



The abundance and distribution of
British Greylag Geese in Orkney,
August 2014

**A report by the Wildfowl & Wetlands Trust to Scottish Natural
Heritage**

Carl Mitchell ¹, Alan Leitch ², & Eric Meek ³

October 2014

¹ The Wildfowl & Wetlands Trust, Slimbridge, Gloucester, GL2 7BT

² The Willows, Finstown, Orkney, KY17, 2EJ

³ Dashwood, 66 Main Street, Alford, Aberdeenshire, AB33 8AA

© The Wildfowl & Wetlands Trust

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

This publication should be cited as:

Mitchell, C., A.J. Leitch & E. Meek. 2014. *The abundance and distribution of British Greylag Geese in Orkney, August 2014*. Wildfowl & Wetlands Trust Report, Slimbridge. 23pp.

Wildfowl & Wetlands Trust

Slimbridge

Gloucester

GL2 7BT

T 01453 891900

F 01453 890827

E monitoring@wwt.org.uk

Reg. Charity no. 1030884 England & Wales,

SC039410 Scotland

Contents

Summary	4
Introduction.....	5
Methods	7
Field counts.....	7
Random stratified survey	7
Age counts	8
Results	9
Field counts.....	9
Habitat preferences of Greylag Geese	13
Random stratified survey	14
Comparing field counts and the random stratified survey.....	15
Age counts	15
Discussion	17
Acknowledgments	20
References	21
Appendices.....	22

Summary

1. A survey involving field counts of British Greylag Geese on the Orkney archipelago counted 22,911 birds in late August 2014, a 7.2% increase on the number counted there in August 2013. The mean density of geese on agricultural land was 0.59 birds ha⁻¹.
2. A sample of geese was aged and was found to contain 30.5% young. The mean brood size was 3.07 young per successful pair. If the proportion of young is indicative of the whole population in Orkney, then there were potentially 2,276 successful breeding pairs of Greylag Geese in Orkney in summer 2014.
3. Greylag Geese were found primarily on improved grass fields (59.5% of those counted, excluding those found on waterbodies). The geese showed a strong preference for arable stubble fields and improved grass and avoided rough grassland and heather moorland (mountain, heath and bog). No geese were recorded in un-harvested arable crops.
4. A randomised stratified survey was also carried out on Mainland. Eighty-two random 1km squares were surveyed as well as eight 1km squares thought to contain geese. The estimate was 12,419 geese, which was 6.8% larger than the number counted during field counts (11,621), although the 95% confidence intervals were large (range 10,116 to 14,925).
5. The random stratified survey counted a total of 1,804 geese in 82 1km squares, or 0.22 geese ha⁻¹. This compared with 0.23 geese ha⁻¹ counted during the 'look-see' field counts, thus giving some confidence that the field counts were reasonably accurate.
6. Between ~20,000 and ~23,000 Greylag Geese have been counted in Orkney during late August in 2012 to 2014 suggesting that the rapid increases in numbers up to 2012 (of up c. 19% per annum) has stopped and that, due to increased shooting of the summering stock, the population trend has stabilised.
7. Suggestions are given to explain why the population has apparently stabilised. These include:
 - i. The August 2014 census over-estimated the number of birds present;
 - ii. The estimate of the proportion of young in Greylag Goose flocks in August 2014 underestimated breeding success;
 - iii. Of the 8,462 Greylag Geese shot between October 2013 and the end of the hunting season, the bag comprised a lower than estimated proportion of British Greylag Geese;
 - iv. There were inaccuracies in the reported bag either during the pilot scheme and/or during the open season.

Introduction

The largely sedentary British Greylag Goose population is increasing in abundance and distribution in Scotland, with breeding now occurring over much of the mainland, Western Isles and Northern Isles (Mitchell *et al.* 2010a). Local increases in the number of British Greylag Geese have also led to an increase in reports of damage to agricultural economic interests and the implementation of pilot population control projects by the Scottish Government and Scottish Natural Heritage (SNH) on the Uists, Tiree and Orkney.

The British Greylag Goose (hereafter Greylag Goose, unless referring to the Iceland population) is the only native species of goose breeding in Britain. At the end of the 18th century, the species had a much wider distribution within Britain, breeding in many areas of Scotland and more locally in England, Wales and probably Ireland (Holloway 1996). However, during the 19th century, numbers began to decline and it seems likely that over-hunting, and the drainage and cultivation of the fens, were responsible for the extinction of the species in England and Wales. A remnant population, probably numbering fewer than 500 birds, persisted in the 20th century in the Outer Hebrides (see Mitchell *et al.* 2010b for a review).

There is no evidence that Greylag Geese bred in Orkney in the 18th, 19th or the first 80 years of the 20th century; records suggest that presumed winter migrants from Iceland were encountered regularly on passage and small numbers occasionally over-wintered (Booth *et al.* 1984). The lack of breeding records seems somewhat surprising given the wealth of suitable habitat available for breeding, although the same lack of evidence of breeding is true of Shetland.

In the early 1980s, c. 50 Greylag Goose goslings from Anglesey (but descended from South Uist stock – see Mitchell *et al.* 2010b) were released on Shapinsay, Orkney over a period of three years. It is thought that the colonisation of Shapinsay, the Kirkwall area and nearby uninhabited islands resulted from these releases. The first breeding record is of a pair in Birsay in 1985. However, whether nesting elsewhere in Orkney resulted from this introduction is unknown. An alternative possibility is that wintering birds (from the Iceland population), perhaps involving some individuals injured by shot, began to over-summer in Orkney rather than returning to their usual breeding grounds in Iceland. In addition, a small number of neck-collared individuals from the mainland British population, marked at Loch Loyal, Sutherland, were seen in Orkney, including at least two with broods of young and one incubating a clutch of eggs. Part of the colonisation may therefore have occurred naturally from mainland Scotland. It is also possible that a combination of all three sources may have been involved in the establishment of breeding Greylag Geese in Orkney. However, up to 2000, colonisation of the islands had been rather modest, and less than 100 pairs were thought to be nesting throughout Orkney (Meek 2008).

A comprehensive survey of Greylag Geese in Orkney was carried out in July 2008, at a time when the geese were moulting. Allowing for a small amount of double counting and flocks being missed, the total in that year was estimated at c. 10,000 birds (range 9,000 to 11,000). Breeding pairs and post-breeding flocks were recorded on almost all islands in the archipelago, and it is thought that the proximity and mixture of moorland breeding areas, remote and safe offshore islands, large inland lochs, and intensively managed grasslands all helped to fuel the increase in numbers.

In order to manage British Greylag Geese in Scotland, regular assessments of the status and distribution of the geese are required. This is particularly pertinent in Orkney where the Scottish Government and SNH have initiated a pilot adaptive harvest management system to manage Greylag Goose abundance. Assessing the abundance and annual productivity of Greylag Geese in Orkney in summer will therefore provide essential baseline data for the demographic modelling required by this process.

Two late summer archipelago-wide surveys have been carried out to date. A survey in late August 2012 estimated 21,367 Greylag Geese (Mitchell *et al.* 2012) and the 2013 survey estimated 20,242 geese (Brides *et al.* 2013).

Methods

Field counts

Following the methods employed in late August 2012 (see Mitchell *et al.* 2012), Greylag Geese were counted in Orkney during late August 2014, a time when the geese have completed their moult and have moved to feeding areas on the main islands. Local observation in previous years, and the results from the 2012 and 2013 late August surveys, suggested that, by this time, the geese would largely be using agricultural land (a time which brings them into conflict with agricultural economic interests) and an understanding of the distribution of the geese at this time of year was therefore considered desirable. The survey in 2014 aimed to ensure that all habitats were adequately checked.

WWT staff liaised with professional and volunteer goose counters in Orkney to arrange co-ordinated 'look-see' coverage of agricultural land and natural wetland habitats on 26-31 August 2014, covering the same areas checked during annual winter counts. Land was checked for geese by following the road network and stopping at suitable vantage points. Counters were also asked to walk to vantage points, where necessary, to check areas not visible from the road. In addition, accessible areas of moorland were also checked, especially where re-seeded fields were adjacent to moorland and areas of moorland held grass patches. No minimum time limit was set for each site and counters could spend as much time as necessary to thoroughly check surrounding areas for feeding geese. Counters were asked to record information on flock size, exact location and the broad habitat class that the geese were using. Smaller offshore islands were either visited (*e.g.* Graemsay) or checked using telescopes from vantage points on larger islands if access to the islands proved difficult (*e.g.* Switha).

Random stratified survey

On Mainland (West Mainland, East Mainland and Deerness), a random stratified sample of 1km squares was checked for geese on 28 August by five teams of SNH, British Association for Shooting and Conservation (BASC), Scottish Agriculture Science Agency (SASA), Scottish Government (SG) and WWT staff who, with the exception of CM of WWT, did not participate in the look-see survey. A sampling methodology was developed in August 2012 to facilitate increased survey effort in areas with higher than predicted occupancy by geese in different habitats (see Mitchell *et al.* 2010b for methods). All areas within each 1km square chosen for counting were thoroughly searched to ensure that no geese were overlooked and all geese present were counted. No minimum time limit was set for each 1km square and counters could spend as much time as was necessary to thoroughly check the area for geese. Information on flock size, exact location and habitat was recorded.

Using the count data collected on 28 August from the randomly checked squares, a bootstrap method was then used to derive population estimates for Greylag Geese in individual strata (see Mitchell *et al.* 2010b for details). Within each stratum, n counts were randomly selected, with replacement, from the 2014 data using 999 repetitions, where n equalled the number of 1km squares not visited in that stratum. It was assumed that the probability of detection of geese was similar for all habitats. The n values for each stratum were summed to produce an estimate of the number of geese present in the unvisited 1km squares. This value was added to the sum from the actual counts for that stratum to give a total population estimate. The 499th, 25th and 974th ordered bootstrap values were taken to give the median and lower and upper 95% confidence limits of the estimates, respectively.

Age counts

A sample of Greylag Geese was aged as either adult or gosling (identified through plumage characteristics). Brood sizes of successful pairs, detected by watching the behaviour of associating geese, were also recorded by CM.

Results

Field counts

Whole archipelago counts were completed on 26-31 August and involved c. 27 person days of time (see Appendix 1). All areas checked during the annual winter counts were checked during the August count. Coverage was considered good and no counters reported that they felt that they had missed birds. Count conditions were favourable with fair weather and long day length throughout the survey period.

A total of 22,911 Greylag Geese was counted in 188 flocks (median flock size 53 birds, range 2 to 865), with the largest numbers found on Mainland, South Ronaldsay and Sanday (Table 1, Figure 1). Mainland accounted for approximately half of the total number of geese counted (50.7%, 11,621 geese). The density of Greylag Geese per hectare ranged from 0 ha⁻¹ on several islands to 0.67 ha⁻¹ on Gairsay, with an overall density of 0.23 ha⁻¹ for the whole archipelago (Table 1).

Table 1. The abundance and distribution (by major island) of Greylag Geese in Orkney, during 26-31 August 2014, with estimated densities overall and on agricultural land.

Area ¹	Count	Area (ha) ²	Density (geese ha ⁻¹)	Density (geese ha ⁻¹) on agricultural land ³
Mainland ⁴	11,621	52,325	0.22	0.57
South Ronaldsay	2,233	4,980	0.45	0.86
Sanday	2,083	5,043	0.41	0.68
Stronsay ⁵	1,978	3,430	0.58	0.92
Shapinsay	1,282	2,948	0.43	0.96
Westray	983	4,713	0.21	0.33
Eday	708	2,745	0.26	0.65
Rousay/Eynhallow ⁶	576	4,935	0.12	0.50
Burray ⁷	571	1,098	0.52	1.19
North Ronaldsay	355	690	0.51	0.74
Gairsay	160	240	0.67	1.30
Papa Westray	157	933	0.17	0.36
Egilsay	146	650	0.22	0.47
Flotta/Fara/Switha ⁸	58	1,212	0.05	0.39
Hoy/South Walls ⁹	0	14,558	0	0
Wyre	0	311	0	0
Graemsay	0	409	0	0
Small Holms ¹⁰	nc ¹¹	265	-	-
Auskerry	nc	85	-	-
Copinsay	nc	73	-	-
Swona	nc	92	-	-
Total	22,911	101,663	0.23	0.59

Notes:

¹ Islands not checked for geese include Cava (107ha). See also Appendix 2 for extent of coverage.

² Source: http://en.wikipedia.org/wiki/List_of_islands_of_Scotland. Estimates based on Ordnance Survey maps and General Register Office for Scotland statistics. Accessed on 31/10/12.

³ Improved grassland (LCM 2007 code 4) and arable land (LCM 2007 code 3) combined.

⁴ Includes West Mainland, East Mainland and Deerness.

⁵ Includes Stronsay (3,275ha), Papa Stronsay (74ha), Linga Holm (57ha) and Holm of Hulp (24ha).

⁶ Includes Rousay (4,860ha) and Eynhallow (75ha).

⁷ Includes Burray (903ha), Hunda (100ha), Glims Holm (55ha) and Lamb Holm (40ha).

⁸ Includes Flotta (876ha), Fara (295ha) and Switha (41ha).

⁹ Includes Hoy (13,458ha) and South Walls (1,100ha).

¹⁰ Includes Faray (180ha), Holm of Faray (29ha), Muckle Green Holm (28ha), Sweyn Holm (18ha), Rusk Holm (6ha) and Little Green Holm (4ha).

¹¹ nc = not counted

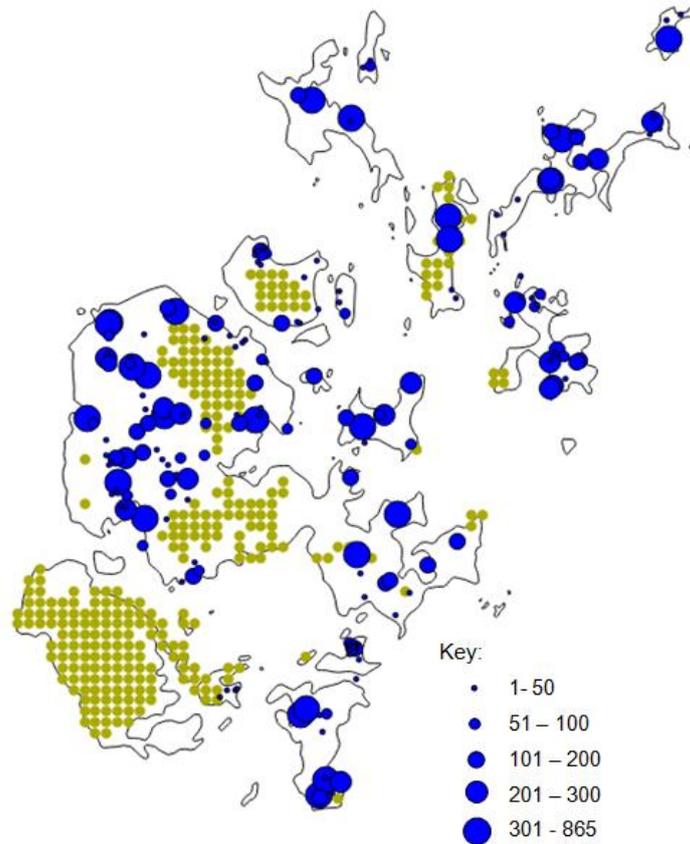


Figure 1. The distribution of Greylag Geese found during field surveys in late August 2014. Blue dots are proportional to flock size. One km squares dominated by moorland are shaded in green.

The 2014 estimate is 7% higher than the estimate from the previous year although, since August 2012, the total number of geese in Orkney has remained at between ~20,000 and ~23,000 birds (Figure 2).

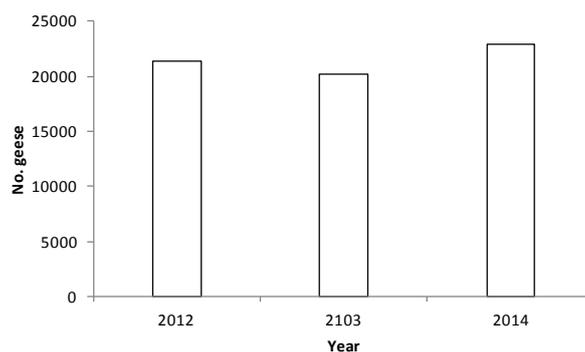
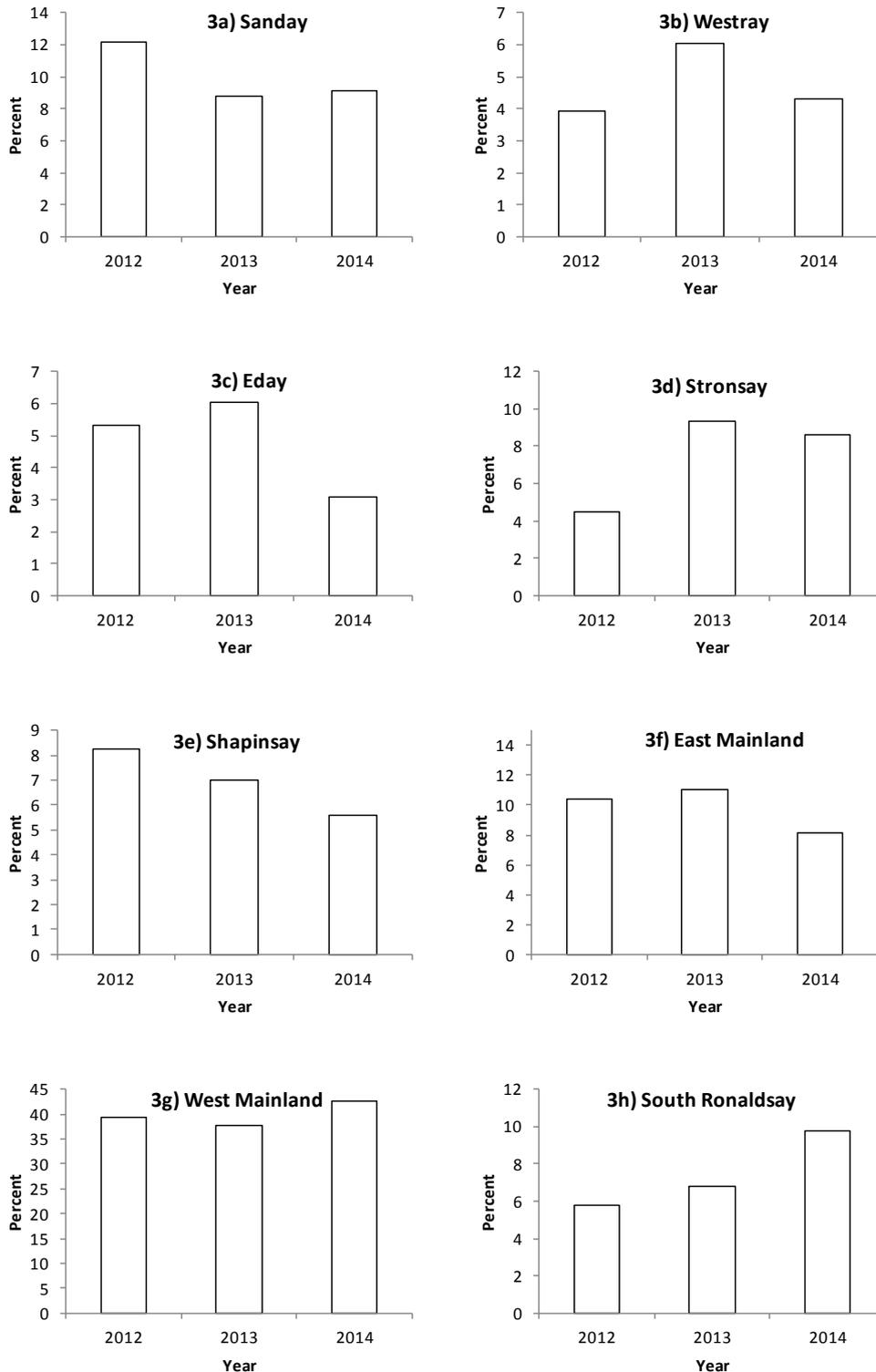


Figure 2. The number of Greylag Geese found during field surveys in Orkney in late August 2012 to 2014.

Some of the habitat in Orkney is moorland (Figure 1) which, although providing a suitable habitat for breeding Greylag Geese, holds few birds outwith the breeding period when the geese prefer to utilise agricultural land. Comparing the counts of geese to the availability of agricultural land (the area of improved grassland and arable land combined), the density of Greylag Geese per hectare ranged from 0 ha⁻¹ on several islands to 1.30 ha⁻¹ on Gairsay, with an overall density of 0.59 ha⁻¹ for the whole archipelago (Table 1).

Based on the counts from the three late summer surveys, there have been some changes in the distribution of Greylag Geese on the main islands in Orkney (Figures 3a to 3h).



Figures 3a-3h. Changes in the distribution of Greylag Geese counted during field surveys on eight of the largest islands in Orkney in late August in 2012 to 2014. Figures are expressed as the percent of the total counted in Orkney each year. Note that the y-axis scales vary.

Relative to the total number of geese counted, numbers have increased on Stronsay and South Ronaldsay and decreased on Sanday, Eday, Shapinsay and East Mainland.

Flock size was highly skewed; of the 188 flocks recorded, 93 (49.4%) were of fewer than 50 birds (Figure 4). However, 40 flocks (21.2%) contained over 200 birds, the largest flocks being of 580, 580, 605, 655 and 865 birds.

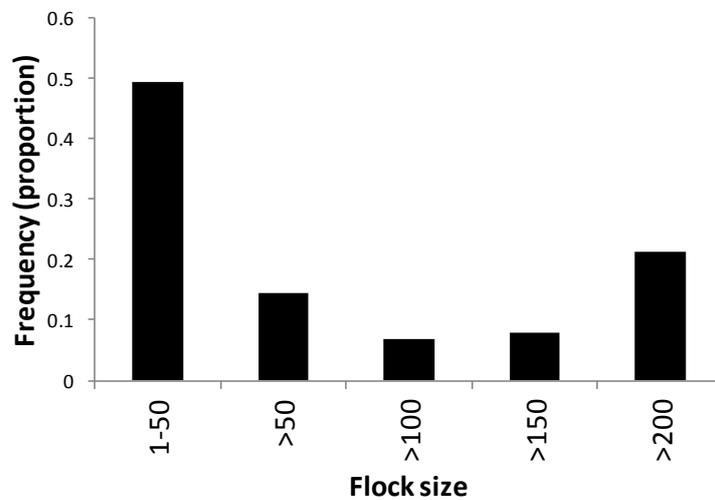


Figure 4. Frequency of flock size of Greylag Geese encountered during field surveys in Orkney in late August 2014.

The number of flocks recorded during the late summer surveys has declined from 260 in 2012 to 188 in 2014 (Figure 5a). Over the same period, the mean flock size increased from 82 in 2012 to 121 in 2014 (Figure 5b). The reasons for these changes are not known and may have occurred by chance. However, it is possible that the shooting of geese, which now starts in early August, before the counts are undertaken, has led to the geese becoming more wary, seeking a greater sense of protection by forming larger flocks.

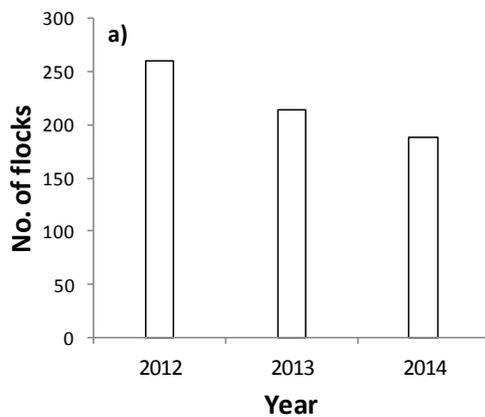


Figure 5a. The number of flocks of Greylag Geese encountered during field surveys in Orkney in late August in 2012 to 2014.

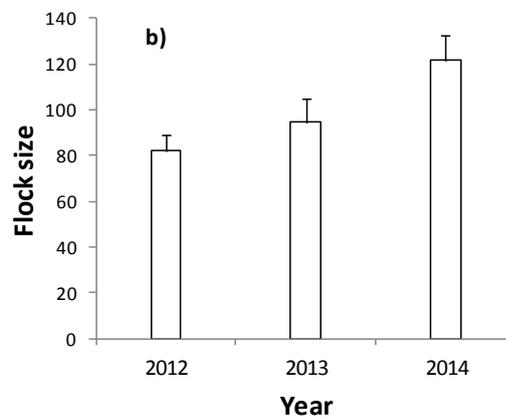


Figure 5b. The mean flock size (+SE) encountered during field surveys in Orkney in late August in 2012 to 2014.

Habitat preferences of Greylag Geese

The majority of Greylag Goose records (96.2%) were accompanied by habitat information. Greylag Geese encountered on either open freshwater or saline/brackish waterbodies (8,955 birds) and any geese counted in flights (53 birds) were excluded from this analysis, since geese were only encountered there loafing or after being disturbed from feeding areas. Records of geese recorded in the remaining habitats revealed a strong preference for arable stubble fields and improved grass and avoidance of semi-natural grass fields and heather moorland, relative to the habitat available (Table 2, Figure 6).

Table 2. The location of flocks of Greylag Geese encountered during late August 2014 in relation to various habitat classes (excludes freshwater and saltwater habitats). See also Appendix 2.

LCM 2007 habitat class	LCM 2007 habitat code	Area (ha) in Orkney	Percentage of total area	No. geese counted in habitat class in August 2014	Percentage of geese counted in habitat class	Jacobs Index ¹
Arable stubbles	3	2,589	2.7	2,235	17.1	0.76
Improved grass	4	35,969	37.1	7,757	59.5	0.43
Semi-natural grassland	5,6,7,8,9	29,029	29.9	2,093	16.1	-0.38
Moorland (mountain, heath, and bog)	10,11,12,13,14	23,462	24.2	950	7.2	-0.61
All other habitats	1,2,15-23	5,886	6.1	0	0	nc
Total		96,935 ²	100.0	13,035 ³	100.0	

Notes:

¹ Jacobs (1974)

² Total excludes areas of freshwater (LCM 2007 code 16) and saltwater (LCM 2007 code 17).

³ Total excludes birds counted on waterbodies (n=8,955) and in flight (n=53).

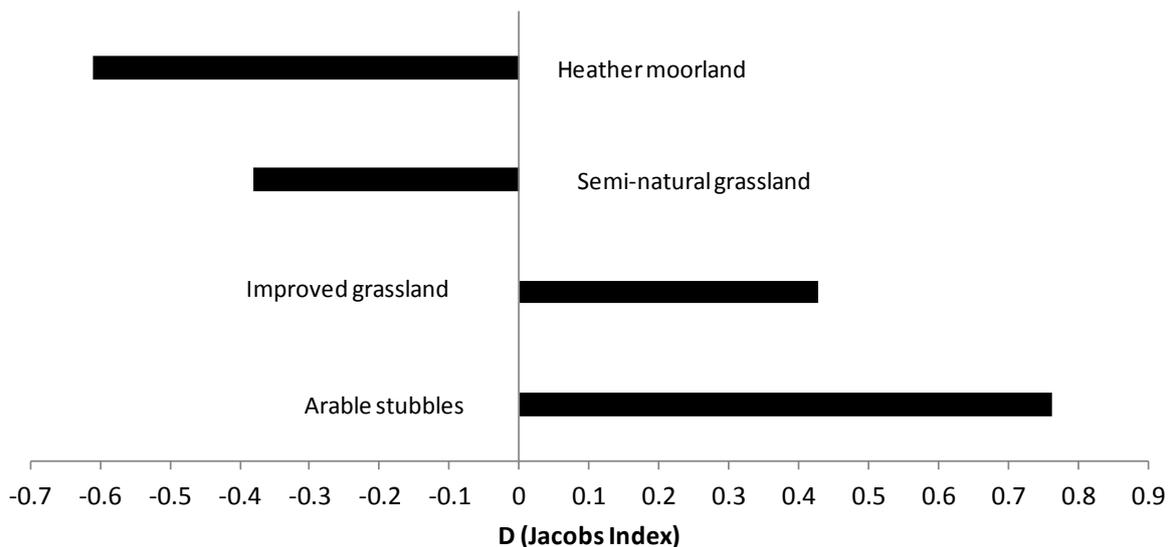


Figure 6. Terrestrial habitat preferences of Greylag Geese in August 2014 expressed by Jacobs Index (D). The index ranges from -1 (complete avoidance) to +1 (exclusive use).

However, even when Greylag Geese were found in moorland habitats, the geese tended to feed in small patches of semi-natural grass within the heather (pers. obs.).

All records of Greylag Geese on arable land were of geese feeding on arable stubbles. No geese were encountered on un-harvested arable crops.

Random stratified survey

Eighty-two random 1 km squares (out of a total of 561 1km squares, a sampling rate of 14.6%) were surveyed on Mainland, with squares holding improved grassland as the habitat being surveyed at a greater rate than 1km squares dominated by other habitat types (Table 3, Figure 7). In addition, eight 1km squares thought to hold geese (known squares) were also checked.

Table 3. Extrapolated estimate from a random stratified survey using bootstrap analysis for individual strata during late August 2014.

	No. 1 km squares in all strata	No. sampled (% of total sampled)	Lower 95%	Mean	Upper 95%
Estimate	561	82 (14.6)	8,639	10,942	13,448
Known sites	8 ¹	8	1,477	1,477	1,477
Overall estimate (including known sites)	569	90	10,166	12,419	14,925

Notes:

¹ – six of the known 1km squares were dominated by improved grassland and two were dominated by semi-natural grassland.

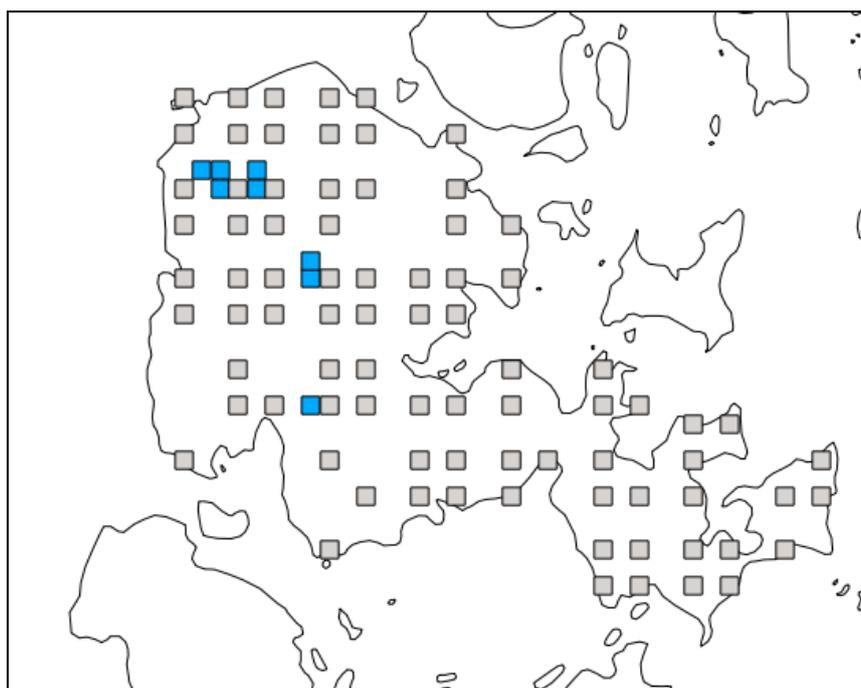


Figure 7. The distribution of 82 1km squares surveyed as part of the random stratified survey (grey), together with the distribution of the 8 'known sites' squares (blue).

The estimate from the bootstrap analysis (12,419) was 6.9% larger than the value obtained through field counts (11,621). The random stratified surveys carried out in 2012 and 2014 both gave estimates that were larger than those obtained from 'look-see' counts, however the 'look-see' counts, in both years, fell within the upper and lower 95% confidence intervals generated by the bootstrap analysis (Figure 8). The confidence intervals were large in both years (+15.9% and -17.1% of the estimate in 2012 and +18.5% and -20.1% of the estimate in 2014). This is probably due to the highly clumped nature of goose flocks (see also Figures 4 & 5).

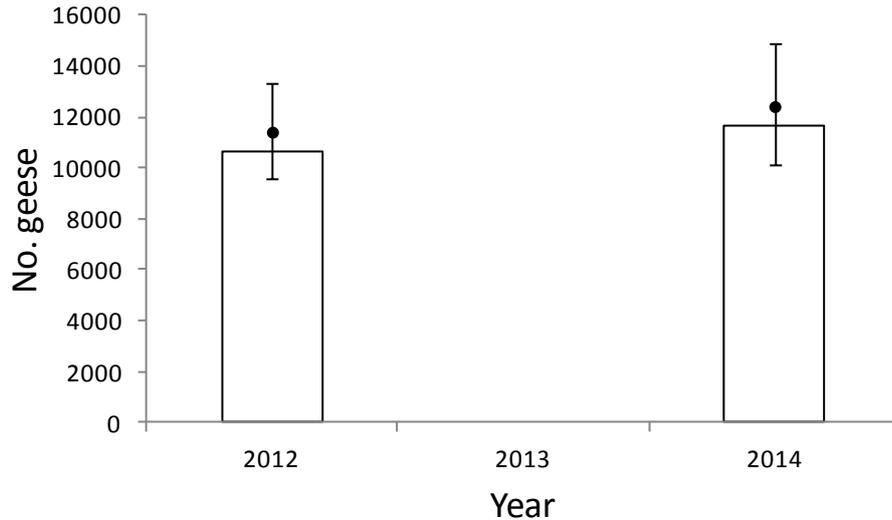


Figure 8. The results of ‘look-see’ counts of Greylag Geese on Mainland, Orkney in late August in 2012 and 2014 (columns) and estimates (●) and 95% confidence intervals generated by bootstrap analyses from random stratified surveys carried out at the same time.

Comparing field counts and the random stratified survey

Using the simplest comparison, the random stratified survey counted a total of 1,804 geese in the 82 random 1km squares; or 0.22 geese ha⁻¹, similar to the estimated density of 0.23 geese ha⁻¹ counted during the ‘look-see’ field counts (11,621 geese counted on Mainland (52,325 ha), Table 1). However, it was not possible to directly compare the counts made during the ‘look-see’ field counts with those made during the random stratified survey. The latter occurred two days before the former, during which time goose flocks may have moved between fields and consequently moved from one 1km square to another.

Age counts

A sample of 933 geese was aged on Mainland of which 285 (30.5%) were young birds. The sample represented c. 4.1% of the Orkney population. The mean brood size was 3.07 young per successful pair. There was large variation in the proportion of young encountered (Figure 9). Occasionally, single families or small groups of families, with a correspondingly high percentage of young were encountered in fields. However, in contrast to 2012, no flocks that were aged contained no young (see Mitchell *et al.* 2012).

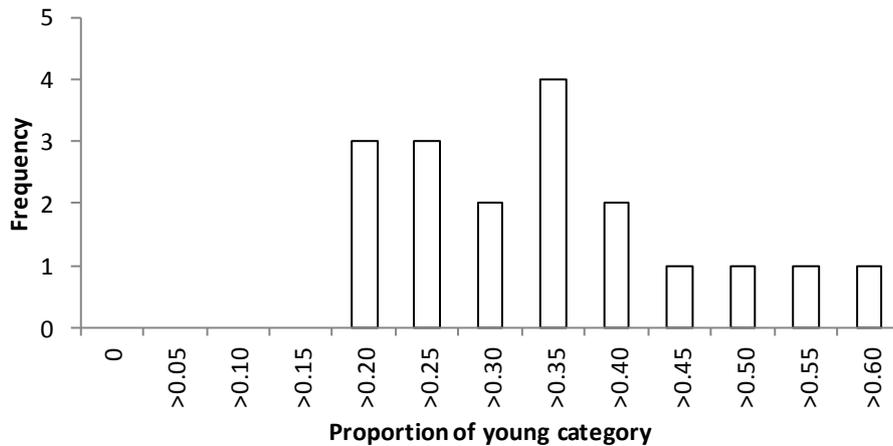


Figure 9. Frequency of categories of proportion of young encountered during field surveys in Orkney in late August 2014.

If the proportion of young recorded was indicative of the whole population in Orkney, then approximately 6,988 birds were goslings ($22,911 * 0.305$). The mean brood size was 3.07 goslings, suggesting that, as an approximation, there were potentially 2,276 successful pairs of Greylag Geese in Orkney in summer 2014. Using these approximations, the estimated number of successful pairs has increased since 2012 (Figure 10).

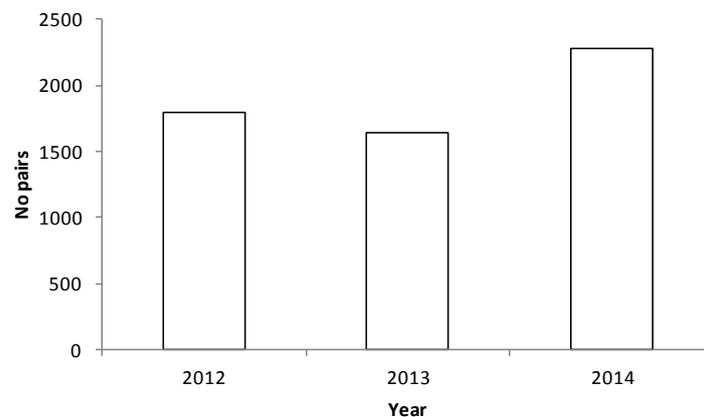


Figure 10. Estimated number of successful pairs of Greylag Geese in Orkney in late August in 2012 to 2014.

However, the above calculation does not include pairs of geese that failed to breed. In a detailed study of Greylag Geese breeding on South Uist in the Outer Hebrides, it was found that the proportion of failed nests (pairs) varied between 30 to 50% annually (Newton & Kerbes 1974). The main factor reducing the production of fledged young was the complete loss of clutches, some of which were taken by predators (notably Hooded Crows *Corvus cornix*) and others deserted. The proportion of clutches successful each year was associated with the timing of nesting. The earlier the population as a whole bred, the greater the proportion of clutches that hatched, and the greater the number of young fledged per nesting pair (Newton & Kerbes 1974). The total number of breeding Greylag Geese in Orkney is therefore likely to be higher than the estimated 2,276 successful pairs. This also makes it difficult to draw conclusions about the trend in the number of pairs.

Discussion

The survey in late August 2012 provided the first archipelago-wide assessment of the abundance and distribution of Greylag Geese in Orkney at this time of year. The total number of geese counted (21,367) was more than twice the number estimated in Orkney in July 2008, when Mitchell *et al.* (2010a) reported an estimate of 10,000 birds (range 9,000 to 11,000). Such an increase in numbers would have therefore involved an estimated annual rate of increase of c. 19% per annum.

In late August 2013, 20,242 Greylag Geese were counted and, in late August 2014, the count was 22,911 birds. The results of the surveys from 2012 to 2014 are below the projected rate of increase at the estimated rate up to summer 2014 (Figure 11) and numbers therefore appear to have stabilised. The projected counts in Figure 11 assume that the count in July 2008 was 10,000 birds and the estimated annual rate of increase was c. 19% per annum.

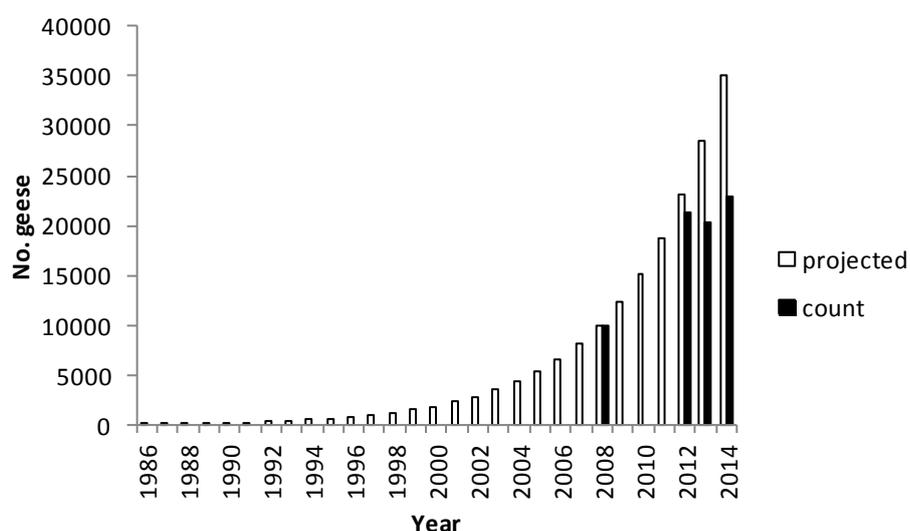


Figure 11. The projected number of Greylag Geese in Orkney, based on an estimated rate of increase of c. 19% annual compared to the number counted in 2008 and 2012 to 2014.

The numbers of Greylag Geese reported to have been shot in Orkney since spring 2012 are shown in Table 4.

Table 4. Summary of reported bag returns of Greylag Geese shot in Orkney 2012/13 to 2013/14 (from SNH annual reports).

	Bag type	2012/13	2013/14
British Greylag Geese	Under licence (May to end August)	89	258
	By pilot project (Aug)	445	473
	By pilot project (Sept)	2,087	1,175
	Recreational hunting (Sept)	570	900
Total		3,191	2,806
British and Iceland Greylag Geese combined	Recreational hunting (Oct to end of shooting season)	6,600	8,262
	Under licence (Feb to April)	209	200
Total		6,809	8,462

A proportion of the total number of geese reported as being shot from October 2013 through to the end of the hunting season in early 2014 (8,462 in total, Table 4) would have been summering British Greylag Geese. However this proportion, and hence the number of British geese shot, is unknown, since there is no way of distinguishing between the two

populations during the winter months, even in the hand. SNH estimated this proportion by using the ratio of the number of British geese counted in the summer to the number of British and Iceland geese counted in November. Using these estimates, together with bag data from Table 4 and abundance and productivity data from Brides *et al.* (2013), SNH estimated that the British Greylag Goose population was 15,129 birds at the start of the 2014 breeding season. With 30.5% young estimated in the post breeding flocks, it might have been expected that the 2014 August count would have been lower than the 22,911 birds counted.

There are several explanations for this difference, including the pre-breeding season estimate of numbers, determined by SNH, being too low and/or the post breeding population estimate being too high. Possible explanations include:

1) The count of Greylag Geese in Orkney in August 2014 over-estimated the number of birds present. This is possible, but attempts were made to avoid double counting and no large flock movements were noted. When counting a flock of birds, both stochastic and systematic errors are likely to occur. Errors in estimating single flock sizes are possible. Count accuracy of $\pm 10\%$ was reported for flocks of ducks (Matthews 1960), and when comparing visual estimates of large flocks of geese during aerial surveys with photographic counts of the same flocks, systematic underestimation of flock sizes by visual estimates has been found (Kerbes *et al.* 1999) suggesting that large flocks may also be under-estimated during ground counts. The risk of missing flocks altogether is greater. Thus, over-estimating the number of Greylag Geese in Orkney seems unlikely. Because of their large body size, preference for open habitat and gregarious behaviour, geese ought to be relatively easy to count accurately, but an estimate of $\pm 5\%$ count accuracy (or $\pm 1,145$ geese), would give an estimated range of 21,766 to 24,056 birds.

The random stratified survey indicated that, despite large confidence intervals (probably a result of the highly clumped nature of goose flocks in an agricultural landscape), the 'look-see' counts fall within the range of expected results, and both the 'look-see' counts and the bootstrap estimate for Mainland showed an increase between 2012 and 2014. This suggests a degree of confidence in the 'look-see' counts.

2) The estimate of the proportion of young in Greylag Goose flocks in August 2014 underestimated breeding success. The number of young was estimated as being 6,988 (see 3.5 above for calculations). Adding these to the SNH estimate of 15,129 birds at the start of the breeding season, and assuming no over-summer mortality amongst the adults, would give an expected total of 22,117 geese, or 794 fewer than the count suggested. Underestimating the annual breeding success is possible since the sample of birds aged ($n=933$) only represented c. 4% of the population. British Greylag Geese can have particularly high annual rates of breeding success. For example, on Tiree the mean percentage young has been 30.0% (mean for 2002 to 2011) and, on the Uists, the comparable figure was 28.8% (mean for 2002 to 2011). In late summer 2014, 35.2% young were recorded in British Greylag Goose flocks on Tiree (J. Bowler pers. comm.) suggesting that productivity in other parts of northwest Scotland in 2014 appears to have been high. Assuming that the SNH estimate of 15,129 birds at the start of the breeding season was reasonable, in order to 'match' the August 2014 count of 22,911 birds, the breeding success figure would have had to be 34% (15,129 adults + 7,789 goslings).

Additionally, in August 2014, the age counts were only recorded from flocks on Mainland. The proportion of young on Mainland may have been lower than on other islands in the archipelago. This may have been due to differences in productivity rates between islands, or due to shooting starting earlier in the year on Mainland (and before the counts took place). Inexperienced, first year birds can form a disproportionately large part of the bag (Wright & Boyd 1983) and this may reduce the proportion of young recorded on Mainland.

On Tiree, annual productivity increased following years when the population had decreased (Figure 12) although the relationship was not significant ($F_{14}=2.45$, $P=0.14$). Tiree is also subject to shooting to control numbers of Greylag Geese. The reasons for this relationship are unclear and are presumably also influenced by spring weather conditions, however it suggests that following years when the population is lower (for example after a large number of geese are culled), productivity increases and the young of the year simply replace the previous years' losses.

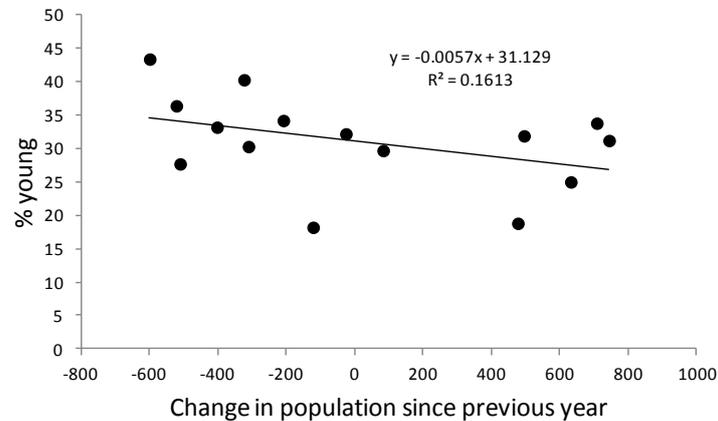


Figure 12. The relationship between the proportion of young in Greylag Goose flocks on Tiree (data from 1997 to 2012) and the change in population during the previous year.

3) **Of the 8,462 Greylag Geese shot between October 2013 and the end of the hunting season, the bag comprised a lower than anticipated proportion of British Greylag Geese.** This is possible, since the pilot has no control over the provenance of the birds shot at this time of year. A lower than anticipated proportion of British Greylag Geese in the bag (SNH use count ratios to estimate the proportion shot) would have led to a higher number of British birds surviving the winter, thus the SNH estimate of 15,129 birds at the start of the breeding season would have been too low. It is possible that increasing the number of Greylag Geese being shot in Orkney from October onwards has a greater impact on the Icelandic migrants rather than on the British population. Having no control over which population of Greylag Goose is shot once the Iceland migrants arrive in Orkney from October onwards is clearly a major weakness in a management process that is seeking to reduce the size of the British Greylag Goose population in Orkney.

4) **There are inaccuracies in the reported bag either during the pilot scheme and/or during the open season.** The reporting of bag data during the open season, and outwith the pilot, is voluntary. It is possible that the number of geese reported as being shot (at any time) was too high, although the reasons for such a discrepancy remain unclear.

It is possible that small inaccuracies in any, or all, of the above values (abundance, annual breeding success and bag data) could contribute to the higher than expected number of Greylag Geese counted in Orkney relative to the SNH estimate of 15,129 birds at the start of the breeding season.

In order to better explain the abundance of British Greylag Geese in Orkney, an attempt could be made to collate all existing demographic data on breeding pairs (e.g. Meek 2008), annual assessments of productivity and survival rates based on recent ringing and use these to model rates of increase. Certainly going forwards, annual modelling of demographic rates is a prerequisite for successful adaptive harvest management (Madsen & Williams 2012).

Acknowledgments

Scottish Natural Heritage funded the survey. Special thanks are extended to: Helen & David Aiton, Mike Cockram, Tim Dodman, Paul Hollinrake, Stan Groundwater, Don Otter, Lee Shields, Robert Simpson, Patrick Taylor, Kaye Thomas, Andrew Upton and Mark Warren for help with the survey. Thanks also to Ian Bainbridge, Gail Churchill, Matt Ellis, Gill Hartley, Morag Milne, Jessica Shaw, Christine Skene and Andrew Taylor for help with counting the random squares. Richard Hearn, Baz Hughes, Gail Churchill, Jessica Shaw and Ian Bainbridge kindly read an earlier draft of this report and made useful comments.

References

- Booth, C., M. Cuthbert & P. Reynolds. 1984. *The Birds of Orkney*. The Orkney Press, Kirkwall.
- Brides, K., A.J. Leitch & E. Meek. 2013. *The abundance and distribution of British Greylag Geese on Orkney, August 2013*. Wildfowl & Wetlands Trust Report, Slimbridge. 16pp.
- Holloway, S. 1996. *The Historical Atlas of Breeding Birds in Britain and Ireland 1875-1900*. Poyser, London.
- Jacobs, J. 1974. Quantitative measurement of food selection. *Oecologia* 14: 413–417.
- Kerbes, R.H., V.V. Baranyuk & J.E. Hines. 1999. Estimated size of the Western Canadian Arctic and Wrangel Island Lesser Snow Goose populations on their breeding and wintering grounds. In Kerbes, R.H., K.M. Meeres & J.E. Hines (eds) *Distribution, Survival, and Numbers of Lesser Snow Geese of the Western Canadian Arctic and Wrangel Island, Russia*: 25–38. Canadian Wildlife Service Occasional Paper 98.
- Madsen, J. & J.H. Williams (Compilers) 2012. *International Species Management Plan for the Svalbard Population of the Pink-footed Goose Anser brachyrhynchus*. AEWA Technical Series No. 48. Bonn, Germany.
- Matthews, G.V.T (1960). An examination of basic data from wildfowl counts. Proc XII Int. Orn. Cong., Helsinki 1558: 483-491.
- Meek, E. (2008). Greylag Geese in Orkney. *Orkney Bird Report, 2007*.
- Mitchell, C., L. Griffin, M. Trinder, J. Newth & C. Urquhart. 2010a. The status and distribution of summering Greylag Geese in Scotland, 2008/09. *Bird Study* 58: 338-348.
- Mitchell, C., L. Griffin, M. Trinder & J. Newth. 2010b. *The population size of breeding Greylag Geese Anser anser in Scotland in 2008/09*. Wildfowl & Wetlands Trust Report to Scottish Natural Heritage, 70pp.
- Mitchell, C., A.J. Leitch, K. Brides & E. Meek. 2012. *The abundance and distribution of British Greylag Geese on Orkney, August 2012*. Wildfowl & Wetlands Trust Report, Slimbridge. 33pp.
- Newton, I. & R.H. Kerbes. 1974. Breeding of greylag geese in the Outer Hebrides, Scotland. *Journal of Animal Ecology* 43: 771-783.
- Wright, G. & Boyd, H. (1983) Numbers, age and sex of Greylag and Pink-footed Geese shot at Loch Leven National Nature Reserve, 1966-1981. *Wildfowl* 34: 163-167.

Appendices

Appendix 1. Person-days needed to count Greylag Geese in Orkney during 26-31 August 2014.

Area	Person-days	Transport needed
Mainland (East Mainland, West Mainland and Deerness)	8	5-8 cars ¹
Sanday	2	Ferry plus car
Shapinsay	1	1 car
South Ronaldsay	1	1 car
Eday	1	1 car
Stronsay	1	Ferry plus car
Westray	1	1 car
Burray	0.5	1 car
Rousay	0.5	Ferry plus car
North Ronaldsay	1	1 car
Papa Westray	0.5	1 car
Hoy	1	1 car
Small Holms	nc ²	
Flotta	0.5	Ferry
Gairsay	0.5	Counted by local resident
Auskerry	nc	
Egilsay	0.5	1 car
Wyre	0.5	Ferry plus 1 car
Copinsay	nc	
Swona	nc	Checked from ferry
Graemsay	1	Ferry
Total	21.5	

Notes:

¹ – Five cars are needed if Mainland is counted over two days; eight cars are needed if counted on one day.

² –not counted, but checked from ferry. Can be counted by two people in a RIB.

Appendix 2. The land area and calculated area of selected habitat types in Orkney.

Area	Total area (ha)	Area arable (ha) ¹	Area improved grass (ha)	Total area 'agricultural' land ²
Mainland (includes West Mainland, East mainland, Deerness, Holm of Gimbister and Damsay).	52,325	1,799	18,560	20,358
Sanday	5,043	82	2,980	3,062
Shapinsay (including Helliar Holm and Grass Holm)	2,948	107	1,227	1,334
South Ronaldsay	4,980	91	2,512	2,603
Eday (including Faray, Holm of Faray and Calf of Eday)	2,745	38	1,060	1,098
Stronsay (including Papa Stronsay, Holm of Huip and Linga Holm)	3,430	96	2,052	2,148
Westray	4,713	191	2,793	2,984
Burray (including Lamb Holm, Glimps Holm and Hunda)	1,098	27	456	483
Rousay (including Eynhallow and Holm of Scockness)	4,935	27	1,138	1,165
North Ronaldsay	690	68	410	478
Papa Westray (including Holm of Papa)	933	5	427	432
Hoy (including Rysa Little)	14,558	30	1,233	1,263
Small Holms (including Faray, Sweyn Holm)	265	0	163	163
Flotta ³	1,212	4	143	147
Gairsay	240	0	124	124
Auskerry	85	0	41	41
Egilsay	650	2	312	314
Wyre	311	17	113	130
Copinsay	73	1	46	47
Swona	92	0	30	30
Graemsay	409	4	150	154
Total	101,663	2,589	35,969	38,558

Notes:

¹ – Values calculated from LCM 2007 data (figures have been rounded up to nearest hectare).

² – Agricultural land defined as arable and improved grassland combined.

³ - East side of Fara, south side of Flotta and north side of Switha were all checked from Flotta, but no birds were recorded.