Optimisation of Open-habitat Bird Surveys – a report to the Forestry Commission (FC)

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Summary

In the process of offering financial grants to landowners seeking to create new areas of woodland in England, the Forestry Commission (FC) requires surveying of proposed woodland creation sites for breeding birds in order to assess the suitability of sites for woodland creation. FC commissioned a report to analyse existing breeding bird survey data in the interest of determining optimal timing and number of visits required for breeding bird surveys, specifically investigating the effect of reducing survey effort while aiming to maintain survey efficacy. We aimed to investigate the efficacy of a reduced number of surveys at prescribed timings in identifying species richness within a proposed woodland creation site and estimating the density of breeding bird territories, simulating the impact of reduced survey visits at specific timings as per new FC guidance.

Reports of breeding bird surveys in England in 2021 and 2022 were initially assessed on their compliance with FC guidance for surveys at woodland proposal sites, quantified based on criteria met by surveys. Species richness analysis sought to compare the number of species detected after five or six survey visits spread across the breeding season (as per FC guidance for 2021 and 2022) with the simulated number of species detected after four randomised visits and four visits following new guidance survey date windows. The proportions of simulated species richness estimates after four randomised visits and four visits within new survey windows relative to species richness after six visits were compared to assess the efficacy of random spacing of surveys against surveys specifically spaced within new survey windows. Estimates of territory densities were determined by assessing mapped survey records to estimate territories within sites for seven bird species of conservation importance and with sufficient data for analysis, comparing estimates derived from six survey visits to mean estimates derived from comparing all four-visit combinations of the six survey visits.

Species richness reduced by a mean of 10% with four randomised survey visits and 11% with four visits within the new survey windows, relative to species richness after six survey visits. There was no significant difference between the two methods of four-visit selection, with each method producing similar results. Territory density was found to decrease by a mean of 33% when reducing survey visits from six to four, approximately matching the reduction in survey effort of one third. The proportion of territories still detected after four visits varied widely between species (20-100%) but for the two wader species analysed, curlew *Numenius arquata* and lapwing *Vanellus vanellus*, the estimates only dropped just below key thresholds for additional site assessment on two occasions.

Overall, our data suggest that the proposed change from six to four visits would have a relatively minor impact on species richness detected relative to the reduction in survey effort. The change in breeding territory density for species considered is predicted to be more substantial, but given the number of visits will still be higher than some widely used wader survey methods, and that in most cases the reduction would not have caused a change in decision-making, this is likely to remain a robust survey approach. The proposed use of defined consecutive survey windows is likely to provide a more even distribution of surveys across the season. Our analyses give a potential framework for future analysis to assess future changes in guidance for breeding bird surveys at woodland creation sites, and to simulate the effects of proposed changes to guidance prior to implementation using existing data.

1. Background

The Forestry Commission (FC) offers financial grants to landowners, land managers and public bodies wishing to create new areas of woodland in England. The Woodland Creation Planning Grant and the England Woodland Creation Offer aim to encourage and support the creation of woodlands as part of the UK Government's Net Zero Strategy, for the benefit of biodiversity, and to enhance wider ecosystem services provided by woodlands (Department for Environment, Food & Rural Affairs, 2022). In the year to March 2022, 13,850 ha of new woodland was planted in the UK (Forest Research, 2022). In order to reach the 30,000 ha per year target by 2025 set out in the UK's Net Zero Strategy (Department for Environment, Food & Rural Affairs, 2022) and to further increase planting rates to meet 2030 and 2035 targets, significant areas of land will have to be converted to woodland, with the potential to negatively impact floral and faunal communities if proposed sites are not assessed appropriately prior to woodland creation.

The FC provides guidelines for the assessment of the suitability of sites for woodland creation (Forestry Commission, 2020; Forestry Commission, 2021; Forestry Commission, 2022) with the requirement to survey one or more of habitats, vegetation, peat and breeding bird populations, as advised by the FC. Additionally, the Department for Environment, Food & Rural Affairs, Forestry Commission & Natural England (2022) provide guidance to advise when a site may be important for wading bird species and assess suitability for woodland creation. Woodland creation proposers must submit a survey to the FC to help determine whether a site is suitable for woodland creation and the survey must meet the specifications set out in the guidelines in order to be accepted. To inform a woodland creation proposal, proposers must seek quotes from external contractors/surveyors for the necessary surveys required. The successful tender is chosen by the FC based on the proposed methodologies and their compliance with FC guidance, the experience and qualifications of surveyors, and proposed costs. The successful external surveyors must then conduct the survey scheme in line with all proposed work set out in the approved woodland creation proposal, providing a detailed report of the methods, findings and recommendations associated with the survey results.

1.1 The Breeding Bird Survey

Surveying of the breeding bird population at sites of prospective woodland creation provides a method of assessing the potential impacts on bird communities posed by a potential woodland creation. Surveys are intended to identify species and/or communities of conservation value such as Schedule 1 (Wildlife and Countryside Act, 1981), Annex 1 (Birds Directive, 2009), Section 41 (Natural Environment and Rural Communities Act, 2006) and UK red/amber-listed species of conservation concern (Stanbury et al., 2021).

Breeding bird surveys vary in methodology but generally involve walking a transect route covering all areas of a site to within a prescribed distance (depending on the methodology followed) and recording all bird species encountered on the site. Habitats or other features likely to be used by birds to shelter or hide are scanned to detect birds using these features. Locations and behaviours of birds are recorded onto maps or using mapping software on electronic devices in the field. Surveys take place over a number of visits, usually up to six, and are spread across different times of day spanning sunrise and sunset in order to detect crepuscular, nocturnal and diurnal species. Spreading the visits evenly over the breeding season allows for the detection of relatively earlier and later breeding species (Gilbert et al, 1998; Bird Survey & Assessment Steering Group, 2022).

Successive versions of the FC's guidelines document have been produced and are published in the year prior to the one where surveying takes place, i.e. the newest guidelines published in 2022 will inform surveys taking place from 2023. FC's 2020 guidance required five survey visits following the Common Bird Census (CBC) methodology (Gilbert et al., 1998), with the 2021 guidance requiring six visits following methods set out in the Bird Survey Guidelines (BSG) for assessing ecological impacts (Bird Survey & Assessment Steering Group, 2022).

1.2 Report Rationale

The FC commissioned us to produce an analysis and report to assess existing bird survey data and reports from 2021 and 2022 at sites for proposed woodland creation, in the context that their survey guidelines are due to change for surveys taking place from 2023. The key change to the guidance is in the number and timing of survey visits, from six "evenly-spaced" visits between late March and early July (although with specific spacing not prescribed), to four surveys where each respective survey is within a specific date windows (Table 1).

Table 1: Date windows of four survey visits set out in FC guidance (Forestry Commission, 2022)

Survey visit	**Date window**
1	20th March – 10th April
2	16th April – 15th May
3	16th May – 15th June
4	16th June – 10th July

The overall aim of this project is to investigate survey efficacy in terms of identifying species within the survey footprint (species richness) and estimating breeding territory density of individual species that depend on open habitats for breeding or foraging.

To achieve this aim, we had the following objectives:

1. Evaluate the extent to which bird surveyors met the requirements set out in existing FC guidance for surveys, considering consistency between reports and compliance with survey methodology. This is reported in Section 2.
2. Analyse the data provided from breeding bird surveys to evaluate to what extent changing the number and timing of visits would be likely to influence estimation of species richness and breeding territory densities. Analysis involving species richness will consider separate

analyses consisting of (i) all species, (ii) red and amber-listed species and (iii) red-listed species only. This is reported in Section 3.

3. To synthesise the findings to produce recommendations for FC in terms of the likely impact of the change in survey approach adopted for 2023 and potential future considerations in terms of surveying and reporting, which is given in Section 4.

2. Assessment of Reports

2.1 Reports summary

The reports of breeding bird surveys conducted at 31 proposed woodland creation sites were analysed in this report. Two further reports were received after analysis was complete and therefore are not included in this report. The majority of sites were located across northern England with the exception of one site further south (Figure 1). Many of the sites are within designated areas including North Pennines Area of Outstanding Natural Beauty (AONB), Nidderdale AONB, Northumberland National Park, Yorkshire Dales National Park and the Lake District National Park.

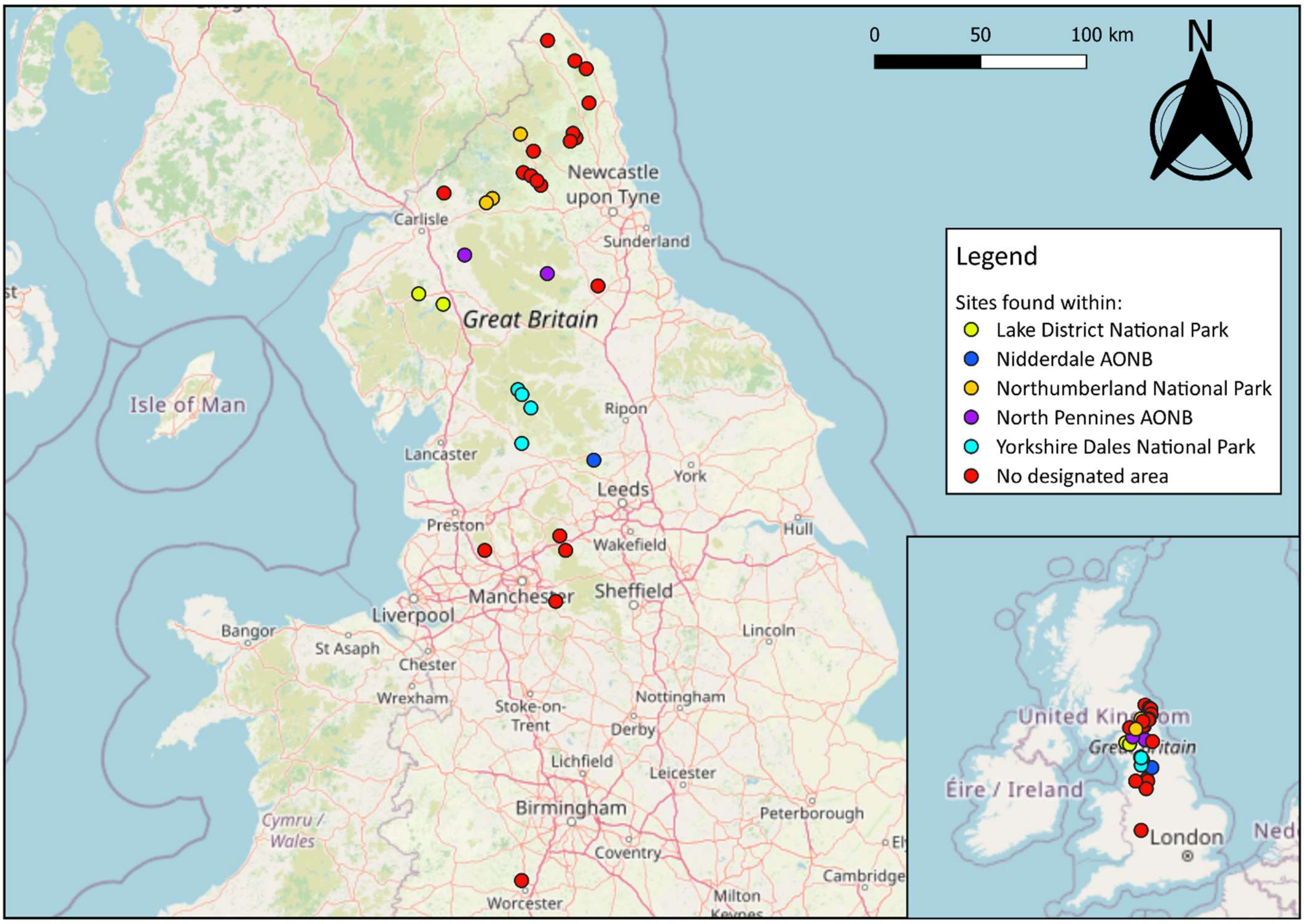


Figure 1: Geographical distribution of surveys at potential woodland creation sites considered in this analysis. Map created using QGIS Desktop 3.22.14, basemap retrieved from OpenStreetMap (OpenStreetMap contributors, https://www.openstreetmap.org/copyright).

2.2 Compliance with existing guidance

FC guidance directs surveyors to the relevant survey method to follow in each version of its guidance document and specifies a number of criteria to be met in survey methods. The compliance of reports in meeting survey method criteria in site footprint (woodland creation area) surveys are summarised in Table 2.

Table 2: Number of reports from surveys undertaken in 2021 and 2022, their compliance with criteria for surveying site footprint specified in FC guidance, and reports which mention survey limitations of (i) weather unsuitable for surveying and (ii) access issues to the site. Survey methods are those stated in BirdSurveyGuidelines (BSG), the Common Bird Census (CBC), Brown & Shepherd (B&Sh) and BTO Breeding Bird Survey (BBS). Total number of reports = 31.

Criterion	**Category**	**Year of Report**		**Total**
		2021	**2022**	
Visits made	Six	2	22	24
	Five	5	0	2
	Four	2	0	5
Survey method	BSG	0	17	17
	CBC	7	4	11
	B&Sh	2	0	2
	BBS	0	1	1
Site covered to within 50m	Yes	7	17	24
	No	2	5	7
At least one evening survey visit made	Yes	6	13	19
	No	3	9	12
Optimal weather	Yes	9	18	26
	No	0	4	4
Access OK	Yes	6	19	25
	No	3	3	6

2.2.1 Method and visits

Of the 22 reports conducted in 2022, 17 followed the advised BSG methods and met the six-visit requirement across the survey season. Four reports in 2022 followed the CBC method and one followed the British Trust for Ornithology's Breeding Bird Survey method, with all five of these still meeting the requirement of six visits. Of the nine reports conducted in 2021, seven followed the then advised CBC methods with four of those meeting the requirement of five visits, two going beyond this to six visits, and one only making four visits across the season. Two reports in 2021 used the Brown and Shepherd (1993) 'method for censusing upland breeding waders' (which was advised only for the buffer area, not the footprint and is not designed for surveying all breeding bird species), with four and five survey visits made.

2.2.2 50m coverage

Both the CBC and BSG methods specify that all areas of the site should be covered by the surveyor to within a distance of 50m, with the Brown and Shepherd method specifying coverage to within 100m. Of the reports following BSG methods, three did not meet this coverage specification, with two surveys stating 100m coverage was reached and one site specifying the 50m coverage was met; however, transect maps within the report show this was not met in all areas. One report in 2022 following CBC methods did not comply with the 50m coverage criteria due to access issues, while the two reports in 2021 using Brown and Shepherd did meet 100m coverage across the site, however this is not comparable with the CBC and BSG methods as the main surveying method differs. The one site following BBS methods reached 100m coverage of the site, by following a single transect through the site. Assessing the compliance to this criterion of the methods set out by FC guidance was not always obvious, with some reports making no mention of the distance to which surveyors covered areas of the site. Some reports stated the 50m coverage was met but without providing maps of transects walked it can only be assumed and not confirmed that this was actually met.

2.2.3 Evening survey

The FC’s 2020 and 2021 guidelines for surveying specify that most survey visits should take place in the morning, starting half an hour before or after sunrise. A minimum of one evening visit is also suggested in both versions of the guidelines, starting during the last hours of daylight and extending beyond sunset for at least one hour in order to consider crepuscular or nocturnal species. Nineteen of the 31 reports (61%) included at least one evening survey visit (two reports included two evening surveys), with 12 (39%) either not including an evening visit or stating that one took place, but which ended before sunset.

2.2.4 Weather

Survey methodologies suggest surveys should not be carried out in suboptimal weather conditions, including in heavy rain and reduced visibility as to not impact detectability or survey during reduced bird activity. Four survey visits across four reports were conducted in heavy rain, two of which also noted reduced visibility, therefore results of these individual surveys may not accurately reflect bird communities present. However, each of these sites received six survey visits in total so it is unlikely that one visit of reduced counts will greatly impact overall findings for the site.

2.2.5 Access

Surveys from five reports mention access issues as limiting factors to their surveys. The first noted the presence of cattle in fields surrounding the planting site and in buffer zones surrounding the site in two of six survey visits, as well as access refusal by landowners in some areas of the buffer zone. Four reports note the presence of cattle across the site footprint and buffer area during all or most of the survey visits, indicating that surveys were conducted from the nearest empty fields in these cases. One of these reports also noted that during one of the visits cattle posed a particular issue resulting in an estimate of less than 15% of the site being surveyed optimally.

2.3 Data Entry

Reports varied in their presentation of field survey results, particularly in reporting the results of individual survey visits, as was the interest of the analysis in this report. Data were extracted from digitised or raw field maps in 32% of reports, from GIS shapefiles in 29% of reports, from summary tables in 23% of reports and from Microsoft Excel files in 16% of reports. While some reports presented data in more than one format, these numbers represent the data sources which provided sufficient detail to extract data for use in this report. This variation in data presentation also affected the level of detail provided with records, ranging from recording species counts only, to recording detail such as vocalisations, behaviour, age, sex, family groups and breeding status.

2.3.1 Issues with the data

Variation in the level of detail recorded between reports limits the analysis to the lowest common level of recording between all reports. Therefore, the species richness analysis looked at all records of birds present within the planting site boundary during a survey, regardless of behaviour and breeding status, while territory density analysis considered behaviour, breeding evidence and any additional information recorded. Juveniles were excluded from the data and, as such, where family groups were recorded and the number of birds in that record was not recorded as >1, the record was counted as 1 adult individual.

Any obvious errors in the survey results presented in the reports were carefully considered, checked against species distributions and edited where necessary and when confident. For example, a record of razorbill (BTO species code RA) was made in an inland upland site which was subsequently changed to raven (BTO species code RN) as this species had been recorded in other survey visits in the same site but had not been recorded in this visit. Repetition of records was observed occasionally, where multiple consecutive lines of data were repeated (particularly where data was provided in Microsoft Excel format). The same process was followed as for incorrect species codes and changes made where necessary and when confident an error had been made.

Survey results presented in map format required accurate counting of the individuals recorded. BTO species codes representing the species observed were counted and systematically checked off using in-browser PDF editing tools to prevent double-counting and to identify when all records had been counted. Where records were observed as being recorded outside of the planting site boundary, these were excluded from the dataset with a strict cut-off at the site boundary line in order to avoid inconsistencies in data extraction. An exception was made where a 100m buffer was set around the planting site and was consistently surveyed across all survey visits at that site, since our specific analysis simply needed a consistent method and count area, and we weren’t considering any management implications.

2.3.3 Excluded sites

After considering discrepancies in the survey methods of all reports, four were excluded from any further analysis regarding breeding bird surveys but were included in the assessment of reports; sites 14, 15, 28 and 30. The report for site 14 was excluded as the majority of records were made outside of the site boundary and were mostly found in the buffers, surrounding fields and nearby existing woodland. One survey visit had no records (the only report where this occurred) and the total species richness across five visits was just four. The report for site 15 was the only report in which woodland-edge birds and species not associated with upland habitat were not recorded by surveyors. Other reports also stated this approach would be taken, however site 15 was the only report which did not provide records of these species in the data. As a result, species richness was far lower than other sites (4-8 species per visit). The report for site 28 was the only report to follow the BTO's Breeding Bird Survey (BBS) methodology, with 5x100m transects followed and birds recorded at 25m and 100m from the transect line, rather than either of the FC's recommended approaches. Uncertainties around the data arose where ambiguous comments were made when referring to groups of birds ("some individuals", "a few flying about") and where numbers and comments referring to birds were frequently repeated verbatim at the same points across different survey visits. It was not possible to include report for site 30 as survey data were provided as scans of hand-annotated maps which were not legible and did not include a site boundary overlain on the map.

Although there were other inconsistencies in survey methods between reports, these were either deemed minor enough as to not cause issues with the data (such as slightly varying survey methods but which still followed similar protocol) or could be accounted for by considering in separate analyses (such as lower number of survey visits).

2.3.4 Excluded species

Prior to further analysis, 22 bird species were excluded from the dataset (Table 3). Initially, all species with less than 10 individuals recorded across all sites and visits were selected and considered as to whether they are ecologically relevant to the analysis. Raptors, owls and other upland-associated birds were retained, regardless if they were recorded at <10 individuals or not due to their likelihood of occurring at low densities (with the exception of Montagu's harrier *Circus pygargus*, which was excluded after being recorded once and due to its limited distribution it was not likely to be recorded elsewhere). Golden pheasant *Chrysolophus pictus* was excluded with low numbers across all sites and visits (n=2) and due to its limited distribution. Cetti's warbler *Cettia cetti* and Dartford warbler *Sylvia undata* were also excluded as species not likely to be recorded at the majority of sites due to their limited distribution. Seabirds, sea ducks and most waterfowl were removed, unless occurring frequently across different sites (e.g. Canada goose *Branta canadensis*, greylag goose *Anser anser*). The farmland-associated species corn bunting *Emberiza calandra* was excluded with only a single record across all sites and visits.

Table 3: Common and scientific names of species recorded in the data but excluded from analysis due to association with non-upland habitats, low recording frequency and/or limited distribution. Listed in taxonomic order.

Common name	**Scientific name**
Mute swan	*Cygnus olor*
Bewick's swan	*Columbianus bewickii*
Egyptian goose	*Alopochen aegyptiaca*
Shelduck	*Tadorna tadorna*
Shoveler	*Anas clypeata*
Gadwall	*Anas strepera*
Teal	*Anas crecca*
Tufted duck	*Aythya fuligula*
Long-tailed duck	*Clangula hyemalis*
Red-breasted merganser	*Mergus serrator*
Golden pheasant	*Chrysolophus pictus*

Feral pigeon	*Columba livia*
Moorhen	*Gallinula chloropus*
Coot	*Fulica atra*
Great-crested grebe	*Podiceps cristatus*
Common sandpiper	*Actitis hypoleucos*
Common Guillemot	*Uria aalge*
Cormorant	*Phalacrocorax carbo*
Montagu's harrier	*Circus pygargus*
Cetti's warbler	*Cettia cetti*
Dartford warbler	*Sylvia undata*
Corn bunting	*Emberiza calandra*

3. Data Analysis

3.1 Species richness analysis

In order to assess the potential impact of reducing the number of survey visits of the breeding bird survey on the ability to detect species present at a site, species richness was analysed. Species richness refers to the number of species present at a site. Our general approach was to compare the species richness observed by surveyors over six (or in one case five) visits from the 2021 and 2022 data with predicted values of species richness that would have been found if they had made only four visits (as per the new guidance); we also considered the species richness detected if these four visits were selected randomly from those made, or (where possible) fitted the four-survey-window criteria of the 2023 guidelines (Table 1).The analysis first considered all species, before considering a filtered dataset containing red and amber-listed species and then red-listed species only (see Appendix A for classification of species).

3.1.1 Species accumulation curves

Species accumulation curves (SACs) show the observed or predicted increase in species richness seen as survey effort increases. In our case survey effort refers specifically to the number of survey visits made within a site and year. SACs were plotted in R (R Core Team, 2020) using the 'vegan' package (Oksanen et al., 2019) to visualise the effectiveness of successive survey visits in detecting the total species assemblage present at a survey site. The curves were plotted with sample-based data using the 'random' method to find the mean number of species detected per visit from all possible permutations of the data and therefore randomising the order of visits (Ugland et al., 2003). The resulting plots indicate the accumulating observed species richness from each survey visit, with an asymptote expected where survey effort has sufficiently detected all species in a habitat, and further visits are unlikely to detect additional species. The absence of an asymptote after the surveying regime at a site is complete indicates that additional surveying would likely have continued to detect more species.

Plotting SACs also allows us to predict the species richness which would have been detected, on average, after fewer visits, a way of assessing the impact of reducing the number of survey visits in the new FC guidance. Because the new guidance specifically advises four visits, we focused on comparisons of observed species richness after six (or five) visits made in the 2021-22 surveys with predicted species richness from four visits.

3.1.2 Simulating new protocol survey windows on existing data

In order to evaluate the efficacy of detecting species present under the new survey windows specified in the most recent FC guidelines for woodland expansion, reports were identified where the survey dates could be fitted to the new survey windows. The distribution of visits from 2020 and 2021 extracted from reports, and with the four new required survey windows overlain, are shown in Figure 3. Twelve reports, each with six survey visits in total, could be fitted to these survey windows with at least one visit occurring in each of the four windows. In other words, a subset of these 12 reports' data unknowingly followed the new guidance for 2023 surveys (Forestry Commission, 2022). Where multiple visits occurred in one window, one of these visits was chosen at random to be included in the analysis. Where an evening visit and a morning/non-evening visit fell in the same window, the evening visit was excluded as the new FC survey guidance states surveys should be started 30 min before or after sunrise and does not require an evening visit. The selected visits falling within the new survey windows were termed the four 'targeted' visits for subsequent analysis.

The observed species richness (S_{obs}) was taken from the original six visits and a simulated species richness (S_{Sim}) was calculated for the four targeted visits selected from within the new survey windows, i.e. in a hypothetical scenario that the surveyors had followed the new survey guidelines. The simulated species richness from four visits was then calculated as a proportion of that from the original six visits to give the predicted proportion of species which would have been detected under the new survey windows specified in the FC guidelines 2022, as opposed to the previous 2021 guidance of six evenly spaced visits. Similarly, the S_{sim} at each site derived from four randomised visits was compared to and calculated as a proportion of the total S_{obs} after six visits. The randomised S_{sim} was taken from the random-method SACs (section 3.1.1, above), representing the mean number of species detected across four visits from all possible four-visit permutations of the data.

To examine the effect of reducing from six to four visits, for each site analysed we divided the simulated species richness predicted to be found after four visits (either randomised or targeted) by the observed species richness from six visits. This proportion can be interpreted as the proportion of species likely to still be detected following the reduced survey effort. For example, a value of 0.9 predicts that 90% of species detected after six visits will be detected after four visits.

The randomised average S_{sim} of each hypothetical number of visits, given as proportions of the total S_{obs} detected after six visits, were compared across sites. The predicted proportion of S_{sim} calculated from four targeted visits was also compared, providing an overall comparison of the predicted S_{sim} which would be detected at each hypothetical number of survey visits (1–5), as well as the simulated four targeted visits. This analysis allowed us to consider the efficacy of a four-visit survey regime, in relation to the S_{obs} in the six-visit regime, while also considering the proportion of species which would have been detected at different hypothetical numbers of visits. Comparing S_{sim} at each number of visits allows us to identify the extent to which species are not detected at each reduction in the number of survey visits within the survey regime.

This analysis also allowed us to identify if one of the survey regime approaches was significantly more effective at detecting species richness than the other. That is, whether making the specification in the survey guidance to spread out survey visits into four new windows (see Table 1) will lead to higher efficiency at detecting species present at a site compared to randomly making four visits at any time across the breeding season. Because these data are paired (a randomised and a targeted estimate per site) we use a Wilcoxon signed rank sum test to compare the proportion of species richness detected by each estimate.

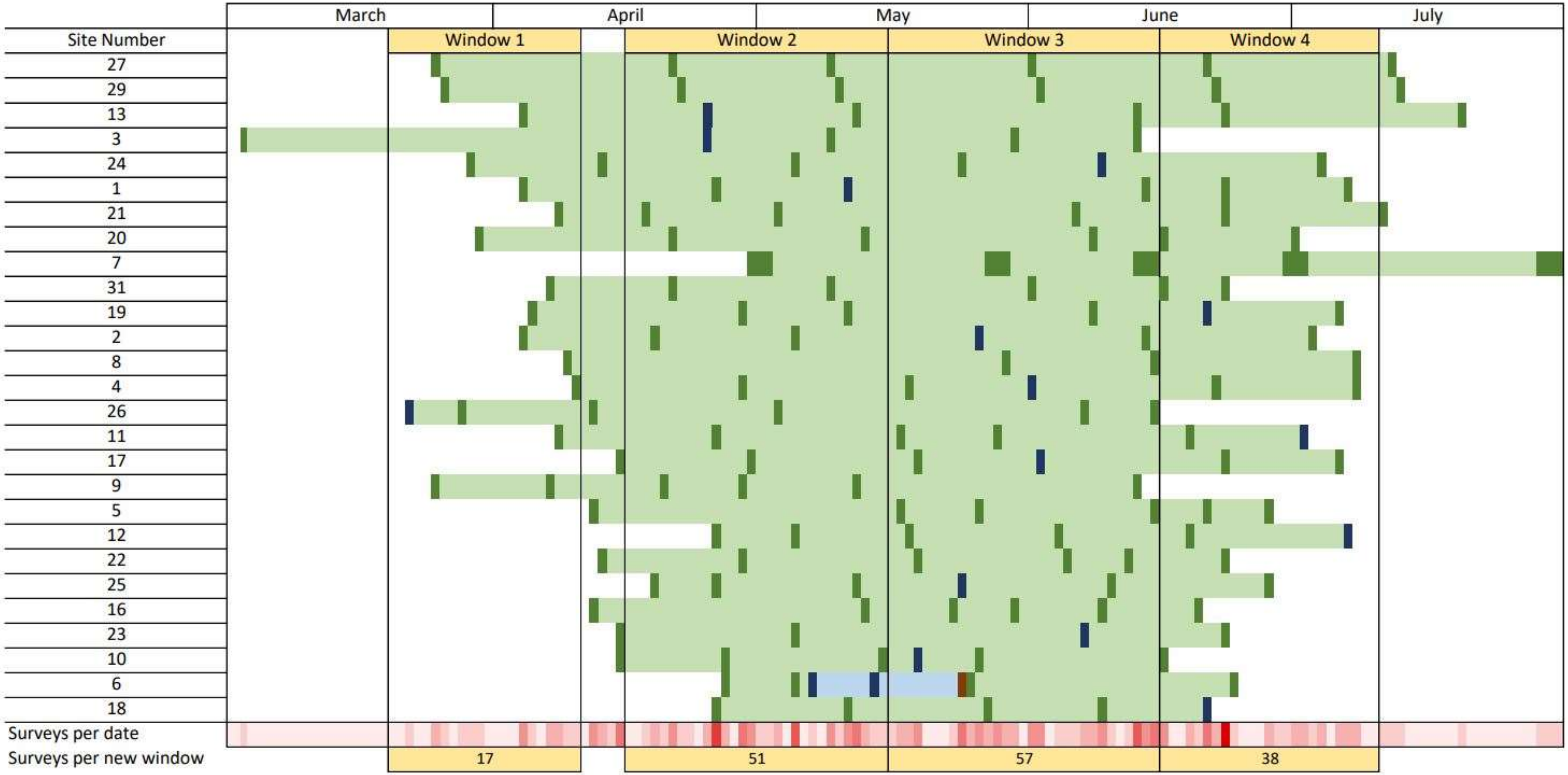


Figure 2: Distribution of survey visits across all survey sites from 2021 and 2022, with the new 2023 survey windows overlain. Dark green = survey visit, light green = days between survey visits, dark blue = evening survey visit, light blue = days between a split evening survey visit, brown = morning and evening survey visit. Red shading indicates frequency of survey visits per day, figure in lower yellow box indicates number of survey visits per new survey window.

3.1.3 Total species richness and the proportion of total richness detected at 4 visits

The relationship between total species richness at a site detected after six visits and the proportion of species richness detected after four randomised visits was investigated. A generalised linear model was used to test the strength of the relationship between these variables, allowing us to determine whether the effect of reducing the number of survey visits will disproportionately impact sites relative to their total species richness. A significant relationship in this analysis would indicate that a disproportionate impact will be found, with a four-visit survey regime being either more or less efficient at detecting all species as total species richness increases, depending on the nature of the relationship.

3.1.4 Species richness results

The species accumulation curves described in section 3.1.1 considering all species are shown in Figure 4 below. The plots show a degree of levelling off to an asymptote by the final visit at the majority of sites. The mean species richness at four randomised visits (horizontal red line) remains as a high proportion of the total observed species richness at each site where it has been plotted (all species mean=90%, range=81-98%; red and amber-listed species mean=90%, range=82-98%; red-listed species mean=91%, range=81-98%). Results were similar between analyses considering all species, red and amber-listed species, or just red-species, so only the plots for all species are shown here, with those for red and amber, and just red-listed species shown in Appendices B and C.

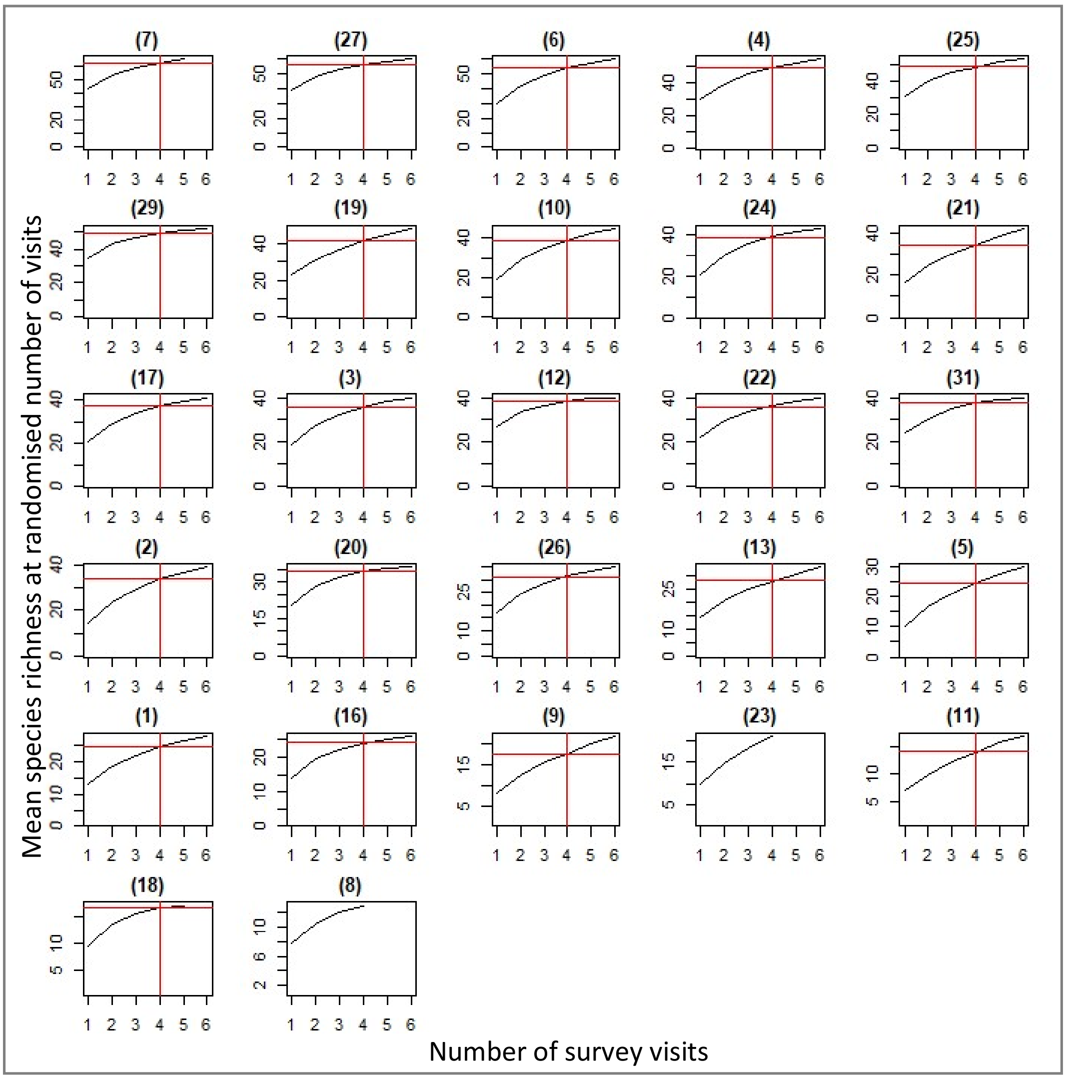


Figure 4: Random-method species accumulation curves of the results of all breeding bird surveys, presented in descending order of total observed species richness by site (site number provided above plots). Red vertical line indicates fourth randomised visit relating to the new survey method from 2023 which will adopt four visits, red horizontal line indicates mean observed species richness at fourth randomised visit. Plots without red lines represent sites which received only four survey visits in total.

The results of the simulation of species richness detected through the new survey windows are presented in Table 4. The greater value of S_{obs} and percentage of total site S_{obs} was found evenly between four randomised and four targeted visits (in six out of twelve sites for each method). Mean S_{obs} after four visits was only marginally greater in targeted survey visits (36.8) than randomised (36.7). The rounded percentage of total site S_{obs} after four visits was equal for randomised and targeted visits (89%). A Wilcoxon signed rank sum test found no significant difference in the percentage of total observed species richness at four visits between the two visit selection methods (all species V=34, P=0.73, n=24; red and amber-listed species V=67.5, P=0.82, n=24; red-listed species V=68, P=0.84, n=24).

Table 4: Observed species richness after six visits, simulated species richness and percentage (rounded) of the total observed species richness after six visits of (i) four randomised visits and (ii) four targeted visits within the new guidance survey windows. The higher value between randomised and targeted visits in each instance is in bold. Table in descending order of S_{obs} after six visits. Mean values of each variable given in final row.

Site number	S_{obs} After 6 Visits	S_{sim} After 4 Visits		% of Total Site S_{obs} After 4 Visits	
		Randomised	Targeted	Randomised	Targeted
27	60	**55.9**	54	**93**	90
4	54	48.7	**51**	90	**94**
29	52	**49.2**	47	**95**	90
19	48	**41.2**	41	**86**	85
24	43	38.6	**43**	90	**100**
21	42	34.4	**35**	82	**83**
31	40	37.6	**38**	94	**95**
2	39	33.6	**35**	86	**90**
20	36	**34.1**	33	**95**	92
13	33	**27.9**	23	**85**	70
1	28	24.8	**27**	89	**96**
11	17	**14.2**	14	**83**	82
Mean	*41*	*36.7*	***36.8***	***89***	***89***

The mean percentage of total S_{obs} derived from four randomised and four targeted survey visits when considering all species, red- and amber-listed species and red-listed species only, is presented in Table 5. In both instances, the mean values of the randomised four visits are greater than those of the targeted visits, however only marginally (1-3% difference), reflecting the similar marginal differences in the analysis considering all species stated prior. See Appendices D and E for full table of results from this analysis for red and amber-listed species and red-listed species only.

Table 5: Mean percentage of total site S_{obs} after four random and four targeted survey visits, for all species, red- and amber-listed species and red-listed species only. Higher value between randomised and targeted visits in each instance is in bold.

Species considered	Mean % of Total Site S_{obs} After 4 Visits	
	Randomised	Targeted
All species	**89**	**89**
Red- and amber-listed	**92**	91
Red-listed only	**91**	88

Figure 5(a-c) shows the distribution of the proportions of total observed species richness at each hypothetical number of survey visits as described in section 3.1.3, when considering (a) all species, (b) red and amber-listed species, and (c) red-listed species only. In all cases, the overall trend shows a greater proportion of total observed species richness being detected at increasing numbers of hypothetical survey visits (1-5), and a decreasing range between minimum and maximum values. The boxes in green highlight the four targeted visits within the new survey windows. In all cases, four targeted visits have a greater range in values than four randomised visits but have the same or similar median values (difference in values between 0 and 0.01). Figure 5 shows that reducing the number of species to consider to only red or red and amber-listed species in the analysis increases the range in proportion of species richness detected from four targeted visits, increasing from (a) 0.3 to (b) 0.39 and (c) 0.5, representing an actual range in the proportion of species detected from 30% to 50%.

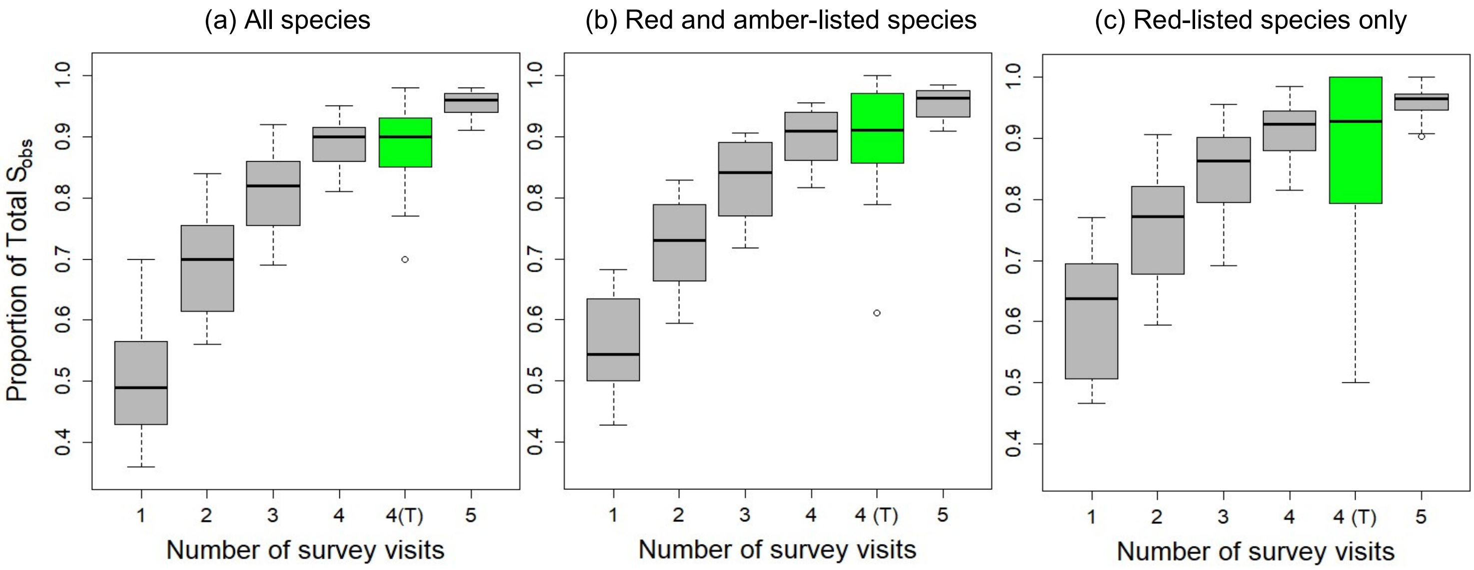


Figure 5(a-c): Predicted mean proportion of total species richness which would be detected at each number of survey visits, relative to the species richness after six actual visits. Box and whisker plots show the variation across all 27 sites for visits 1-5. Green box, 4(T) visits, indicates the predicted proportion of species richness detected after four targeted visits, i.e. if visits had followed the new guidance survey windows, from the subset of 12 sites where visits fell within these windows.

The relationship between the percentage of total observed species richness at four random and four targeted visits is shown in Figure 6(a-c). Data points are paired by site and show the non-significant difference in proportions between the methods of selection of survey visits (random vs targeted) across each set of species analysed. A significant trend would have shown a more consistent increasing or decreasing difference in S_{obs} between random and targeted visits with lines between paired points sloping more consistently in the same direction, however the differences in this instance are inconsistent between sites, with the targeted simulation outperforming the randomised simulation in some sites, and vice versa in others.

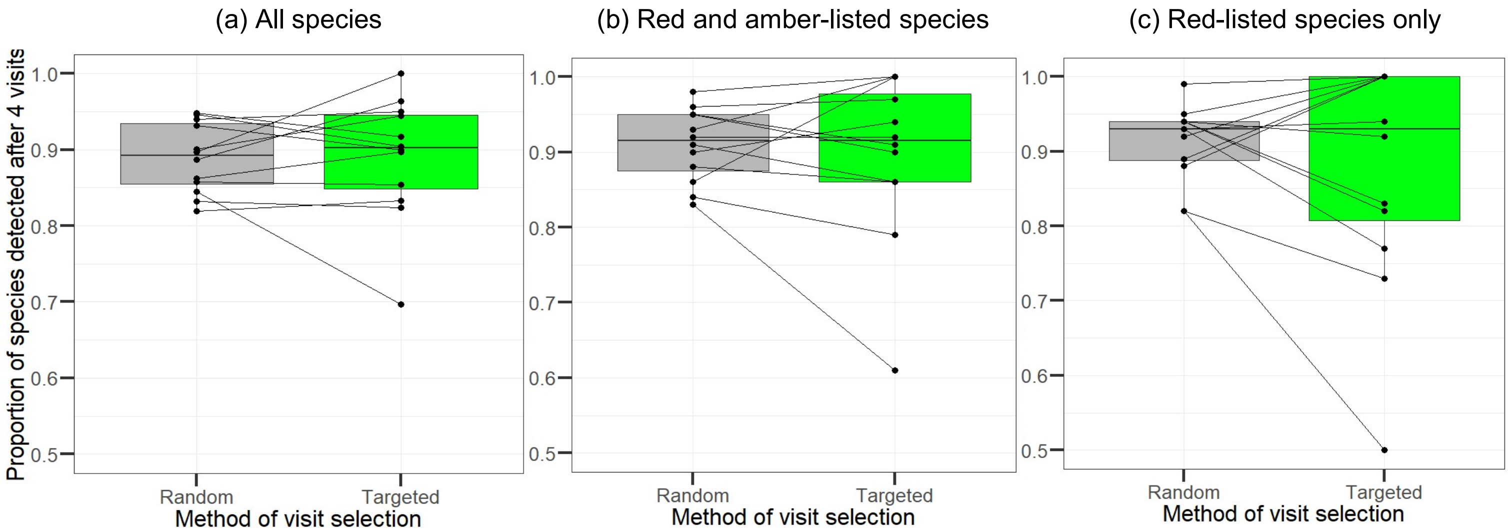


Figure 6(a-c): Proportion of total observed species richness detected after four random and four targeted visits within the new survey windows, relative to the observed species richness after six visits. Points are paired by site indicating the difference in proportion of observed species richness when considering random vs targeted visits at the same site.

The proportion of the total species richness at a site was found to be weakly but significantly positively related to the total species richness at a site (Figure 7; generalised linear model, F=5.3, df=1, 22, R^2=0.2, P=0.03). That is, the more species that had been detected at a site from six visits, the more efficient four visits was at detecting those species. However, this was a weak relationship where with every additional species detected from six visits at a site, the proportion of species richness detected in four randomised visits is predicted to increase by 0.2% (±0.1% SE).

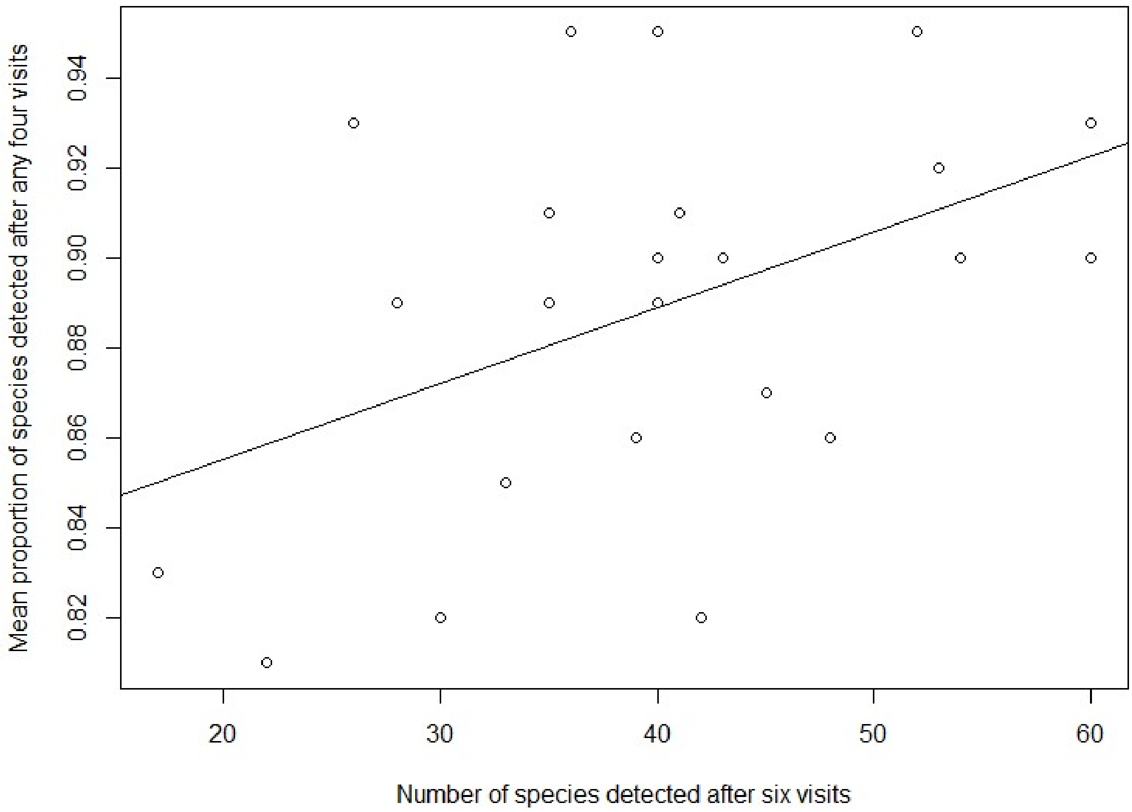


Figure 7: Relationship between total species richness at a site after 6 visits and the proportion of total species richness detected at 4 randomised visits. Generalised linear model added to show significant positive relationship.

3.2 Territory density analysis

To assess the potential impact of reducing the number of survey visits from six to four, a comparison of territory density estimates derived from either six or four breeding bird survey maps was conducted. Estimating territory density for key species such as waders has direct implications for the process of screening and assessing sites for woodland creation (Department for Environment, Food & Rural Affairs, Forestry Commission & Natural England, 2022). Identifying the extent to which territories are undetected at fewer visits show how the decision-making process may be affected by reducing survey effort.

3.2.1 Estimating territories

To assess the territory of a bird, an approach similar to the territory mapping technique as set out in the BTO Common Birds Census Instructions (Marchant, 1983) was followed by surveyors. Using maps of bird registrations where numbers, sexes, vocalisations and/or breeding evidence was recorded across survey sites and across visits, estimates of territories were made. The BTO's Breeding Status Codes (BTO, *n.d.*) were used to assess the likelihood (possible, probable and confirmed) of each recorded bird behaviour indicating breeding evidence and thus holding a territory.

Given that territory estimation is to a degree subjective and the exact methods used by surveyors are potentially variable and unknown to the authors of this report, two approaches to the method of territory estimation were trialled. The methods varied in their way of evaluating breeding evidence using the BTO's breeding status codes (BTO, *n.d.*). The first followed strict criteria and gave a conservative estimate of a territory based on stronger evidence of breeding: one instance of confirmed breeding behaviour, 2-3 instances of possible or probable breeding in the same or similar location over different survey visits. The second approach followed more lenient criteria for assessing a territory, where a single observation of a male bird singing on one visit or any single instances of probable or confirmed breeding indicates a territory. The former approach would tend to, on average, predict a lower number of territories than the latter. We could tell from careful evaluation of maps from individual visits (where available) and final maps/counts of territories that the surveyors differed in which approach they used. As such, the two approaches were trialled and compared with territory estimates given in the reports, with the strict method giving closer estimates in 60% of trials (n=6) and the lenient method giving an estimate equal to or equally deviating from the report estimate as the strict method in the remaining 40% of trials (n=4).

A set of 16 suitable sites were chosen for this analysis under the criteria that the accompanying reports provided maps or GIS shapefiles of bird registrations for individual survey visits, or indicated which visit each registration was made. Survey maps or shapefiles must have also indicated numbers of birds and breeding evidence (vocalisation, nests, juveniles etc.) to identify breeding birds on territory.

Seven bird species were chosen as target species for this analysis, based on having sufficient data across multiple reports for a meaningful analysis, and prioritising species of conservation concern or likely to be particularly impacted by afforestation. Eurasian curlew *Numenius arquatus* and northern lapwing *Vanellus vanellus* are red-listed wading bird species associated with upland habitats and sensitive to woodland creation. Meadow pipit *Anthus pratensis*, reed bunting *Emberiza schoeniclus*, skylark *Alauda arvensis*, stonechat *Saxicola rubicola* and yellowhammer *Emberiza citronella* were chosen as species dependent on upland habitats for foraging and nesting, with skylark and yellowhammer also having red-listed status (Stanbury, 2021). From this set of sites and species, analysis was conducted for sites with at least 1 record of the species to be analysed in three or more survey visits.

3.2.2 Comparing 4 vs 6 visits

To identify the extent to which the detection of territories may be impacted by reducing the number of required surveys from six to four, we took an approach similar to the one taken by Calladine et al. (2009) by calculating the number of territories identified from all possible four-visit combinations of six visits (15 unique combinations) and comparing the mean value of these estimates to the number of territories identified when considering all six survey visits. Physical survey maps were used to consider each combination of four visits, identifying the number of territories which could be detected from that set of visits. The number of territories was then converted to a territory density (territories per km^2) using the area of the site footprint.

When considering curlew and lapwing territory densities, a density of 1 territory per km^2 and 2 territories per km^2, respectively, are used as thresholds for the requirement of an agricultural environmental impact assessment or necessitate further discussions around site suitability when assessing breeding waders at sites for woodland creation (Department for Environment, Food and Rural Affairs, Forestry Commission & Natural England, 2022). Simulating the number of territories of curlew and lapwing detected after four visits compared to six visits would allow for identification of instances where this change in number of survey visits would have technical impacts on the requirement for further site assessment.

3.2.3 Buffer densities

The densities of curlew and lapwing territories obtained from wader surveys in buffer zones surrounding a site were added to the plots of territory densities in the site footprint for comparison. Buffer densities were taken directly from reports which stated numbers of territories or pairs as well as either a density estimate or a buffer zone area measurement (to allow density to be calculated). The addition of buffer zone estimates allows us to consider the accumulative effect of counting buffer territories on the overall density of territories at a site, which may be crucial if some territories are not detected within the site boundary when reducing the number of survey visits, especially in terms of crossing thresholds for further site assessment.

3.2.4 Territory density results

Results of the territory density analysis are presented in Figure 8(a-g). There were only two instances (curlew, sites 4 and 17) where the mean number of territories detected from four visits fell below the wader density thresholds where they had been estimated above the thresholds after six visits. In each of these instances, considering the buffer territory density estimates along with the four-visit estimate would still not have raised the density to the threshold level as they were also below the threshold. However, as each of these estimates were just 0.09 territories per km^2 below these thresholds, it is likely these sites would have still been recommended for further assessment if these estimates were obtained from real surveys.

For each species, a mean territory density for each site was calculated from all combinations of four visits. From these four-visit mean territory density estimates across all species and sites, a mean of 67% of territories were detected out of those detected after six visits. The lowest mean estimate for individual species across all sites as a proportion of the six-visit territory density was for stonechat (59%) and the highest was for lapwing (78%). The four-visit mean territory density detected 100% of the six-visit territory density at two sites for curlew, one site for lapwing and one site for skylark. The species with the lowest maximum density across all sites was stonechat, where the mean four-visit territory density at site 17 was 70% of the six-visit estimate. The lowest proportion of territories detected across four visits was for meadow pipit, with just 20% of the six-visit territory estimate detected at site 10.

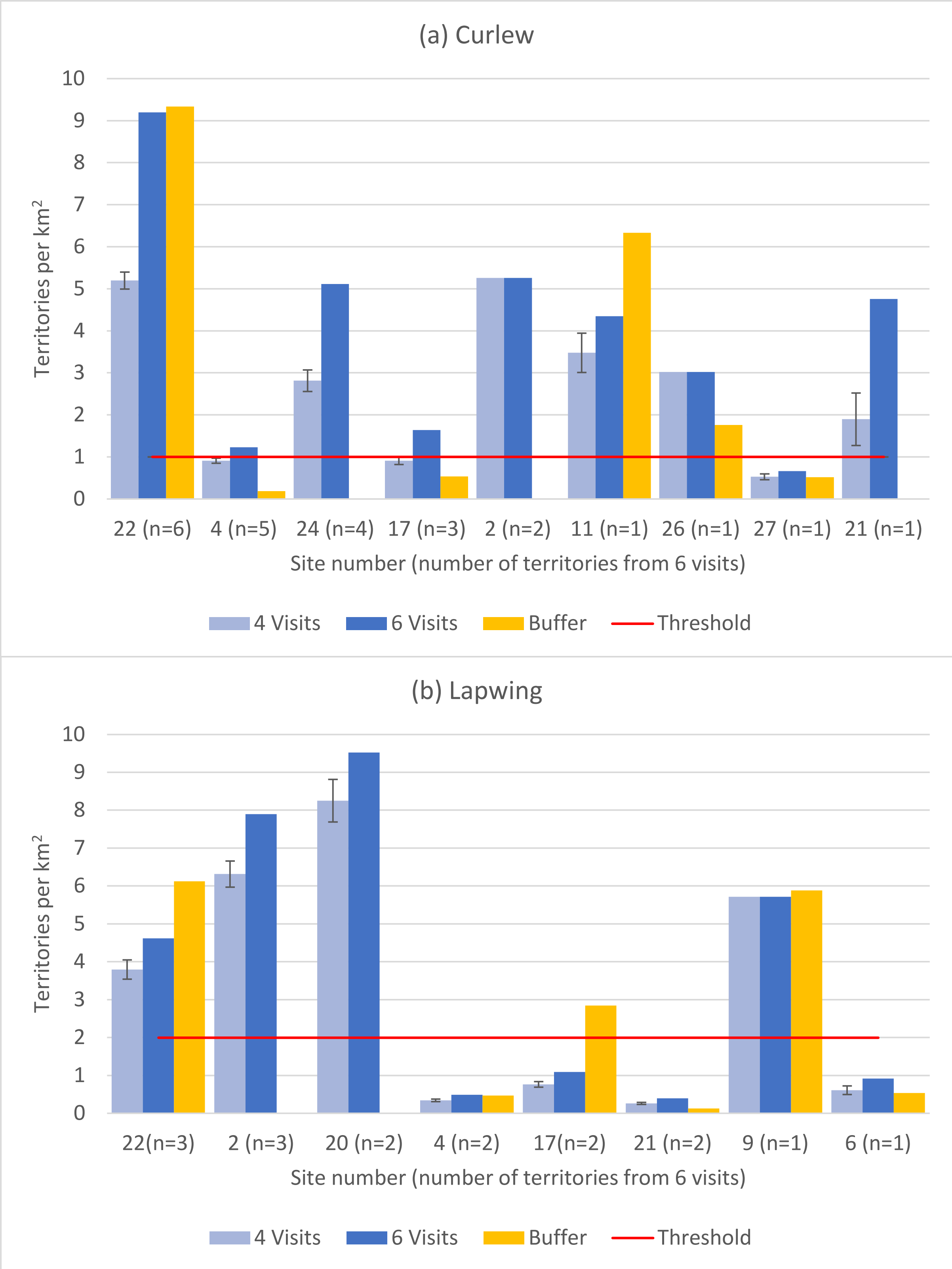
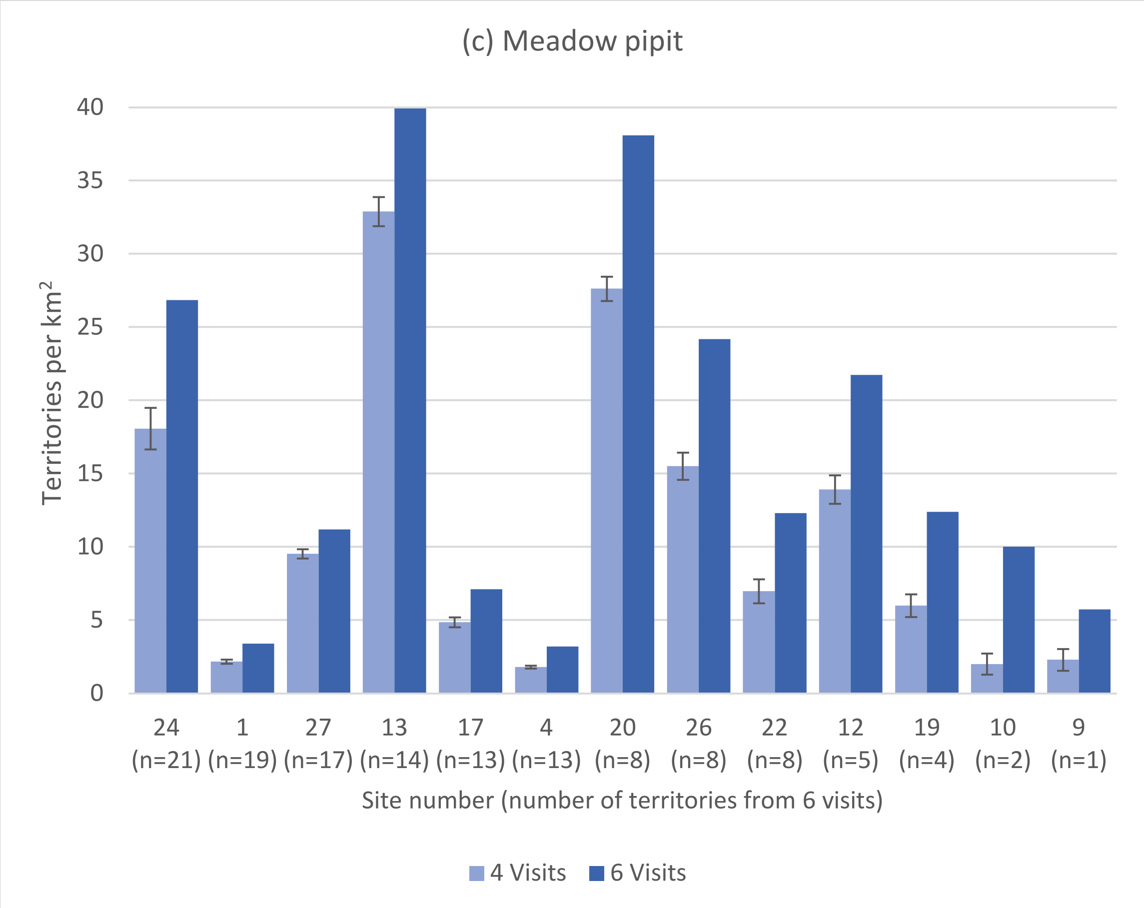


Figure 8(a-g): Estimated number of territories per km^2 of seven target species at selected sites, considering all 6 visits, the mean of all combinations of 4 visits + standard error, and the buffer density stated in reports (curlew and lapwing only). Sites are arranged in descending order of the number of territories detected when considering all 6 visits (n). Territory density threshold for curlew and lapwing indicating requirement for further assessment of site suitability. (Continues…)



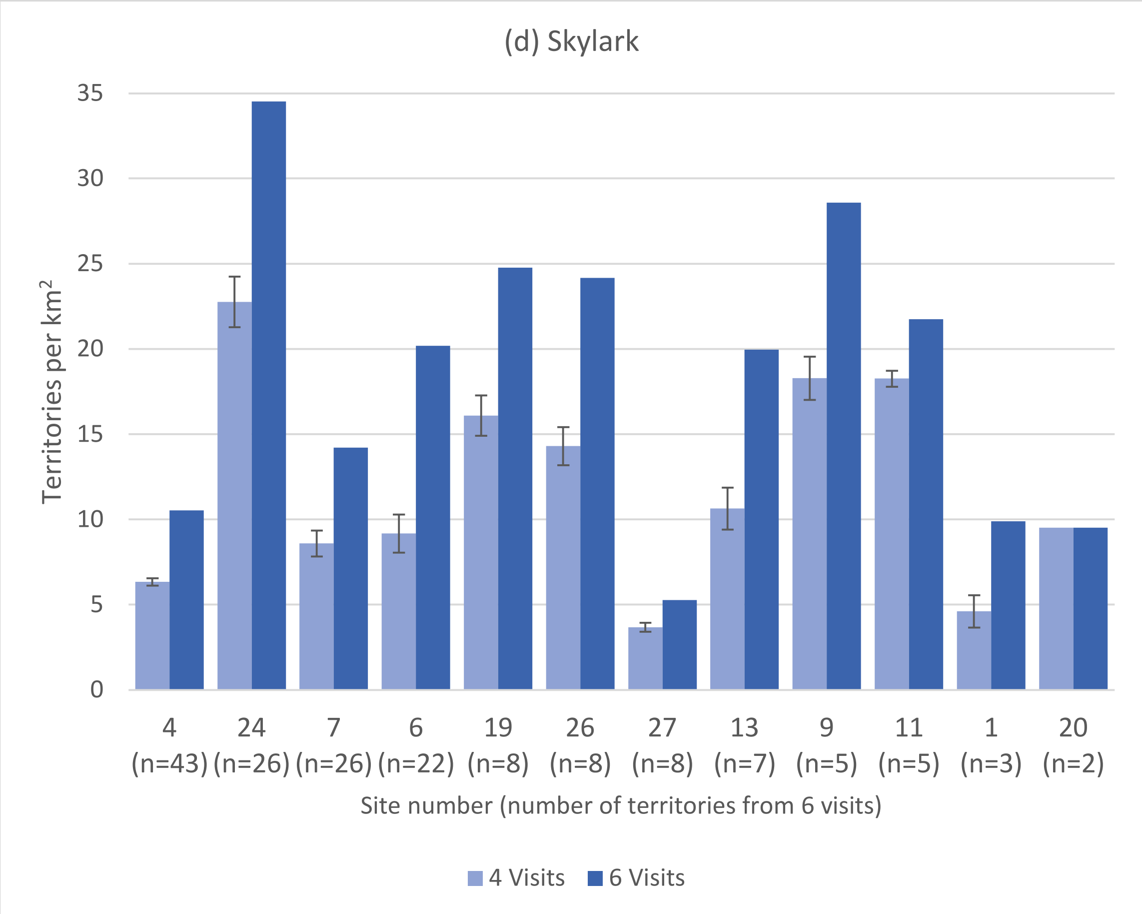


Figure 8 (Continued…)

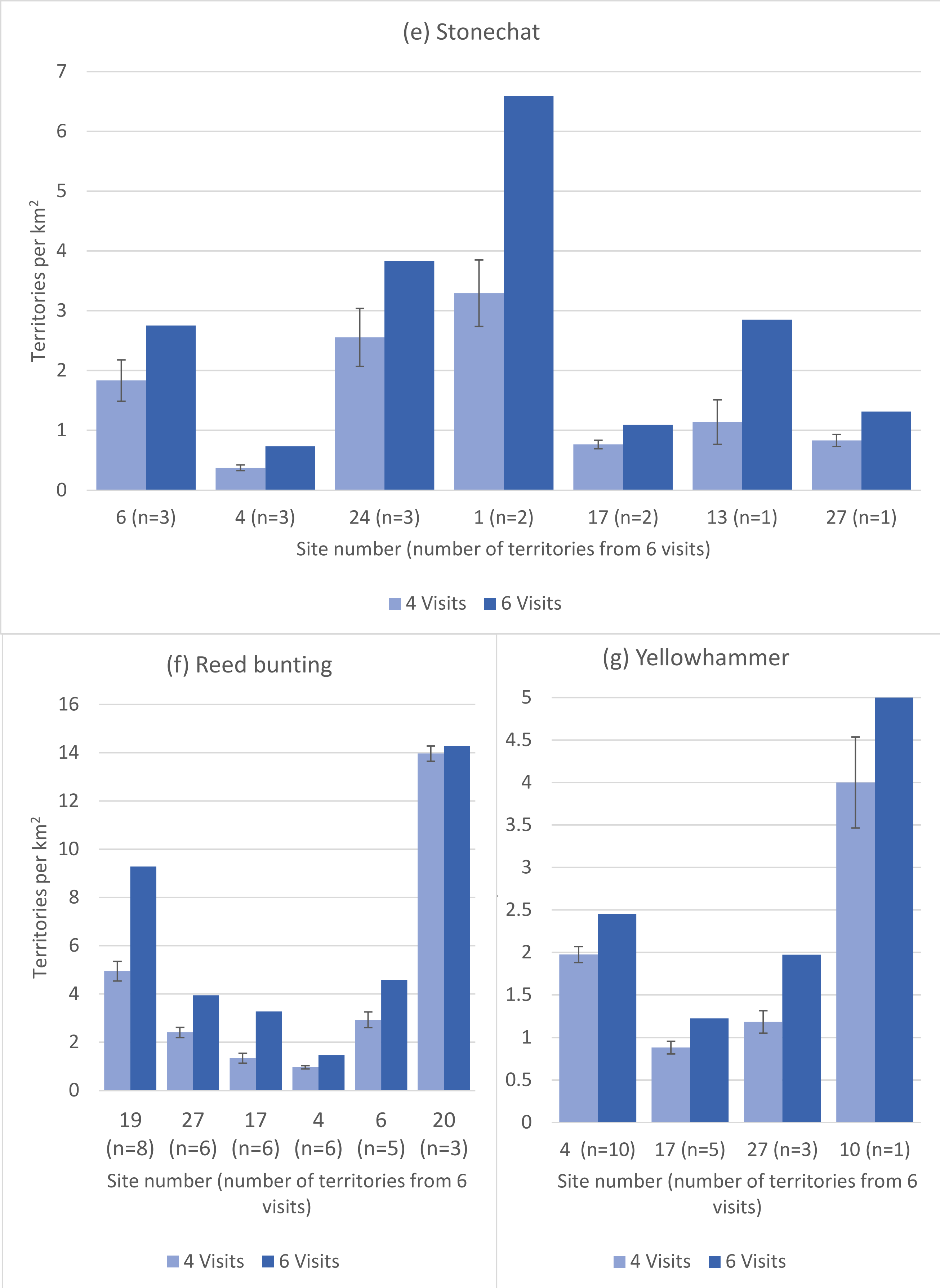


Figure 8 (Continued…End of figure)

4. Discussion

From the analyses presented, it can be assumed that reducing the number of survey visits in a breeding bird survey scheme at a woodland proposal site will reduce the species richness detected and reduce estimates of territory densities, which is inevitable given a reduction in survey effort is likely to reduce the probability of detecting some species or territorial activity. However, the predicted proportional reduction observed in species richness (section 3.1) is substantially less than the reduction in survey effort which would be achieved in reducing survey visits by a third. The mean reduction in species richness was only 10% in four randomised visits (range across sites 5-18%) and 11% in four targeted visits (range across sites 0-30%), suggesting four visits may represent an adequate trade-off between effort and efficacy. These results broadly support a finding by Calladine et al. (2009) who simulated the effect of reducing the number of survey visits on population estimates of breeding birds in moorland habitats using a constant-effort-search method, finding that four survey visits is the minimum required to produce reliable estimates. Thus, four visits should be sufficient to assess species richness.

In contrast, for the seven species analysed, the reduction in territory density estimates from six to four visits (section 3.2) was greater than the reduction in species richness, with a mean of 33% of territories missed when reducing visits (range of means across species 22-41%). This suggests that the reduction in survey effort was, on average, matched by the reduction in territories detected. A greater reduction in territory density than in species richness would be expected, as the nature of territory estimation requires multiple records of the same species of bird over successive visits, whereas species richness only requires one record of a species in a single visit to be counted. The CBC method of breeding bird survey and territory mapping (an altered version of which was the suggested method of survey in the FC's 2020 guidance, requiring five visits) required 10 survey visits in order to accurately identify territories of breeding birds (Marchant, 1983). However, in our analysis there were only two instances in which a reduction from six to four visits caused the territory estimate of a wading bird species to fall below the threshold which would have direct implications for the process of screening and assessing sites for woodland creation. In addition, the two accepted methods of survey for upland breeding waders (O'Brien & Smith, 1992 and Brown & Shepherd, 1993) use a minimum of either three or two visits respectively. Thus, given four visits generally was not predicted reduce densities of curlew and lapwing substantially and change the management implication of the data, it is likely that four visits will be sufficient to assess territory densities for these species, and is still more visits that two widely used breeding wader survey methods.

Finding a significant relationship between total species richness at a site and the species richness detected after four visits (section 3.1.3) suggests a possible disproportionate effect of reducing the number of survey visits on different sites. Reducing the required number of survey visits from six to four is likely to have a greater detrimental effect on detecting the total species assemblage at sites containing lower species richness than sites with greater species richness. This relationship, however was relatively weak, and was not found to be significant when considering red and amber-listed or just red-listed species, so the benefit of considering relationship in designing survey guidelines are not clear.

Despite analysis showing no significant difference in the proportion of species richness detected at four random or four targeted survey visits relative to six visits, the targeted visits may bring additional benefits beyond the measure of species richness. Introducing the new survey windows is likely to result in a greater level of consistency in the timing and spread of survey visits across the breeding season. For example, considering the surveys analysed in this report, just 15 of 31 sites received surveys within the new ‘window 1’ dates, with two of these sites making two survey visits each in this window, one site completing its first and second visits either side of this window, and 15 sites conducting their first survey after this window. Therefore, retaining these windows would bring these sites further in line with one another and is likely to reduce variation in survey timings, making comparisons between sites more valid in the assessment of their suitability for woodland creation, as well as for future analysis using similar data.

One of the main challenges of this report was in the management of data from different reports, where each report varied in terms of content, data presentation and methodology. A greater emphasis on meeting and demonstrating survey criteria set out in FC guidance would bring greater consistency between reports and again make comparisons between reports easier and more valid. Often, assessing whether reports met criteria required the assumption that a criterion was met if it was not specified in the methods or demonstrated another way, such as in providing survey transect maps to demonstrate site coverage. A requirement to demonstrate how survey criteria were met, and potentially including a template for reports, would improve standards of consistency between reports and improve confidence in comparability between them.

The findings of this report represent the analysis of a set of 31 breeding bird survey reports and presents the predicted outcome of reducing the number and prescribing the timing of survey visits on two metrics of evaluating bird communities. It also presents a potential framework for future analysis to consider a greater number of reports spanning more years, including those that will use the new FC survey guidelines.

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Appendices

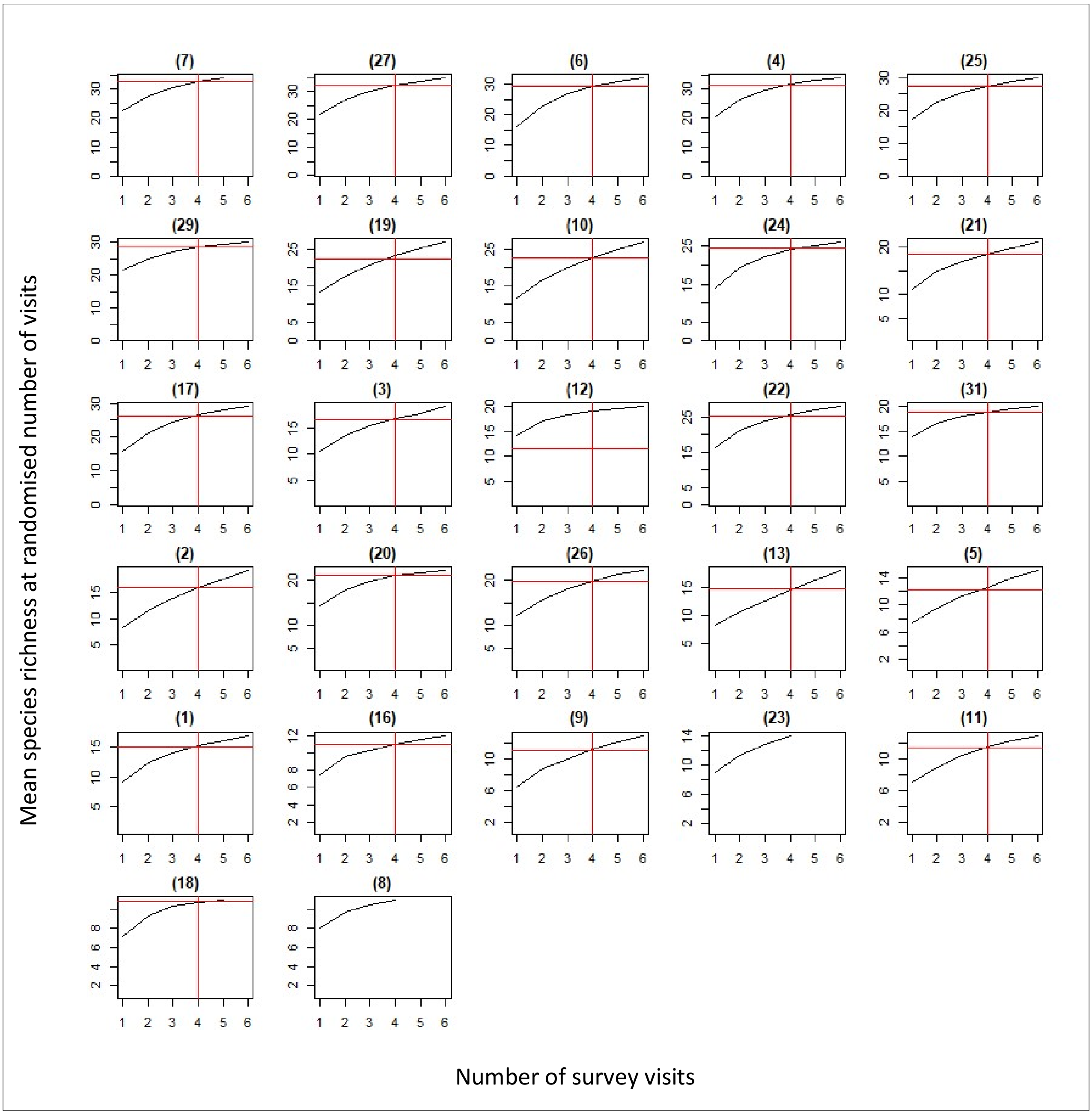
Appendix A: List of BoCC classifications (Stranbury et al., 2021) of species in the dataset

Species	*Scientific name*	BoCC classification (green, amber, red-listed)
Canada goose	*Branta canadensis*	
Greylag goose	*Anser anser*	
Mallard	*Anas platyrhynchos*	
Goosander	*Mergus merganser*	
Red grouse	*Lagopus lagopus*	
Black grouse	*Tetrao tetrix*	
Grey patridge	*Perdix perdix*	
Pheasant	*Phasianus colchicus*	
Red-legged partridge	*Alectoris rufa*	
Swift	*Apus apus*	
Cuckoo	*Cuculus canorus*	
Stock dove	*Columba oenas*	
Woodpigeon	*Columba palumbus*	
Collared dove	*Streptopelia decaocto*	
Oystercatcher	*Haematopus ostralegus*	
Lapwing	*Vanellus vanellus*	
Golden plover	*Pluvialis apricaria*	
Whimbrel	*Numenius phaeopus*	
Curlew	*Numenius arquata*	
Woodcock	*Scolopax rusticola*	
Snipe	*Gallinago gallinago*	
Redshank	*Tringa totanus*	
Black-headed gull	*Chroicocephalus ridibundus*	
Common gull	*Larus canus*	
Herring gull	*Larus argentatus*	
Lesser black-backed gull	*Larus fuscus*	
Grey heron	*Ardea cinerea*	
Osprey	*Pandion haliaetus*	
Sparrowhawk	*Accipter nisus*	
Red kite	*Milvus milvus*	
Buzzard	*Buteo buteo*	
Barn owl	*Tyto alba*	
Short-eared owl	*Asio flammeus*	
Tawny owl	*Strix aluco*	
Great-spotted woodpecker	*Dendrocopos major*	
Green woodpecker	*Picus viridis*	
Kestrel	*Falco tinnunculus*	
Merlin	*Falco columbarius*	
Peregrine	*Falco peregrinus*	

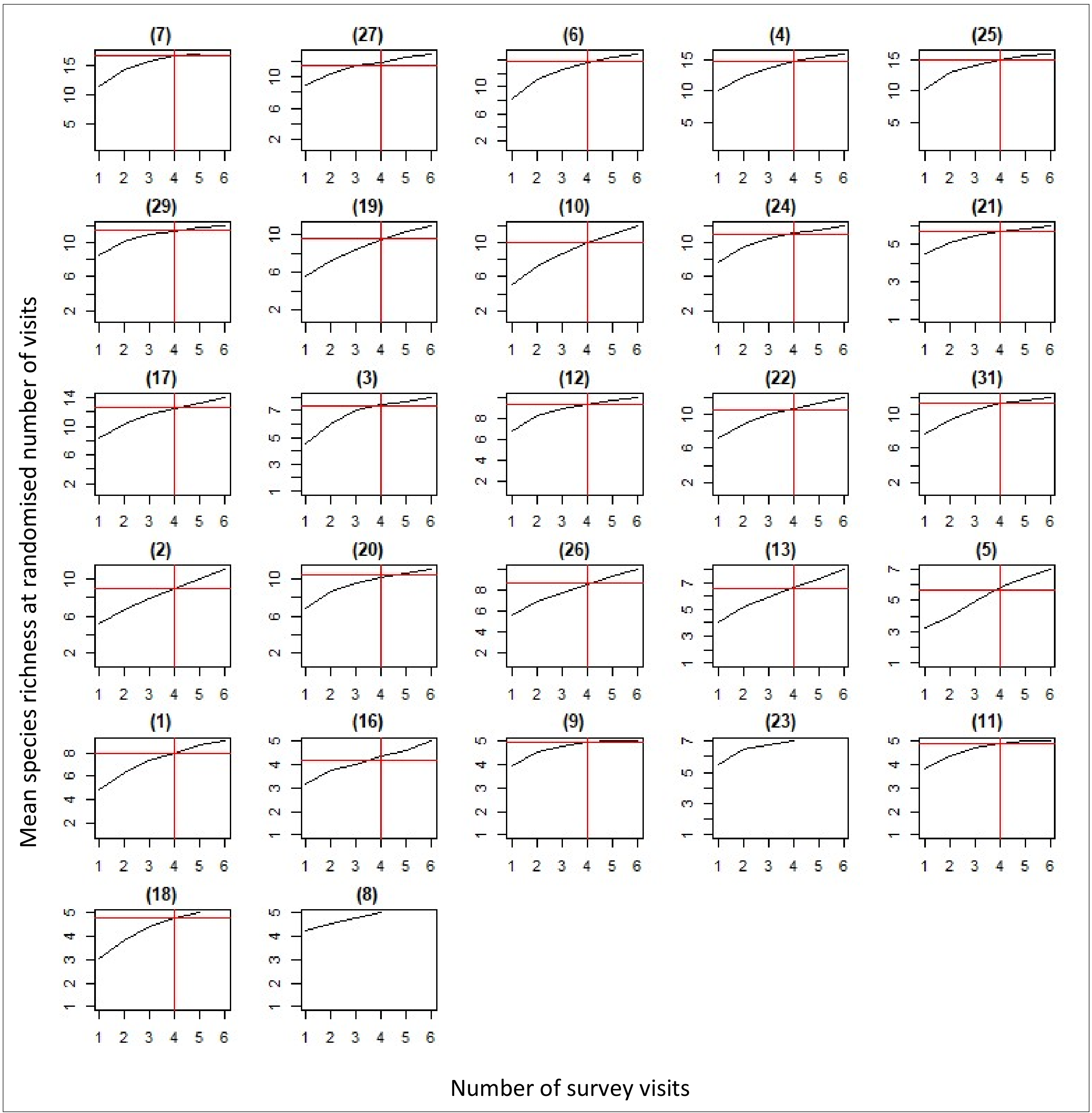
Jay	*Garrulus glandarius*
Magpie	*Pica pica*
Jackdaw	*Coloeus monedula*
Rook	*Corvus frugilegus*
Carrion crow	*Corvus corone*
Raven	*Corvus corax*
Coal tit	*Periparus ater*
Marsh tit	*Poecile palustris*
Willow tit	*Poecile montanus*
Blue tit	*Cyanistes caeruleus*
Great tit	*Parus major*
Skylark	*Alauda arvensis*
Sand martin	*Riparia riparia*
Swallow	*Hirunda rustica*
House martin	*Delichon urbicum*
Long-tailed tit	*Aegithalos caudatus*
Willow warbler	*Phylloscopus trochilus*
Chaffinch	*Fringilla coelebs*
Sedge warbler	*Acrocephalus schoenobaenus*
Reed warbler	*Acrocephalus scirpaceus*
Grasshopper warbler	*Locustella naevia*
Blackcap	*Sylvia atricapilla*
Garden warbler	*Sylvia borin*
Lesser whitethroat	*Curruca curruca*
Common whitethroat	*Curruca communis*
Goldcrest	*Regulus regulus*
Wren	*Troglodytes troglodytes*
Nuthatch	*Sitta europaea*
Treecreeper	*Certhia familiaris*
Starling	*Sturnus vulgaris*
Song thrush	*Turdus philomelos*
Mistle thrush	*Turdus viscivorus*
Redwing	*Turdus iliacus*
Blackbird	*Turdus merula*
Fieldfare	*Turdus pilaris*
Ring ouzel	*Turdus torquatus*
Spotted flycatcher	*Muscicapa striata*
Robin	*Erithacus rubecula*
Pied flycatcher	*Ficedula hypoleuca*
Common redstart	*Phoenicurus phoenicurus*
Whinchat	*Saxicola rubetra*
Stonechat	*Saxicola rubicola*
Wheatear	*Oenanthe oenanthe*
Dipper	*Cinclus cinclus*

Tree sparrow	*Passer montanus*
House sparrow	*Passer domesticus*
Dunnock	*Prunella modularis*
Grey wagtail	*Motacilla cinerea*
Pied wagtail	*Motacilla alba*
Meadow pipit	*Anthus pratensis*
Tree pipit	*Anthus trivialis*
Chiffchaff	*Phylloscopus collybita*
Bullfinch	*Pyrrhula pyrrhula*
Greenfinch	*Chloris chloris*
Twite	*Linaria flavirostris*
Linnet	*Linaria cannabina*
Common redpoll	*Acanthis flammea*
Lesser redpoll	*Acanthis cabaret*
Crossbill	*Loxia curvirostra*
Goldfinch	*Carduelis carduelis*
Siskin	*Spinus spinus*
Yellowhammer	*Emberiza citrinella*
Reed bunting	*Emberiza schoeniclus*

Appendix B: SACs for red and amber-listed species



Appendix C: SACs for red-listed species only



Appendix D: Species richness table for red and amber-listed species

Site	S_{obs} After 6 Visits	S_{sim} After 4 Visits		% of Total Site S_{obs} After 4 Visits	
		Random	Targeted	Random	Targeted
1	17	15.3	**16**	90	**94**
27	35	**31.9**	30	**91**	86
2	19	**15.9**	15	**84**	79
4	33	31.6	**34**	96	**97**
29	30	**28.5**	27	**95**	90
11	13	**12**	**12**	**92**	**92**
13	18	**14.9**	11	**83**	61
19	27	23.1	**27**	86	**100**
20	22	**20.9**	20	**95**	91
21	21	**18.5**	18	**88**	86
24	26	25.5	**26**	98	**100**
31	20	18.7	**20**	93	**100**
Mean	*23.4*	***21.4***	*21.3*	***91***	*90*

Appendix E: Species richness table for red-listed species

Site	S_{obs} After 6 Visits	S_{sim} After 4 Visits		% of Total Site S_{obs} After 4 Visits	
		Random	Targeted	Random	Targeted
1	9	8.0	**9**	89	**100**
27	13	**12.1**	10	**93**	77
2	11	**9.1**	8	**82**	73
4	16	14.8	**15**	93	**94**
29	12	**11.3**	11	**94**	92
11	5	4.95	**5**	99	**100**
13	8	**6.6**	4	**82**	50
19	11	9.7	**11**	88	**100**
20	11	**10.3**	9	**94**	82
21	6	**5.6**	5	**94**	83
24	12	11.0	**12**	92	**100**
31	12	11.4	**12**	95	**100**
Mean	*10.5*	***9.6***	*9.3*	***91***	*88*