Norriss (NPWS), Liam Lysaght and Dr. Simon Berrow (Heritage Council), Prof.. John O'Halloran (University College Cork), Oran O'Sullivan and Richard Coombes (BirdWatch Ireland).

The maps illustrating regions and coverage were produced using DMAP written by Dr. Alan Morton.

Finally we would like to thank the many volunteers who have taken part in the BBS and CBS and for whom both surveys depend heavily on their dedication, enthusiasm and skill.

REFERENCES

- Coombes, R. H., O. Crowe, L. Lysaght, D. Noble, J. O'Halloran, O. O'Sullivan and H. J. Wilson. 2002. Countryside Bird Survey Report, 1998-2000. BirdWatch Ireland, Dublin.
- Field, R.H. & Gregory, R.D. 1999. *Measuring population changes from the Breeding Bird Survey*. Research Report No. 217, British Trust for Ornithology, Thetford.
- Joys, A.C., Noble, D.G. & Baillie, S.R. 2003. *Evaluation of species coverage and precision using the BBS indexing method*. BTO Research Report No. 317.
- McCullagh, P. and J. A. Nelder. 1989. *Generalized Linear Models, 2nd Edition*. Chapman and Hall, London.
- Mitchell, P. I., S. F. Newton, N. Ratcliffe and T. E. Dunn. 2004. *Seabird Populations of Britain and Ireland*. T. & A. D. Poyser, London.
- Noble, D.G., Bashford, R.I., Marchant, J.H., Baillie, S.R. & Gregory, R.D. 1999 *The Breeding Bird Survey 1998*. BTO Research Report 225. Thetford (BTO).
- Raven, M.J., Noble, D.G. & Baillie, S.R. 2004. *The Breeding Bird Survey 2003*. BTO Research Report 363. Thetford (BTO).
- SAS. Institute Inc. 1996. SAS/Stat Software: Changes and Enhancements through Release 6.11. SAS Institute, Inc., Cary, North Carolina.
- Smal, C. 1995. *The Badger and Habitat Survey of Ireland*. The Stationary Office, Dublin.