BTO RESEARCH REPORT 703

Monitoring Breeding Waders in Wensleydale: trialling surveys carried out by farmers and gamekeepers

A report to the Yorkshire Dales National Park Authority

David Jarrett, John Calladine, Chris Wernham & Mark Wilson

Looking out for birds

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1 EXECUTIVE SUMMARY

1. Wader populations have declined significantly in recent decades in the UK. During this time, areas of moorland managed for grouse shooting and associated farmland, especially rough pasture fringing moorland have been identified as persisting strongholds for breeding waders. However, these habitats are often poorly represented in existing wader surveys and monitoring projects due to issues such as remoteness, lack of available surveyors, and access constraints. Moreover, the farmers and gamekeepers who work in upland areas have often been overlooked as potential survey volunteers or sources of information on breeding waders.

2. The objective of this pilot project was to test methods for involving gamekeepers and farmers in surveying breeding waders and monitoring their nests, and to consider whether and how these methods could be applied more widely within the Yorkshire Dales National Park (YDNP) and similar areas. The work took place in the Wensleydale area of the Yorkshire Dales National Park, primarily at the Bolton Castle Estate. Over the course of the breeding season a BTO staff member worked with two estate gamekeepers and the landowner, and also spent time working with a YDNPA staff member and four of farmers from across Wensleydale.

3. During the 2017 breeding season, gamekeepers and farmers carried out breeding wader surveys at a range of sites across Wensleydale using survey methods tailored to fit with their work schedules. BTO staff and gamekeepers also worked together to monitor wader nests using temperature data loggers and trail cameras. We describe the survey and monitoring methods adapted for these specific stakeholder groups, considering aspects of these methods that worked successfully, as well as those that may require further development.

4. The breeding wader surveys revealed relatively high densities of Curlew, Golden Plover, Lapwing, Redshank and Snipe where habitats were appropriate for each species. In areas surveyed by both BTO field staff and gamekeepers/farmers, simple comparisons showed that the findings of these two groups of surveyors were comparable.

5. Thirty-four wader nests were monitored (8 Curlew, 2 Golden Plover, 21 Lapwing, 1 Redshank, 1 Oystercatcher, and 1 Snipe). Thirteen nests failed during the egg stage, of which ten were confirmed as predated. Nest predators identified by cameras were sheep (3 nests), Badgers (2), hedgehogs (2), unidentified mammal (1) a pet dog (1) and corvids (1). In addition, two nests were trampled by livestock and one was abandoned. Sheep have been rarely documented as a nest predator of breeding waders. Although based on a limited sample size, the results of this pilot study do suggest that more extensive monitoring would generate useful (and potentially surprising) information on wader nest predation.

6. The sample sizes of farmers (n = 4) and gamekeepers (n = 3) involved in the project were small, so statements about the attitudes, motivations or skill of participants in this report are unlikely to be wholly representative of their respective professions. The overriding intention of the work was to trial the suitability and practicality of survey methods *for* members of the relevant stakeholder groups, rather than to make generalisations *about* these stakeholder groups.

7. Survey methodologies that fit into gamekeeper's work routines have the potential for wide uptake and would generate useful data, provided that appropriate guidance was made available. Embedding the monitoring of breeding waders within the work practices of gamekeepers could prove to be an effective approach for improving the monitoring of breeding waders in key areas. Limited trials in Wensleydale suggest that designing a methodology that is compatible with typical workloads for farmers to carry out wader surveys would be more challenging.

8. For projects on wader conservation in upland moorland areas, there will be benefits of collaboration between diverse stakeholders. Shared participation in monitoring could help to build trust and promote knowledge sharing among participants, and to align conflicting interest groups behind one or more common objectives. Synergies could also be gained from sharing data and methods between projects and, where possible, following comparable methods and approaches. Drawing on data and results from different projects could increase our understanding about the drivers of change, and the consequences of management interventions.

2 INTRODUCTION

Populations of waders have declined significantly over recent decades in many parts of the world (Stroud *et al.* 2006). In the UK, declines have occurred widely across the range of habitats in which waders occur (Wilson *et al.* 2005, Sim *et al.* 2005, Balmer *et al.* 2013), although enclosed farmland has experienced the most severe and long-term declines (Baines 1990, O'Brien *et al.* 2002, Wilson *et al.* 2005, Shrubb, 2007). The magnitudes of declines in UK breeding wader populations between 1995 and 2015 are estimated as -23% for Oystercatcher *Haematopus ostralegus*, -43% for Lapwing *Vanellus vanellus*, -48% for Curlew *Numenius arquata*, -38% for Redshank *Tringa totanus* (Harris *et al.* 2017) and -20% for Golden Plover *Pluvialis apricaria*. Common Snipe *Gallinago gallinago* has also experienced severe declines since the 1970s (Siriwardena *et al.* 2000). On their breeding areas, drivers of population change include agricultural intensification and associated habitat loss, afforestation by commercial conifer plantations, field drainage and disturbance, and increased numbers of generalist predators (Galbraith 1988, Ottvall 2005, Smart 2006, Eglington *et al.* 2010, Showler *et al.* 2010, Fletcher e*t al.* 2010, van Dijk *et al.* 2015, Ainsworth et al. 2016, Franks *et al.* 2017). In upland moorland areas of the UK where predator control is carried out for grouse moor management, waders have been found to breed at higher densities than in moorland without predator control (Evans 2004, Tharme *et al.* 2001, Fletcher *et al.* 2010, Franks *et al.* 2017). Declines in most areas are unlikely to be the result of a single cause however, and in many cases predation, habitat change and disturbance will be acting synergistically to make conditions less suitable for breeding waders (Eglington *et al.* 2009, van der Wal & Palmer 2008, Calladine *et al.* 2014).

Within the UK, Wensleydale is one of the most important areas for breeding waders, with amongst the highest densities of breeding Curlew and Golden Plover (Balmer *et al.* 2013). The mix of heather moorland managed for driven grouse shooting, large areas of moorland fringe rough grazing, and less intensively managed lowland fields provide a broad suite of habitats suitable for breeding waders. Wensleydale is one of two areas in England trialling a new "payment by results" agri-environment scheme ("Results-based agri-environment pilot study in England", 2017) which is also being trialled in other parts of Europe (Birge *et al.* 2017). Instead of following a prescriptive set of management rules to receive payments, the quality of habitat on a farm is assessed under the trial scheme and if it meets certain criteria, the farmer receives payment. Part of the Yorkshire Dales National Park Authority (YDNPA)'s motivation for taking part in this pilot project was to develop methods for monitoring the impact of this trial scheme, which in 2017 involved nineteen farms in Yorkshire Dales National Park (YDNP). As such, within the YDNP there is interest in wader conservation from diverse interest groups, and the opportunity to work constructively with multiple stakeholders including estate owners, gamekeepers, farmers and volunteers. Importantly, a stakeholder-led and outcomes-oriented wader conservation project has the potential to directly inform local management and land use policy aimed at creating conditions for sustainable breeding wader populations. The purpose of this pilot study was to inform methods used in such a project.

The project was based at the Bolton Castle Estate in Wensleydale, an estate with high densities of breeding waders occupying driven grouse moor, extensive moorland fringe rough grazing, silage meadows and lowland enclosed fields.

2.1 Aims

The main focus of the project was to establish the effectiveness of different methods of encouraging and enabling gamekeepers, farmers and estate staff to monitor breeding waders. The project comprised three distinct field elements:

i) Involving farmers and gamekeepers in the monitoring of wader nests, using infra-red trail cameras and temperature data-loggers to assess nesting success and timing and causes of failure;

ii) Establishing the extent to which farmers and gamekeepers were willing to carry out breeding wader surveys; and trialling different methods for farmers and gamekeepers to undertake surveys of breeding waders that are sufficiently robust to contribute to ongoing monitoring;

iii) BTO and YDNPA staff carrying out breeding wader surveys on a selection of sites within Wensleydale to potentially be re-surveyed in the future, to aide YDNPA wader monitoring efforts, and to calibrate with surveys carried out by farmers and gamekeepers.

The number of gamekeepers and farmers involved in the project was small: the intention of the project was to test and refine the suitability and practicality of methodologies with a small number of individuals, rather than to make broader conclusions about these stakeholder groups. The Bolton Castle estate has in the past taken part in various collaborative conservation projects including work on waders. As such, many of the participants already had an active interest in conserving waders. This, together with the small sample of people involved, should be borne in mind when considering the findings in this report.

3 METHODS

The project involved three visits by a BTO staff member to Wensleydale during the 2017 breeding season: two weeks in April, one week in May, and one week in June. A significant amount of time was spent in April meeting key personnel, establishing where surveys would take place, discussing methods, and finalising the scale and scope of the project with the aim that all the work carried out was compatible with existing workloads of participants but would still produce data sufficiently robust for the purposes of monitoring.

3.1 Study areas

Of the six wader species that regularly breed on moorland and associated habitats of Wensleydale and that were the focus of this project, Golden Plover breed almost exclusively on the heather moorland, while the others (Lapwing, Snipe, Curlew, Oystercatcher, Redshank) breed across a suite of habitats, with Curlew densities highest in the unimproved marginal grazing areas which fringe the moorland. Other waders breeding in Wensleydale but not a focus of the project are Woodcock, Common Sandpiper, Ringed Plover and Little Ringed Plover.

Survey sites were selected to cover a range of important habitat types for breeding waders. Following discussion with gamekeepers, to limit disturbance of grouse on the heather moorland, the only surveys carried out on the moorland were carried out by gamekeepers (described in section 3.3). The study areas selected for breeding wader surveys by BTO / YDNPA staff included three areas of unimproved rough pasture areas on the Bolton Castle Estate [site A, site C and site E], and a further area [site F] near to the Bolton Castle Estate with enclosed grazing fields with suitable wader habitat. Two of the survey sites were included in the new results-based agri-environment scheme [site D and site G], and two more [site B and site H] were typical upland farms with large areas of extensively grazed marginal land.

The nest monitoring was largely carried out in the study areas on the Bolton Castle Estate, although some nests which were found incidentally in other areas were also monitored. Some nest monitoring also took place in areas on or close to the Bolton Castle Estate where breeding wader surveys were not carried out.

3.2 BTO/YDNPA wader survey methodology

The methodology for surveys carried out by BTO / YDNPA staff largely followed the approach set out in Brown and Shepherd (1993), but with 3-4 visits to improve the reliability of population estimates (Calladine et al. 2009). A constant search effort was used of approximately 20-25 minutes per 500m x 500m quadrat of survey area. The recorder followed a route through the survey area such that all parts of the survey area were approached to within 100m. All waders seen and heard were recorded and mapped on survey visits, and behavioural codes for ‘displaying’, ‘calling’, ‘alarm calling’ and ‘aggressive encounter’, were used to capture territorial behaviour. On second and third visits, juveniles were recorded whenever these were encountered. Flights were also recorded to help identify territory boundaries. While carrying out surveys some nests were located and subsequently monitored, but the focus of these surveys was on recording numbers and behaviour of individual birds.

Survey visit information was interpreted according to the rules described by Brown and Shepherd (1993). On an individual survey visit, where multiple individuals of the same species were present in an area and it was impossible to determine the number of breeding pairs they represented, individuals of all species were deemed to represent different pairs only if the distance between them was greater than 500m. These distances broadly reflect the distances over which individuals may be observed to move (e.g. when mobbing intruders) during a single survey visit. When the three visits were complete, observations of pairs observed on different visits were considered to be separate only if at least 1000m apart. These distances reflect the distance that pairs, especially with young, might move between census visits. Where possible the surveys were carried out between 08:30 and 18:00 to avoid the periods when bird activity is known to be more variable. All surveys were carried out in relatively calm and dry conditions. For all surveys, precipitation (none, drizzle, rain), wind (calm, breeze, windy), and visibility (clear, moderate, poor) were recorded.

Adult alarm calling or the presence of juveniles on the third survey visits were taken to indicate breeding success. Other observations associated with territory occupation, such as display behaviour, non-alarm calling or presence of pairs, were not taken to indicate breeding success. An index of breeding productivity was calculated for each site by dividing the number of alarm calling pairs by the maximum number of pairs recorded on any of the three survey visits.

3.3 Gamekeeper wader survey methodology

Following discussions with gamekeepers on the Bolton Castle Estate about their workload and daily schedules in spring and early summer, it was agreed to trial a survey methodology based on the routes they regularly walk to check traps as part of their predator control measures. The two gamekeepers on the Bolton Castle Estate each chose two of these 'traplines' to carry out breeding wader surveys. During each survey visit they walked their traplines at a steady pace, stopping only to check their traps, and recording all birds seen and heard (regardless of distance from the trapline) following the methodology and rules described in section 3.2. Waders were recorded as singing/displaying, (non-alarm) calling, alarm calling, engaging in aggressive disputes, and flights were recorded to assist identification of territories. On later visits juveniles were recorded. The same weather variables were recorded as in section 3.2.

Gamekeepers were given a one page set of instructions (see appendix A) outlining the survey method and providing the species codes and the correct annotations for the different behaviours. They were also provided with maps of trapline survey areas on which to plot bird locations and record their route. Data from multiple survey visits was interpreted using the methodology described in section 3.2. An index of breeding productivity was also calculated following the method described in section 3.2.

The main difference between the trapline surveys and the surveys carried out by BTO/YDNPA staff was that the former were effectively line transect surveys, while the latter aimed to achieve complete survey coverage in a defined study area by approaching all parts to within 100m.

3.4 Farmer wader survey methodology

Two different methods for surveying waders were discussed with four farmers during the project and offered as an option to those interested in carrying out surveys. The first method (taken up by 1 farmer) was based on the approach described in section 3.2 – three visits over the breeding season to a pre-defined study area to identify wader territories. The requirement for a constant search effort per unit area (i.e. 20-25 minutes to cover 500 m x 500 m) was relaxed however, partly because the areas being covered were likely to be small, but also because inexperienced surveyors might feel they needed more time for counting or identification. It was agreed that the survey areas trialled with this methodology should be small (one or two fields), partly to make it straightforward to get to within 100 m of all parts of the survey area, but also to ensure that the survey did not take too much time, as this was identified as an important factor in determining whether farmers could take part.

Farmers were given a one page set of instructions (see appendix A) outlining the survey method and providing the species codes and the correct annotations for the different behaviours. They were also provided with maps of their selected survey area to record onto, and also to record their survey route.

The second method that was discussed with and offered to farmers was a simpler method that involved counting the number of each wader species by field, with no recording of behaviour and no plotting of bird location on maps. The three farmers who were interested in this option all agreed in discussion that it would not be too onerous to carry out the survey multiple times during the breeding season, so three visits would be possible.

The instructions and survey forms for the two methodologies are in provided in Appendix A.

3.5 Nest monitoring methodology

BTO staff and estate staff spent time finding wader nests, typically watching suitable habitat from a distance with binoculars or telescope to scan for incubating birds or watch birds back onto the nest. When nests were found, trail cameras (Bushnell Trophy Cam Aggressors) were mounted at a height of 0.5 – 0.75 m (depending on vegetation) on a wooden stake with cable ties, and set up approximately 2-3 m from the nest overlooking the nest area. A thin wooden cane was attached to the top of the stake to prevent corvids perching. The cameras were triggered by an infrared sensor, which worked during both night and day. We programmed the trail cameras to record one still photograph and thirty seconds of video each time the camera was triggered. The photographs and video clips were saved onto a 32 GB SDHC memory card. After sufficient time had elapsed for the nesting stage to be completed the cameras were retrieved and the nest outcome checked and recorded by participants.

Thermocron ibutton temperature data-loggers were also deployed in nests. The data loggers were sealed in a small plastic bag, tied to a screw with garden wire, and fixed in the centre of the nest beneath the nesting material.

The temperature loggers were programmed to record temperature at regular intervals (15 - 25 minutes). From this information, the status of nest (active vs inactive) can be ascertained because the temperature in active nests remains relatively constant. Nest success or failure can be determined from the temperature data because when chicks hatch the temperature in the nest falls gradually as incubation becomes intermittent and chicks leave the nest. When a nest is predated the drop in temperature is contrastingly sudden. Other studies have drawn inferences about predator type from the timing of predation events, assuming that predation by mammals almost always occurs at night, while avian predation typically occurs during the day (Calladine *et al.* 2017, Eglington *et al.* 2009, Mason *et al.* 2017).

4 RESULTS

4.1 BTO/YDNPA wader surveys

Surveys for breeding waders were carried out at eight sites in Wensleydale. First visits were carried out between the 9th April and the 4th May, second visits between the 8th and 25th May, and final visits between 11th and 16th June. All surveys were carried out in dry weather with good visibility and low winds.

Figures 1 to 8 show the different survey areas and the probable territory centre for breeding waders identified at each site using the rules for identifying separate territories from the Brown & Shepherd (1993) methodology described in section 3.2. The data are summarised across all the sites in table 1, and an index of breeding success is shown based on the approach described in section 3.2.

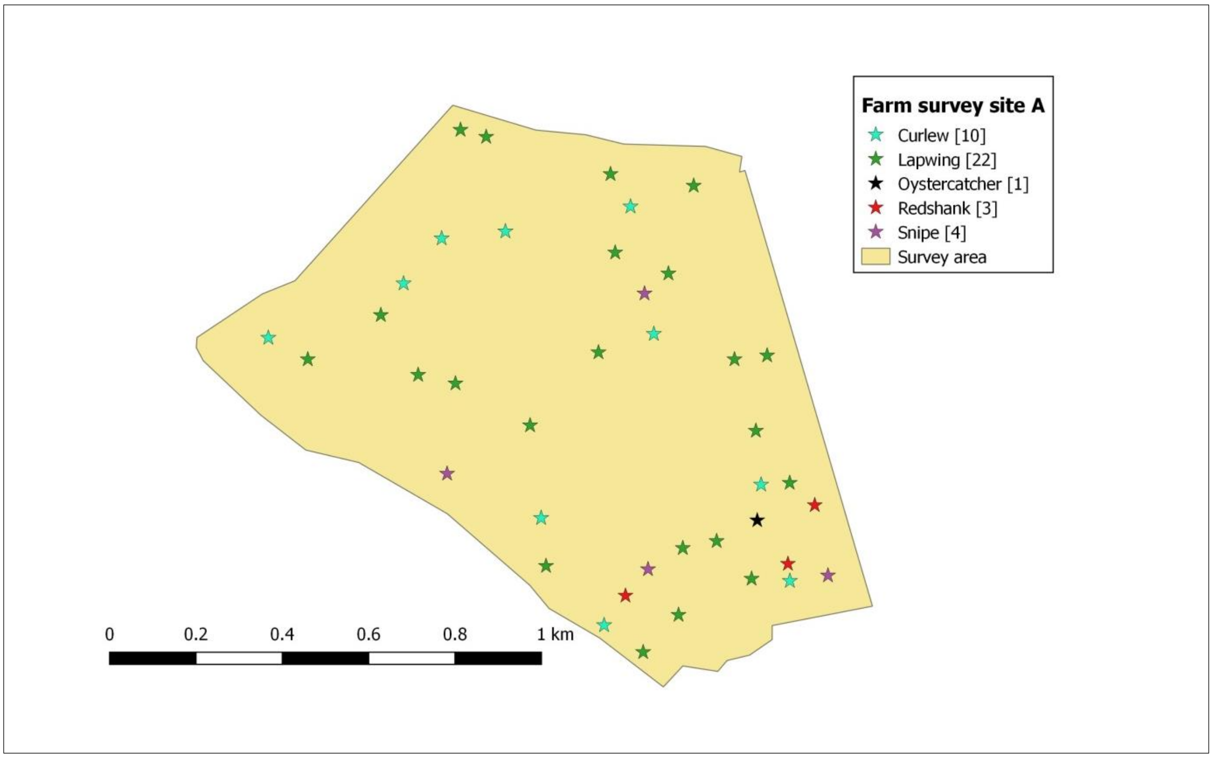

Figure 1: Farm survey site A results

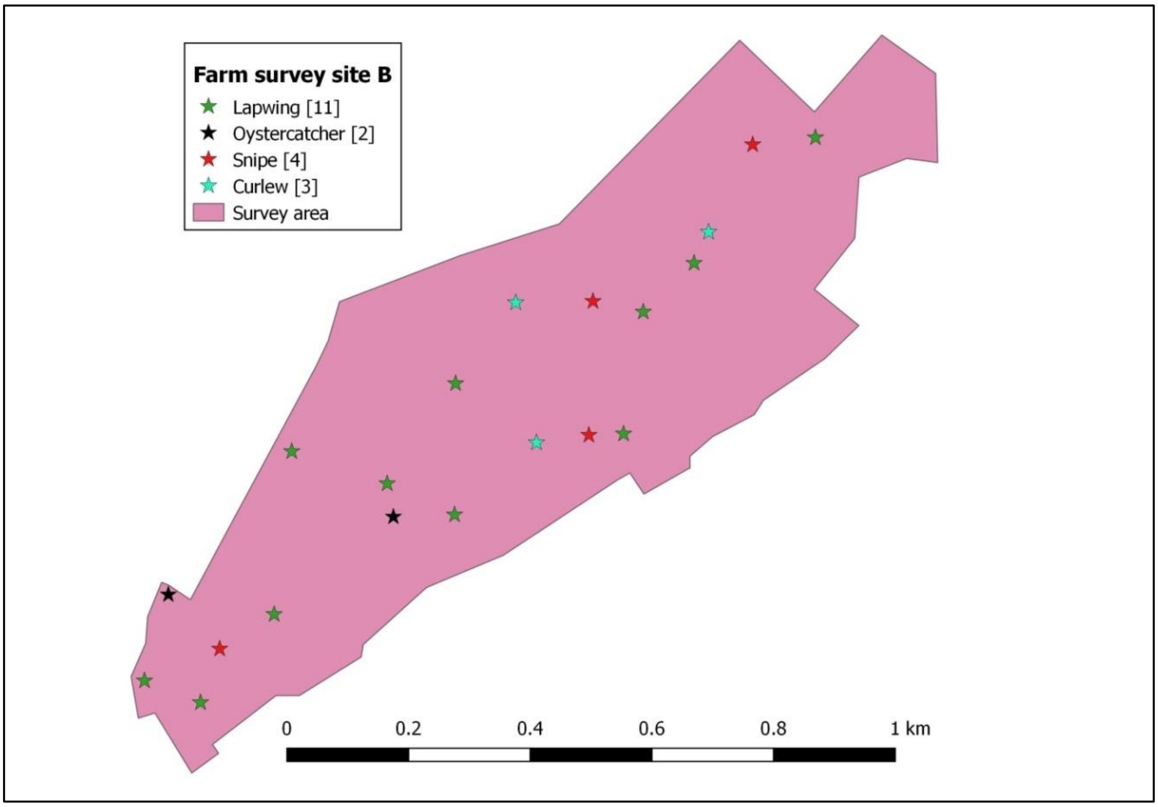

Figure 2: Farm survey site B results

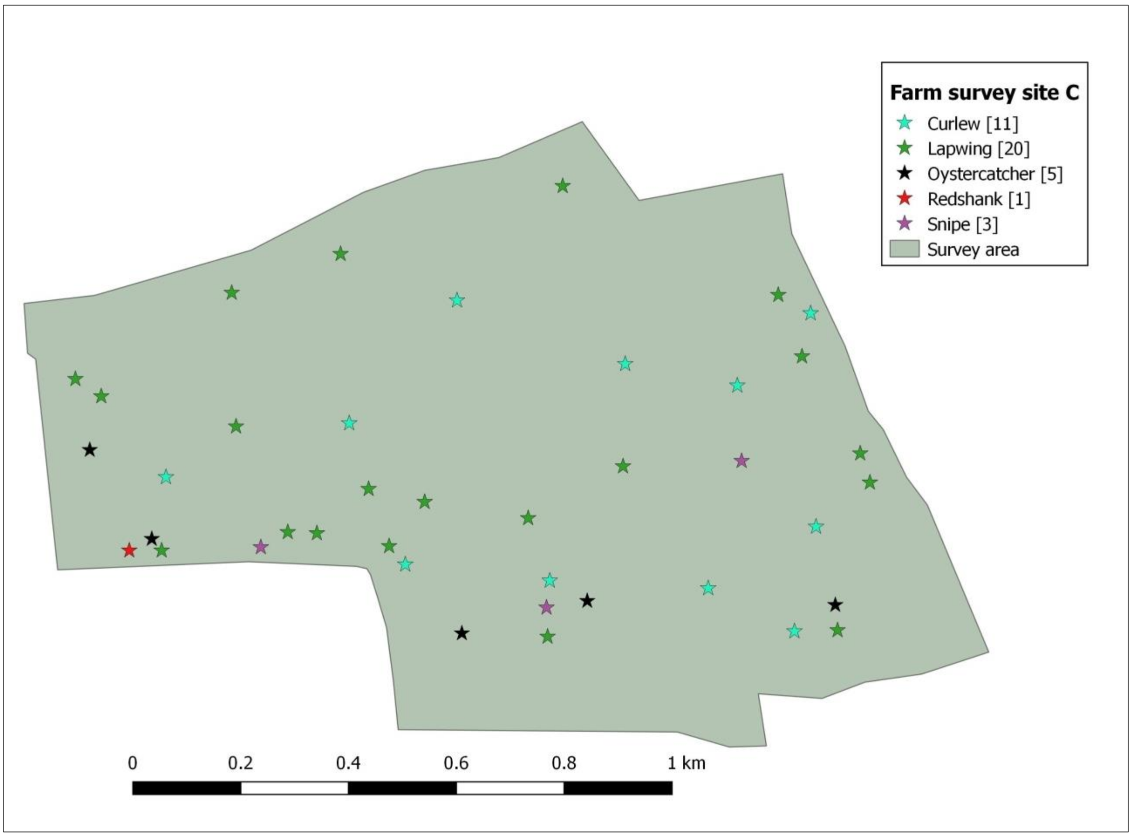

Figure 3: Farm survey site C results

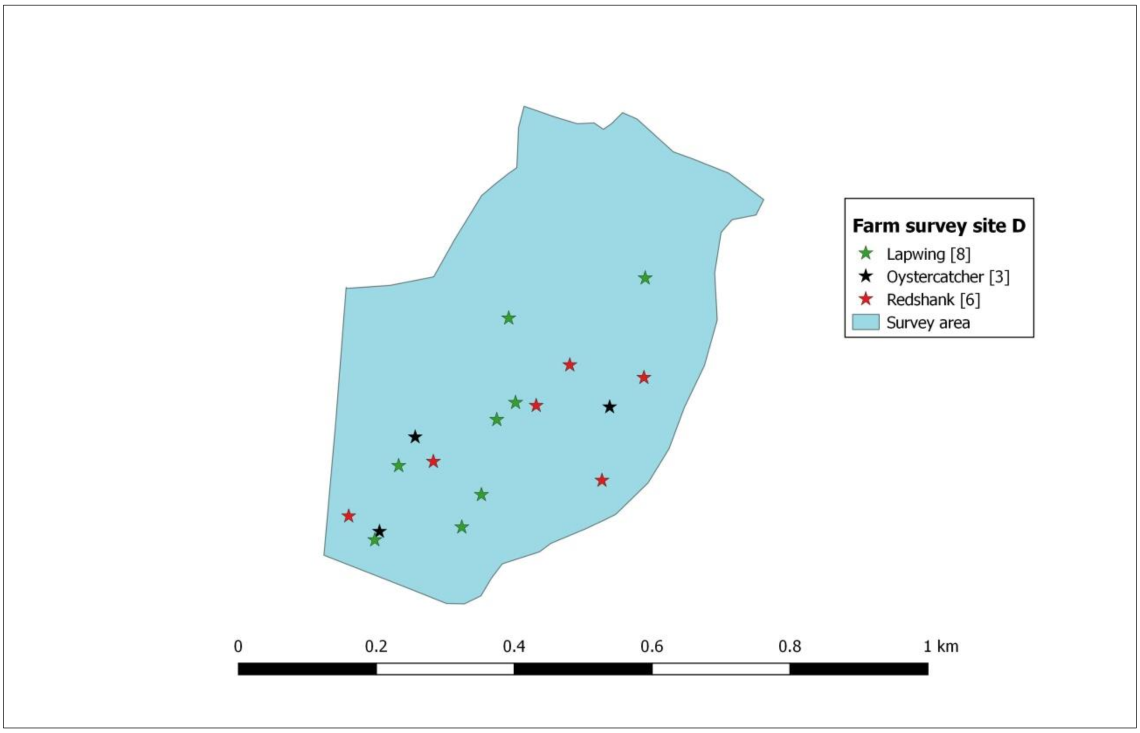

Figure 4: Farm survey site D results

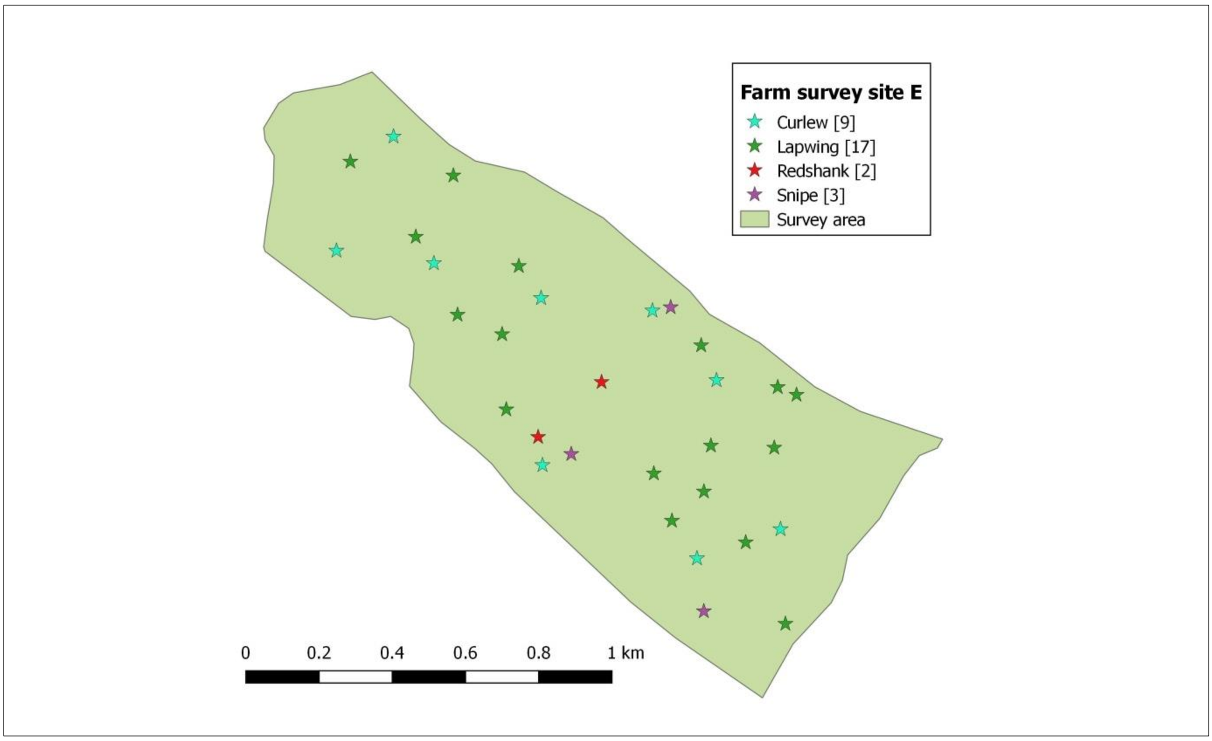

Figure 5: Farm survey site E results

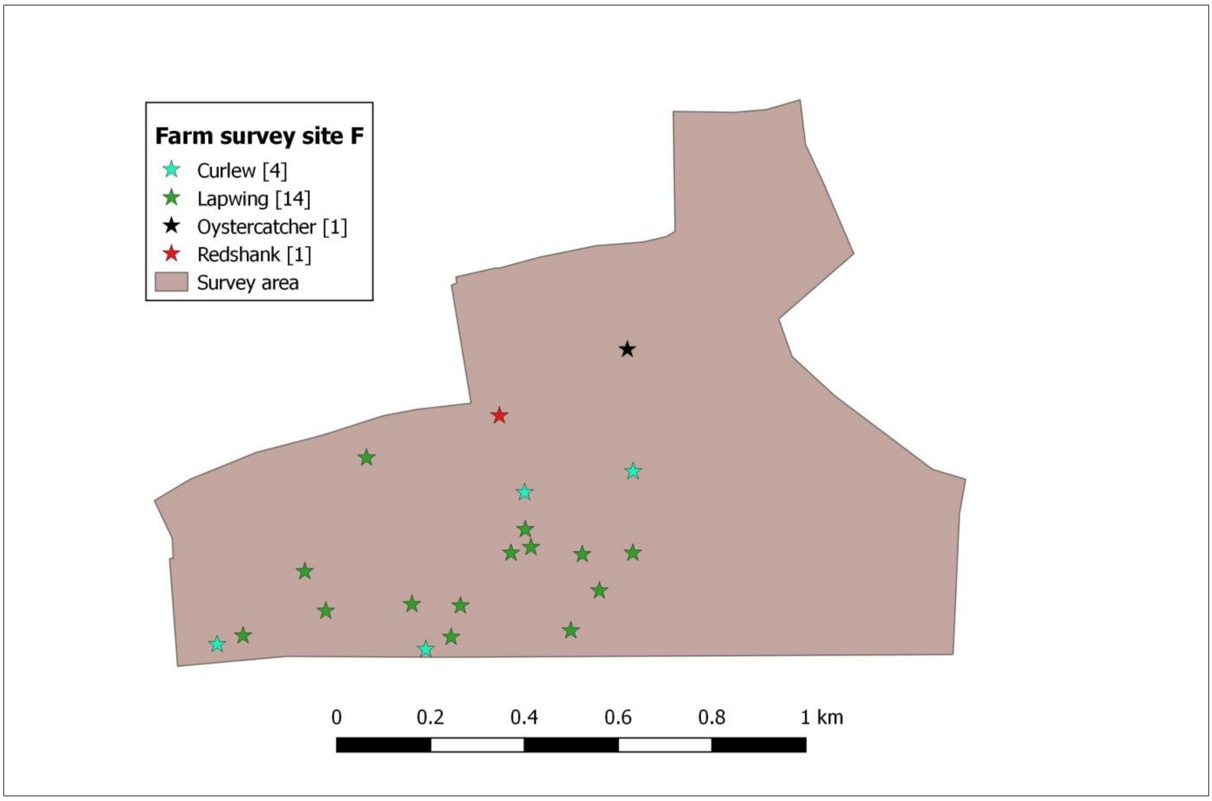

Figure 6: Farm survey site F results

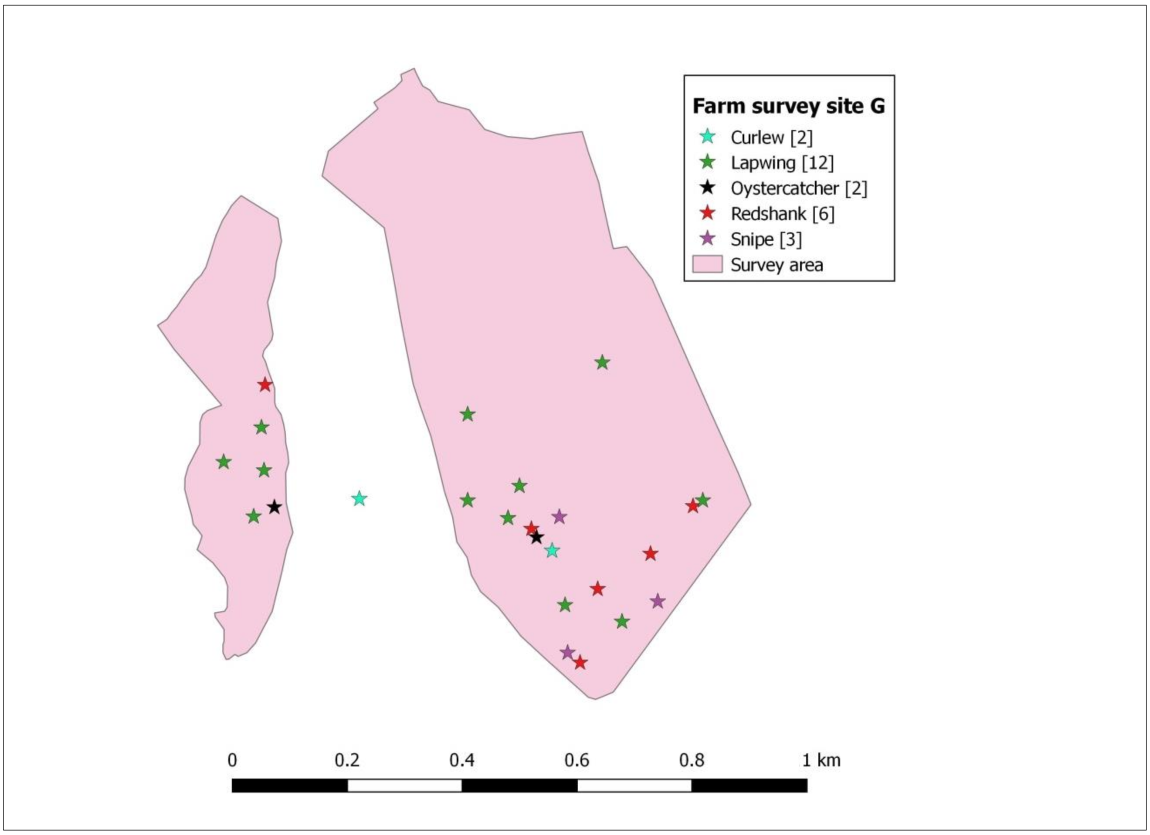

Figure 7: Farm survey site G results

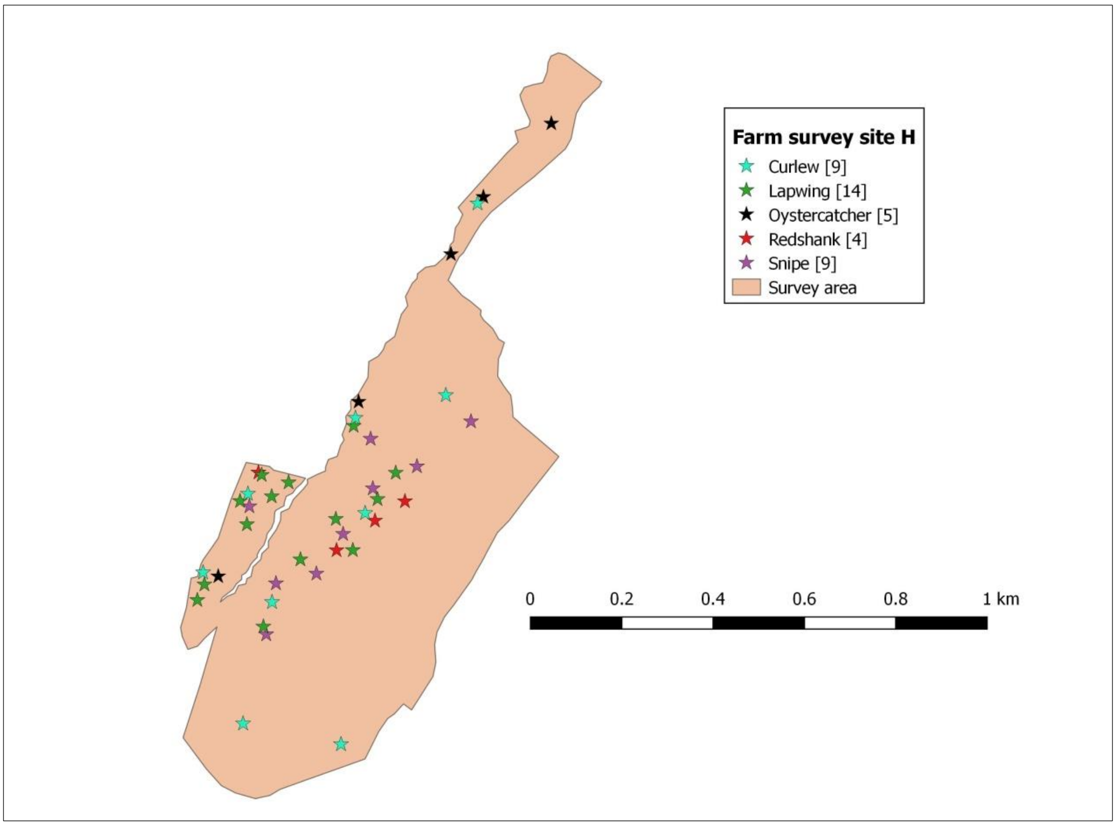

Figure 8: Farm survey site H results

Table 1 Summary of survey results from sites surveyed by BTO / YDNPA staff.

Numbers of pairs relate to the number of probable territories identified using the Brown & Shepherd (1993) methodology described in section 3.2. 'Breeding success index' is the percentage of probably territories with either alarm calling or juveniles in the third visit in June. This was not calculated for Snipe because breeding success of Snipe cannot be easily inferred from behaviour and juveniles are rarely seen. The totals for breeding success are adjusted to take into account that there was no final data from survey site E.

Study area	Area	Curlew		Lapwing		Oystercatcher		Redshank		Snipe
		Probable territories	Index of breeding success	Probable territories	Index of breeding success	Probable territories	Index of Breeding success	Probable territories	Index of breeding success	Probable territories
Farm survey site A	1.51 km^2	10	70%	22	45%	1	100%	3	66%	4
Farm survey site B	1.22 km^2	3	67%	10	100%	2	100%	0	-	4
Farm survey site C	1.14 km^2	11	55%	20	30%	5	60%	1	0%	3
Farm survey site D	0.26 km^2	0	-	8	25%	3	0%	6	17%	0
Farm survey site E	1.26 km^2	9	No final survey	17	No final survey	0	No final survey	2	No final survey	3
Farm survey site F	1.30 km^2	4	50%	14	21%	1	0%	1	0%	0
Farm survey site G	1.10 km^2	2	50%	12	42%	2	0%	6	50%	3
Farm survey site H	2.34 km^2	9	33%	14	21%	5	80%	4	75%	9
Totals across all sites		**48**	**54%**	**90**	**43%**	**19**	**53%**	**23**	**43%**	**26**

4.2 Uptake by gamekeepers and wader survey results

Gamekeepers on the Bolton Castle Estate and the neighbouring estate were keen to be involved in studies and enthusiastic about carrying out wader surveys. The gamekeepers on Bolton Castle and the neighbouring estate had good optical equipment and the ability to identify by sight and sound regularly occurring upland birds, and in particular had a good knowledge of the different calls, songs and behaviours of breeding waders. The two gamekeepers on the Bolton Castle Estate carried out trapline wader surveys on a total of four routes. All surveys were carried out in good weather conditions, between the hours of 08:00 and 19:00. First visits were carried out between 18 – 21 April, second visits between 20 – 29 May, and third visits between 8 – 20 June. For trapline survey route B, a fourth visit was carried out on 7 July, with only two visits to trapline survey route C and D. Data were submitted over the course of the breeding season following survey visits.

Maps showing the approximate locations of breeding wader pairs (as analysed using the rules described in section 3.2) found during the trapline surveys are shown in figures 9, 10 and 11. Table 2 shows summaries of all the trapline data including the lengths of the routes and an index of breeding success using the same approach described in section 3.2.

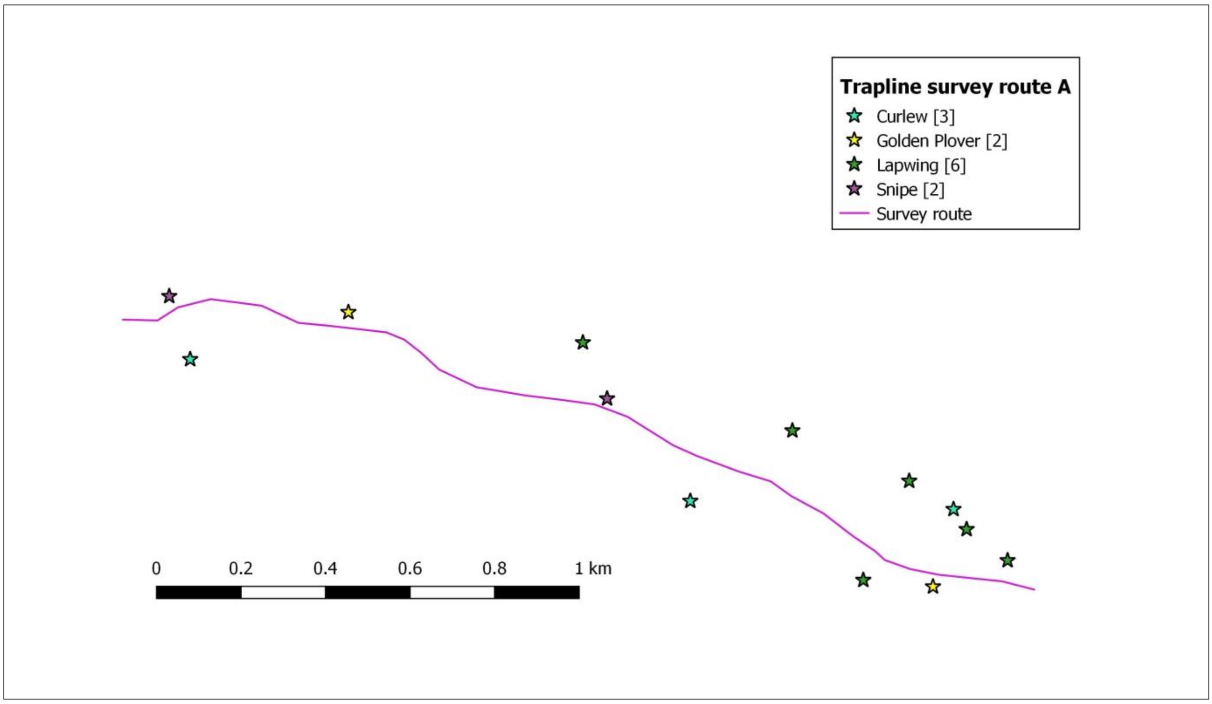

Figure 9 : trapline survey route A results

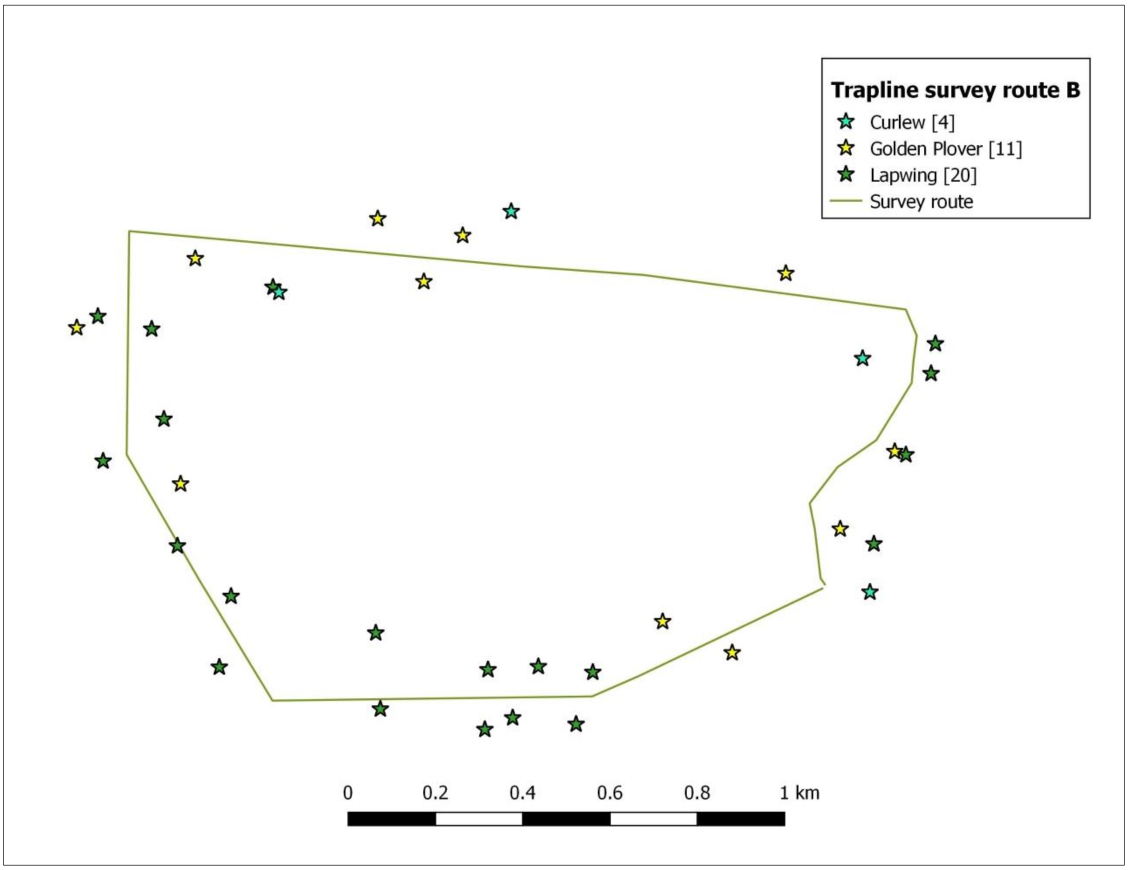

Figure 10 Trapline survey route B results

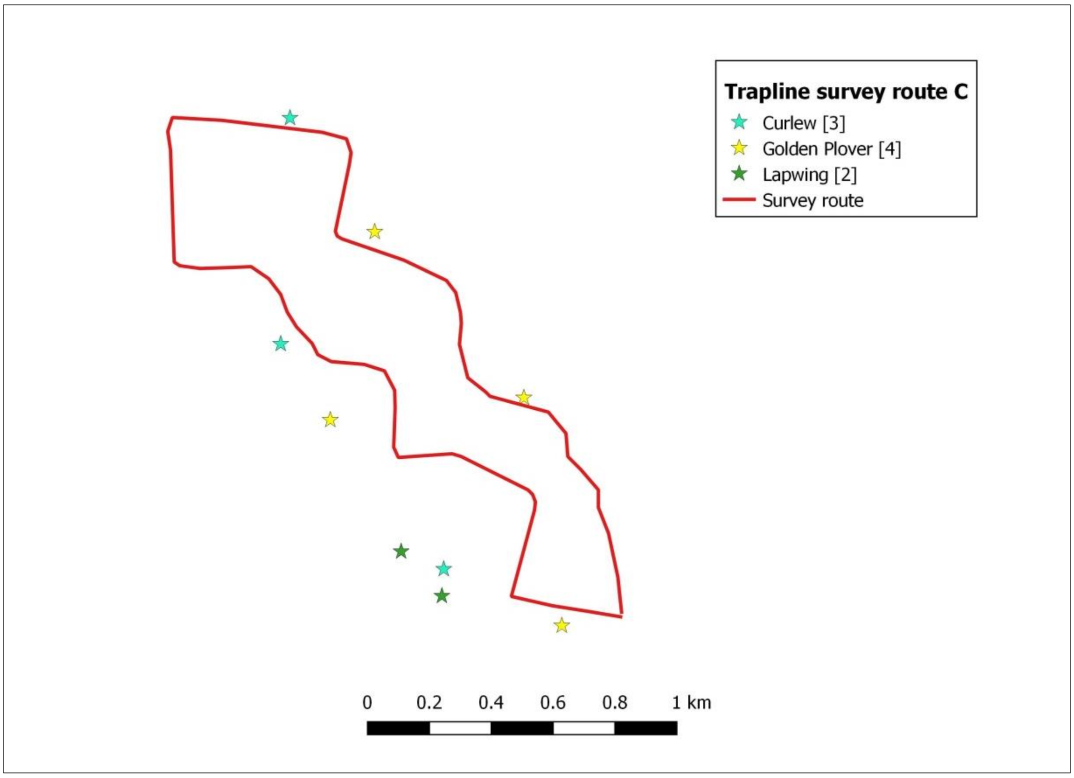

Figure 11 Trapline survey route C

Table 2 Summary of survey results from traplines surveyed by Bolton Castle Estate gamekeepers.
Numbers of pairs relate to probable territories identified using the Brown & Shepherd (1993) methodology described in section 4.2. 'Index of breeding success' is the percentage of probable territories with either alarm calling or juveniles in the third visit in June. This was not calculated for Snipe because breeding success of Snipe cannot be easily inferred from behaviour and juveniles are rarely seen.

Trapline	Length	Curlew		Golden Plover		Lapwing		Oystercatcher		Redshank		Snipe
		Probable territories	Index of breeding success	Probable territories	Index of breeding success	Probable territories	Index of Breeding success	Probable territories	Index of breeding success	Probable territories	Index of breeding success	Probable territories
Trapline survey route A	**2.40 km**	3	67%	2	0%	6	50%	0	-	0	-	2
Trapline survey route B	**5.19 km**	4	75%	11	64%	20	45%	0	-	0	-	0
Trapline survey route C	**4.48 km**	3	67%	4	100%	2	50%	0	-	0	-	0
Trapline survey route D*	**10.48 km**	19	100%	0	-	19	100%	4	100%	4	100%	0
Totals across all sites		**29**	**90%**	**17**	**65%**	**47**	**68%**	**4**	**100%**	**4**	**100%**	**2**

*The high level of breeding success recorded on trapline survey route D may be a result of a different interpretation of adult behaviours on final survey visits, as described in section 4.3.

4.3 Comparison of Gamekeeper survey data with BTO survey

A section (approx. 0.8km^2) of farm survey site C, an area of marginal grazing with some areas of sparse woodland cover that was covered by a BTO fieldworker using the Brown & Shepherd (1993) methodology described in section 3.2, was also included in a trapline survey (survey D) carried out by a gamekeeper using the survey method described in section 3.3 (both surveys also covered adjacent areas as well). Based on the times taken to carry out the surveys, the level of survey effort applied to each of these methods in the area of overlap was similar. The trapline route followed is also the most similar (of the four routes surveyed) to a typical route followed by a Brown and Shepherd survey, and is comparable to the route followed by the BTO fieldworker. The number of likely wader territories identified by the different surveys (using the rules described in section 3.2) is shown in Table 3. Surveying breeding waders at high densities is challenging, so these results are promising. The similarity between the results suggests that gamekeeper trapline surveys may be able to generate data comparable to that of professional fieldworkers (or skilled volunteers), assuming they are carried out by gamekeepers who have appropriate field skills and motivation. The area selected for comparison and the trapline route are shown in Figure 12.

Table 3 Summary of comparison between Brown & Shepherd (1993) wader survey carried out by professional fieldworker and trapline survey carried out by a gamekeeper in the same study area.

	Curlew	Lapwing	Oystercatcher	Snipe
BTO wader survey	10	13	2	2
Gamekeeper trapline survey	11	12	3	1

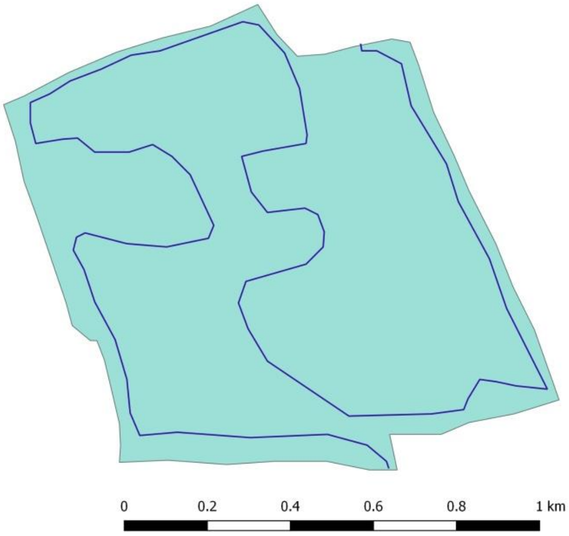

Figure 12 The area selected for comparison between the BTO wader surveys (study area shaded in blue) and the route of the trapline survey (marked with the dark blue line)

It is not possible to make a more rigorous comparison between the surveys carried out by gamekeepers and the surveys carried out by BTO/YDNPA staff, because the majority of these surveys covered different areas and habitats. Breeding productivity indices derived from surveys carried out by gamekeepers are significantly higher than those derived from surveys carried out by BTO/YDNPA staff (Curlew 90% - 54%, Lapwing 68% - 43%; from tables 1 & 2). This may be due to differences in habitat or predation levels, because three of the four gamekeeper surveys were carried out on heather moorland where levels of predator control are likely to have been higher than in the marginal grazing and enclosed fields surveyed by BTO/YDNPA staff. However, the greatest differences in productivity estimates between gamekeeper and BTO surveys were for farm survey site C, the area of overlapping surveys discussed above, where the comparison for Curlew was 100% (gamekeeper suvey) - 55% (BTO survey), and for Lapwing 100% (gamekeeper survey) - 30% (BTO survey). The timing of survey visits may also contribute to differences (survey dates are shown in appendix B), though the lower productivity estimates were not always on later survey visits. This suggests that at least a component of this variation may be caused by differences in the interpretation of adult behaviours observed on June (and July) survey visits. This underscores the need to ensure that the information recorded and reported by fieldworkers is as consistent as possible, through the provision of training and guidance, verification processes and feedback to survey participants.

4.4 Uptake by farmers and survey results

It was difficult to arrange meetings with farmers early enough in the breeding season to fully test methods due to the effect of the lambing period in April. This limited uptake and engagement with the project, and the extent to which farmers were able to carry out surveys. However, all four farmers involved were positive about having wader surveys on their land. Amongst the farmers engaged by the pilot project there were a range of attitudes towards waders, from those who were very interested in waders and wader habitat, to those who had limited interest. It was typical for those who did express a keen interest in waders to highlight that their attitude and interest in waders had developed over many years - “When I first started here twenty years ago, I didn’t even notice them.”

One of the farmers involved in this pilot project and the results based agri-environment scheme was keen to carry out surveys and felt that it should be a requirement of the results based agri-environment scheme: “If you’re getting paid because the waders are there, then you ought to have to do something [surveys].” All farmers interviewed expressed that to get farmers involved in monitoring waders, it would be necessary to think about how wader monitoring would fit with existing agri-environment options. Agri-environment schemes have changed a lot over recent years, so some of the farmers interviewed in this pilot project expressed a scepticism of new initiatives in general, and more specifically about whether the current conservation interest in breeding waders would be sustained.

The four farmers interviewed in the pilot project didn’t have binoculars to use for surveys, although for surveying a small group of very different looking wader species binoculars are not necessary. While the farmers involved in the pilot project had the ID skills necessary to carry out surveys, the difficulty of accurately counting breeding waders in fields with high densities of birds was highlighted by all four farmers as one of the biggest difficulties when carrying out surveys.

Of the four farmers who participated in the project, one carried out a detailed wader survey with two visits and reported that both the counting of birds/pairs and the recording of behaviour were challenging. She was keen to carry on with surveys the following year - though she also felt that the detailed survey methodology would be too complicated for most farmers to carry out, at least initially. The area surveyed by this farmer was also covered by BTO/YDNPA surveys, and yielded similar findings. While the BTO survey returned counts of 6 pairs of Lapwing, 2 pairs of Oystercatcher and 4 pairs of Redshank in the surveyed field, the farmer surveys recorded counts of 5 pairs of Lapwing, 4 pairs of Oystercatcher and 5 pairs of Redshank.

The other three farmers either trialled counting waders on a birds per field basis or agreed that this would be their preference, but because we were not able to hold meetings until towards the end of the breeding season little data was gathered during the project.

4.5 Nest monitoring results

In total 34 nests were monitored (all with nest cameras and 29 with data loggers as well). These nests spanned the range of wader habitats found in Wensleydale, from heather moorland, marginal grazing and enclosed farmland (Figure 13).

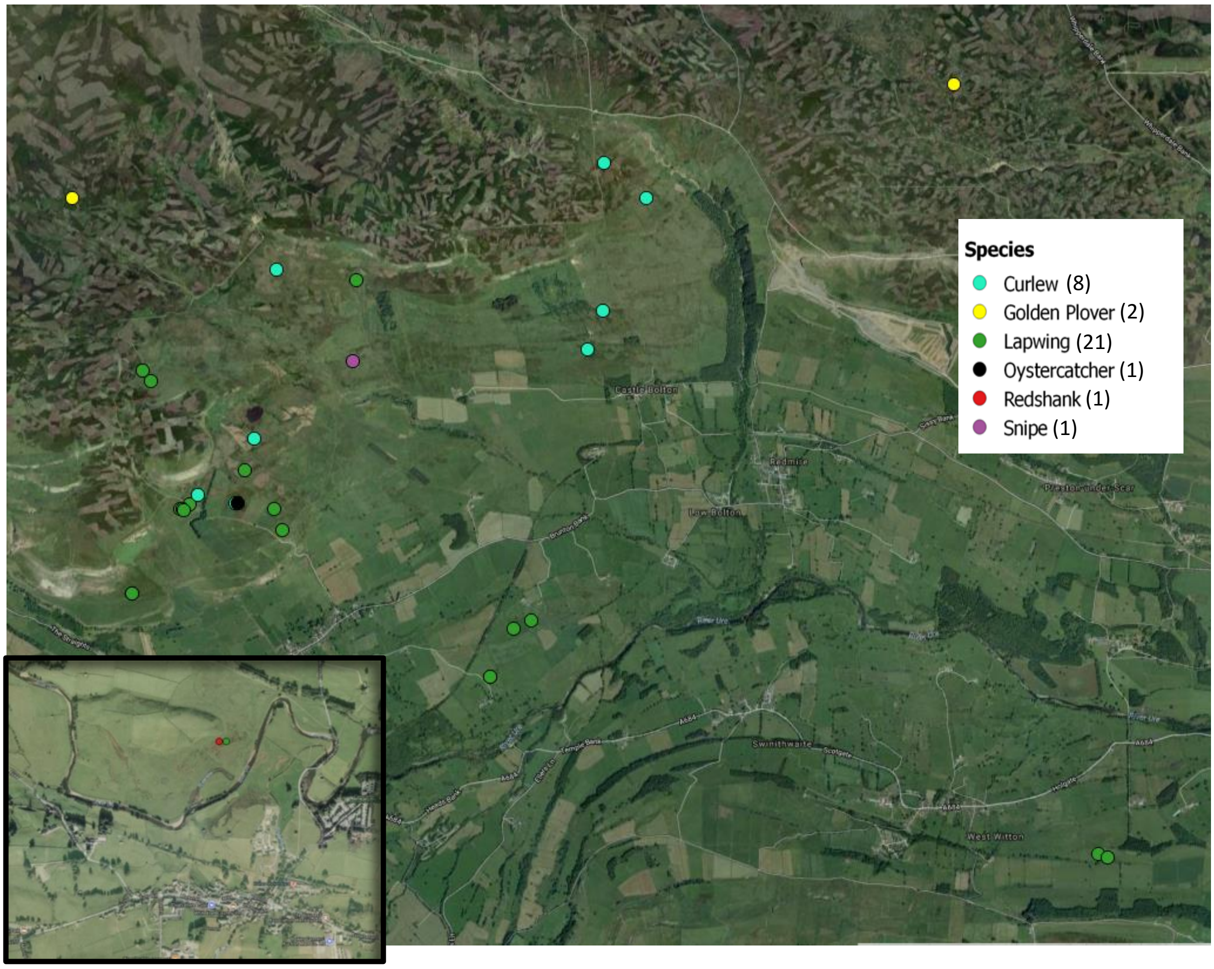

Figure 13 Locations of nests monitored during the project. Where Lapwing nests were close together, one dot may represent multiple nests. The inset shows two nests monitored near Hawes (approx. 9 miles west of the main area shown).

Nine of the 21 Lapwing nests monitored during the pilot project were monitored solely by Bolton Castle Estate gamekeepers, with the other twelve monitored by BTO staff. Of the eight Curlew nests monitored during the pilot project, six were found and monitored by BTO staff and two by estate staff. Two Golden Plover nests were found and monitored by estate staff on the heather moorland. In addition, one nest each of Oystercatcher, Redshank and Snipe was found and monitored by BTO staff.

The results of the nest monitoring are shown in Table 4. For five of the nests the outcome was 'unknown' - either because the camera stake was knocked by livestock, or because the memory card filled up before the nest outcome was recorded. For all the nests monitored where none of these issues occurred, the outcome of the nesting attempt was ascertained easily by reviewing the footage. By first checking the data logger for the approximate time that incubation ceased, and then scanning quickly through the still images taken by the camera around that time, locating the videos or images which show either chicks or a predation event usually took less than 15 minutes. Without data loggers, finding the relevant images or video clips still usually took less than 30 minutes.

At all nests where cameras or data loggers were set up, attending adults returned to incubate after the equipment was deployed. No predation events were recorded within 24 hours of the cameras/data loggers being set up.

The nest monitoring outcomes were determined from the video/camera footage and the data from the temperature data loggers. Figures 14 and 15 show how temperature logger data can be used to interpret nest outcomes. For all nests that were monitored using the temperature loggers and nest cameras, the conclusions drawn from each monitoring method were consistent with one another – when a predation event was logged in the footage, the data loggers showed the expected drop in temperature following the event.

There were 5 nests lost to livestock (one trampled by sheep, one trampled by cattle, and three predated by sheep, where in all three cases video footage clearly showed the sheep eating eggs) and one nest predated by a pet dog, all during daylight hours. If nests had been monitored with temperature loggers but without cameras then conventional wisdom would have attributed these nest losses to avian predation.

Table 4 Nest monitoring outcomes for the 34 nests found and monitored during the project

The ‘unknown’ outcomes were a result of data loggers and camera SD cards filling up, or livestock knocking the camera over.

	Outcome				**Cause of Failure**							
	Total Nests	Hatched	Failed	Unknown	Sheep predation	Livestock trampling	Badger Predation	Hedgehog	Corvids	Pet dog	Mammal (unidentified)	abandoned
Lapwing	21 (9 monitored by estate staff)	9	10	2	2	1	2	2	1	1	1	0
Curlew	8 (2 monitored by estate staff)	5	1	2	1	0	0	0	0	0	0	0
Golden Plover	2 (2 monitored by estate staff)	0	1	1	0	0	0	0	0	0	0	1
Redshank	1	0	1	0	0	1	0	0	0	0	0	0
Oystercatcher	1	1	0	0	0	0	0	0	0	0	0	0
Snipe	1	1	0	0	0	0	0	0	0	0	0	0
Total	**34**	**16**	**13**	**5**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**1**

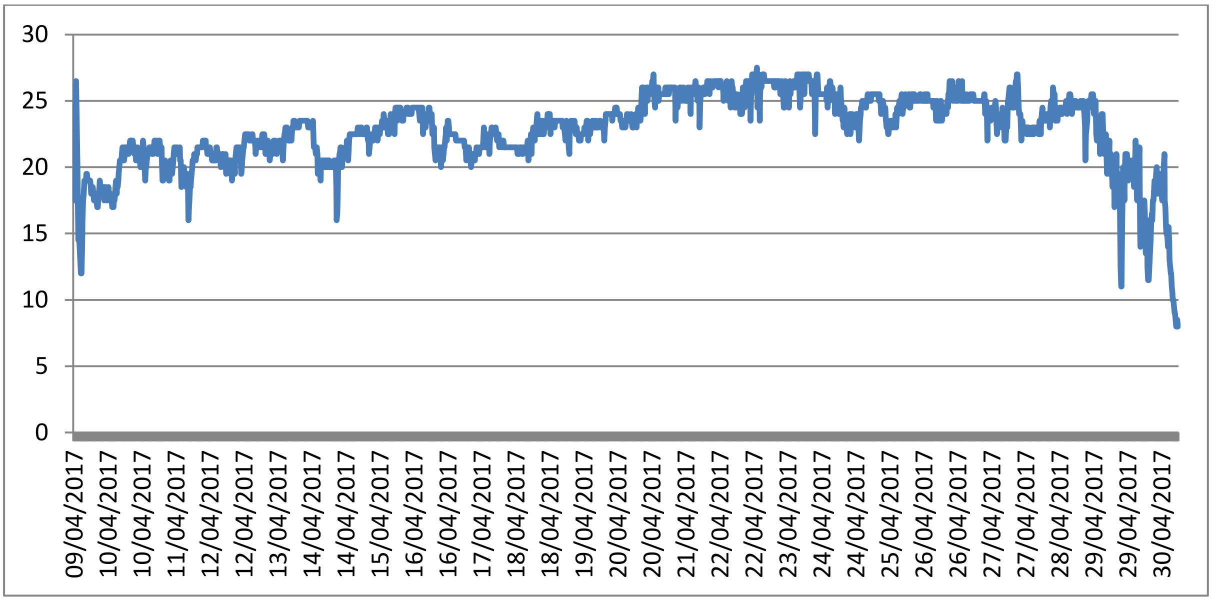

Figure 14 Example of data from temperature loggers from a successful Lapwing nest.
The Y-axis shows nest temperature (X-axis=time). Footage of chicks was captured at 19:00 on the 29/4, coinciding with the falling temperature observed in the graph as incubation becomes intermittent.

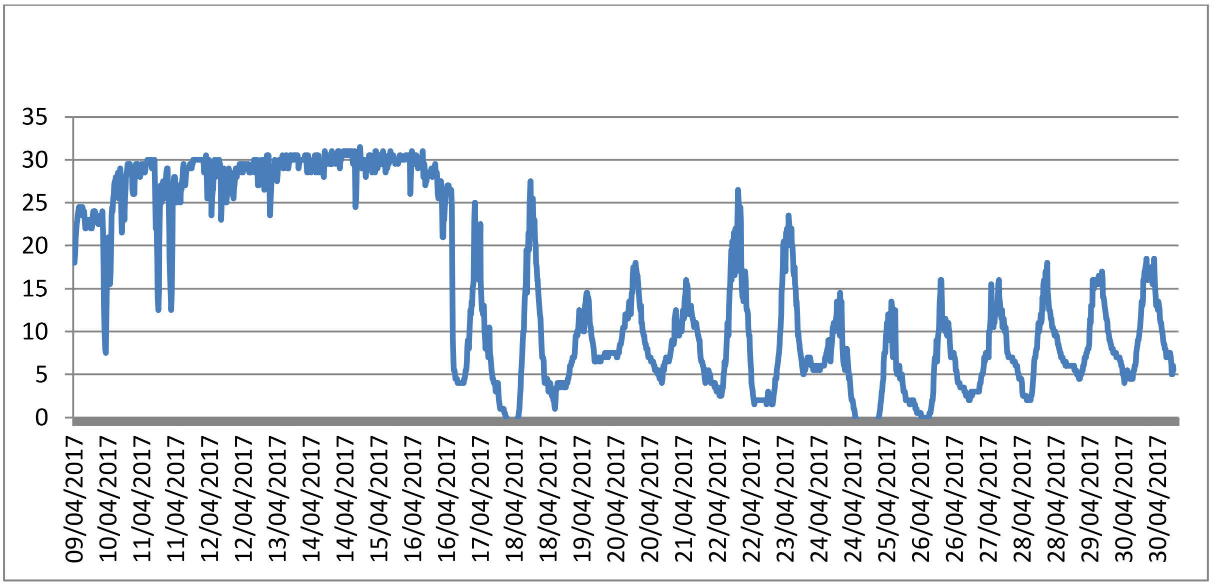

Figure 15 Example of temperature data from an unsuccessful Lapwing nest.
The Y-axis shows nest temperature (X-axis=time). Hedgehog *Erinaceus europaeus* predation was captured on video at 01:20 on 17/4, coinciding with the dramatic fall in temperature as incubation ceases. Following predation the data logger continues to record natural temperature variation between night and day.

4.5 Nest Survival Rates

The Mayfield method (Mayfield 1975) was used to calculate daily nest survival rates across all the nests monitored – the probability that the nest will survive from one day to the next. The formula is as follows:

Daily survival probability = (exposure days* – failed nests) ÷ exposure days*.

*exposure days being the number of days a nest is known to be active and thus susceptible to predation (measured in half days).

For Curlew, daily survival probability was 0.9896 (95 days exposure, 1 failed nest), and for Lapwing daily survival probability was 0.9609 (255.5 days exposure, 10 failed nests). Due to the small sample sizes of other species these were the only two species for which the calculation was carried out.

To calculate a survival probability for the entire nesting period, the daily probability of survival is raised to a power equal to the appropriate hatching period. Assuming a hatching period for Curlew of 29 days (28-30 days; Ferguson-Lees *et al.* 2011) and for Lapwing 26.5 days (26-27 days; Ferguson-Lees *et al.* 2011) gives a probability of nest success of 73.8% for Curlew, and 34.8% for Lapwing.

5 DISCUSSION

The objective of this pilot project was to test methods for involving gamekeepers and farmers in surveying breeding waders and monitoring their nests, and to consider whether and how these methods could be applied more widely within the Yorkshire Dales National Park (YDNP) and similar areas. The results of the gamekeeper trapline survey methodology were promising, and these are discussed in section 5.1. A discussion of the farmer surveys is presented in section 5.2 and an alternative approach described. Nest monitoring with cameras and data loggers was successful and generated useful data, and is described in section 5.3 with discussion of the challenges of gathering accurate data on breeding productivity. The relevance of the project to the YDNPA regarding future wader monitoring is discussed in section 5.4, and broader conclusions about the future direction of wader projects presented in section 5.5.

5.1 Gamekeeper wader surveys

The trapline survey methodology was agreed following discussions with the gamekeepers on the Bolton Castle Estate. Gamekeeper's existing work commitments are likely to be the biggest factor restricting the possibility of carrying out these or alternative types of bird surveys. However, they are on the moor for a significant proportion of their working day, so surveys that can fit into their work activities, like the trapline survey methodology, are more likely to be taken up and carried out regularly than methods that require them to set specific time aside. An additional factor that could restrict take-up of more intensive survey methods, particularly those involving randomly selected transects, is reluctance to increase disturbance in areas where grouse are nesting during key periods of the breeding season.

Trapline routes are suitable for long-term monitoring surveys because small mammal traps usually remain in the same place from one year to the next, tend to be checked frequently during spring and early summer and are usually checked while gamekeepers are on foot.

Expanding the gamekeeper trapline surveys across a wider cohort of estates in the national park (and in other areas) could improve the monitoring of breeding waders on managed moorland. Such surveys would not necessarily be representative of all moorland habitat because they would focus on areas where predator control and other aspects of moorland management associated with grouse moors are most intensive. Trapline routes also often follow linear features such as dry stone walls, fences, burns and tracks, which may affect the representativeness of the data. Although indices of wader abundance, and therefore ultimately trends, could be derived from surveys along traplines, further work is needed to explore how such data might be integrated with ongoing surveys (e.g. the BBS) and existing datasets (e.g. Moorland Bird Survey data held by Natural England and the YDNPA) to contribute towards wider moorland bird trends.

To roll-out trapline surveys on a wider scale, guidance and training should ideally be offered to ensure that the recording methods are standardised and the data submitted in a format suitable for efficient analysis. Scaling up this model of survey would entail ongoing costs associated with data management, analysis and reporting. For example, manual digitising and interpreting the map data from trapline surveys is time consuming, and could place a considerable burden on those responsible for data collation if the volume of data was increased. This burden could be greatly reduced if data were submitted on electronic forms, with traplines split into 200 m sections (similar to the Breeding Bird Survey online data entry). Such an approach would require consideration of the use of distance bands (or a cut-off distance) while keeping the survey methods as simple as possible. Online submission or management of survey data, and the development of a smartphone recording app could also be investigated as ways to facilitate reporting and data management. Developing any of these options would incur significant initial costs, but would make recording, data sharing, analysis and reporting easier and more effective in the future.

The Bolton Castle Estate was already proactively involved in wader conservation prior to this project (as noted in section 2.2) and the landowner and gamekeepers well-disposed towards working collaboratively. There was significant motivation and skill amongst the estate gamekeepers (and those of neighbouring estates) to successfully monitor breeding waders. The gamekeepers who carried out the surveys reported that they found them enjoyable and straightforward, and reported that they added very little extra time to the walking of their trapline routes. For many gamekeepers, distinguishing between different species, calls, songs and behaviour of waders would not be difficult, particularly if they had access to clear guidance about survey methods. The Bolton Castle gamekeepers were confident that gamekeepers on the other estates within Wensleydale would be willing and able to carry out trapline surveys in following years. To encourage take-up of this kind of survey across a wider area, indoor meetings prior to the breeding season were suggested as a preferable means of engagement due to their work commitments during the spring and summer.

5.2 Farmer wader surveys

Perhaps the biggest challenge with getting farmers involved in wader surveys will be timing - the first wader survey visit takes place during peak lambing period in early-mid April in Wensleydale. Involving farmers in wader monitoring in future projects will depend on a) getting farmers together for a meeting well before the breeding/lambing season, and b) establishing survey timings that are compatible with farmers' lambing schedules.

The farmers who participated in this project were chosen by the YDNPA to some degree because of their interest in breeding waders or because they were taking part in the results-based agri-environment trial, and so were likely to be well disposed towards wader conservation. Even so, motivation to carry out the detailed wader survey methodology was not strong for most farmers interviewed - one was enthusiastic, three others less so. The time required to carry out the surveys was the main obstacle for those who were not keen, though they were interested in waders and wader conservation. Those farmers who were interested in carrying out detailed three-visit wader surveys could be encouraged to do so as part of the YDNP's possible future monitoring of results-based agri-environment schemes. Allowing farmers to have first refusal to carry out surveys on their own land might also encourage involvement, and over time the proportion of sites monitored by farmers rather than external volunteers/YDNPA staff may increase.

While all farmers involved proved willing and able to carry out the simpler 'birds per field' survey methodology, the uses of the data generated from the 'birds per field' counts may be limited – because there are no behavioural observations, no information on breeding success can be inferred, and the occurrence of non-breeding or post-breeding birds/flocks (that cannot be easily distinguished from breeders) could reduce the value of the information. Further work is required to investigate how such data might be integrated with other schemes.

A possible add on (or alternative) to these systematic bird surveys could involve farmers reporting the highest evidence of breeding success they observed during the breeding season for each wader species on a scorecard such as table 4 (below). This could be carried at on a farm or a field basis. This would remove the challenge of identifying and counting pairs/territories, and also importantly remove the requirement to find time to carry out the survey during busy periods. Over the course of a breeding season, farmers in their daily work regularly come across nests and chicks incidentally, and this method of recording would utilise this knowledge effectively. All farmers asked were enthusiastic about the idea of recording information on breeding waders in this format.

This could be a useful tool for the YDNPA in i) engaging and growing interest among farmers in breeding waders and carrying out surveys and ii) informing prioritisation of YDNPA farm advice work. It would also be possible to extend this reporting model in the future to suit differing requirements.

Table 5 Example scorecard method for recording breeding waders on farms

Breeding wader scorecard					
	Large chicks /fledglings seen	**Nest site or small chicks found**	**Agitated adult, alarm calling/mobbing**	**Bird(s) displaying/ singing**	**Individual or pair present**
Curlew				✓ (23/4/2017)	✓
Lapwing	✓ (12/6/2017)		✓	✓	✓
Redshank					✓ (16/4/2017)
Oystercatcher			✓ (22/5/2017)	✓	✓
Snipe	✓ (27/6/2017)			✓	✓

5.3 Monitoring breeding success

Nest monitoring was popular amongst participants, who enjoyed the challenge of nest finding and were enthusiastic about the videos of predation events taking place. These were felt to be a good way to communicate their impression of a negative impact of predation and the benefits of predator control. However it was pointed out by some participants that nest predation is only part of the story, and chick predation may be just as important in determining breeding productivity (e.g. Mason *et al.* 2017).

Going through the footage to establish nest outcomes was easy and quick, and did not require any specialist knowledge. In most cases the cause of failure was obvious, and could be ascertained with little or no prior experience, especially if help was available to check identification of some predators. In this regard, a database of predation and hatching events would be useful to keep for wider verification purposes. It was not possible to accurately count chicks from video footage. Once hatched, chicks leave the nest site quickly, so that all chicks from a brood are rarely present in the same video or image. Sometimes there were just one or two images or videos which proved hatching success at a nest.

During the Wensleydale pilot project all the nest finding was done by gamekeepers, BTO staff and other Bolton Castle Estate staff. Farmers did express some interest in nest monitoring and were happy for nest monitoring to take place on their farms. They also passed on details of nests they had come across incidentally. However because it is time-consuming showing people how to use nest monitoring equipment, and impractical to give out equipment to lots of different people, involving farmers directly in carrying out nest monitoring was not a part of the pilot project. The small number of farmers interviewed during the pilot study did not demonstrate the same degree of interest in predation as gamekeepers.

The gamekeepers on Bolton Castle found it straightforward to locate and monitor Lapwing nests, and could have found and monitored far more than was done in this project if more cameras and data loggers had been available. Finding Curlew nests was more time-consuming and challenging for gamekeepers (and BTO fieldworkers). It may be unrealistic to expect farmers or gamekeepers to devote the necessary time to find many Curlew nests each year, but sample sizes could still be considerable if methods were deployed in a larger project over a number of years. Curlew can be very site-faithful from year to year, so information gained in one year will make it significantly easier to find nests in subsequent years, and may make it possible to monitor sample of nests every year.

For 8 nests monitored (from a total of 29 monitored with data loggers) the data loggers filled up with data and stopped recording before the nest outcome was determined. The £10 ibutton data loggers used in this project can hold 2,024 data points, and so reach capacity in 20 days if set to record every 15 minutes, and 40 days if set to record every 30 minutes (a maximum interval of 20 minutes is recommended to minimise the risk that nest outcome becomes difficult to discern from the data collected). To program data loggers to begin taking temperature readings (and to specify the interval between readings), the loggers need to be connected to a laptop using an ibutton receptor cable, and programmed using the software program Thermodata Viewer (or similar). Together, the receptor cable and a Thermodata Viewer licence can cost up to £90. It is ideal to give out programmed temperature data loggers to gamekeepers or farmers, which they can deploy opportunistically if they come across a nest during their daily work, but the space limits on the cheaper ibuttons mean that if the logger is not deployed quickly, then the data loggers will not have enough free space to record to the end of the nesting period. Given that the cable/software needed to program the loggers is expensive (and the task of reprogramming loggers can be onerous and easily overlooked) it is unrealistic to expect participants themselves to be reprogramming data loggers periodically to ensure they are ready to deploy. Because of the complications of programming and re-programming the data loggers, for data loggers to be used successfully there would need to be someone on site (probably at each estate involved) willing to take on the task of using the software to program the data-loggers and retrieve the data. Alternatively, for

£50, the ibutton DS1922T data logger holds 8,192 data points, which would be enough to cover a whole breeding season without it needing to be reprogrammed; however the increased cost obviously reduces the attractiveness of this option (the primary advantage of data loggers is that their price allows more nests to be monitored than with more expensive cameras).

Some of the cameras on nests were retrieved by farmers (attempting to be helpful) who were unaware that there was also a data logger in the nest, so there were some data loggers lost during the project (because re-finding the data logger is then difficult). Good communication obviously reduces the risk of such occurrences, but there are likely to be some losses of data loggers over time in such a project.

The results of the nest monitoring, as expected, suggest that in areas with intensive predator control different threats may be posed to wader nests. Some studies have found that fox *Vulpes vulpes* is the most significant mammalian nest predator of breeding waders (Teunissen *et al.* 2008, Eglington *et al.* 2009), but no instances of fox predation were recorded in this project. Apparent low predation rates by foxes are a likely consequence of low population densities in the study areas: control of foxes is an integral part of grouse moor management in Wensleydale. Although sample sizes are too small to draw firm conclusions, no predation events were recorded by mammal species that can be controlled legally. The role of intra-guild relationships amongst predators, and the impact of controlling a limited suite of species on those that are not, deserves further research, particularly in relation to nest predation. Hedgehog and badger *Meles meles* were each recorded predating nests twice. The most frequent nest predator recorded was Sheep (3 nests), which has rarely been documented by past studies as a predator of breeding waders or chicks (Furness 1988, Pennington 1992). Cattle have also been observed eating bird eggs (Nack & Ribic 2005). It has been hypothesised that predation by livestock may be a consequence of dietary deficiency (Furness 1988), though we are not aware of any detailed studies on this phenomenon. Rolling out a larger wader nest-monitoring project might generate useful information on wader nest predation of this type, and shed light on how representative the findings from the small sample of nests monitored in this project were.

If a large, multi-estate project was set up, then giving out up to 10-15 nest cameras per estate for Lapwing nest monitoring and allocating at least two half-days (bearing in mind that it can be difficult to get estate staff together at the same time because of range of work commitments) for a project officer to show participants how to deploy cameras on active Lapwing nests would be ideal. Showing participants how to use the cameras and data loggers would be best done on-site in early April, with active Lapwing nests, so that the technical details of setting up the cameras and/or data loggers are fresh in participants' minds.

Lapwing is likely to be the most numerous species monitored because of the relative ease of finding nests compared to the other wader species. Therefore for Lapwing there will be greater statistical power to detect influences of management or environmental factors at a local or estate scale. Monitoring of other wader species' nests could be encouraged incidentally (when nests are happened upon through the course of regular work duties), but active searching for Curlew, Snipe, Redshank and Golden Plover nests is time-consuming and can be challenging. If a large number of estates were involved however, cumulative data collected on these species from many sites should make it possible to detect management effects at larger spatial scales from which local inferences will be possible. One further solution to the problem of how time consuming it is to find these nests might be to recruit skilled volunteers (from outside estate staff) to participate in nest-finding. This would require good communication between volunteers and estate staff to ensure that disturbance of sensitive areas is avoided where possible, but would generate very valuable larger samples of the more difficult to find nests.

Lapwing nest monitoring may be more beneficial in a semi-structured way - for a participant to choose one or more study sites (easily accessible fields passed regularly in course of general work) and try and monitor all Lapwing nests occurring within the study site over the breeding season. This may generate more useful data than the ad-hoc monitoring of nests. Seymour *et al.* (2003) and Macdonald & Bolton (2008) both found that Lapwing nest success is influenced by the densities at which Lapwing are nesting (larger groups of Lapwing can be more effective at deterring predation). Constant long-term monitoring of fields over a number of years would generate useful information, for example as the suite of predators or habitat management changes. By combining intensive nest monitoring study sites with breeding wader surveys and other types of more intensive work such as the colour-ringing of chicks, it would be possible to test the extent to which nest survival could be used as a proxy indicator for overall breeding success.

The likely importance of source-sink population dynamics for breeding waders means that accurate monitoring of breeding productivity is key to understanding patterns of population change at a landscape scale. An index of breeding productivity based on adult behavioural responses and observations of chicks during June and July surveys, as used in this project, may give a rough indication of likely breeding success within a population. While such an approach has been validated for Lapwing (Bolton *et al* 2007), for Curlew breeding at high densities with multiple overlapping territories the approach is challenging. It was common later in the season in such areas to see near-fledged chicks in close proximity to still incubating adults, due to variation in the timing of egg laying and the propensity of birds to relay following nest failure. The potentially large movements of chicks could also reduce the reliability of this index. Furthermore, the interpretation of alarm calling or agitated behaviour can vary significantly between observers (and it is difficult with some species to be certain of correct interpretation), a problem that may be accentuated by involving a wider cohort of volunteers in wader monitoring. In lower density breeding areas however, for all species, the approach is likely to be much more representative.

Additional survey visits in June and early July might improve the accuracy of breeding success indices, and clearly defined protocols for classifying behaviour at later season visits could reduce observer effects. Systematic counting of post-breeding flocks (possibly combined with final survey visits) of Lapwing, Curlew, Redshank and Golden Plover in breeding habitat to determine the ratio of juveniles to adults could also be trialled to augment data gathered from surveys on breeding productivity. Juveniles and adults (though some birds, particularly female Golden Plover, may depart early) will typically remain on or near territory for a few weeks post-fledging. The timing of the survey would need to be tested to work out the optimal date(s) for counting, and the identification of juveniles among post-breeding flocks can be challenging, particularly if looking at larger flocks.

5.4 Relevance to Yorkshire Dales National Park

With the introduction of the results-based agri-environment pilot scheme in Wensleydale, which has been adopted by 19 farms, monitoring the effects of any resultant changes is an important objective for the YDNPA. One approach would be to set up long term study plots on selected sites (some sites within the new scheme, and some control sites outside) to carry out three-visit breeding wader surveys using Brown & Shepherd (1993) methodology. The surveys could be carried out by a mixture of stakeholders, potentially including volunteers, YDNPA staff and farmers.

Site selection would require careful consideration – the sites in the results-based scheme appear to have been selected because they already had habitats suitable for breeding waders, so it might be expected that numbers on these sites would be higher than those on a set of control sites even in the absence of any management change. This could make it challenging to discern the impact of changes in management. It may also be possible to compare trends on the results-based agri-environment schemes with wider trends for upland farmland breeding waders, possibly using the results of the BTO Breeding Waders of English Upland Farmland (BWEUF) survey in 2016. The data from the BWEUF survey may also be useful in the selection of control sites.

The YDNPA also reports periodically on the status of waders within the national park as part of the Local Biodiversity Action Plan (LBAP). To achieve this, data from the BTO/JNCC/RSPB Breeding Bird Survey (BBS) has been used to generate breeding wader trends. However, the annual indices produced are of insufficient precision to enable detection of all but the largest changes in density (De Palacio and Harris 2017). One approach would be to augment BBS coverage with additional random squares, potentially stratified appropriately to target areas where further coverage is required within the national park to improve the precision of the trends. However, there has already been a drive to attract new surveyors with a series of training events in recent years, and volunteer coverage is probably already close to what is possible to achieve locally.

Further work should explore the practicalities of combining data from new survey approaches (e.g. trapline surveys) to augment data from established schemes such as the BBS.

5.5 A need for a joined up approach

The purpose of this pilot project was to inform possible future projects on breeding waders in the Yorkshire Dales National Park and further afield. For future projects on wader conservation that take place in upland moorland areas, the benefits of working collaboratively with different stakeholders and interest groups involved is significant. Knowledge relating to bird ecology, survey methods and moorland management was shared between participants of the project, hopefully to the benefit of all involved.

With various projects and initiatives around the UK working towards similar aims as described in this report, there are obvious synergies to be gained from the sharing of data and methods, and where possible, from following the same methods and approaches so that data and results are comparable. Bringing data and results together from different projects has the potential to greatly increase our understanding about the drivers of change and the consequences of management interventions. Finally, it is important to point out again that decisions need to be made about how data collected through surveys such as those described here should be collated, processed and reported. A protocol for validating data would also need to be established, and would be important in ensuring confidence in outputs from the survey data. In addition, a centralised data-holding infrastructure would need to be developed (and therefore funded) before rolling out any of the survey methods described in this report on a wider basis.

6 ACKNOWLEDGEMENTS

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7 REFERENCES

Ainsworth, G., Calladine, J., Martay, B., Park, K., Redpath, S., Wernham, C., Wilson, M. & Young, J. 2016. Understanding Predation. A review bringing together natural science and local knowledge of recent wild bird population changes and their drivers in Scotland. *Moorland Forum*

Balmer, D.E., Gillings, S., Caffrey, B.J., Swann, R.L., Downie, I.S. & Fuller, R.J. 2013. *Bird Atlas 2007-2011: the breeding and wintering birds of Britain and Ireland*. BTO Books, Thetford.

Baines, D. 1990. The roles of predation, food and agricultural practice in determining the breeding success of the Lapwing (*Vanellus vanellus*) on upland grasslands. *Journal of Animal Ecology*, **59**, 915–929.

Bolton, M., Tyler, G., Smith, K. and Bamford, R. 2007. The impact of predator control on lapwing Vanellus vanellus breeding success on wet grassland nature reserves. *Journal of Applied Ecology*, 44: 534–544

Birge, T., Toivonen, M., Kaljonen, M., & Herzon, I. 2017. Probing the grounds: Developing a payment-by-results agri-environment scheme in Finland. *Land Use Policy*, **61**, 302-315.

Brown, A. F., & Shepherd, K. B. 1993. A method for censusing upland breeding waders. *Bird Study*, **40**(3), 189-195.

Calladine, J., Critchley, C.N.R., Baker, D., Towers, J. & Thiel, A. 2014. Conservation management of moorland: a case study of the effectiveness of a combined suite of management prescriptions which aim to enhance breeding bird populations. *Bird Study,* **61**, 56-72.

Calladine, J., Garner, G., Wernham, C. & Thiel, A. 2009. The influence of survey frequency on population estimates of moorland breeding birds. *Bird Study,* **56**, 381–388.

Calladine, J., Humphreys, E.M., Gilbert, L., Furness, R.W., Robinson, R.A., Fuller, R.J., Littlewood, N.A., Pakeman, R.J., Ferguson, J. & Thompson, C. 2017. Continuing influences of introduced hedgehogs *Erinaceus europaeus* as a predator of wader (Charadrii) eggs four decades after their release on the Outer Hebrides, Scotland. *Biological Invasions,* **19**, 1981-1987.

De Palacio, D. and Harris, S. 2017. Wild Bird Population Trends for the Yorkshire Dales National Park 1994-2016. BTO Report.

Eglington, S.M., Gill, J.A., Smart, M.A., Sutherland, W.J., Watkinson, A.R. & Bolton, M. 2009. Habitat management and patterns of predation of northern lapwings on wet grasslands: the influence of linear habitat structures at different spatial scales. *Biological Conservation*, **142**, 314–324.

Eglington, S.M., Bolton, M., Smart, M.A., Sutherland, W.J., Watkinson, A.R. & Gill, J.A. 2010. Managing water levels on wet grasslands to improve foraging conditions for breeding northern lapwing *Vanellus vanellus*. *Journal of Applied Ecology*, **47**, 451–458.

Evans, K. L. 2004. The potential for interactions between predation and habitat change to cause population declines of farmland birds. *Ibis,* **146**, 1-13.

Ferguson-Lees, J., Catell, R. & Leech, D. 2011. *A Field Guide to Monitoring Nests*, BTO books, Thetford.

Fletcher, K., Aebischer, N.J., Baines, D., Foster, R. & Hoodless, A.N. 2010. Changes in breeding success and abundance of ground-nesting moorland birds in relation to the experimental deployment of legal predator control. *Journal of Applied Ecology*, **47**, 263–272.

Franks, S. E., Douglas, D. J. T., Gillings, S. & Pearce-Higgins, J. W. 2017. Environmental correlates of breeding abundance and population change of Eurasian Curlew Numenius arquata in Britain, *Bird Study*, 64:3, 393-409

Furness, R. W. 1988. Predation on ground-nesting seabirds by island populations of red deer *Cervus elaphus* and sheep *Ovis*. *Journal of Zoology,* **216**, 565–573.

Galbraith, H. 1988. Effects of agriculture on the breeding ecology of Lapwings *Vanellus vanellus*. *Journal of Applied Ecology*, **25**, 80–84.

Harris, S.J., Massimino, D., Gillings, S., Eaton, M.A., Noble, D.G., Balmer, D.E., Procter, D. & Pearce-Higgins, J.W. 2017. *The Breeding Bird Survey 2016*. BTO Research Report 700, British Trust for Ornithology, Thetford.

MacDonald, M.A. & Bolton, M. 2008. Predation on wader nests in Europe. *Ibis*, **150**, 54–73.

Mason, L. R., Smart, J. & Drewitt, A. L. 2017. Tracking day and night provides insights into the relative importance of different wader chick predators. *Ibis*. doi:10.1111/ibi.12523

Mayfield, H. F. 1975. Suggestions for calculating nest success. *The Wilson Bulletin*, **87**, 456-466.

Nack, J. L. & Ribic, C. A. 2005. Apparent predation by cattle at grassland bird nests. *The Wilson Bulletin*, **117**, 56- 62.

O’Brien, M., Tharme, A. & Jackson, D. 2002. Changes in breeding wader numbers on Scottish farmed land during the 1990s. *Scottish Birds*, **23**, 10–21.

Ottvall, R. 2005. Breeding success and adult survival of Redshank *Tringa totanus* on coastal meadows in SE Sweden. *Ardea,* **93**, 225–236.

Pearce-Higgins, J. 1999. The Ecology of Golden Plovers Pluvialis apricaria in the Peak District. PhD Thesis, University of Manchester.

Pennington, M. G. 1992. Predation of birds' eggs and chicks by herbivorous mammals. *Scottish Birds*, **16**, 285.

Results-Based Agri-environment Payment Scheme (RBAPS) pilot study in England 2017, March 3. Retrieved from: https://www.gov.uk/government/publications/results-based-agri-environment-payment-scheme-rbaps-pilot-study-in-england#history

Seymour, A.S., Harris, S., Ralston, C. & White, P.C.L. 2003. Factors influencing the nesting success of lapwings *Vanellus vanellus* and behaviour of red fox *Vulpes vulpes* in lapwing nesting sites. *Bird Study*, **50**, 39-46.

Showler, D.A., Stewart, G.B., Sutherland, W.J. & Pullin, A.S. 2010. What is the impact of public access on the breeding success of ground-nesting and cliff-nesting birds? *Collaboration for Environmental Evidence Systematic Review*, **16**, 1–75.

Shrubb, M. 2007. *The Lapwing*. T. & A. D. Poyser, London.

Sim, I.M.W., Gregory, R.D., Hancock, M.H. & Brown, A.F. 2005. Recent changes in the abundance of British upland breeding birds. *Bird Study,* **52**, 261–275.

Siriwardena, G.M., Baillie, S.R., Crick, H.Q.P., Wilson, J.D. & Gates, S. 2000. *The demography of lowland farmland birds.* In Proceedings of the 1999 BOU Spring Conference: Ecology and Conservation of Lowland Farmland Birds (eds. N.J. Aebischer, A.D. Evans, P.V. Grice & J.A. Vickery), pp 117–133. British Ornithologists' Union, Tring.

Smart, J., Gill, J.A., Sutherland, W.J. & Watkinson, A.R. 2006. Grassland-breeding waders: identifying key habitat requirements for management. *Journal of Applied Ecology*, **43**, 454–463.

Stroud, D.A., Baker, A., Blanco, D.E., Davidson, N.C., Delany, S., Ganter, B., Gill, R., González, P., Ha anstra, L., Morrison, R.I.G., Piersma, T., Scott, D.A., Thorup, O., West, R., Wilson, J. & Zöckler, C. (on behalf of the International Wader Study Group). 2006. *The conservation and population status of the world's waders at the turn of the millennium.* In Boere, G.C., Galbraith, C.A. & Stroud, D.A. (eds) Waterbirds Around the World: 643–648. The Stationery Office, Edinburgh.

Tharme, A.P., Green, R.E., Baines, D., Bainbridge, I.P. & O'Brien, M. 2001. The effect of management for red grouse shooting on the population density of breeding birds on heather-dominated moorland. *Journal of Applied Ecology*, **38**, 439–457.

Teunissen, W., Schekkerman, H., Willems, F. & Majoor, F. 2008. Identifying predators of eggs and chicks of Lapwing *Vanellus vanellus* and Black-tailed Godwit *Limosa limosa* in the Netherlands and the importance of predation on wader reproductive output. *Ibis* **150**: 74–85.

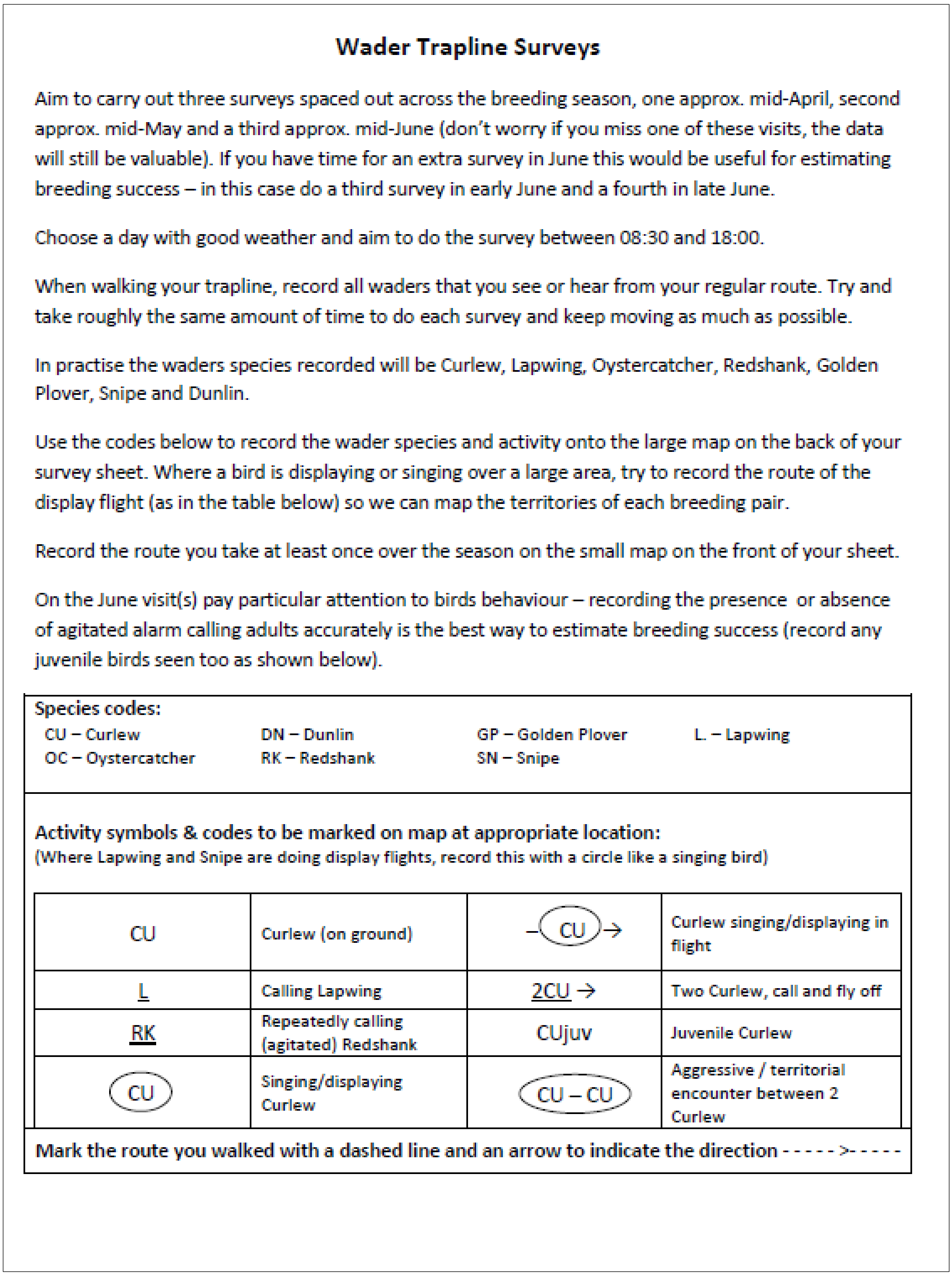
Van der Wal, R. & Palmer, S.C.F. 2008. Is breeding of farmland wading birds depressed by a combination of predator abundance and grazing? *Biological Letters*, **4**, 256–258.

Van Dijk, J., van der Vliet, R.E., de Jong, H., van Emmichoven, M.J.Z., van Hardeveld, H.A., Dekker, S.C. & Wassen, M.J. 2015. Modelling direct and indirect climate change impacts on ecological networks: a case study on breeding habitat of Dutch meadow birds. *Landscape Ecology*, **30**, 805–816.

Wilson, A.M., Vickery, J.A., Brown, A., Langston, R.H.W., Smallshire, D., Wotton, S. & Vanhinsbergh, D . 2005. Changes in the numbers of breeding waders on lowland wet grasslands in England and Wales between 1982 and 2002. *Bird Study,* **52**, 55–69.

Appendices

Appendix A Survey Instructions for Gamekeepers and Farmers.



Wader Trapline Surveys

Aim to carry out three surveys spaced out across the breeding season, one approx. mid-April, second approx. mid-May and a third approx. mid-June (don't worry if you miss one of these visits, the data will still be valuable). If you have time for an extra survey in June this would be useful for estimating breeding success – in this case do a third survey in early June and a fourth in late June.

Choose a day with good weather and aim to do the survey between 08:30 and 18:00.

When walking your trapline, record all waders that you see or hear from your regular route. Try and take roughly the same amount of time to do each survey and keep moving as much as possible.

In practise the waders species recorded will be Curlew, Lapwing, Oystercatcher, Redshank, Golden Plover, Snipe and Dunlin.

Use the codes below to record the wader species and activity onto the large map on the back of your survey sheet. Where a bird is displaying or singing over a large area, try to record the route of the display flight (as in the table below) so we can map the territories of each breeding pair.

Record the route you take at least once over the season on the small map on the front of your sheet.

On the June visit(s) pay particular attention to birds behaviour – recording the presence or absence of agitated alarm calling adults accurately is the best way to estimate breeding success (record any juvenile birds seen too as shown below).

Species codes:

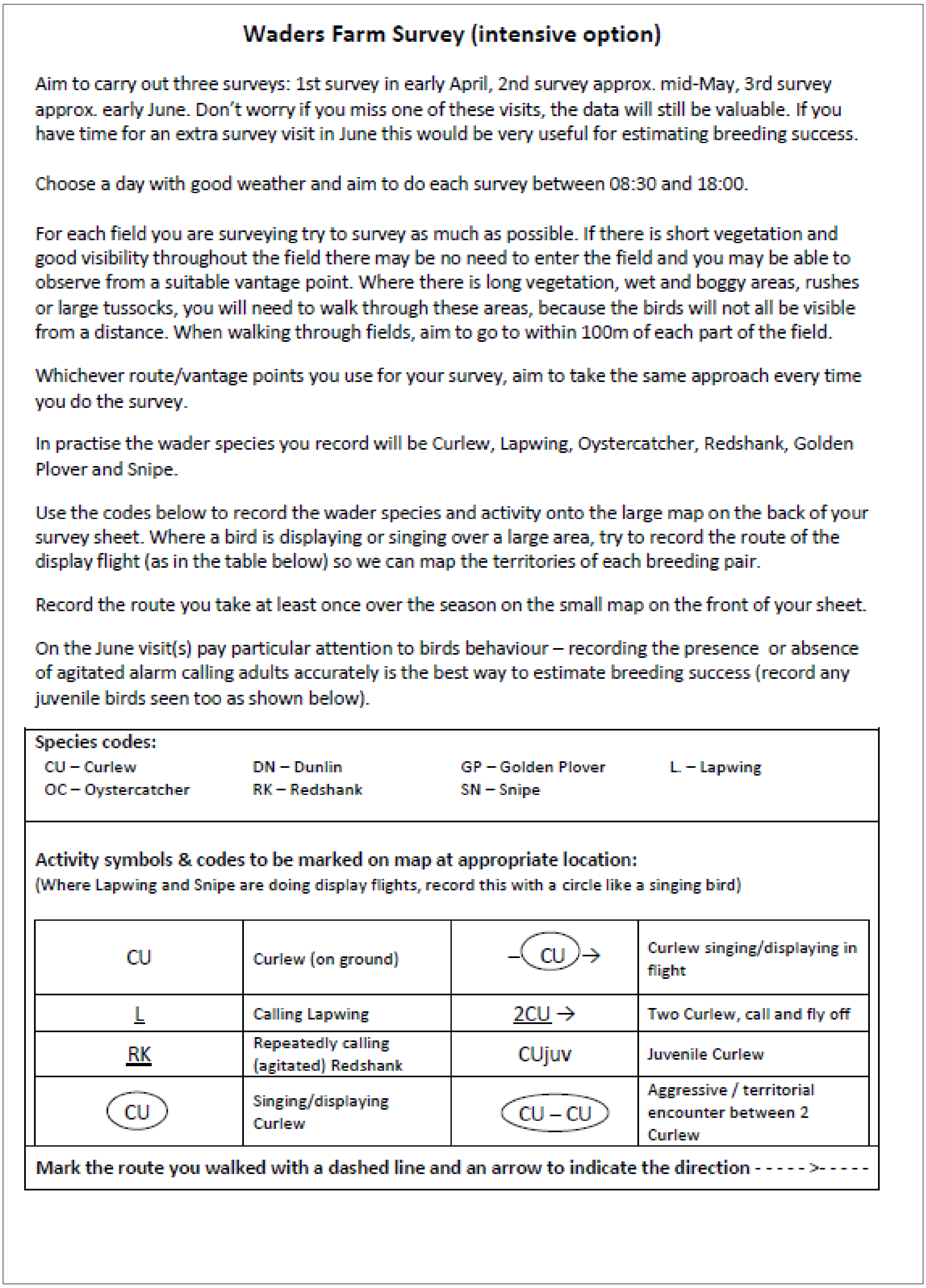
CU – Curlew
OC – Oystercatcher
DN – Dunlin
RK – Redshank
GP – Golden Plover
SN – Snipe
L – Lapwing

Activity symbols & codes to be marked on map at appropriate location:
(Where Lapwing and Snipe are doing display flights, record this with a circle like a singing bird)

CU	Curlew (on ground)	–(CU)→	Curlew singing/displaying in flight
L	Calling Lapwing	2CU →	Two Curlew, call and fly off
RK	Repeatedly calling (agitated) Redshank	CUjuv	Juvenile Curlew
(CU)	Singing/displaying Curlew	(CU – CU)	Aggressive / territorial encounter between 2 Curlew

Mark the route you walked with a dashed line and an arrow to indicate the direction - - - - - >- - - - -

Figure A 1 Instructions for trapline surveys used by gamekeepers



Waders Farm Survey (intensive option)

Aim to carry out three surveys: 1st survey in early April, 2nd survey approx. mid-May, 3rd survey approx. early June. Don't worry if you miss one of these visits, the data will still be valuable. If you have time for an extra survey visit in June this would be very useful for estimating breeding success.

Choose a day with good weather and aim to do each survey between 08:30 and 18:00.

For each field you are surveying try to survey as much as possible. If there is short vegetation and good visibility throughout the field there may be no need to enter the field and you may be able to observe from a suitable vantage point. Where there is long vegetation, wet and boggy areas, rushes or large tussocks, you will need to walk through these areas, because the birds will not all be visible from a distance. When walking through fields, aim to go to within 100m of each part of the field.

Whichever route/vantage points you use for your survey, aim to take the same approach every time you do the survey.

In practise the wader species you record will be Curlew, Lapwing, Oystercatcher, Redshank, Golden Plover and Snipe.

Use the codes below to record the wader species and activity onto the large map on the back of your survey sheet. Where a bird is displaying or singing over a large area, try to record the route of the display flight (as in the table below) so we can map the territories of each breeding pair.

Record the route you take at least once over the season on the small map on the front of your sheet.

On the June visit(s) pay particular attention to birds behaviour – recording the presence or absence of agitated alarm calling adults accurately is the best way to estimate breeding success (record any juvenile birds seen too as shown below).

Species codes:

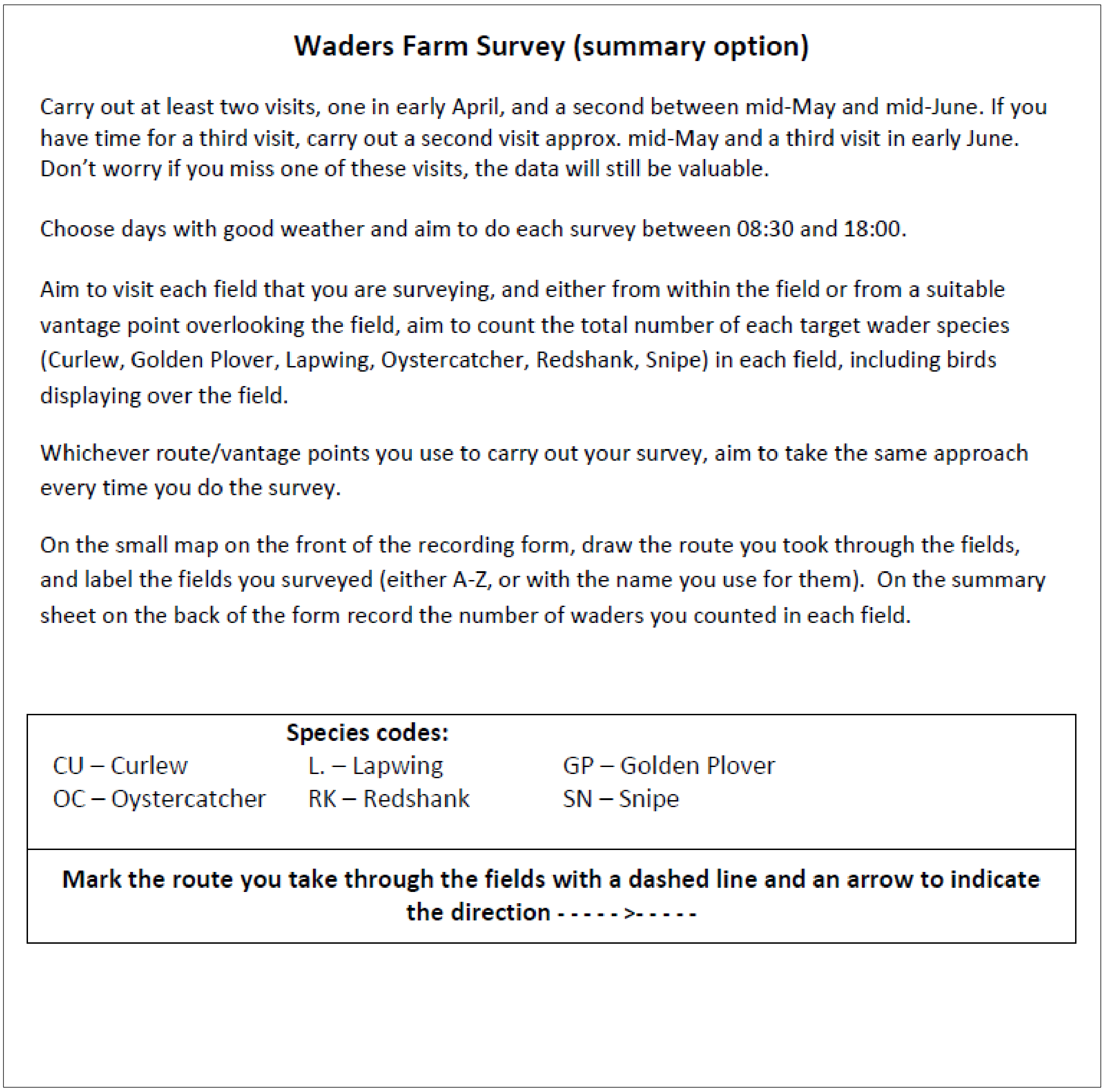
CU – Curlew	DN – Dunlin	GP – Golden Plover	L – Lapwing
OC – Oystercatcher	RK – Redshank	SN – Snipe	

Activity symbols & codes to be marked on map at appropriate location:
(Where Lapwing and Snipe are doing display flights, record this with a circle like a singing bird)

CU	Curlew (on ground)	–(CU)→	Curlew singing/displaying in flight
L	Calling Lapwing	2CU →	Two Curlew, call and fly off
RK	Repeatedly calling (agitated) Redshank	CUjuv	Juvenile Curlew
(CU)	Singing/displaying Curlew	(CU – CU)	Aggressive / territorial encounter between 2 Curlew

Mark the route you walked with a dashed line and an arrow to indicate the direction - - - - >- - - - -

Figure A 2 Detailed survey instructions used by farmers



Waders Farm Survey (summary option)

Carry out at least two visits, one in early April, and a second between mid-May and mid-June. If you have time for a third visit, carry out a second visit approx. mid-May and a third visit in early June. Don't worry if you miss one of these visits, the data will still be valuable.

Choose days with good weather and aim to do each survey between 08:30 and 18:00.

Aim to visit each field that you are surveying, and either from within the field or from a suitable vantage point overlooking the field, aim to count the total number of each target wader species (Curlew, Golden Plover, Lapwing, Oystercatcher, Redshank, Snipe) in each field, including birds displaying over the field.

Whichever route/vantage points you use to carry out your survey, aim to take the same approach every time you do the survey.

On the small map on the front of the recording form, draw the route you took through the fields, and label the fields you surveyed (either A-Z, or with the name you use for them). On the summary sheet on the back of the form record the number of waders you counted in each field.

Species codes:

CU – Curlew
L. – Lapwing
GP – Golden Plover
OC – Oystercatcher
RK – Redshank
SN – Snipe

Mark the route you take through the fields with a dashed line and an arrow to indicate the direction - - - - - >- - - - -

Figure A 3 Simple survey instructions used by farmers

Appendix B Timing of survey visits.

Gamekeeper surveys	Visit 1	Visit 2	Visit 3	Visit 4
Trapline route A	18/4	22/5	14/6	3/7
Trapline route B	19/4	23/5	20/6	7/7
Trapline route C	29/5	20/6		
Trapline route D	21/04	08/6		

BTO / YDNPA Surveys	Visit 1	Visit 2	Visit 3	Visit 4
Site A	9/4	8/5	15/6	
Site B	26/4	23/5	16/6	
Site C	11/4	8/5	11/6	
Site D	15/	12/5	12/6	
Site E	9/4	9/5		
Site F	18/4	10/5	13/6	
Site G	21/4	11/5	13/6	
Site H	4/5	25/5	14/6	