BTO RESEARCH REPORT 727

Audit of local studies of breeding Curlew and other waders in Britain and Ireland

Mark Wilson, John Calladine and Chris Wernham

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A report funded by the Esmée Fairburn Foundation

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BTO Research Report 727

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1. EXECUTIVE SUMMARY

1. Due to large historical and ongoing population declines in Britain and Ireland and mainland Europe, and its 'near-threatened' global status, the Eurasian Curlew (*Numenius arquata*) is widely considered by many stakeholders to be one of the highest bird conservation priorities in the UK and Ireland. A number of other breeding waders have also showed marked declines during a similar time frame, and a multitude of field initiatives across Britain and Ireland have been established, or tailored, to support conservation of these wader species.

2. This audit aimed to collate information from as many of these British and Irish breeding wader projects as possible, to allow BTO to assess how best it might assist local to national initiatives through partnership working in future. The audit was designed to assess the appetite of the interested community for scientific guidance, mechanisms to share data and findings, and any other roles that would benefit from BTO's areas of expertise and experience.

3. This report presents information drawn from a variety of projects on breeding Curlew and other waders. Questionnaires were sent out to 41 projects in October 2017, asking about their structure, aims, and monitoring and management activities. We also carried out a literature review of breeding wader survey methodologies.

4. Questionnaire responses were received for 31 projects. The majority of projects had been started recently, but with the intention of carrying on for as long as funding permitted.

5. The geographic scope of projects varied greatly, from individual farms and discrete areas of good wader habitat, to much larger areas, typically with very low wader densities. Several projects covered multiple areas.

6. Almost half of the projects that responded were led by RSPB, but several were organised and carried out principally by independent individuals. The remainder were led by staff in National Parks or Areas of Outstanding Natural Beauty, University of the Highland and Islands, and BTO.

7. Many projects relied extensively or exclusively on volunteer input of manpower and expertise. Where projects had access to internal funding from hosting organisations, or external funding from grants and donations, this was typically time-limited or of uncertain duration.

8. Most projects carried out counts of breeding waders. The majority of these used standard wader survey techniques. Two others employed transect surveys, and three focussed on finding breeding pairs at historic breeding sites in areas of low density. Three more projects, in areas managed for grouse shooting, were undertaken by gamekeepers during their daily routines.

9. Fewer projects carried out nest monitoring or engaged in systematic recording of breeding productivity. Most respondents acknowledged the importance of productivity information, but many felt constrained by lack of resources as well as uncertainty about which methods would be most suited for them to use.

10. Six projects carried out colour-marking and/or remote-tracking of Curlews, aimed primarily at improving understanding of the factors influencing chick survival, and local movements of adults.

11. More than half of the projects collected information on habitat quality and (particularly agricultural) land management. Only one project claimed to collect systematic information on occurrence or activity of predators, though several others recorded data on predators opportunistically. Four projects looked explicitly at food availability for breeding Curlews.

12. Roughly half of the projects included work on habitat management. In some cases this was carried out directly by project participants, while other projects gave advice to and made agreements with farmers – often in the context of applications for funding under agri-environmental schemes.

13. Methods aimed at systematically counting breeding waders are well developed, with the literature containing much useful advice on timing of surveys (within day and season), number of surveys, the information that surveyors should record and how this should be interpreted.

14. Determining nest success (i.e. hatching success) of waders is reasonably straight-forward, though finding and monitoring wader nests can be time-consuming. However, wader chicks leave the nest soon after hatching and do not fledge for another 2–4 weeks. This makes nest success an unreliable signal of overall breeding productivity, which is of greater overall significance.
15. Methods for assessment of breeding productivity are less well developed. Although many different approaches are described in the literature, many of these are time-consuming, and there is often a lack of consensus regarding which approach is most appropriate. Moreover, little consideration is given to how the findings from different methods should be compared with one another.
16. Many stakeholders would appreciate the provision of guidance on methods for wader monitoring in more user-friendly forms than currently exist. Such guidance should steer fieldworkers towards the survey types that are best suited to their situation, and give specific advice about aspects such as timing, effort and sampling design.
17. Guidance on collection of breeding productivity data should emphasise the lack of consensus on how best to do this, and the importance of documenting details of methodology. This will enable information collected to contribute to assessments of what works best for determining productivity in different situations, and will better place projects to take advantage of new developments in this area.
18. There is wide recognition that a system to effectively capture wader monitoring data would be useful not only to individual projects, but also to the wider wader conservation community. Such a system would need to be flexible enough to accommodate a wide range of users and types of information. Most stakeholders would be willing for their data to be widely shared to promote and enhance wader conservation efforts.
19. Improved monitoring of waders could be aided through the appointment of a Wader Project Officer. The role could include over-arching support for individuals and organisations working on waders, promotion of best practice, encouraging synergies and helping to guard against duplication of effort, and management and development of a wader information hub.
20. The resource-limited nature and common objectives of many wader projects are well suited to partnership working. As well as boosting the efficiency and effectiveness of initiatives to monitor and manage waders, partnerships between different groups of stakeholders are likely to result in opportunities for knowledge transfer, and increased mutual understanding and tolerance of stakeholders with potentially divergent views.

2 INTRODUCTION

Since the completion of the *Bird Atlas 2007–11* (Balmer *et al.* 2013), awareness about the precarious conservation status of several widespread species of breeding wader in Britain and Ireland has grown. In particular, Eurasian Curlew (*Numenius arquata*) has been widely recognised as one of the highest bird conservation priorities in the UK and Ireland (Brown *et al.* 2015; O'Donoghue 2017). Concern for Curlews in the UK, and a shared desire to improve their prospects, have recently made this species something of a flagship for other declining species of waders and ground-nesting birds.

A wide variety of work on Curlews has been initiated, including monitoring and management, and with the scale of effort ranging from state-sponsored national programmes with high levels of funding, through to independent projects involving a handful of volunteers. Many participants in such projects have sought input from BTO in terms of guidance about study design and methods, provision or interpretation of existing data, and logistical support with various aspects of the work, including training, equipment, fieldwork, data processing, analysis and reporting. Individual members of staff have responded to these requests as helpfully as they can, but resources and available time necessarily constrain BTO's contributions to individual projects. Moreover, BTO as an organisation has been considering how best to draw together the findings and recommendations from individual projects, to consolidate guidance and methodological approaches used by these projects, and identifying ways in which the time and money spent by BTO can yield the greatest possible benefits for waders and wader workers alike. In order to do this, we need to find out about as many Curlew projects as possible, to understand the kinds of information they are collecting, the methods they are using, and the aspirations of those involved.

2.1 Aims

The aim of this audit was to collect standardised information on a wide variety of projects being carried out on breeding Curlews and other waders, particularly where this was relevant to consideration of factors relevant for Curlews. In collecting this information we hoped to arrive at a better understand of what these projects hope to achieve, the methods they are currently using, and their desire and willingness to collaborate and to share information and expertise with BTO and others. Specific objectives of the work were to:

1. Collate information from all known local Curlew projects, in particular gathering information on:

    a. duration (both past and projected future)

    b. geographic scope

    c. project partners

    d. project funding (including in-kind contributions if any)

    e. activities (surveys, nest monitoring and what kind, ringing, habitat assessment, etc)

    f. specific methods being used for activities above

    g. what data have been/are being collected, how they are being used locally

2. Assess appetite for scientific guidance, particularly with regards to recommended standardisation of basic methods across projects, as potential partnerships with other partners including BTO.

3. Assess appetite for sharing of data with the BTO for the purposes of pooling across sites for more robust analyses at broad geographic scales.

4. Review and summarise the most effective and transferable methods for collection of data on breeding Curlew.

5. Develop scientific guidance on a set of appropriate, standardised methods, where methods can be scaled as a hierarchy of effort.

6. Consider whether and how BTO could help such projects, particularly with data submission and collation.

7. Assess how local projects could work in partnership with the BTO in future.

8. In the process of collating information on Curlew initiatives, collate similar relevant information on other breeding waders.

3 METHODS

3.1 Local Curlew and wader projects

3.1.1. Sources of information

During this audit, we tried to establish contact with, and get information from, as many existing breeding Curlew projects as possible. The 46 projects that we contacted are listed in Table 1, along with eight RSPB reserves where monitoring and management is carried out for waders. Contact with many of these projects was established during work carried out as part of BTO's Curlew Appeal, or during the Understanding Predation (2014–2015; Ainsworth *et al.* 2016) and Working for Waders (2016–present) initiatives in Scotland. Other projects were added to this list based largely on information received from existing contacts who responded to requests for more information during the audit.

3.1.2 Questionnaire

In October 2017 we sent a questionnaire to project representatives asking about project structure and activities, as well as their aspirations for work on Curlews and other waders (Appendix I). This questionnaire was divided into themed groups of specific questions on contact information (four questions), project location, duration and scale (nine questions), breeding numbers (seven questions), nest monitoring (seven questions), productivity (one question), marking and tracking (one question), other environmental information (six questions), management and intervention (three questions), and collaboration and data sharing (seven questions).

The questionnaire took an estimated 30 minutes to complete (based on trials among BTO staff before it was sent out). Although we received feedback from some respondents to the effect that they felt it placed an unwelcome burden on their time, most responses to the questionnaire were clear and helpful, with many respondents providing supplementary information in the optional notes and comments fields. In a few cases information was collected from these projects via telephone conversation. Questionnaires were filled in subsequently, using the information provided during these conversations, and the completed questionnaires sent to the project contact for them to verify.

3.2 Wader methodology review

Studies of breeding Curlew and other waders published over the last 40 years were reviewed in order to document methods for assessing distribution, abundance, nest success and productivity. From this literature, we describe the main methodologies and how these have been used in breeding wader studies. We also consider some of the advantages, limitations and resource requirements of these different methods.

Information on existing methods gained from this review was considered together with information from individual projects, received primarily through the questionnaires, to help identify elements of methodology and practice that could contribute to a standardised set of wader monitoring options. This information was also used to inform a discussion of how BTO could enhance work on Curlews and other waders by helping with data collection and collation, and by working in partnership with local projects.

4 RESULTS

4.1 Local Curlew and wader projects

4.1.1 Questionnaire responses

Questionnaire responses were received or compiled for 31 projects. The following summaries are based solely on these responses, and do not apply to any of the above-mentioned projects for which we did not receive a response. The full responses to questionnaires are archived at BTO Scotland.

4.1.1.1 Start date and intended duration

Most projects had start dates within the past few years. Many recent projects had well-defined start dates (Figure 1a), often coinciding with the timing of funding that had made the project possible. However, the timing of some projects was less clear, either because different elements of the project had started in different years, or because more recent surveys or management followed on from initial work carried out years or even decades before.

Although a small number (three) of the projects we contacted had been recently completed, the majority were ongoing (Figure 1b). More than two thirds (22) of the 31 projects that gave information about their intended duration replied that this was indefinite, or that duration depended on the (as yet unknown) availability of resources. Six projects were due to finish at some point over the next three years (mostly due to the short term nature of their funding).

Figure 1. Distribution of projects according to a) start year (the first year in which projects collected, or are anticipated to collect, data; or for projects that do not involve formal data collection, the first year in which management work for waders was carried out) of 27 projects, and b) intended duration of 31 projects.

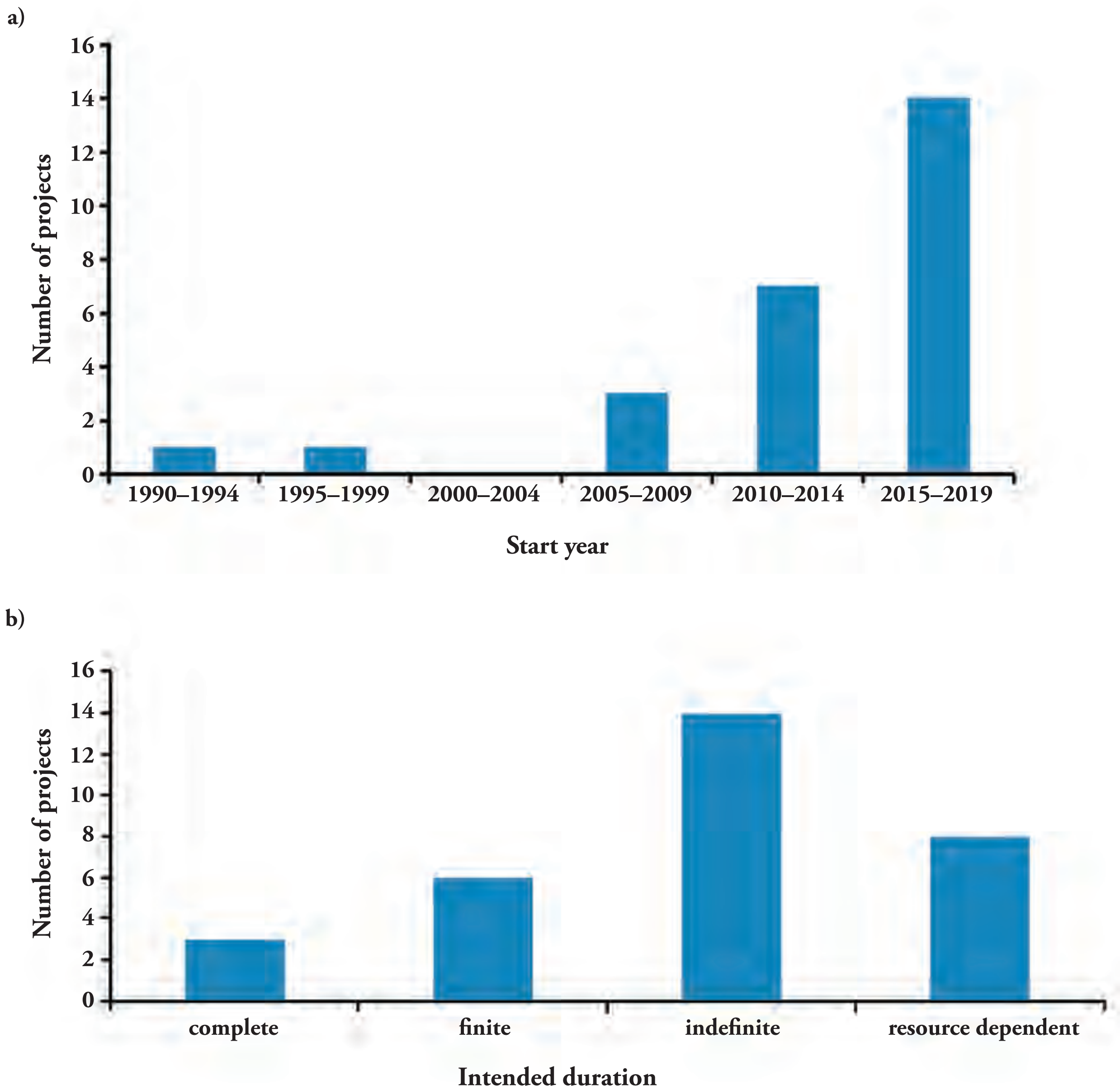


Table 1. List of Curlew and wader projects contacted for information. The type of project (either independent or given as the lead organiser), whether or not a questionnaire was filled in for the project, the number of breeding pairs of Curlews included, and the corresponding breeding density (according to the size of the area covered by the project) are given, where this is known. ID numbers in this table correspond with the numbers on the map in Figure 2. More detail on all projects is given in the supplementary spreadsheet *Curlew project details.xlsx.* Acronyms featured in this table are: BBS (Breeding Bird Survey); BTO (British Trust for Ornithology); GWCT (Game and Wildlife Conservation Trust); IPCC (Irish Peatland Conservation Council); NPA (National Park Authority); NPWS (National Parks and Wildlife Service); RSPB (Royal Society for the Protection of Birds). * Summary information about RSPB reserves received from RSPB Scotland HQ in March 2018

ID	Project	Lead organiser	Questionnaire response	Curlew pairs	Breeding Curlew density (pairs per km^2)
1	Shetland Wader Project	RSPB	Yes	2300	6.05
2	Breeding wader surveys on Orkney LNCS	RSPB	Yes		3.27
3	Caithness Wetlands and Wildlife Initiative	RSPB	Yes		
4	Dale Farm Conservation Project	University	Yes		
5	Uist Wader Survey	RSPB	Yes	20	0.03
6	Strathspey Wetlands and Waders Initiative	RSPB	Yes	288	3.2
7	Tomatin Moorland Group	Independent	Yes		
8	Grampian Wetland & Wader Initiative	RSPB	Yes	150	4.29
9	East Cairngorms Moorland Partnership	NPA	No		
10	Angus Glens Moorland Group	Independent	No		
11	Tayside Wader Survey	RSPB	Yes	339	4.3
12	Glen Dochart Wader Project	NPA	Yes	6	1.69
13	Fife Wader Survey	RSPB	Yes	3	0.25
14	Strathallan Breeding Wader Survey	Independent	Yes	10	0.56
15	PhD: Breeding Waders & Grassland Management	RSPB	Yes		
16	Threepwood Farm	Independent	Yes	2	0.47
17	Clyde Valley Wader Initiative	RSPB	Yes	200	0.4
18	Edinglassie	Independent	No		
19	GWCT - repeat wader surveys in Ayrshire	GWCT	No		
20	Northumberland National Park Curlew Project	NPA	Yes	475	0.45
21	Bransdale wader study	Independent	Yes		
22	Wensleydale Wader Project	Independent	Yes	125	2.47
23	Yorkshire Dales BBS	NPA	No	250	4.17

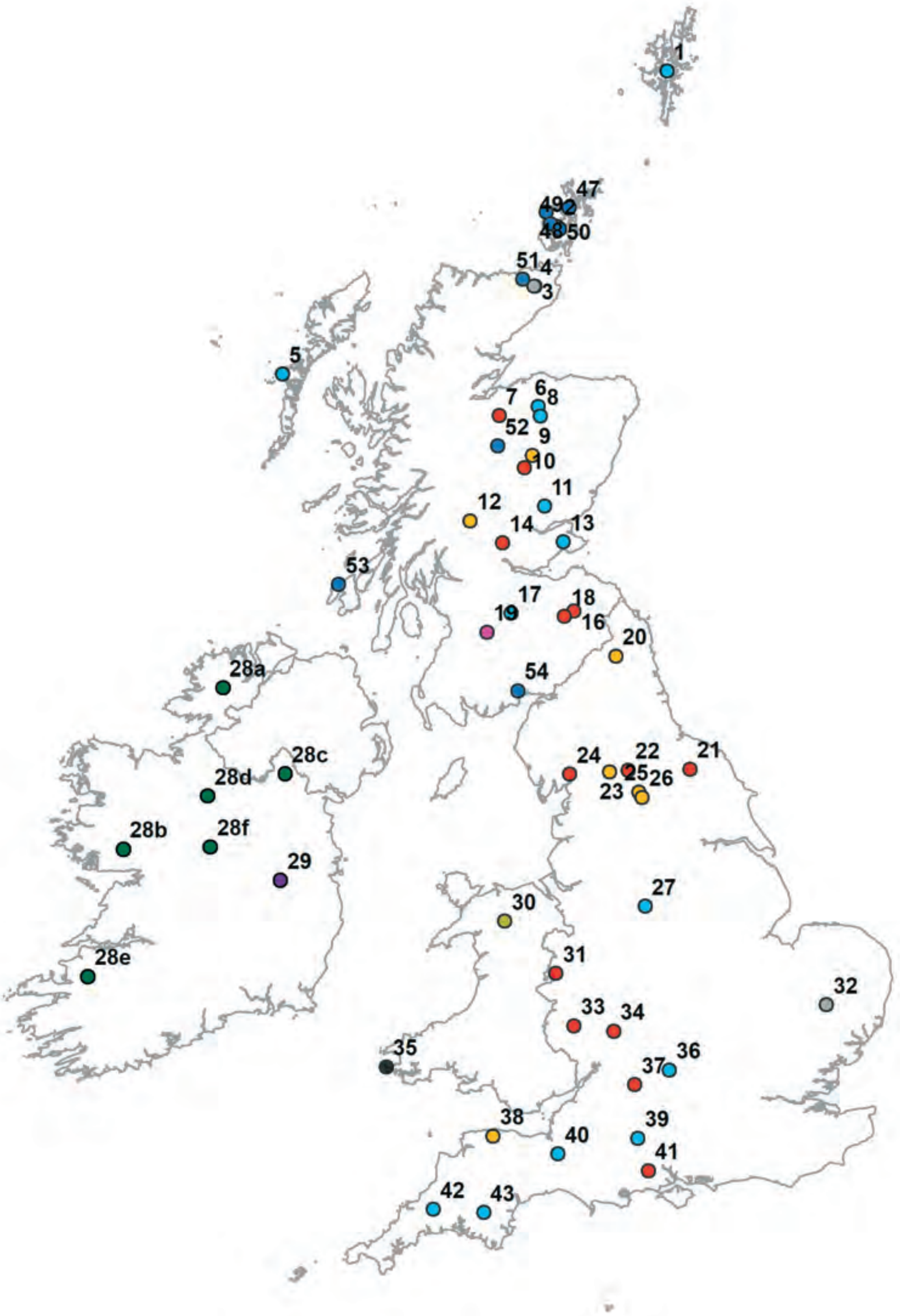
24	Cumbria Curlew Project	Independent	Yes		
25	Upper Nidderdale Landscape Partnership	NPA	Yes	130	0.74
26	Wild Watch Project (Nidderdale)	NPA	Yes		
27	South West Peak	RSPB	Yes	270	0.76
28	Curlew Conservation Programme	NPWS	No	5	
29	Lodge Bog	IPCC	No	2	5.71
30	Tracking of Welsh upland breeding curlew	BTO	Yes	3	
31	Curlew Country	Independent	Yes	45	0.23
32	Breckland Curlew project	University	No	35	0.95
33	Herefordshire Curlews	Independent	Yes	10	0
34	Breeding Curlews in the Severn and Avon Vales	Independent	Yes	38	0.32
35	Skomer breeding Curlew	Reserve warden	No	3	1.03
36	Upper Thames curlew project	RSPB	Yes	47	0.13
37	North Wilts (no formal project yet)	Independent	Yes	5	0
38	Exmoor	NPA	No	4	0.01
39	Salisbury Plain Curlew Monitoring Project	RSPB	Yes	8	0.08
40	Somerset Levels Breeding Curlew Recovery	RSPB	Yes	30	1.5
41	Wild New Forest	Independent	No		
42	Cornwall	RSPB	Yes	2	0.01
43	Dartmoor	RSPB	No	4	0
44	RSPB Curlew Trial Management Plan	RSPB	No		
45	GWCT - work on curlew and grouse moors	GWCT	No		
46	GWCT - wader surveys during grouse counts	GWCT	No		
47	RSPB Onziebust*	RSPB reserve	No	42	15.22
48	RSPB The Loons/Loch of Banks*	RSPB reserve	No	36	39.13
49	RSPB Brodgar*	RSPB reserve	No	10	27.78
50	RSPB Hobbister*	RSPB reserve	No	16	2.1
51	RSPB Broubster Leans*	RSPB reserve	No	12	4.1
52	RSPB Insh Marshes*	RSPB reserve	No	99	9.57
53	RSPB Loch Gruinart/Ardnave*	RSPB reserve	No	18	0.64
54	RSPB Kirkonnell Merse*	RSPB reserve	No	17	5.67

4.1.1.2 Geographic Scope

The geographic scope of the studies and projects that submitted responses varied greatly, being largely determined by the nature of the study or project. At the smaller end of the spectrum are projects comprising work for wader conservation being carried out on individual farms, and studies of a discrete and well-defined area of suitable wader habitat (some long-term monitoring studies, others experimental manipulations), the smallest of which covers a total of 64 ha (spread over 16 fields in eight sites). The largest examples are projects operating in areas of very low wader density where the aim is to find the majority of breeding pairs in the area. The majority of these are Curlew projects operating in southern England (and Wales), where a common objective is to find out how many breeding pairs there are within the study area, and the extent to which these are breeding successfully.

Figure 2 shows the location (as a single point indicating a central position within the study area) of those projects for which we have this information.

Figure 2. The locations of projects, with numbers corresponding to those in Table 1. Locations not plotted for projects 44–46. Colours indicate lead organisation of each project (purple = IPCC, orange = NPA, dark green = NPWS, blue = RSPB (dark blue = RSPB reserve), black = SWWT, pink = GWCT, grey = University, red = independent.



4.1.1.3 Project partners

Of the 31 projects that responded to the questionnaire, almost half (15) were RSPB projects (Figure 2). Many of these projects were focussed on providing assessments of national and regional wader hotspots, ranging from sites with the highest wader densities in the UK (e.g. Shetland, Orkney and the Uists), to small or sparsely distributed Curlew populations in the south of England (e.g. Somerset, Salisbury Plain, Upper Thames and Cornwall).

The next most common types of projects were those organised and carried out principally by independent individuals. They included projects on individual farms or estates, where owners and managers were interested in finding out more about the effects of their management on Curlews and other waders; clusters of large estates coordinating their efforts to carry out wader surveys; long-term studies of breeding waders carried out by individuals with the aim of identifying trends in local populations; and small groups of independent enthusiasts trying to find out more about numbers, distribution and breeding success of Curlews in large areas where breeding Curlews were sparsely distributed.

Of the remaining six projects, four were led by staff in the authorities of National Parks or Areas of Outstanding Natural Beauty (all working in partnership with local communities of volunteers, farmers and land-owners); one was an initiative on a study farm managed by the University of the Highland and Islands, expecting to involve monitoring input from staff and students there; and one was a GPS-tracking project by BTO staff in Wales.

4.1.1.4 Project resourcing

Most independent projects relied heavily on 'own time' voluntary input from a small group of organisers and participants, many indicating that manpower was one of the most important constraints on the extent and effectiveness of project activities.

Only one independent project (Curlew Country) had access to major external funding (i.e. covering more than costs of equipment), through the Heritage Lottery Fund. During the course of this project this funding enabled a range of activities including monitoring by professional ornithologists, outreach and community engagement, and purchase and deployment of nest cameras and radio-tracking equipment. Uncertainty of future funding for this project (see below) led to its organisers questioning its viability. Curlew Country was one of only two independent projects whose future was judged to be resource-dependent (rather than indefinite). Interestingly, the response for another independent project included a comment that, while funding to transform the project into "an operation like the Curlew Country project" would be ideal, it was uncertain to what extent it would risk "efforts becoming institutionalised and losing the voluntary enthusiasm". This statement highlights the ever-present need to balance any offers of assistance from a larger organisation against the necessary perception of autonomy and control that drives many volunteers to invest so much time and energy in local initiatives.

The 13 RSPB projects were split more or less evenly between projects aiming to run indefinitely (a couple of which stated that their future was conditional on finding or confirming availability of funding or time), and projects which had either ended or were ending within one to three years. Reasons for RSPB projects ending included time-limited funding (e.g. PhD projects or HLF grants), and discrete survey aims (often applying to projects aiming to update previous survey findings).

The remaining six projects were all resource-limited, being complete, of set duration, or dependent on finding or securing funding for their intended activities.

4.1.1.5 Activities and methods

Measuring population size

Of the 31 projects for which questionnaire responses were submitted, 27 included counts of breeding waders as one of the activities that they carried out, making surveys of numbers or abundance of breeding waders common to more projects than any of the other reported activities. The majority (20) of these projects surveyed waders using a standard wader survey technique, such as that described by O'Brien & Smith (1992). Two other projects employed BBS (Breeding Bird Survey) transect survey methods. Three projects, all in relatively large areas of low Curlew density, focussed their survey effort on historic breeding sites. Three more projects, all in areas managed for grouse shooting, were undertaken by gamekeepers and took advantage of gamekeeper working routines. Two of these projects involved trapline surveys (transect surveys carried out while walking the routes taken by gamekeepers to check and maintain traps for predators), while the other involved surveys of waders carried out during standardised counts of Red Grouse (*Lagopus lagopus*).

Nearly all (24) projects recorded the location of individual pairs (either as six figure grid references or by individual field). Most (16) projects also systematically recorded the apparent breeding or territorial status of the birds encountered, with a further four projects recording information on breeding status opportunistically or incompletely. Table 1 shows the density of Curlew pairs reported by these projects (estimated as the number of breeding pairs divided by the size of the project area).

Nest monitoring

Eleven projects carried out nest monitoring. The majority of monitoring was done with direct visits to nests, with recorded visit rates as low as one visit per nest, but more typically in the region of two to four visits while nests were active. Nine out of eleven projects that monitored nests generated estimates of hatching success, and seven of them used information collected from failed nests to assess causes of breeding failure. Among the 20 projects that did not claim to gather information from nests, the most commonly given reason for this was lack of sufficient resources to find and monitor nests. Three projects stated that concern about impacts of nest visits was among the reasons that they did not monitor nests. Remote sensing technology was used by relatively few studies, with four deploying temperature loggers in nests (to record variation in nest cup temperatures) and two of these also deploying nest cameras.

Breeding productivity

Only seven projects engaged in systematic collection of information on productivity, with three of these indicating explicitly that they were unhappy with the quality or reliability of the information being collected. A further eight projects either collected productivity information opportunistically, or else hoped to be in a position to collect this information in the future. Two projects based assessments of productivity solely on direct observations of chicks, enabling estimates of brood size (with accuracy depending largely on how easily the vegetation allowed all chicks in a brood to be observed) and fledging success (provided that survival of young was confirmed beyond their attaining independence). Two other studies described their assessments as being based exclusively on behaviour of adults, both of these stating that while this allowed an approximation of the proportion of adults with fledged young, the number of young fledged by each successful pair remained unknown from this information. Three more projects used both of these types of information in conjunction with one another to inform estimates of productivity. Finally, three projects employed remote (VHF radio) tracking of chicks to follow their movements and gain an understanding of chick daily survival rates up to fledging.

Marking and tracking

Only a small number of projects had carried out marking or tracking, though several more expressed an interest in doing so if given access to the necessary equipment and expertise. Three projects involved colour-ringing of unfledged young, and one of these also carried out adult colour-ringing (through cannon-netting of pre- and post-breeding flocks). Three projects (one also colour-ringing) have carried out VHF radio-tracking of Curlew pulli. One more project had focussed on GPS tracking of breeding adults with data retrieved via VHF download to mobile base stations. One more project had purchased GPS tags but had yet to deploy them. It is notable that this project (Curlew Country) was the only one to be poised to be carrying out all types of marking and tracking discussed here, and received a higher level of funding than any wader monitoring projects of a similar scale. Projects reported that colour-marking and remote tracking helped them to understand patterns of breeding failure, habitat use (especially for foraging) of adults and chicks, and post-breeding movements and migratory routes.

Environmental data collection

More than half of the projects included systematic recording of information on habitat (19), and land management (15). In contrast, only one project (Severn and Avon Vales) claimed to record information on predators consistently (and this did not include mammalian predators), though nine more projects reported that ad hoc information on predators was recorded; the majority of projects recognised that the impact of predators on breeding success of the waders in their study areas, or ongoing management to control these predators, had an important effect on wader breeding success. Only four projects looked explicitly at the food supply of Curlews.

Management for Curlew and other waders

Roughly half (16) of the projects included work on habitat management – either carried out directly by project participants, or else involving advice to and agreements with farmers – often in the context of applications for funding under agri-environmental schemes. The majority of habitat management involved at least some manipulation of agricultural operations (principally grazing and mowing), though many also included other activities such as scrape creation, water-level management and control of unfavourable vegetation, such as dense rush cover and scrub.

4.1.1.6 How the data collected are being used locally

Twenty-five of the 31 projects that submitted questionnaire responses indicated one or more specific uses for the data collected by these projects. The most common of these, reported by 15 projects, was to inform the management of these local areas for waders, typically through advice given to farmers (often in the context of their application for agri-environmental grants) or other land managers (such as gamekeepers). A total of 13 projects intended to share the data they collected to inform local or regional reporting of wader populations (six projects), to inform decisions on monitoring and management made by other local projects (five projects), or for both of these purposes (two projects). A further three projects stated that their findings would be used directly to improve understanding of local population changes. Two projects intended to use the data they collected to address specific research hypotheses: one testing whether wader breeding success differed between islands in Orkney with and without introduced Stoat *Mustela erminea* populations; and the other testing the effect of liming on the prey and breeding populations of waders.

4.1.2 Other projects

A few projects did not complete a questionnaire, but responded to our request with useful information about their activities. A number of other projects did not send us information within the time frame of this report. More detailed information about these can be found in Appendix 2.

Information about some other initiatives can be found in the Southern England Curlew Forum newsletters (www.curlewcall.org) or on the Working for Waders website (www.workingforwaders.com). In Scotland, a renewed call for information about work to benefit waders has gone out through the Working for Waders initiative, and will be promoted and circulated by organisations and individuals in relevant sectors, including conservation and farming and game management.

4.2 Wader methodology review

4.2.1 Estimating abundance

4.2.1.1 Survey method

The most commonly used and referenced types of methodology for assessing the abundance of breeding waders involve surveys of breeding waders by field or by unit area (depending on landscape). Area-based counts have been implemented by many past and ongoing studies of breeding waders. The standard papers cited by studies that employ these methods are O'Brien & Smith (1992) for counts of waders in enclosed fields, Brown & Shepherd (1994) for counts of waders on unenclosed land (such as open moorland), and Reed & Fuller (1983) for counts of waders breeding on machair. The first two types of survey typically entail multiple (three to four) visits, during which all areas with suitable wader habitat are approached to within a minimum distance of 100m. Reed & Fuller recommend single survey visits, because multiple survey visits to machair sites, where waders often breed at high density, are thought to pose an unacceptable increase in predation risk (Calladine *et al.* 2014b). Overviews of bird survey techniques (e.g. Gilbert *et al.* 1998, Bibby *et al.* 2000, Joint Nature Conservation Committee 2004) all recommend counting breeding waders by field or by area. These texts either explicitly refer to the three publications mentioned above, or else describe methods that are similar to and broadly compatible with them.

Several studies that look at patterns in abundance of upland breeding waders have used data collected by transect surveys. Transect surveys for waders are typically similar to those employed in the Breeding Bird Survey methodology (Harris *et al.* 2018), with waders being recorded while walking along two parallel transects within each of a set of 1 km squares. In fact, particularly where the scale of analysis is large (e.g. Massimino *et al.* 2011, Franks *et al.* 2017), BBS data have been analysed to show how spatial and temporal variation in abundance of Curlew and other waders are related to habitat and land use. Calladine *et al.* (2014a) supplemented information from standard BBS with comparable transects in an additional set of upland squares, in order to generate sufficient data for generating robust population trends for several UK upland species. In order to help correctly interpret records of waders detected on both transects within a square, both transects may be surveyed at the same time by teams of two fieldworkers (e.g. Sim *et al.* 2005). This makes it easier to distinguish duplicates from genuine records of multiple birds.

Although it is common for transect surveys to be carried out in randomly selected areas, allowing their results to be interpreted as representative of a wider survey area, this is not always the case. Jarrett *et al.* (2017) reported on preliminary performance of 'trapline surveys', a new format of survey designed to fit with the working schedules of gamekeepers. Like most other transect-based methods, these surveys involve counting birds while walking along a pre-determined route. However, rather than being selected at random, the routes used are those routinely walked (to check and maintain traps) by gamekeepers participating in the survey. Comparing the findings of a small number of trapline surveys (carried out by gamekeepers with good bird identification skills) with data collected by a professional bird surveyor following Brown & Shepherd (1993) methodology, Jarrett *et al.* (2017) found that trapline surveys can yield comparable data to more conventional survey methods. Similarly, though at a much larger scale, road-based transects have been used to estimate numbers of breeding Long-billed Curlews *Numenius americanus*, a North American species that occurs at low densities over large areas of open rangeland and prairie (Downey 2004, Gregory *et al.* 2012; Jones *et al.* 2008; Stanley and Skagen 2007). All of these studies involved driving along 32 km survey routes, stopping every 800 m to observe and record Curlew up to a distance of 800 m away.

Many dedicated wader surveys in the UK have had a sufficiently restricted focus, in terms of the landscapes and habitats they cover, that just one of the methods described above has been adopted, whether field-by-field surveys for enclosed farmland (e.g. O'Brien 1996, Wilson et al. 2005, Smart *et al.* 2014), fixed-effort area searches in unenclosed upland habitats (e.g. Fletcher et al. 2010, Douglas *et al.* 2017), or machair-specific methods (e.g. Calladine *et al.* 2014b). However, some surveys aiming to report on wader populations in a broader range of habitats have adopted a mixed approach, using different methods in different situations. Amar *et al.* (2011) investigated relationships between wader population change and land use in the uplands using information collected by a mixture of constant-effort search area-based surveys (following Brown & Shepherd 1993) and BBS-style transect surveys. Wader surveys in Northern Ireland have used field-by-field counts in lowland areas and transects in unenclosed moorland (Henderson *et al.* 2002; Colquhoun *et al.* 2015). Calladine *et al.* (2014a) assessed the effect of moorland management on waders and other species within a focal area that had been subject to a particular management regime. Population changes within this area were assessed primarily on the basis of fixed-effort, Brown & Shepherd type surveys. However, in order to set these trends into the context of wider population change, data from enhanced BBS surveys were also used.

4.2.1.2 Survey effort and timing

When describing standard wader surveying methods for enclosed land, O'Brien & Smith (1992) do not specify how much time surveyors should spend in surveying each field, simply stating that all parts of each surveyed field should be approached to within 100 m. In contrast, Brown & Shepherd (1994) formally limit the time that surveyors in unenclosed land should spend looking for waders to (roughly) one minute per hectare. Reasons for this difference in approach are not explicitly addressed by the description of either method, but are likely based on an assessment that ensuring even survey coverage may be more difficult in a landscape with no or few obvious boundaries than in a landscape that is subdivided into fields.

Several studies have explored the effect of survey visit number on the robustness of breeding population estimates. The original survey paper by Brown & Shepherd (1994) concluded that counts derived from two survey visits were underestimates (e.g. counts of Curlew were 67%–97% of actual population estimates), and that precision of counts decreased in areas with high densities of breeding waders. Calladine *et al.* (2009) examined the effect of numbers and timings of visits, following the Brown & Shepherd (1994) method, on abundance estimates for Curlew, Golden Plover and Snipe. For all three species, they found that the majority of breeding pairs detected over four visits (80% for Snipe and 90% for Curlew and Golden Plover) were identified in the first three visits. Following the O'Brien & Smith (1992) protocol, Bolton *et al* (2011) confirmed the reliability of two or three visit O'Brien & Smith to estimate numbers of breeding Lapwings *Vanellus vanellus*, but recommend five visits in order to be able to estimate productivity.

Outside of the UK, surveys such as those conducted by Currie & Valkama (2000) in Finland and by Berg (1994) in Sweden appear to have been based on higher survey effort, involving up to 12 visits in a single year. Such high visit rates suggests a survey along the lines of territory mapping (Bibby *et al.* 2000, Gregory *et al.* 2002) as carried out for surveys of territorial passerines such as the Common Bird Census (Marchant *et al.*

1990). However, description of survey effort in both of these studies provides insufficient detail to assess what information was gathered on each survey visit, and how this was interpreted to yield estimates of numbers or densities of breeding waders.

Many studies have found that time of day can affect counts of waders, with early counts tending to be larger than later ones. Some authors (e.g. Bolton *et al.* 2011, Sim *et al.* 2005) have argued that later counts are more reliable as an index of abundance (due to their being less variable). Others have concluded that the higher peaks of activity around dawn and (to a lesser extent) dusk mean that surveys carried out in the first two hours after dawn should be more accurate than at other times (Reed *et al.* 1983 & 1985). However, constraining time-demanding surveys of large areas to this narrow window of time will often not be feasible. Brown & Shepherd (1993) recommend carrying out surveys that avoid dawn and dusk peaks of activity, in order to allow a long period of surveys each day, while ensuring that survey results are reasonably comparable with one another.

4.2.1.3 Information collected

The systematic nature of transect surveys lends itself to adjustment of estimates derived from incomplete counts. Such adjustment is typically done according to estimates of detection probabilities which may be estimated by comparisons of detection between different distances from the observer (e.g. Buckland *et al.* 2001, Newson *et al*. 2005) or, in the case of the static counts carried out during road transect surveys in North America, between different time intervals during the count (Gregory *et al.* 2012)

Counts may also (in addition, or as an alternative, to correcting for detectability) be adjusted using rules based on behaviour, timing or the findings of previous studies, to make them better approximations of breeding population size, which for waders is typically expressed as number of breeding pairs. This is most important if wanting to compare findings across studies based on different methodologies or to base management decisions on absolute numbers of breeding pairs. It is not so important if the main aim is to measure trends in abundance.

A common rule applied to the findings of many multi-visit wader surveys is to take the maximum count from any one visit. This strategy makes sense if the majority of birds counted breed in the study area, especially if some of them will likely be missed on some survey visits. An alternative approach that has been used by some studies (e.g. Grant *et al.* 2000) is to take an average count over all visits (assuming that breeding pairs that go undetected in some surveys will balance against detection of non-breeding individuals or double-counting in others). Recognising that breeding pairs may be missed in every survey visit, some analyses of wader data have adjusted counts in an attempt to make them more accurate. Grant *et al.* (2000) compared mean counts of breeding Curlew in Northern England, derived from a typical, three-visit O'Brien & Smith type survey, with the findings of a more intensive survey (aimed at assessing productivity) carried out in the same area. They found that mean counts correlated reasonably well with estimates based on the more intensive assessment, but were consistently higher. They therefore recommended that densities derived from survey counts should be adjusted with a correctional formula (multiplying by 0.71 and adding 0.1) taken directly from the regression between these estimates. Some other studies (e.g. Smart *et al.* 2014) have applied this formula to improve estimates of Curlew made in different areas and habitats. However, the validity of such corrections may not hold when they are extended to circumstances beyond those used to derive them (e.g. different densities, different habitats, different areas). Moreover, provided that comparisons are made across datasets generated using similar counting methods, their reliability (or lack thereof!) will be unaffected by such multipliers.

4.2.2 Productivity

4.2.2.1 Nest success

Several studies focus efforts on assessing productivity primarily or exclusively by determining nest success (i.e. hatching success). Although observing nests is often more straightforward than collecting and interpreting information on chick survival, the potential importance of chick mortality after chicks have hatched and left the nest area makes nest success an unreliable signal of overall productivity. Bolton *et al.* (2011) assessed the relationship between nest success and overall productivity, and found it to be weak, most likely due to the influence of mortality caused by predation of young soon after hatching.

In some studies (e.g. Ottvall *et al*. 2005) information about nest success is derived from repeated nest visits. However, most researchers recognise that disturbance due to nest visits can have negative consequences for nest success of waders and other ground nesting birds (e.g. Bêty & Gauthier 2001), and take opportunities to reduce the need for nest visits to collect information. Malpas *et al* (2013) carried out watches of nests to determine status from a distance, following up watches where no evidence of incubation was seen with visits to determine nest fate. Several authors (e.g. Fletcher *et al.* 2010, Grant *et al.* 2000) observe that Curlew hatching success can be determined from vocal behaviour of adults, but that this inference becomes less reliable in areas where Curlew breed at high density, or where an area with breeding Curlew is used for foraging by other birds breeding in adjacent habitats. Fletcher *et al.* (2010) deduced hatching in Curlew and Golden Plover from increased vocal behaviour of parents (acknowledging that, for Curlew, this signal becomes less reliable in areas with high density of breeding Curlews). For Lapwing, the authors followed a similar approach to Bolton *et al.* (2011) in using a mix of behavioural cues to infer the presence of chicks.

Many other recent studies now employ technology to record nest status and activity without the need for direct observation, either using nest cameras, thermal loggers, or both (e.g. Jarrett *et al.* 2017, Calladine *et al*. 2014b). As well as reducing the survey effort and potential disturbance effect required to monitor nests, a significant advantage of these methods is that they can yield useful information on the identity of nest predators. Temperature loggers can be used to work out the timing of nest failures, which in some cases may be used to inform assumptions about predator identity (e.g. to distinguish between diurnal and nocturnal predators), while cameras may directly reveal the identity of nest predators. In some situations, nest cameras have been found to have no negative effect on nest success (e.g. Calladine *et al.* 2014b). However, Dadam *et al.* (2014) found that rates of nest abandonment were significantly higher at nests with than at nests without cameras.

4.2.2.2 Adult behaviour

Just as nest success can be inferred from adult behaviour without the need for nest visits, so it may be possible to gauge chick survival and overall breeding success from the behaviour of adult birds. Schekkerman *et al.* (2009) reported that adult behaviour of Black-tailed Godwits *Limosa limosa* reliably indicates survival of offspring until one week after fledging. Breeding densities in this study were sufficiently high that tagging one parent greatly aided assessment of chick fates. In Shetland, Van der Wal & Palmer 2008 inferred the productivity of breeding waders from the proportion of pairs showing territoriality (alarming, displaying or distraction behaviour).

However, while adult behaviour may be used to infer whether a breeding pair has successfully fledged one or more chicks, it cannot be used to gauge the exact number of chicks fledged. Valkama & Currie (1999) assessed productivity of Curlew by recording the response of adults to disturbance around the time of fledging. Adults with chicks were more visible and starting alarming when approached by humans. The authors also calculated average brood size from a subset of broods counted close to fledging. They were able to estimate productivity per breeding pair by multiplying average brood size by the number of successful broods, divided by total number of breeding pairs.

4.2.2.3 Direct observation of chicks

Bolton *et al.* (2011) point out that wader productivity estimates based on sightings of unfledged chicks are likely to be considerably less reliable than those based on counts of fledged young. This is partly because unfledged chicks are typically harder to see and picked up less reliably by surveyors (for Lapwing, the authors found detection rates of 15% for unfledged chicks compared to 60% for fledged young); but also because the relationship between counts of unfledged young and productivity are affected by chick mortality rates, which can vary in both space and time. Subsequent studies following the recommendations of these authors include Malpas *et al.* (2013), who assessed productivity according to the number of well-grown or fledged young recorded between the 3rd and 5th visits. However, Dadam *et al.* (2014) caution that, depending when young birds leave their nest site, some may be counted on multiple visits, leading to overestimates of productivity if all young recorded on each visit are assumed to be different.

Bolton *et al.* (2011) acknowledge that detectability of well-grown and fledged young is likely to vary between different areas, according to habitat as well as to the length of time young stay in the vicinity of the parental territory after fledging. Bell & Calladine (2016) based their analysis of wader productivity in a farmland landscape on the productivity of pairs nesting in a subset of fields where any fledged young could be easily and reliably observed.

An alternative to observing young directly, adopted by many studies over the past 10 years, is to deploy tracking devices on wader chicks to enable them to be followed remotely. However, the value of assessing productivity through studies involving tagged chicks depends on the behaviour and survival of these chicks being representative of untagged chicks in the same population. Schekkerman *et al.* (2009) tagged Lapwing and Black-tailed Godwit chicks, and handled chicks of both species regularly to check the status of both wader and tag. They found that condition of Lapwing chicks (but not godwits) was reduced by tagging and handling; possibly because tags comprised a higher proportion of Lapwing weight (5.5%) than of godwit weight (3.5%). Sharpe *et al.* (2009) tagged 700 lapwing chicks with transmitters weighing 0.6 g (3.3% of chick weight). Tagging (and subsequent handling) reduced body condition (related to survival) not just of tagged chicks, but also of their siblings. Their results suggest that most negative effects are from repeated handling and disturbance (to the whole brood) during this time. The authors suggest that it may be possible to avoid these effects by keeping post-tagging recapture of chicks to a minimum handling interval of 8 days or more.

Radio-tracking does not simply increase the efficiency with which the fate of chicks in a breeding wader population can be determined. Rickenbach *et al.* 2011 point out that, in addition, it enables assessment of survival to fledging to be related both to provenance of nests (all chicks hatched came from nests where predators were excluded) and to detailed knowledge about the areas used by chicks.

5 DISCUSSION

5.1 Wader surveying methodology

5.1.1 Survey method

Most studies of waders published over the last three decades, as well as the majority of local studies engaged with during this audit, use one or more of the standard, area-based survey methods described above (Brown & Shepherd 1993 for unenclosed land; O'Brien & Smith 1992 for enclosed farmland; and Reed & Fuller 1985 for high density wader populations on machair). These methods are proven to be effective for surveying wader populations, and have the advantage of being relatively efficient in terms of the number of waders and overall area that can be covered, at least in areas of moderate to high wader densities.

Surveys tailored to particular stakeholder groups, such as the trapline survey for gamekeepers, hold the potential to take advantage of survey effort in areas where the availability of alternative surveyors may be limited. Other types of specialised survey methods that may be useful to develop include surveys carried out by gamekeepers during standardised grouse counts (these are already done informally on some shooting estates, and their potential for generating useful estimates of wader abundance is being investigated by GWCT). As with all survey methods, it is always important to consider the potential for biases to be introduced if a non-random approach is taken (e.g. surveys along traplines) and to take this into account when making inferences from the survey findings.

When these methods are newly developed, surveyors, organisers and data users may identify aspects that can be improved or refined. Care must be taken, both by those using the surveys and by organisations like BTO who are helping to develop and promote them, to ensure that improvements and innovations do not lead to methodologies diverging unnecessarily, with the result that the findings they generate become more difficult to compare.

For surveys aimed at gathering information on Curlew and other breeding waders distributed at low density over large areas, standard methodologies will often prove an impractical and inefficient use of limited survey effort. In such situations, projects adopt a wide range of approaches, tailored to fit the available manpower and the experience of surveyors. Typically, surveys will target those areas thought most likely to hold breeding Curlew, often taking advantage of historical information where this was available. While this approach will usually maximise the number of Curlew found, it can make it difficult to compare Curlew numbers in different areas, due to uncertainty both about how exhaustively the areas surveyed were searched, and also whether and how many Curlew may have been missed in areas where they were assumed to be absent.

Where possible, it may help for project organisers deciding where to carry out surveys in a large area to stratify between areas where Curlews are known or suspected to occur (and where search efforts are likely to be concentrated), and areas suspected to hold negligible numbers of breeding Curlew. This could allow assumptions about the absence of Curlews in the latter areas to be tested, without the need for exhaustive surveys, by sampling these areas. A recent breeding bird atlas may be useful, both to aid decisions about how to stratify an area on the basis of occurrence or abundance, and also to help extrapolate findings from a sampling survey using measures of relative abundance. While information from the most recent national bird atlas (Balmer *et al.* 2013) may be useful for this purpose, the scale of recent wader declines means that patterns of distribution and abundance should be interpreted with caution. In some areas, local bird atlases may be available to provide finer scale (or more up to date) information. Where an area does not contain suitable breeding habitat, an assumption of absence may be justifiable without the need for surveys. However, care should be taken that the definition of suitable habitat does not depend too closely on the distribution of previous survey effort, as this may result in unknown populations being missed.

5.1.2 Survey effort

At least in principle, it may be possible to compensate for lack of detail recorded on individual visits by making multiple visits over the course of a season. A comparison between two areas based on a few detailed counts, as opposed to many 'snapshot' assessments, might result in similarly robust conclusions about abundance. However, there are many types of information for which it may be difficult or impossible to make up for limited detail by carrying out more surveys. A series of quick counts is likely to have limited potential to generate useful information on factors such as breeding status, parental behaviours, and numbers of birds at different ages. This should be borne in mind when thinking about how to make the best of opportunities for collection of wader information by groups like walkers, farmers and gamekeepers. These are all capable of collecting high quality information, but some individuals in these groups may be unable or unwilling to invest the time required to carry out systematic surveys that garner detailed information over a few visits. They may still be able to collect useful information, particularly if their normal activities allow them to visit and collect data from one or more areas of interest on multiple occasions. In designing surveys to suit a situation, the advantage of repeated observations should be balanced against the type and quality of information that can be collected.

In all cases, interpretation of survey information is greatly assisted by knowledge of survey effort. For systematic surveys following well-established guidelines, effort per unit survey area is typically standardised, facilitating comparisons between different areas and surveyors, as well as over time. This is particularly an advantage when surveys are one-off or carried out on a less-than-annual basis, as results will often be compared with information collected in other areas and by other surveyors, possibly even using different methods. It will often be useful, in such situations, to express survey findings in terms of absolute densities (apparent pairs per unit area) of waders, allowing comparisons between data collected using different methods. In making such comparisons, an awareness of the underlying assumptions and methodological biases that apply to each of the relevant methods, and the consequences for the conclusions reached from these methods, are particularly important.

For less structured surveys, information such as the amount of time spent per visit, the number of visits made, or the estimated level of survey coverage could all assist in interpretation of survey findings, and in drawing comparisons between different areas. However, if surveys are intended principally to inform assessments of temporal change in a single area, there is not the same need for standardisation in methods across different areas. So long as individuals survey the same areas in a similar way from year to year, the resulting data should still allow reliable detection of changes over time. It is important not to assume that such changes measured over one area are representative of wider areas however if the survey does not have some formal sampling design.

If the aim of a survey is to generate a reliable estimate of breeding population size, knowing how counts at different times of day relate to actual population size, and what time of day yields the most accurate counts, may be important. From the perspective of being able to compare numbers of waders between surveys, the question of whether early or late counts are more accurate may not be so important, but it may still be necessary to take account of variation due to survey timing. If wader counts being compared with one another were carried out at similar times of day then the influence of this variable could be ignored. If not, it may, at least in theory, be possible to address some of the effects of time of day on results by including time of day as an explanatory variable in the analysis of counts. However, the relevant variation between numbers recorded and time of day is likely to be non-linear, and to differ between species and habitats.

The influence of seasonality may be more complex, as inter-annual variation in phenology means that surveys carried out on the same dates in different years may encounter populations at different stages of the breeding season. Ideally, survey timings should be standardised against a biological calendar, using timing of birds' arrival, first egg dates, or other phenology-related cues to determine when surveys should occur. In practice, the need to schedule many types of fieldwork well in advance of the breeding season, and the difficulty of gauging breeding bird phenology before any surveys are carried out, mean that timing of survey visits is typically determined according to ranges of dates. However, guidance may be given to fieldworkers and survey organisers indicating that, if years are obviously 'late' or 'early', survey timings may be adjusted slightly to compensate. Where resources permit, this issue may also be addressed by scheduling sufficient survey visits (e.g. four visits for Brown & Shepherd type surveys) to ensure that comparable information will be collected regardless of inter-annual variation in timing of wader breeding.

5.1.3 Information collected

Reporting the results of surveys as numbers of breeding pairs has advantages and disadvantages. On the plus side, the number of breeding pairs is a standardised unit that is somewhat suitable for comparing between different areas and studies, even if findings of these studies are based on different methods. Of course, comparisons do not need to be based on absolute numbers, and some of the most robust comparisons between different areas and time periods are made using population size indices (Harris *et al.* 2018) or measures of relative abundance (Balmer *et al.* 2013). However, the number of breeding pairs is an intuitive measure that may be easier to relate to a wide range of disparate methods than more abstract quantities. The intuitive nature of this measure may also be of use when communicating findings to managers, regulators, policy-makers and the general public, as 'real' numbers will be easier to conceptualise, understand and remember than indices and relative measures, whose meaning depends on their relation to other numbers. Finally, there may be situations, particularly in areas where breeding Curlew are scarce, where knowledge of the actual number of pairs is useful (for example, to advise on when farming operations can take place without risk to breeding Curlew, on the basis of number of fledged broods observed; or to be able to identify thresholds of population size warranting a response such as management, study, or agricultural payment).

If estimates of the number or density of breeding pairs are to be further calibrated using the relationships between survey data and other estimates considered to be more accurate or precise, such corrections should ideally be based on relationships that are derived from directly relevant datasets.

The negative side of reporting survey estimates as real numbers is that, because numbers of breeding pairs are intuitive, people may think about and use them less critically than they would abstract indices. In particular, comparisons between different studies and different methods may be made with limited or no awareness of the influence of the different methods, and the assumptions underlying these, for the numbers they generate. Generating population estimates can also absorb a lot of time and effort, for relatively little benefit. For example, updating the UK's Curlew population estimate in order to get a better handle on the proportion of the world's Curlew population held in the UK is arguably misguided, given the lack of certainty about the number of breeding Curlew situated outside of the UK.

5.1.4 Productivity

Information on productivity is tremendously valuable to most wader projects. There is widespread acknowledgement that breeding wader declines in the UK (and, in particular, the failure of waders to recolonize or increase in remaining or newly created areas of suitable habitat) are driven by low productivity rather than adult survival. The role of source and sink populations for breeding waders is also poorly understood. Some apparently high breeding densities have had low breeding success and have presumably been sustained by immigration from more productive source populations. The proportion of breeding attempts that succeed in fledging young, or the overall number of young produced per pair or from a discrete area, can be compared between areas, or across a time series, and allows evaluation of local actions aimed at boosting productivity. Productivity information can be used to contextualise the conservation status of local populations, helping wader projects to prioritise between different areas or courses of action. It also has an important role to play in analysis of large datasets drawn from multiple areas aimed at improving our understanding of interactions between management, land use, habitat, predator populations and other environmental variation.

However, good information on wader productivity is very hard to come by. A wide variety of methods have been proposed and trialled, but all of these have drawbacks that limit one or more of the circumstances in which they can be used, the quantity of information they generate, or the usefulness of this information. The respondents to this audit used a wide variety of methods to get information about various components of breeding success, including nest monitoring, chick tagging, assessment of adult behaviour, pre-fledging counts of young, and post-fledging counts of young.

As well as the inherent disadvantages and limitations of these methods, an additional drawback to anyone trying to choose between or implement these methods is that there is currently a need for more understanding and consensus about how the information they generate should be interpreted. One of the reasons for this is that many of these methods have not been used by many people or for a long period of time, resulting in limited opportunity to refine our understanding of the data they generate. This is compounded by the fact that many of the projects trialling these methods are now operating in situations where breeding Curlew are scarce, and all the evidence suggests that breeding success is low. This limits the quantity of data yielded by the (inevitably limited) available field effort, as well as the potential for these data to include positive data points (i.e. successfully fledged young). These factors on their own mean that data with which the effectiveness of these methods can be assessed accumulate slowly. On top of this, very few studies are able to compare data on productivity collected using one method with substantially more reliable data collected using a different, independent method. Finally, the accuracy of many methods will vary markedly between studies, being affected by factors such as habitat, patterns of offspring mortality, timing of observations and the density of breeding waders. This all makes it difficult to be sure about accuracy or precision of estimates produced by any particular method. However, the most important thing, particularly for projects aiming to document changes in productivity over time, but also when comparing productivity between different areas, is to try to ensure that comparable (preferably identical) approaches are followed in all surveys, in order to make comparisons as fair and reliable as possible.

5.1.5 Guidance on methodologies

From a data management and user perspective, it makes sense to encourage wader projects to adopt a standardised set of methodologies, each generating data that can be compiled or contrasted with those from any other project collecting similar types of information. From the perspective of a project organiser, fieldworker, or stakeholder wanting to contribute their observations to enhance wider understanding of Curlews and other waders, an expectation to conform to such standards may be unrealistic. A range of factors may act to widen the gap between the methods practiced by a project, and those that would be ideal from a data purist's point of view. These include not only the quantity but also the timing and expertise of available manpower, equipment, compatibility with other project aims and work demands, methods used to assemble historic datasets with which new data are to be compared, and the preferences and opinions of volunteer data collectors. However, it is likely that most project organisers will welcome some advice about the methods they adopt, and the consequences these may have for their data. Here we provide some points of information and advice that may help projects to find an optimal balance between accommodating individual requirements and problems, and making the data they generate as useful as possible, not just to the wider community, but also to those directly involved in collecting it.

Use of standard methods: In most cases, where resources are adequate, projects should adopt one or more of the standard, area-based survey methods already used by the majority of breeding wader studies and projects. The method chosen should depend on whether the survey is of enclosed farmland, unenclosed land, or areas with high-densities of breeding waders such as are found on Hebridean machair. Above all they should describe their methods in detail to facilitate repeat surveys and permit comparisons that could potentially involve some manipulations of data in order to make findings comparable. Hierarchical suites of methods that can be adapted according to the available effort, with at least some comparisons possible across methods, may be particularly useful. For example, if all surveyors are required to carry out at least one survey visit in June, but a subset also carry out additional surveys in May and July, or carry out nest monitoring, this may allow a basic comparison of abundance across all studies, while comparisons of more precise abundance, or of measures of productivity, may only be possible for subsets of data.

Use of alternative methods: In cases where it is desirable to compare survey results with a run of historic survey data from the same area, or with other surveys carried out elsewhere, the methodology of previous surveys should be followed as closely as possible. This may demand the use of a survey method other than one of the standard methods. The most commonly adopted of these is likely to be transect surveys. Another reason to use transect surveys is in situations where waders are not the only group of birds being surveyed.

Number of visits: A minimum of two visits will be required in most surveys, in order to minimise the influence of seasonal and stochastic variation. Three or more visits will often be preferable, partly to improve numerical estimates, and partly for the information that later visits can yield on productivity. A larger number of visits spread over the season is also advantageous for capturing and accounting for any phenological changes over time (see Seasonality below).

Timing of visits: Placing restrictions on the time of day that surveys are carried out will help to make data more comparable with one another. Wader activity (and therefore detectability) tends to be highest just after dawn and before dusk. Where man-power is restricted (i.e. for most surveys!) it will often be desirable to exclude times within a few hours of sunrise or sunset in order to avoid unwanted variation in detectability between different counts. Where man-power is not limiting, it may be preferable to carry out all surveys during these dawn and dusk periods of maximum detectability.

Seasonality: There is good guidance in the existing literature about timing of surveys, depending on their number and purpose. Calendar-based timings are easier to implement, but it is worth bearing in mind that breeding stage and activity on a particular survey date are likely to vary according to a range of factors including latitude, elevation and weather patterns. There may be more scope for development of survey methods that, rather than being based on formal visits, make use of multiple incidental observations made over the course of a season, as long as survey effort can be either quantified or taken into account in some other way. In some circumstances it may be possible to ensure that effective effort is always greater than a minimum threshold, making results more comparable.

Specialised surveys: Good communication between groups utilising newly developed and emerging methods will help to ensure that improvements and innovations do not result in unnecessary divergence of methodology.

Low density surveys: Be clear about the search and survey methods used, the areas that were surveyed, and the adjoining areas that are assumed to hold few or no waders. Where available survey effort is sufficient, consider stratified sampling surveys to confirm suspected absence.

Nest monitoring: This is particularly useful if objectives of the study include finding out more about the relative importance of different nest predators, establishing stage of failure, or capture (for marking or radio-tagging) of young chicks. However, project organisers should be clear that, on its own, nest monitoring may be of limited value in assessing variation in breeding success over space or time, for the reason that waders are nidifugous. This means that, except in circumstances where most unsuccessful breeding attempts fail at the egg stage, the success of nesting attempts may not be tightly correlated with overall breeding success.

Adult behaviour: It will generally be a good idea to record adult behaviour associated with territorial and pair-bonding displays, parental care of young, mobbing of predators (and surveyors) and all types of alarm calling, on all survey visits. Particularly if three or more visits are made, such information may be used (in many circumstances) to infer breeding success rates among pairs. However, such information is unlikely to yield accurate estimates of productivity (number of young fledged per breeding pair). This approach also requires further development and validation, particularly in the context of how evidence of successful breeding varies between surveys carried out at different times, and in populations of different densities.

Observation of young: Direct observation of young is often a good way to find out about breeding success, and will usually be the most feasible way to get information about the numbers of young fledged by individual pairs. Finding this information for a subset of pairs, and combining it with population level estimates of breeding success (percentage of pairs raising at least one young successfully) is probably the most straightforward way of generating estimates of per pair breeding productivity. However this approach may often be impractical; for example when broods are highly mobile, when vegetation structure restricts ability to see broods, where there are marked differences in the timing of breeding between different birds in the same area, and when wader densities are so high that following the outcome of pairs is simply not possible. It is also important to consider whether the subset of pairs and broods that can be directly observed are representative of the wider population of interest.

Colour-marking: Where the skill sets of participants allow, colour-ringing may bring two benefits. Firstly, colour-ringing (of both chicks and adults) may facilitate estimates of productivity, particularly in areas where breeding waders are at high density. Secondly, colour-ringing of young may continue to yield useful information about post-fledging movements, survival and eventual recruitment. The effectiveness of other wader colour-ringing projects, most notably the international study of Icelandic Black-tailed Godwits (e.g. Alves *et al.* 2013a&b, 2019), has benefited greatly from the sustained efforts of multiple groups of ringers and observers, at different locations, over a period of two decades. The more colour-ringing of Curlew that is done in the UK, the easier it will be to enthuse volunteers in winter about the value of resighting colour-ringed waders (because they will have greater chances of finding marked birds), and the more value may be gained from colour-ringing of waders in general.

Radio-tracking: While this can undoubtedly be a powerful tool for gathering information on chick survival, habitat use and fledging success, care should be taken to try to ensure that behaviour and survival of tagged chicks is not adversely affected by either the tag itself, or the disturbance arising from capture and handling, Such effects could serve to make the information collected from radio-tracking studies difficult to interpret or misleading.

Other types of environmental variation: Several types of environmental variation may greatly enhance the usefulness of information pertaining directly to breeding waders. This includes information on habitat, land use, management of crops, livestock and predators, is all straightforward to collect directly either from direct observation (in the case of habitat and land use) or by seeking input from the relevant land managers (mostly farmers and gamekeepers). Information on predator distribution and activity is also likely to be useful. Avian predators, such as corvids and raptors, are generally straightforward to survey using standardised approaches (e.g. point counts, atlas-type surveys, vantage point watches) that can be reliably compared across space and time. Information on mammalian predator abundance and activity will be more difficult to collect. Efforts to do this (using baited camera traps, for instance) should be documented, and the results shared with other studies, in order to help improve knowledge about how to survey mammal predators (a topic where better and more standardised guidance could benefit a wide range of stakeholders). The principle of scalable hierarchies of method, mentioned above, applies here also. In a situation where effort devoted to recording of environmental information varied between projects or surveyors, it would be useful if all participants recorded broad habitat types, with detailed information being restricted to those with the requisite resources or interest.

5.2 Capture of wader monitoring data

A system and accompanying processes suited to capturing data from wader monitoring or wader management would have to be:

1. flexible enough to capture information from several different survey types.
2. able to capture a wide range of management and habitat-related information; and to be able to record changes in management and habitat over time.
3. suited to extracting information at a range of scales; to inform studies about the effectiveness of management in different situations, as well as to be useful at the level of regions, landscapes and sites to inform management assessments and decisions at these smaller scales.
4. capable of generating summaries, reports, maps or other products of interest and utility to the individuals, organisations and communities that contribute the data.
5. simple and intuitive enough to be used by a wide range of contributors

The requirements of a system of data capture covering birds, their environment and relevant management information has been described by Fuller *et al.* (2016). Such a system could be well suited to the wide variety of data (from different survey types, in different areas, and with different types of management interventions) needed to accommodate the information that will be generated by wader projects such as those engaged with by this audit.

Initiatives such as Working for Waders (WfW) in Scotland and discussions with NRW in Wales may bring opportunities to develop a system that can fulfil the requirements outlined above. Such opportunities may result in resources being made available to help with development costs. The work that BTO has already done on similar systems (on which a new system could 'piggy back') might be considered as part of BTO's contribution to a larger, partnership project. BTO has received funding from SNH, through WfW, to scope such a system capable of dealing with a wide variety of wader-related information, covering population assessments, productivity, tracking data, management and other environmental information. However, the funding provided to date does not cover work on development of the system itself.

In addition to developing a system for dealing with wader survey and management information, BTO has also been considering whether and in what capacity it might be possible to employ a wader project officer. The main aims of such a role would be:

1. to act as a central point of contact between other individuals and organisations working on waders;
2. to promote best practice and, in particular, adoption of standardised survey, recording and reporting methods, such that as many wader studies as possible yield findings that are reliable and can be directly compared with one another;
3. to manage and facilitate the collection, collation and processing of wader data, ideally through a dedicated 'wader hub' type system (as described above), to act as a champion of such a hub and to take the lead on developing strategy for further system development;

4. to co-ordinate and contribute to research efforts to make use of the data generated by wader studies, whether by facilitating access to existing data, or by promoting collaborative and complementary work that directly provides information relevant to management of breeding waders.

5.3 The future role of BTO in facilitating the evidence base around breeding wader conservation

The overall aim of this wader information audit was to establish the best ways that BTO could play a role in work to inform the evidence base around breeding wader conservation. This followed a number of requests and enquiries from independent wader initiatives about BTO assistance. BTO has many relevant areas of skill and experience that could be mobilised to help in future, which include:

- strict independence, objectivity, and non-lobbying stance, which means BTO is respected by a wide range of other organisations and individuals across broad sectors. It also means that BTO is in the position of being able to act as an effective 'honest broker' and bring together diverse groups of stakeholders with differing views to work together towards shared goals.
- many years of experience in developing and implementing relevant survey and monitoring methods, designed for use by a wide range of audiences, including professional field ecologists, skilled volunteer birdwatchers and others who aspire to carry out surveys and monitoring as part of their other daily work activities (e.g. rangers and land managers) or outdoor leisure activities (e.g. hillwalkers);
- many years of designing and curating databases to capture and store bird survey, monitoring and research data, and of building on-line information capture systems to suit the needs of a wide variety of end users;
- many years of working in partnerships with multiple partners with the aim of delivering programmes of mutually agreed action and meeting the shared objectives of groups of stakeholders; and

This audit has shown that most independent projects are very positively disposed towards working with BTO. One of the main areas with which survey organisers of independent projects seek help from professional organisations is resource. BTO is always likely to have very limited capacity to help projects by providing direct funding or increased man-power. However, BTO has plenty of things to offer that are of value to organisers of wader projects. Particularly among smaller, independent projects, there is almost universal appetite for improved guidance on survey methodologies, and increased use of technologies such as temperature loggers, nest cameras and radio-tracking equipment, particular where projects can be helped to access the relevant equipment (guidance on equipment specifications or loans of equipment).

BTO has assisted with three independent Curlew and wader projects over the past two years, providing not only guidance and training in wader survey methods, but also loans of equipment (nest cameras and thermal loggers loaned to two projects, and radio-tracking equipment to another). This kind of contribution can go a long way to enabling small projects to carry out valuable and useful work, and can even be presented to funding bodies as an in-kind contribution in order to leverage matched funding. Furthermore, BTO staff may be able to advise project organisers about where to seek (and how to apply for) funding, enabling us to help projects with resource without directly providing them with resource, although this does involve in-kind commitment from BTO fundraising staff.

Several projects also indicated that they would be interested in receiving help with analysis, interpretation and reporting of their data, which BTO may often be well placed to provide. Finally, many projects are keen to be involved with BTO in order to benefit from BTO's reputation for rigorous and reliable science. This is a positive reflection on our standing with a broad range of stakeholders but BTO staff should always be alive to the possibility that some stakeholders may wish to use BTO's involvement to influence opinions about the quality or impartial nature of their projects in a manner that risks undermining BTO's reputation. However, it will usually be possible to prevent reputational damage, by promptly responding to or rebutting any erroneous claims made by our project partners, and by ensuring that BTO is only associated with projects for which we have sufficient involvement and control to ensure appropriate scientific rigour and objective interpretation. It is worth highlighting that all of the potential contributions that BTO could make to projects would likely be enhanced (from a project's point of view) and streamlined (from a BTO point of view) by the employment and future availability of a BTO wader project officer, as described above.

Several other large research NGOs are also heavily involved in wader monitoring, management and conservation initiatives, including RSPB, James Hutton Institute, and Game and Wildlife Conservancy Trust. As well as being valuable collaborators in their own right, such organisations can also positively influence how other individuals and groups interact with BTO. Good examples are provided by several recent projects BTO has undertaken to explore and develop ways of engaging the game management community in breeding wader monitoring. These have included the Understanding Predation project, the Working for Waders initiative that followed this, and work with gamekeepers in Wensleydale and Cairngorms, all of which have greatly benefited from the willing involvement and cooperation of individuals and organisations involved in game management.

The present funding climate means that resources available to carry out work on wader monitoring and management are very limited (more so than previously). Given this, and the increased pressures on research organisations to fund their staff and to make clear and valuable contributions to wader conservation, tensions regarding competition for the available funding and resources are to be expected. More helpfully, the limited resources available provide even stronger incentives for organisations to work effectively in partnership to meet the challenges around effective wader conservation management, and many funding sources are likely to favour strong and successful partnerships (e.g. the Working for Waders initiative). It is therefore important that BTO maintains and enhances wherever possible its organisational skills and experience in effective partnership working.

Apart from loss of resource to carry out and develop wader-related work, lack of cooperation between BTO and other organisations carrying out wader work is likely to lead to at least some of this work being carried out by a limited range of stakeholders. This, in turn, may limit the range of stakeholders that have access to information about, or arising from, this work and/or wider trust in the findings. This can have a number of undesirable consequences. The insights about wader populations, ecology and surveying that can be gained from wader data often depend on the amount of data available, as well as the spatial and temporal ranges covered. These can all be restricted if data are collected and held by different organisations, particularly in the absence of agreements about how and in what circumstances data can be shared. Even if all data-holding parties are willing to share information, analysing multiple or composite datasets may be complicated by differences in the methods used to gather, record, or process these data. Finally, if data are not collected collaboratively, particularly where they are collected by parties perceived by other stakeholders to have a vested interest in the results, conclusions based on these data may achieve limited acceptance among stakeholders; even when the data are good, and the conclusions justified and valuable.

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Appendix 1 – Curlew monitoring questionnaire and accompanying instructions

CURLEW MONITORING QUESTIONNAIRE

Completed questionnaires and any queries to:

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Instructions

Concern for Curlews in the UK, and a shared desire to improve their prospects, have recently made this species something of a flagship for other declining species of waders and ground-nesting birds. Borne of this concern, a large number of independent projects on Curlews are now involved in local conservation work and monitoring. Cumulatively, these projects have enormous potential to enhance our wider understanding of the Curlew's decline. However, the light that these projects shed on the problems facing Curlew populations will be far brighter if their findings can be brought together effectively. BTO is currently exploring how best to facilitate this, whether by assisting in the development and sharing of best practice, helping to coordinate aspects of fieldwork, or providing a repository for shared data. In order to do this, we need to find out about as many Curlew projects as possible, to understand the kinds of information they are collecting, the methods they are using, and the aspirations of those involved.

This questionnaire may be filled out electronically (as a Word document) or, if printed out, with pen or pencil. If you can, please have a quick look through the questionnaire before starting to fill it in. Although it might seem a bit long, some sections may not be relevant for your project (and so can be ignored), and most questions can be answered quickly if time is limited. On the other hand, plenty of space is provided for those who want to provide lots of detail! Please give as much or as little information as suits you, and in either case we may get back in touch with you to make sure our interpretation is correct. If the answers to any of the questions, or relevant supporting information, are already conveniently assembled (e.g. in a report or guidance note), please feel free to refer to or attach a copy of this in your reply. Finally, if you would like more information about any of these questions, or would rather talk through your answers rather than filling out the questionnaire, please get in touch (contact details below).

This questionnaire is intended to inform our collective decisions about how best we can make a difference for Curlews and help the people studying and conserving them to be as effective as they can. Please be assured that nothing is set in stone, and any information and advice you give us will be gratefully received, shared and taken on board as we all decide what to do next. Many thanks for participating… and let us know if you have any questions of your own!

CONTACT INFORMATION

Name of project

Name and position (in project) of respondent

Contact email

Contact phone number(s)

PROJECT LOCATION, DURATION AND SCALE

Place (please give a brief description of the project's location and any obvious boundaries)

Size (please state the approximate area and type(s) of suitable habitat covered)

For the following questions about Curlews in your area, use the 'Not sure' box either as a main response or to indicate uncertainty about another response (e.g. ticking both 'Breeding success' and 'Not sure' to indicate that you suspect that declines are mainly caused by low breeding success).

Number of breeding pairs of Curlew in study area [ ] Not sure ☐

Over the past 10 (or fewer) years, has the population been (tick as appropriate):

Increasing ☐ Decreasing ☐ Stable ☐ Not sure ☐

If decreasing, do you think this is principally down to:

Breeding success ☐ Poor survival of adults ☐ Not sure ☐

Could you supply a map showing study boundaries (please delete as applicable. Map can be provided later if not readily to hand)? Yes / No

Project start year

Approximate number of participants (including full time, part-time and volunteers) in project

What is the expected time-frame for your project? Any details of funding or other resources that you wish to share will be kept confidential.

BREEDING CURLEW NUMBERS

If you do not carry out any survey work to monitor numbers of breeding Curlew pairs in your study area, please go to the next section on NEST MONITORING.

If such surveys are carried out, please indicate the approximate frequency and timing of visits.

For each of the following types of information that you collect in your project, please tick the small box (or type 'Y') and provide detail in the larger box below.

Numbers of individuals or pairs ☐

If so, please describe whether the counts are complete, samples, estimates etc. If a particular method is followed, please describe or give a reference.

Locations of Curlews ☐

If so, please describe the resolution and type of spatial information collected (e.g. field identity, 1km square, six-figure grid reference etc.)

Breeding status ☐

If so, please describe briefly how breeding status is determined, and what behavioural information is recorded.

Who carries out these surveys (e.g. paid fieldworkers, volunteers etc.)? Does anyone else contribute information relevant to the surveys (e.g. farmers)?

We would also be interested in hearing your thoughts about which of the methods you have tried work best, and also about where the methods you use come from; whether from experience of similar surveys, published guidance, expert advice, or any other sources of information.

If there are particular methods that you wanted to use but didn't, what were they and what prevented you from using them?

NEST MONITORING

Does this project involve nest recording or monitoring? ☐

(tick if yes, otherwise answer the question below and go to section on 'Productivity')

If this project does **not** involve nest monitoring, is this due to (tick, or enter 'Y', in all that apply):

Resource limitations? ☐

Concerns about impacts on breeding success? ☐

Any other reasons? ☐

[If you wish to elaborate, please do so here…]

If you do collect information from nests, how are these nests found (e.g. by chance encounter, focal observations of territorial pairs, etc.)? If nests are visited more than once, please describe how nests are re-found after the first visit.

Please tell us about the (approximate) number of nests visited and the frequency of visits:

Nests found each year ☐ Frequency of visits to each nest ☐

[If you wish to elaborate, please do so here…]

What information is collected from nests (tick all that apply)?

Nest stage or status? ☐ Hatching success? ☐

Clutch size? ☐ Cause of failure? ☐

Egg weights? ☐ Habitat? ☐

[If you wish to elaborate, please do so here…]

Have you used any of the following to collect information from nests:

Temperature loggers? ☐

Nest cameras? ☐

Other technology? ☐

If so, we would be interested in hearing how useful and reliable you have found these to be in determining nest outcomes, causes of failure, and predator identities.

PRODUCTIVITY

The number of young successfully produced by breeding pairs of Curlew is a very important but notoriously difficult thing to measure. We are therefore particularly interested to hear about any ways in which you or your collaborators have tried to get a handle on the breeding productivity of your population, including assessments of adult behaviour over the course of the breeding season; age composition of birds in the study site; marking or remote tracking of young birds; or any other approaches you have tried out or thought of.

Please let us know if you have experience or advice about approaches to measuring productivity that you think might be of interest! We are just as keen to hear about approaches that didn't work as about those that did!

MARKING/TRACKING

A range of activities can give Curlew researchers an insight into the movements and behaviour of Curlew, and could be powerful tools in our efforts to improve understanding about Curlew numbers, breeding success and survival. These include colour-ringing (and resighting surveys), VHF radio tracking, GPS and satellite tracking. If your project currently uses (or has used) any such techniques, please briefly describe the nature and scale of the work, and the intended uses of the information collected (e.g. to inform estimates of fledging success, inter-annual survival, habitat use etc.). In particular it would be good to know how well these technologies worked, and whether you encountered particular problems or unexpected limitations to their usefulness.

For marking and tracking activities that you do not already carry out, how would you feel about the possibility of such work being undertaken (by you or by others) on Curlews in your study area?

OTHER ENVIRONMENTAL INFORMATION

If you don't collect other relevant (but non-Curlew) information as part of your project, please go to the next section (MANAGEMENT AND INTERVENTION).

We would also like to know more about any other (non-Curlew) information collected as part of your project. For each of the relevant categories, please describe briefly the information collected, methods used, and reason(s) for including it in the project.

Abundance or productivity of other wader species ☐

Predator numbers, activity or impacts ☐

Habitat type or land use ☐

Curlew prey diversity, abundance, or distribution ☐

Information on land management (e.g. cropping, agro-chemical use) and interventions to benefit breeding waders (e.g. predator control or exclusion) ☐

Any other relevant information ☐

MANAGEMENT AND INTERVENTION

If your project doesn't involve carrying out (or influencing) management or interventions for Curlew, please go to the next section on COLLABORATION AND DATA SHARING.

Otherwise, please indicate which types of management are carried out, and briefly outline what they entail:

Creation or management of habitat for breeding or foraging Curlew ☐

[What habitats are created or managed, and what management is carried out…]

Movement of livestock, cropping dates etc. to benefit Curlews ☐

[Further detail on what changes are made to farming or other activities…]

Predator control/exclusion ☐

[Any details you can give about the predators involved, methods employed etc.]

COLLABORATION AND DATA SHARING

How do you and other participants in your project currently (or plan to) use your data?

Questions about Curlew ecology and management can be tackled more effectively using information from many individual projects than through a single study. The feasibility of combining datasets, and the range of questions that can be addressed, typically depends on the degree to which information from different sources is comparable, not just in broad type and format, but in the methods used to collect it. With this in mind, would you be interested in any of the following? Please tick one box for each category:

Guidance or training relating to any aspects of monitoring you are engaged in, or would like to carry out in the future.

Yes ☐ No ☐ Maybe ☐

[If you wish to elaborate, please do so here…]

Increased manpower (volunteer or professional) to help with fieldwork.

Yes ☐ No ☐ Maybe ☐

[If you wish to elaborate, please do so here…]

Support to work with your own data (e.g. help with analysis or reporting) to better understand Curlew populations in your area.

Yes ☐ No ☐ Maybe ☐

[If you wish to elaborate, please do so here…]

Sharing project data (retaining ownership of and rights to these data) with others involved in similar projects elsewhere in the UK (for example, to produce multi-authored, multi-project papers about various aspects of Curlew monitoring or population change).

Yes ☐ No ☐ Maybe ☐

[If you wish to elaborate (e.g. about restrictions regarding with whom, or for what purposes, your data were shared)…]

Participating (along with other similar projects) in large scale studies or trials of management (e.g. nest camera monitoring of nests, GPS tagging, control of predator populations).

Yes ☐ No ☐ Maybe ☐

[If you wish to elaborate, please do so here…]

Helping to deliver training or guidance to enable other projects and individuals to take part in studies on Curlews and other breeding waders.

Yes ☐ No ☐ Maybe ☐

[If you wish to elaborate, please do so here…]

ADDITIONAL INFORMATION

If you have time, we would be very grateful for any information you can give us about sources of information and guidance about Curlew monitoring that you think are useful, and also about recent and ongoing projects on Curlews. In either case, we would be particularly interested to hear about information or projects that we are not aware of yet. To give you some idea about the information and projects we are aware of, we enclose a selection of relevant material relating to Curlew monitoring, management and research (Appendix 1), as well as a list of recent and ongoing projects on Curlew in the UK (Appendix 2).

Appendix 2 – Additional information on breeding wader initiatives that did not respond via the standardised questionnaire survey, or that could not respond within the time-frame of the survey.

Lodge Bog, Co. Kildare, Ireland

This project is focussed on achieving successful breeding of just two pairs within a small area (35 ha) of raised bog, situated within a much less suitable landscape. The project is currently run as a collaboration between IPCC and BirdWatch Ireland Kildare volunteers, and includes liaison with and involvement of farmers in surrounding areas. Monitoring of Curlew and other birds started in 2005, with management interventions from 2017. Measures include the erection of a fence to prevent livestock from disturbing nesting birds, predator control and liaising with local farmers to agree on Curlew-safe farming practices during their breeding season.

Breckland Curlew project

An overview of the project was given during a telephone conversation. It is based on a PhD at University of East Anglia to assess two different kinds of mechanical disturbance (ploughing and rotavating) for creating and maintaining areas of bare ground to benefit biodiversity in the Brecks. This work was primarily aimed at high conservation priority species such as Stone-curlew *Burhinus oedicnemus* and Woodlark *Lullula arborea*, which depend on bare ground. The collapse of Rabbit *Oryctolagus cunniculus* populations in the Brecks has reduced the availability of suitable habitat for these species. In response to initial observations that Curlews were establishing breeding territories in areas of experimentally disturbed ground, numbers of pairs and breeding success of Curlew were assessed in 2017. The study found around 20 pairs of Curlew, most of which were nesting in or near the experimentally disturbed plots. Subsequent work in 2018, by an MSc student, has confirmed that few Curlews are located outside of the plots within the general study area, much of which is owned and managed by the Ministry of Defence as a military training ground. Seventeen of the 23 nests monitored in 2017 (using thermal loggers) failed at the egg stage, with two failing post-hatching, and four going on to fledge a total of at least five chicks. In 2018, cameras were deployed at some nests, and showed that fox was the most frequent nest predator (nests were also predated by crows and sheep). A full-time PhD will continue monitoring Curlew on these plots, and more widely, hopefully producing a Curlew population estimate for the Brecks, and also considering what management might be undertaken to enhance the numbers and productivity of these Curlew.

East Cairngorms Moorland Partnership

This project started in 2018 with the aim of improving understanding of breeding wader population trends in the eastern Cairngorms, and how they are related to variation in breeding productivity. It is being run as a partnership between BTO, Cairngorm National Park Authority, and six contiguous estates in Cairngorm National Park (Mar, Mar Lodge, Invercauld, Glen Avon, Glenlivet, Balmoral), covering a total of 1360 km2. Survey work is being carried out by estate ranger staff (on the estates that have them) and volunteers, as well as gamekeepers and other estate staff, and involves a mix of transect surveys, wader nest monitoring with nest cameras and temperature loggers (to get information on nest survival rates and predator identities) and assessment of breeding productivity (based on adult behaviour during later transect surveys).

Pembrokeshire Curlew projects

The island of Skomer holds Pembrokeshire's last breeding Curlews, among the few remaining in western Wales. These pairs, and their breeding output, are monitored annually by Skomer's warden (employed by the South-west Wales Wildlife Trust). The area and number of Curlew are both small enough that no formal survey visits or methods are required to maintain a reasonably detailed record of breeding Curlew performance. For the past five years, three pairs have successfully fledged an average of less than 1 offspring between them.

Yorkshire Dales Curlew BBS

Yorkshire Dales National Park coordinate BBS (Breeding Bird Survey) carried out by a mix of volunteers and Park staff in more than 60 squares in the Park, in order to increase the information available to them on upland breeding birds, including Curlew and other waders. This greatly enhances BBS coverage in this area, and in return BTO produce a report summarising annual trends for a range of bird species within the National Park (De Palacio *et al.* 2018).

RSPB reserves

Many RSPB reserves are managed exclusively or primarily for breeding waders. Annual monitoring of the breeding numbers of target wader species takes place at all of these and, at many, breeding productivity of some species is also monitored. We received a summary of wader-related activity on all reserves in Scotland with important breeding wader populations. The reserves in which Curlew are among the monitored breeding waders are included in Table 1 and Figure 2. A total of 250 Curlew pairs are monitored on these eight reserves. Breeding productivity of Curlews is only monitored on two reserves (Onziebust and The Loons, both in Orkney). Management for waders carried out at all of these reserves includes management of vegetation height (through grazing and/or cutting), with control of rush and/or scrub, and manipulation of water levels also done at most of them. Predator control is not carried out at these reserves, with the exception of Insh Marshes where there is some control of foxes. This emphasis on habitat management over direct manipulation of predator numbers is likely to make information about the waders and management on these reserves useful for improving our understanding of the relative importance of predator control and habitat management, in different landscapes, areas and land uses.

Curlew Conservation Programme

This is a large-scale, multi-site project comprising six large areas within the Republic of Ireland. In 2017 these held around 60 pairs of Curlew, which is just over half the breeding Curlew estimated to be left in the Republic of Ireland. Each area is covered by 3 core staff (a Curlew Advisor, Nest Protection Officer, and Local Curlew Champion), with a postdoc and two students leading a research element, and variable input between areas from NPWS staff, RSPB and BirdWatch Ireland staff. Survey work is carried out through a combination of walking surveys, vantage point watches, use of historical data and gathering information from local sources. This project, and the people involved with it, could be a valuable source of information about effectiveness of different survey approaches in areas where Curlew densities are low and knowledge about recent occupancy is poor. Moreover, although the 2017 report for this project (O'Donoghue 2017) does not give much detail about assessment of productivity, the intention is for this to be an integral part of the project, so the project could be a good source of information about the effectiveness of different forms of assessment.

Cover image: Philip Croft. Back cover: Liz Cutting.

Audit of local studies of breeding Curlew and other waders in Britain and Ireland.

Due to large historical and on-going population declines in Britain and Ireland and mainland Europe, and its 'near-threatened' global status, the Eurasian Curlew (*Numenius arquata*) is widely considered by many stakeholders to be one of the highest bird conservation priorities in the UK and Ireland. A number of other breeding waders have also showed marked declines during a similar timeframe, and a multitude of field initiatives across Britain and Ireland have been established, or tailored, to support conservation of these wader species.

This audit aimed to collate information from as many of these British and Irish breeding wader projects as possible, to allow BTO to assess how best it might assist local to national initiatives through partnership working in future. The audit was designed to assess the appetite of the interested community for scientific guidance, mechanisms to share data and findings, and any other roles that would benefit from BTO's areas of expertise and experience.

This report presents information drawn from a variety of projects on breeding Curlews and other waders. Questionnaires were sent out to 41 projects in October 2017, asking about their structure, aims, and monitoring and management activities. We also carried out a literature review of breeding wader survey methodologies.

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