



**The abundance and distribution of
British Greylag Geese on Orkney,
August 2012**

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

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Summary

1. A survey involving field counts of British Greylag Geese on the Orkney archipelago counted 21,367 birds. The mean density of geese on agricultural land was 0.55 ha⁻¹. A sample of birds was aged and was found to contain 24.9% young. The mean brood size was 2.95 young per successful pair.
2. If the proportion of young is indicative of the whole population on Orkney, then there were potentially 1,800 successful breeding pairs of British Greylag Geese on Orkney in summer 2012.
3. British Greylag Geese were found primarily on improved grass fields (54.2% of those counted, excluding those found on water). The geese showed a strong preference for improved grass and arable fields, used semi-natural grass fields in proportion to those available and avoided moorland (mountain, heath and bog).
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 mean estimate was 11,803 geese, which was close to the number counted during field counts (10,625), although the 95% confidence intervals were large (range 6,472 to 14,968).
5. The random stratified survey counted a total of 1,700 geese in 82 1km squares, or 0.21 geese ha⁻¹. This compared with 0.20 geese ha⁻¹ counted during the field counts, thus giving some confidence that the field counts were reasonably accurate.
6. It is recommended that future monitoring of the abundance of British Greylag Geese on Orkney is carried out in late August through the maintenance of the 'look-see' field counts only and covers all the islands. Shooting of geese should not be carried out up to a week before and during future surveys. The budget for the survey should cover a minimum of 27 person days plus associated costs of transport (ferries and cars) for all the Orkney islands. Other options for monitoring are given.
7. The rapid increase in numbers from 10,000 geese in July 2008 to 21,367 in August 2012 suggests a mean annual increase of c.19%

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1 Introduction

The status and distribution of the two Greylag Goose *Anser anser* populations that occur in Scotland is changing. The population that breeds in Iceland numbers *c.*110,000 individuals (Mitchell 2011). Its winter distribution has shifted north within Britain such that a large proportion of the population (up to 70%) now winters on Orkney with large areas of former winter occurrence in south and east Scotland now abandoned. 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.* 2010). This increase in abundance and distribution has led to some areas (notably Orkney, but also Shetland and the Moray Firth) supporting both populations in winter – making monitoring of the two populations during winter very difficult as they are indistinguishable in the field. Large local increases in the number of British Greylag Geese have also led to an increase in reports of damage to agricultural interests and the implementation of population control by the Scottish Government (e.g. on the Uists and Tiree).

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 the drainage and cultivation of the fens and over-hunting were responsible for the extinction of the species in England.

In Scotland, during the late 19th century, the range of the species also contracted and numbers decreased. The causes of this decline were variously attributed to predation by Red Fox *Vulpes vulpes* and Great Black-backed Gull *Larus marinus*, eggs being taken by shepherds for hatching at home, egg collecting, lochs being abandoned due to disturbance through increasing numbers of anglers and photographers, and the loss of nesting cover through muirburn and overgrazing (Berry 1939). Perhaps the most important factor in many areas was, however, the almost continuous persecution, often through indiscriminate shooting, by crofters and farmers. By the 1870s, Greylag Geese remained only in the Uists, Harris & Lewis and in very small numbers on the west mainland. The north-west Scotland (or native) Greylag Goose population, as it became known, was thus the remnant of the population formerly widespread over Britain.

There is no evidence that Greylag Geese bred on 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 overwintered (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) 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 on Orkney resulted from this introduction is unknown. An alternative possibility is that wintering birds (of Iceland stock), perhaps involving some individuals injured by shot, began to over-summer on Orkney rather than returning to their usual breeding grounds in Iceland. In addition, a small number of neck-collared individuals from the British population at Loch Loyal, Sutherland were seen on 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 on 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).

By 2001, the number of reported breeding pairs had increased to *c.*150, although it was felt that the actual number might have been higher than this. The post-breeding population, prior to the arrival of migrants

from Iceland, was thought to be $\approx 1,500$ birds. The breeding population then underwent a rapid phase of increase both in abundance and distribution and, by 2007, ≈ 600 pairs were thought to be nesting (Figure 1). The post-breeding population, calculated by adding breeding adults, their young and non-breeders, was thought to be $\approx 5,000$ birds in 2007 (Meek 2008).

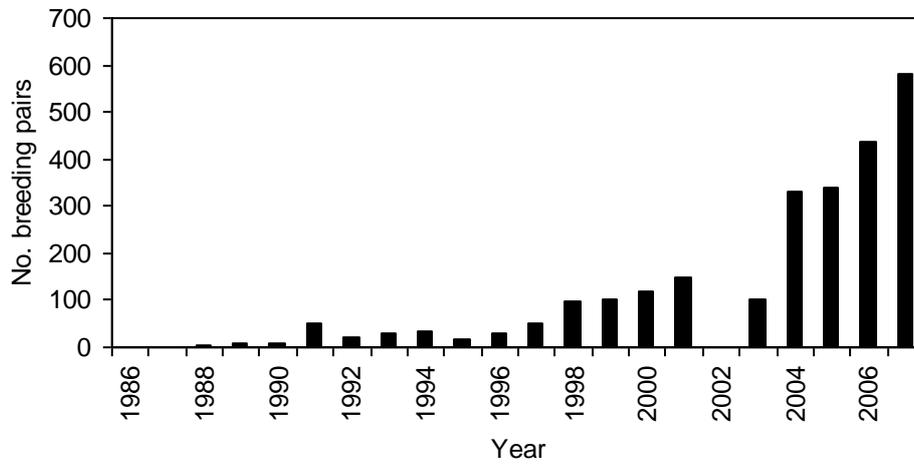


Figure 1. The estimated number of breeding pairs of Greylag Geese on Orkney, 1986 to 2007 (from Meek 2008).

A comprehensive survey of Greylag Geese on 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 $\approx 10,000$ birds (estimated range 9,000 to 11,000). Breeding pairs and post-breeding flocks were recorded on almost all islands in the archipelago, the proximity and mixture of moorland breeding areas, remote and safe offshore islands, large inland lochs, and intensively managed grasslands helping to fuel the dramatic increase in numbers (Figure 2). The number of successfully breeding pairs was estimated at ≈ 800 -1,000. The largest moult gathering was a single flock of 1,485 geese using Linga Holm which comprised non-breeding birds together with many families.

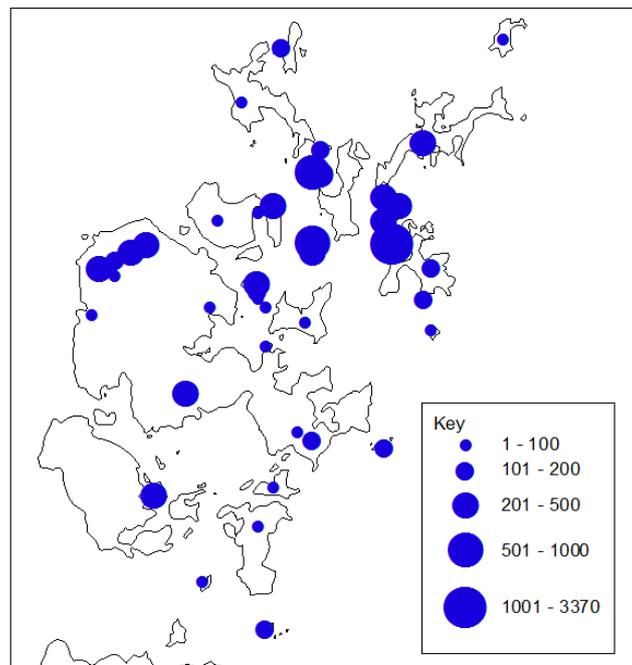


Figure 2. The distribution of Greylag Geese on Orkney in July 2008, when geese were moulting (from Mitchell *et al.* 2010).

In order to manage both Greylag Goose populations in Scotland, up to date information is needed on population delineation and regular assessments on the status and distribution of the geese. This is particularly pertinent on Orkney where both populations occur in winter in large numbers. The Scottish Government and Scottish Natural Heritage (SNH) are considering implementing an adaptive harvest management system to manage Greylag Goose abundance in trial areas of Scotland, including Orkney. Assessing the abundance and annual productivity of Greylag Geese on Orkney in summer will therefore provide essential baseline data for the demographic modeling required by this process. This report also provides suggestions for future monitoring methodology for Greylag Geese on Orkney.

2 Methods

2.1 Field counts

During a national Greylag Goose survey in 2008 (Mitchell *et al.* 2010), Orkney was counted at the time of the annual wing moult (early July). Local counters had suggested that the birds would be dependent on waterbodies and small offshore islands, using the sea as a refuge. During the survey, larger than expected numbers of birds were encountered on offshore islands, particularly in Wide Firth. Repeating a survey at this time of year would have necessitated surveillance using boats and increased the chance of either missing birds due to lack of coverage of certain areas, or double counting birds moving from one area of sea to another. After consultation with local counters, it was decided to attempt to count the geese during late August 2012, a time when the geese have completed their moult and have moved to feeding areas on the main islands. Local observation in previous years suggested that, by this time, the geese would be using largely agricultural land (a time which brings them into conflict with agricultural interests) and an understanding of the distribution of the geese at this was therefore considered desirable. However, the survey in 2012 aimed to ensure that all habitats were adequately checked. In addition, counts of Greylag Geese are also undertaken at this time of year on Tiree & Coll and the Uists, so establishing counts to coincide with these areas was also a consideration.

WWT staff liaised with professional and volunteer goose counters on Orkney to arrange 'look-see' coverage of agricultural land and natural wetland habitats on Orkney on 24-26 August 2012, 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). In addition, several islands in Wide Firth and the Sound of Faray (e.g. Muckle Green Holm) were checked using two observers visiting the islands using a rigid inflatable boat (RIB).

2.2 Random stratified survey

On Mainland (West Mainland, East Mainland and Deerness), a random stratified sample of 1km squares was checked for geese on 27-29 August. Mainland was chosen because of practical resource constraints and because culling of Greylag Geese was being planned on Mainland in late summer 2012.

In February 2012, the locations of wintering geese had been recorded for the first time for the whole Orkney archipelago; the resolution for the distribution was at the 1km square level. This allowed a comparison of habitat type (the dominant habitat type for each 1km square) with the distribution of the geese at that time of year.

A sampling methodology was derived to facilitate increased survey effort in August 2012 in areas with higher than predicted occupancy by geese in different habitats (based on the February 2012 counts). Analysis of the relationship between Centre for Ecology and Hydrology (CEH) remotely sensed 'Land Cover Map of Great Britain' (LCM2007) data and winter Greylag Goose distribution data, when the geese were largely found on agricultural land, indicated that improved grassland was particularly associated with the presence of Greylag Geese on Mainland (see Appendix 1). This variable was therefore used as a stratum within the random stratified sampling (see Appendix 1).

All areas within each 1km square chosen for counting in late August 2012 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 in late August 2012 from the randomly checked squares, a bootstrap method was then used to derive population estimates for Greylag Geese in individual strata. Within each strata, n counts were randomly selected, with replacement, from the 2012 data using 999 repetitions, where n equaled the number of 1km squares not visited in that strata. It was assumed that the probability of detection of geese was similar for all habitats (but see Discussion). 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.

2.3 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.

3 Results

3.1 Field counts

Whole archipelago counts were completed on 24-26 August and involved ≈ 27 person days of time (see Table 4, below). All areas checked during the bi-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.

A total of 21,367 Greylag Geese was counted in 260 flocks (median 36 birds, range 1 to 711), with the largest numbers found on Mainland, Sanday and Shapinsay (Table 1, Figure 3). Mainland accounted for approximately half of the total number of geese counted (49.7%, 10,625 geese). The density of Greylag Geese per hectare ranged from 0 ha⁻¹ on several islands to 0.73 ha⁻¹ on Burray, with an overall density of 0.21 ha⁻¹ for the archipelago (Table 1).

Table 1. The abundance and distribution (by major island) of Greylag Geese on Orkney, during 24-26 August 2012, with estimated densities based on habitat classes.

Area ¹	Count	Area (ha) ²	Density (geese ha ⁻¹)	Density (geese ha ⁻¹) on agricultural land ³
Mainland ⁴	10,625	52,325	0.20	0.52
Sanday	2,591	5,043	0.51	0.85
Shapinsay	1,765	2,948	0.60	1.33
South Ronaldsay	1,234	4,980	0.25	0.47
Eday	1,138	2,745	0.41	1.04
Stronsay ⁵	951	3,430	0.28	0.44
Westray	840	4,713	0.18	0.28
Burray ⁶	731	1,098	0.67	1.52
Rousay/Eynhallow ⁷	399	4,935	0.08	0.34
North Ronaldsay	389	690	0.56	0.82
Papa Westray	343	933	0.37	0.80
Hoy/South Walls ⁸	107	14,558	0.01	0.08
Small Holms ⁹	92	265	0.35	0.57
Flotta/Fara/Switha ¹⁰	87	1,212	0.07	0.59
Gairsay	55	240	0.23	0.45
Auskerry	20	85	0.24	0.49
Egilsay	0	650	0.0	0.0
Wyre	0	311	0.0	0.0
Copinsay	0	73	0.0	0.0
Swona	0	92	0.0	0.0
Graemsay	0	409	0.0	0.0
Total	21,367	101,663	0.21	0.55

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

⁷ Includes Rousay (4,860ha) and Eynhallow (75ha).

⁸ Includes Hoy (13,458ha) and South Walls (1,100ha).

⁹ Includes Faray (180ha), Holm of Faray (29ha), Muckle Green Holm (28ha), Sweyn Holm (18ha), Rusk Holm (6ha) and Little Green Holm (4ha).

¹⁰ Includes Flotta (876ha), Fara (295ha) and Switha (41ha).

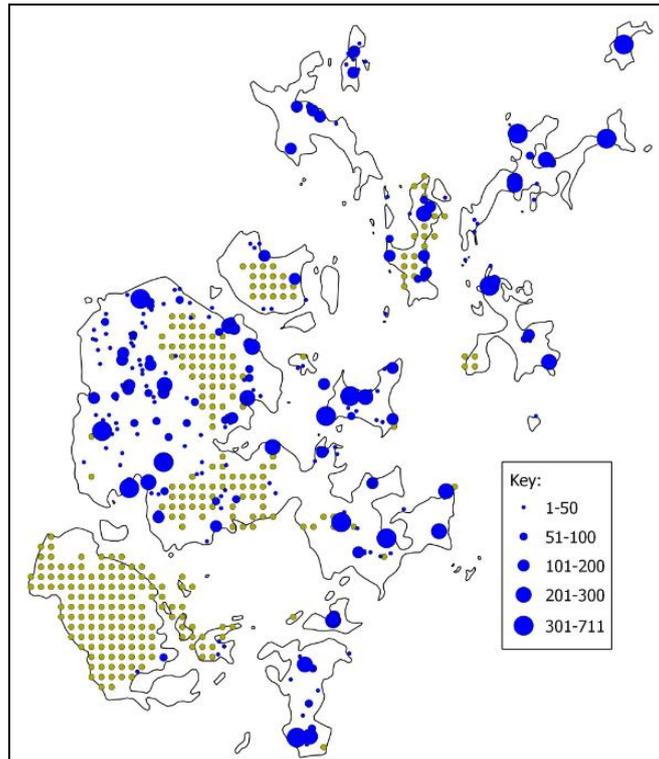


Figure 3. The distribution of Greylag Geese found during field surveys in late August 2012. Blue dots are proportional to flock size. One km squares dominated by moorland are shaded in brown.

Some of the habitat on Orkney is moorland (Figure 3) 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’ (improved grassland and arable combined), the density of Greylag Geese per hectare ranged from 0 ha⁻¹ on several islands to 1.52 ha⁻¹ on Burray, with an overall density of 0.55 ha⁻¹ for the whole archipelago (Table 1).

Flock size (encountered during the field surveys) was highly skewed (Figure 4). Of the 260 flocks recorded, 150 (57.7%) were of less than 50 birds. However, 31 (12%) contained over 200 birds, the largest flocks being of 510, 550, 579, 689 and 711 birds.

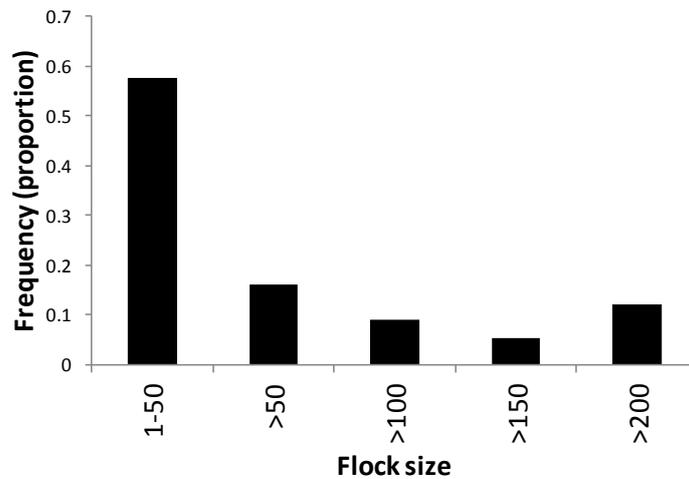


Figure 4. Frequency of flock size of Greylag Geese encountered during field surveys on Orkney in late August 2012.

3.2 Habitat preferences of Greylag Geese

Not all records of Greylag Goose flocks were accompanied by habitat information (although this had been asked for). Consequently, the location of flocks of geese found during August 2012 was compared to habitat types according to the LCM 2007 data set. Waterbodies (either open freshwater or saline/brackish water) were excluded from the analysis since geese were only encountered there loafing or after being disturbed from feeding areas. The comparison revealed a strong preference for improved grass and arable fields, use of semi-natural grass fields in proportion to those available and an avoidance of moorland (LCM 2007 class mountain, heath and bog) (Table 2, Figure 5).

Table 2. The location of flocks of Greylag Geese encountered during late August 2012 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) on Orkney	Percentage of total area	No. geese counted in habitat class in August 2012	Percentage of geese counted in habitat class	Jacobs Index
Improved grass	4	35,969	37.1	9,805	54.2	0.33
Arable	3	2,589	2.7	866	4.8	0.29
Semi-natural grassland	5,6,7,8,9	29,029	29.9	5,499	30.4	0.01
Moorland (mountain, heath, and bog)	10,11,12, 13,14	23,462	24.2	877	4.8	-0.72
All other habitats ¹	1,2,15-23	5,886	6.1	1,056	5.8	-0.02
Total		96,939 ¹	100.0	18,103 ²	100.0	

Notes:

¹ Total excludes areas of freshwater (LCM 2007 code 16) and saltwater (LCM 2007 code 17).

² Total excludes birds counted on freshwater (n=2,139) and saltwater (n=1,125).

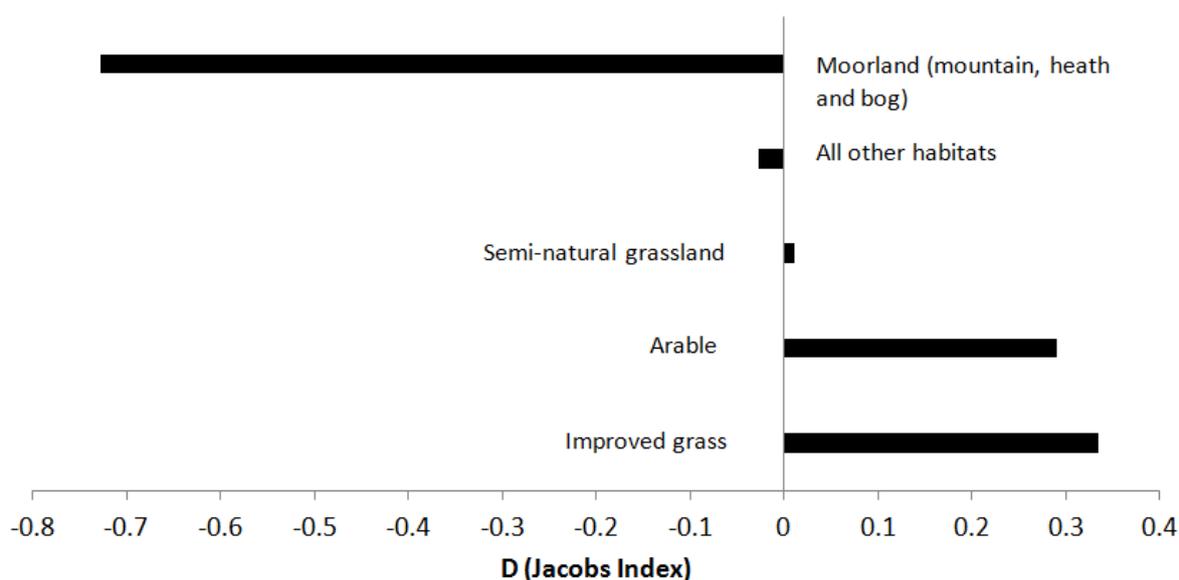


Figure 5. Habitat preferences of Greylag Geese in August 2012 expressed by Jacobs Index (D). The index ranges from -1 (complete avoidance) to +1 (exclusive use).

However, even when Greylag Geese were found in moorland habitats, the geese tended to be feeding in small patches of semi-natural grass within the heather (pers. obs.). The preference for improved grass fields and avoidance of moorland habitats in August 2012 was similar to the habitat preferences found in February 2012, when both Iceland and British Greylag Geese were present (see Appendix 1) and which guided the sampling for the random stratified survey.

3.3 Random stratified survey

In total, 82 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, Appendix 2, Figure 6).

Table 3. Extrapolated estimates using bootstrap analysis for individual strata during late August 2012.

	No. 1km squares in stratum (% of total)	No. sampled (% of total sampled)	Lower 95%	Mean	Upper 95%	Extrapolated estimate
Improved grassland	281 (50.1)	51 (62.2)	4,345	7,630	11,359	7,677
Semi-natural grass	160 (28.5)	20 (24.4)	691	2,525	5,010	2,509
Moorland, (mountain, heath and bog)	110 (19.6)	11 (13.4)	36	379	963	360
Other habitats	10 (1.8)	None surveyed				
Total	561	82 (14.6)	5,072	10,534	17,332	10,546
Estimate			6,472	10,546	14,968	
Known sites	8 ¹	8		1,257		
Overall estimate (including known sites)	569	90	6,472	11,803	14,968	

Notes:

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

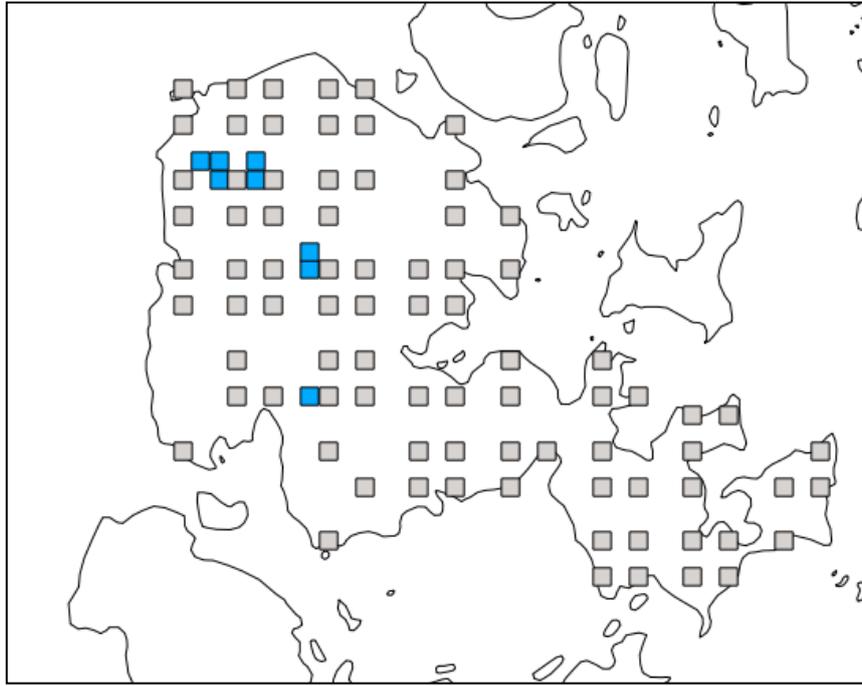


Figure 6. The distribution of 82 1km squares surveyed as part of the random stratified survey (grey), together with the distribution of the 8 'known sites' squares (blue).

Whilst the mean estimate using bootstrap analysis (11,803) was reasonably close to the estimate obtained through field counts (10,625), the 95% confidence limits were very large (6,472-14,968 or -45% to +27% of the mean value). Increasing the sample size of 1km squares surveyed would, presumably, reduce the confidence intervals.

3.4 Comparing field counts and the random stratified survey

Using the simplest comparison, the random stratified survey counted a total of 1,700 geese in 82 1km squares; or 0.21 geese ha⁻¹. This compares with 0.20 geese ha⁻¹ counted during the field counts (10,625 geese counted on Mainland (52,325 ha), Table 1) thus giving some confidence that the field counts were accurate.

However, it was not possible to directly compare the counts made during the field counts with those made during the random stratified survey. The latter occurred between one and three days after the former, during which time goose flocks may have moved between fields and consequently moved from one 1km square to another. For example, of the 82 1km squares surveyed during the random stratified survey, only 18 (22%) 1km squares held geese in which they had been recorded during the field counts one to three days earlier. Whilst this should not matter to the random stratified survey process (the technique involves surveying random squares), adequate coverage of areas of agricultural land on which geese are usually quite visible to experienced counters might generate greater confidence that large numbers of geese are not being missed.

3.5 Age counts

A sample of 1,122 geese was aged on Mainland and Sanday of which 280 (24.9%) were young. The sample represented *c.*5.3% of the Orkney population. The mean brood size was 2.95 young per successful pair. There was large variation in the proportion of young encountered (Figure 7). Occasionally, single families or small groups of families, with a correspondingly high percentage of young were encountered in fields. Other samples contained few young. For example, a sample of 93 Greylag Geese aged in a flock

of 711 geese on Sanday, contained only three young (a single brood of three goslings) and presumably this flock comprised a non-breeding gathering.

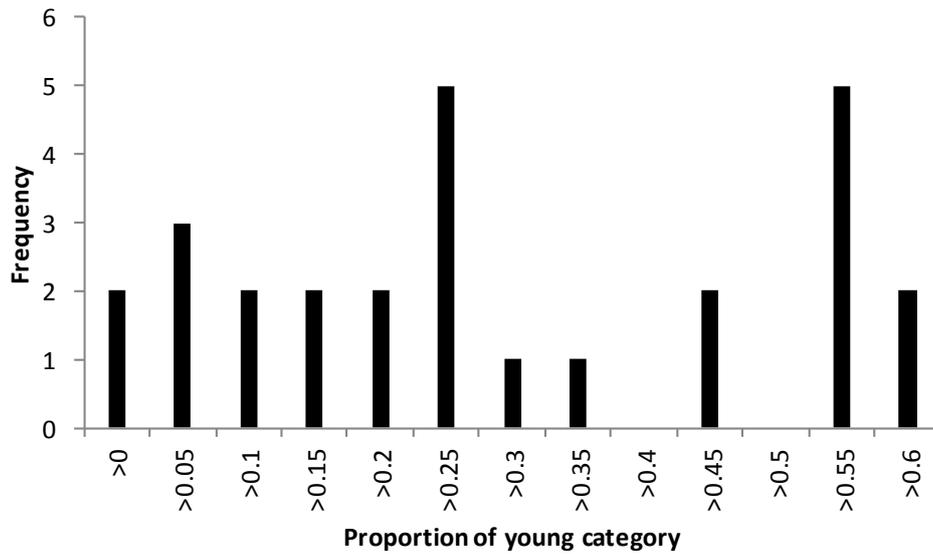


Figure 7. Frequency of categories of proportion of young encountered during field surveys on Orkney in late August 2012.

If the proportion of young recorded was indicative of the whole population on Orkney, then approximately 5,320 birds were goslings ($21,367 * 0.249$). The mean brood size was 2.95 goslings, suggesting that, as an approximation, there were potentially 1,800 successful pairs of Greylag Geese on Orkney in summer 2012. This is three times the estimated ≈ 600 pairs thought to be nesting in 2007 (Meek 2008). 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). Thus, the total number of breeding Greylag Geese on Orkney is likely to be higher than the estimated 1,800 successful pairs.

4 Discussion

4.1 Abundance and rates of increase

The survey in late August 2012 provided the first archipelago-wide assessment of the abundance and distribution of Greylag Geese on Orkney at this time of year. The comparison of densities of Greylag Geese counted during field counts, compared to those counted during thorough checking of 1km squares (0.20 and 0.21 geese ha⁻¹, respectively) gives some confidence that August 2012 count was accurate.

The total number of geese counted (21,367) was more than twice the number estimated on Orkney in July 2008, when Mitchell *et al.* (2010) reported an estimate of 10,000 birds (range 9,000 to 11,000). Such a rapid increase in numbers would therefore involve a theoretical annual rate of increase of *c.*19% per annum (Figs 8a and 8b). Mitchell *et al.* (2010) suggested that the July 2008 survey may have underestimated the true number of geese present at that time. This is because many geese were found moulting on offshore islands (and would retreat to the open sea when disturbed; an aspect of their moult strategy only discovered during the July 2008 survey), and counting them necessitated the use of a boat, particularly in Wide Firth. It is possible therefore, that some moulting flocks on the sea were missed in other parts of the archipelago.

Figures 8a and 8b show the theoretical rates of increase needed to reach a population estimate of 21,367 in August 2012 (*c.*19% per annum). Note that the y-axis in Figure 8a is a logarithmic scale. The graph assumes that the count in July 2008 was 10,000.

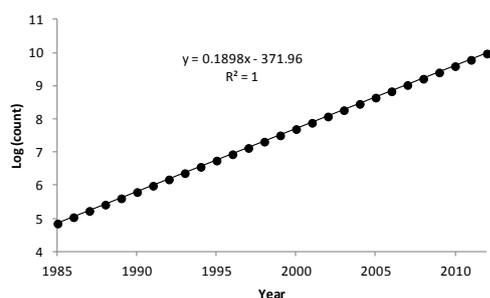


Figure 8a. Theoretical rate of increase in British Greylag Geese on Orkney. Logarithmic scale.

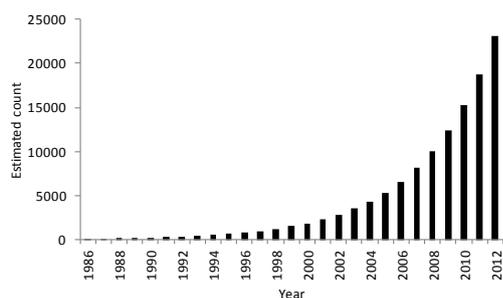


Figure 8b. Theoretical rate of increase in British Greylag Geese on Orkney.

In order to better explain the apparent rate of increase in the number of Greylag Geese on 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 forward, annual modeling of demographic rates is a pre-requisite for adaptive harvest management (Madsen & Williams 2012).

Given the largely sedentary nature of Greylag Geese, colonisation of new areas probably occurs at a rather modest rate. However, once colonisation does occur, and assuming breeding and feeding conditions are favourable, population growth, after an initial slow start, can be quite rapid. A rate of increase of 19% per annum is high but possible, especially where colonisation of new breeding areas is followed by high levels of breeding success.

Between the late 1970s and mid-1990s, grants for re-seeding hill land were available to farmers through Agricultural Improvement Grants. As a consequence, the area of grassland on Orkney increased. Many of these improved fields were set in relatively undisturbed areas of hill land throughout the islands. This created a mosaic of heather moorland, improved grassland and freshwater lochs, perfect habitat for breeding Greylag Geese: moorland for nesting, good grazing in relatively undisturbed areas to feed

goslings and freshwater bodies for safety. In effect, the landscape could not have been managed in a more effective way to encourage Greylag Geese to breed on Orkney.

Greylag Geese can have particularly high annual rates of breeding success, for example on Tìree 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 2012, there was 24.5% young in the sample aged on Orkney, although with marked variation between flocks (see above), 32.2% young were recorded in Greylag Goose flocks on Tìree (J.Bowler pers. comm.) and 25.1% young were recorded on the Uists (P. Boyer pers. comm.).

In Tìree and the Uists, recent high levels of shooting have increased annual mortality and this has either reduced the total population estimate (on Tìree) or stabilised it (on the Uists). Estimated rates of increase in other parts of Scotland range from 11.7% for north and west Scotland overall (Mitchell *et al.* 2010) to c.17–20% per annum between 1999 and 2011 on Shetland (Harvey *et al.* 2012).

Thus it seems likely that the rapid increase in numbers of Greylag Geese on Orkney has been accompanied by characteristically high levels of annual breeding success and relatively low levels of mortality (either natural or through hunting). A tendency towards mild winters since the 1980s, more intensive management of in-bye grassland, an absence of mammalian predators and, thus far, rather little hunting in the early autumn, may all be contributory factors fuelling the rate of increase.

5 Recommendations for future monitoring

If any form of adaptive harvest management of Greylag Geese is to take place on Orkney, then the *minimum* demographic requirements are:

- Annual assessment of abundance.
- Annual assessment of reproductive output (breeding success).
- Annual assessment of survival (derived through analysis of ring/recovery and re-sightings or individually marked birds).

These demographic parameters are then used to model likely outcomes (population level response) from proposed cull levels.

Larger than expected numbers of birds were found moulting on offshore islands in July 2008. Repeating a survey at that time of year would necessitate surveillance using boats and this would increase the chance of either missing birds due to lack of coverage of certain areas, or double counting birds moving from one area of sea to another. During late August, a time when the geese have completed their moult, the geese use largely agricultural land to feed. Counts of Greylag Geese are also undertaken in late August on Tìree & Coll and the Uists. For these reasons, it seems practicable to carry out future surveys in late August, ensuring, wherever possible that other habitats (semi-improved grassland, wetlands and moorland) are checked.

In August 2012, there was no apparent shooting of Greylag Geese on Orkney. Allowing shooting during the time of the survey could potentially disrupt attempts to count the geese. Counts of Greylag Geese on the Uists and Tìree are undertaken prior to the start of the wildfowling season (normally 1 September each year) because, after that date, the geese become nervous and take to flight when cars (and humans) approach them. Shooting at geese causes flocks to move and mix with other flocks, increasing the possibility of double counting. It is recommended that goose shooting does not take place at the time of future surveys and for at least a week beforehand.

The complex nature of the archipelago meant that a total of 27 person-days was needed to survey Orkney for Greylag Geese in late August 2012 (Table 4). The monitoring effort (in terms of manpower and costs) cannot easily be compared with counting Greylag Geese on Tìree or the Uists, where counting is largely limited to single islands or islands linked by causeways. To ensure coverage of islands within the Orkney archipelago, a return ferry journey and a single person-day may be needed to visit some of the smaller islands and a RIB needed to cover some of the smaller islets. In addition, on Orkney, some of the counts were undertaken by volunteer counters. This help may not be available for future surveys.

Table 4. Person-days needed to count Greylag Geese on Orkney during 24-26 August 2012.

Area	Person-days	Transport needed
Mainland	8	5-8 cars ¹
Sanday	2	Ferry plus two cars
Shapinsay	1	1 car
South Ronaldsay	1	1 car or bicycle
Eday	1	1 car
Stronsay	1	Ferry plus one car
Westray	1	1 car
Burray	0.5	1 car
Rousay	2	Ferry plus one car
North Ronaldsay	1	1 car
Papa Westray	0.5	1 car
Hoy	1	1 car
Small Holms	2	RIB
Flotta	0.5	1 car
Gairsay	0.5	RIB (unless counted by inhabitant)
Auskerry	0.5	RIB
Egilsay	0.5	1 car
Wyre	1	Ferry plus 1 car
Copinsay	1	RIB
Swona	0	Checked from ferry
Graemsay	1	Ferry
Total	27	

Notes:

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

For the field survey, Mainland was covered by five counters on one day and three counters on a second day (8 person-days in all, Table 4). The random stratified survey of 82 1km squares was undertaken by two counters and took three days (6 person-days in all), thus the amount of time and cost of surveying using both techniques was comparable, although clearly the area covered by the random stratified survey was less than the field counts.

The road and track network on Orkney gives excellent access and viewing to virtually all agricultural land, and given the preference of Greylag Geese to use agricultural land (Table 2, Figure 5) there is presumably a high chance of detecting geese in this habitat. In some areas, access on foot is required, but this does not limit viewing coverage. Experienced observers resident on Orkney considered that the field count survey gave an accurate assessment of abundance with few, if any, birds being missed (although this cannot be quantified). This is also the approach that has been adopted for winter Icelandic-breeding Goose Census (IGC) counts carried out on Orkney since the 1980s and so the counter expertise and local knowledge needed to undertake this survey comprehensively is high.

Random stratified surveys are excellent for either detecting species that are thinly distributed in the landscape, and/or for estimating the abundance of species in very large areas through sampling (e.g. national surveys). However, the distribution of post-breeding goose flocks tends to be clumped (their behaviour is very much structured around flock dynamics) and, as a consequence, confidence intervals from bootstrapping can be large, as was the case in this study. In addition, the geese on Orkney can be quite mobile, moving from one area to another. Whilst this should not matter to the random stratified survey process (the technique involves surveying random squares), adequate coverage of areas of agricultural land on which geese are usually quite visible to experienced counters might generate greater confidence that large numbers of geese are not being missed. In addition, the total area checked on Orkney for geese is relatively small (only $\approx 1,000$ km²).

Given the very large confidence intervals generated by the random stratified survey and bootstrap analysis, which limits future interpretation of trends in abundance, there are several options for future monitoring of post-breeding Greylag Geese on Orkney, including :

- a) Maintain the 'look-see' field counts only. For coverage of all the islands, if this is a goal of future surveys, in terms of practical resource constraints, this seems the most appropriate strategy. Allow a budget to cover 27 person-days plus associated costs of transport (ferries and cars).
- b) Maintain the random stratified survey on Mainland at the existing sampling rate only (or increase the sampling rates, especially in 1km squares dominated by improved grassland). Consider extending the random stratified survey to the other islands groups if a total population estimate for Orkney is required. Allow a comparable budget for person-days plus associated costs of transport (ferries and cars).
- c) Maintain both the 'look-see' field counts for all islands and random stratified survey on Mainland at the existing sampling rate (or increased sampling rate).
- d) Count Mainland, which held c. 50% of the Orkney population in 2012, each year and account for under one third of the person days, annually and count the whole Orkney islands only periodically (e.g. every three years).

Given the high (but unquantifiable) level of confidence expressed by the counters, the preference showed by the geese for improved grassland and the clumped nature of the counts, it seems practicable to recommend option a) for future monitoring. However, the frequency of assessing the abundance and distribution of Greylag Geese on Orkney needs to be dictated by management needs, but would need to be annual if culls are carried out each year.

An annual assessment of productivity can be undertaken at the same time that post breeding monitoring of abundance is carried out. Collecting as large a sample size as is practicable is desirable and a goal of at least 5% of the total population is recommended. Age counts should be undertaken from a wide range of locations to sample flocks comprising successful breeding pairs and non-breeding aggregations. Samples should also be obtained from a wide range of habitats if possible. Brood sizes should also be obtained wherever practicable.

Counts of brood sizes earlier in the season (e.g. July) have been carried out for several years by RSPB Scotland staff on Orkney. Existing data could be collated and future surveillance encouraged since they offer an additional assessment of breeding success at a time of year when young goslings may be prone to higher mortality than in late August (e.g. from Great Skuas *Stercorarius skua*).

Ringling of Greylag Geese on Orkney has been carried out since the mid 2000s, largely based on summer round ups of moulting birds, with the financial support of SNH. Data resulting from the ringling and marking of individuals helps in understanding movements both within and outwith the Orkney islands. For example, a very small number of summering birds have been recorded further south within Scotland, and as far south as Norfolk, in the non-breeding season. Ring-recovery and ring-sighting data can also be used to generate survival estimates which are a pre-requisite for demographic modeling. Maintaining a cohort of ringling individuals is highly recommended if adaptive harvest management is to be considered.

It is recommended that before any attempt at adaptive harvest management of Greylag Geese is carried out on Orkney, the objectives of such a scheme are identified, and actions follow an adaptive management framework and modelled concept for the population (see Madsen & Williams 2012). Adequate surveillance of demographic parameters are a fundamental pre-requisite for population modeling.

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Appendix 1

Strata used in the random stratified sample of 1km squares on Mainland.

There are 569 1km squares on Mainland (includes West Mainland, East Mainland and Deerness). This is larger than the calculated area (52,325 km²) because coastal 1km squares include areas of sea, which are not included in the calculated area.

Prior to 2012, no systematic surveys of the summer distribution of Greylag Geese had been carried out. In order to see if geese preferred certain habitats, so that more of those habitats during the summer 2012 random stratified survey could be checked, proportionate to the expectation of the presence of Greylag Geese, a comparison was therefore made between the presence/absence of Greylag Geese (>10 birds) using count data from the February 2012 winter survey (resolution 1km square) and habitat classifications at the 1km level. The LCM 2007 dataset allocates aggregated habitat classes to each 1km square in Britain and provided data on three main broad habitat classes on Orkney (Table 5).

Table 5. A comparison of the habitat classifications at the 1km² level for Mainland, Orkney and Greylag Goose distribution in February 2012.

Aggregate habitat class	Number of 1km squares dominated by that habitat (%)	Number of 1km squares in which >10 Greylag Geese were recorded in February 2012 (%)	Jacobs Index	Comments
Improved grassland	281 (50.1)	182 (66.9)	0.330	
Semi-natural grassland	160 (28.5)	70 (25.7)	-0.071	
Moorland (mountain, heath and bog)	110 (19.6)	20 (7.4)	-0.499	
All other habitats	10 (1.8)	0 (0)	-1.000	Too few to consider sampling
	561 ¹ (100.0)	272 (100.0)		

Notes:

¹ - 561 1km squares were considered on Mainland because 8 1km squares were thought to hold Greylag Geese in late summer ('known' sites, see below).

Association between habitat type and presence of feeding geese recorded in February 2012 was expressed by means of the Jacobs preference index, D (Jacobs 1974):

$$D = (r - p) / (r + p - 2rp)$$

where r is the proportion of birds observed in particular habitat types, and p is the proportion of a given habitat in Mainland (based on 1km squares). The index ranges from -1 (complete avoidance) to +1 (exclusive use).

Greylag Geese recorded during the non breeding season appeared to avoid moorland (mountain, heath and bog) and showed a strong preference for improved grassland (Table 5, Figure 10).

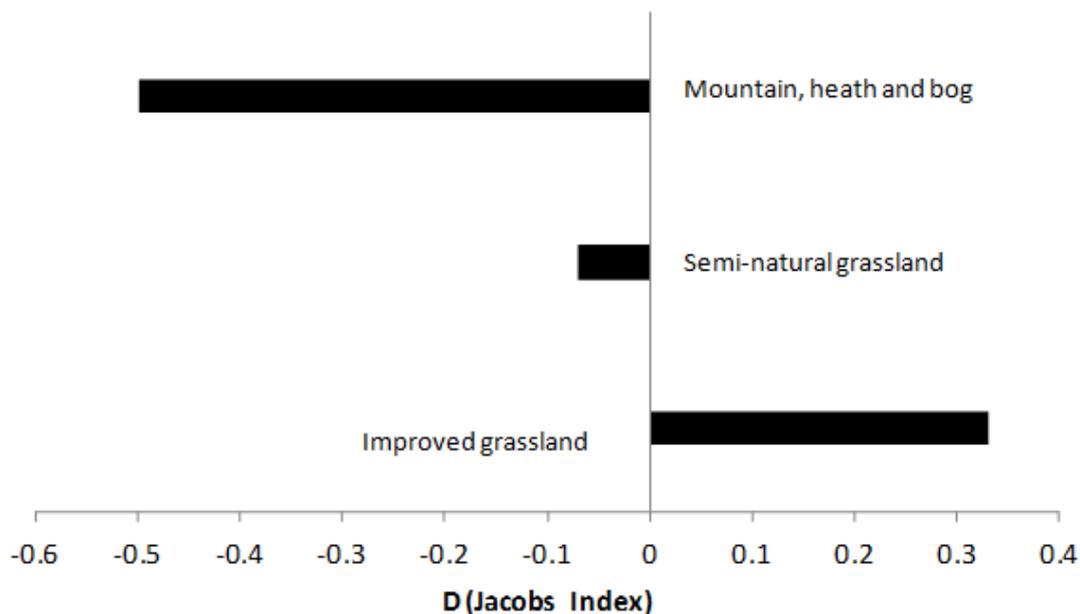


Figure 10. Habitat preferences of Greylag Geese in February 2012 expressed by Jacobs Index (D). The index ranges from -1 (complete avoidance) to +1 (exclusive use).

From discussions with local RSPB conservation staff, eight 1km squares were thought likely to hold feeding Greylag Geese during late summer (Table 6). Since the late summer feeding distribution of Greylag Geese was becoming quite widespread by the late 2000s, undoubtedly more 1km squares could have held feeding geese, the figure of eight 1km squares was considered conservative. The 1km squares thought to hold feeding geese (or ‘known’ sites) were treated as a separate stratum in the bootstrap analysis (see below) and all subsequent calculations relate to the remaining 561 1km squares on Mainland from which a random sample was chosen.

Table 6. Known sites (1km squares) thought to hold Greylag Geese and counted in addition to the random stratified survey.

1km square	Location name	Number of Greylag Geese counted in August 2012
HY3011	Stenness	579
HY3018	Loch of Bosquoy	158
HY3019	The Shunan	357
HY2424	Marwick/The Loons	28
HY2524	The Loons	0
HY2523	Loch of Isbister	5
HY2723	Loch of Banks	43
HY2724	South shore of Loch of Boardhouse	87
	Total	1,257

Sampling rate: The sampling rate was based on an estimate of the time that was available to undertake the counts and consideration given to replicating such a survey in the future. Based on 25 squares in a 5km x 5km block, it was planned to survey approximately four squares (a sampling rate of 16%, Figure 11) with more 1km squares surveyed in areas dominated by improved grassland and fewer squares surveyed in areas dominated by moorland (mountain, heath and bog).

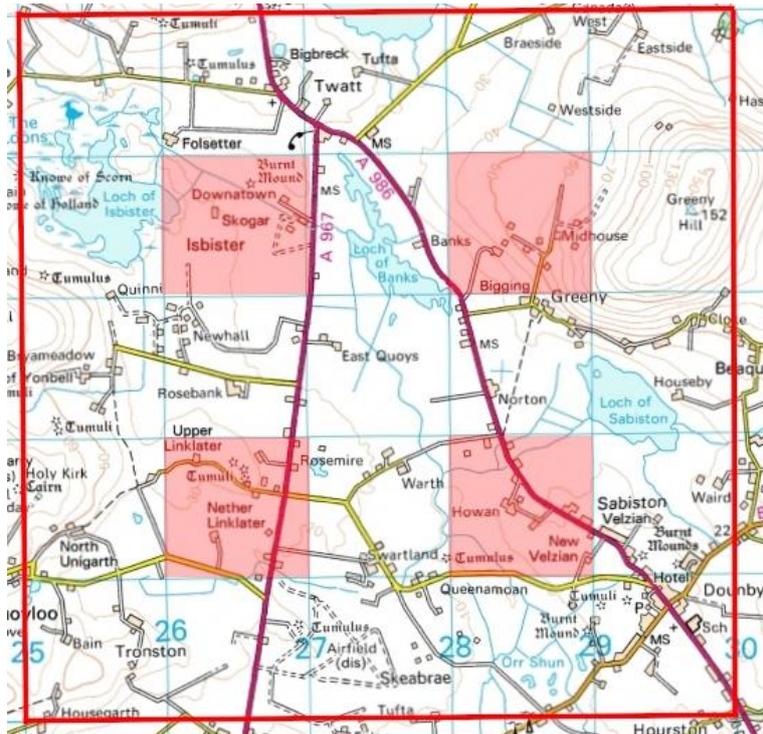


Figure 11. Arrangement of four from 25 1km squares chosen for undertaking the random stratified survey.

Thus, an overall target for sampling was 90 1km squares out of the 561 1km squares (16%) covering Mainland, with a higher sampling rate in habitats with a higher expectation of the presence of Greylag Geese (Table 7).

Table 7. Target and actual sampling rates for the random stratified survey of Greylag Geese on Mainland.

Aggregate habitat class	Number of 1km squares dominated by that habitat (%)	Target number to be surveyed (% of habitat available)	Number actually surveyed in August 2012 (%)
Improved grassland	281 (50.1)	48 (53.3)	51 (62.2)
Semi-natural grassland	160 (28.5)	26 (28.8)	20 (24.4)
Moorland (mountain, heath and bog)	110 (19.6)	18 (20.0)	11 (13.4)
All other habitats	10 (1.8)	None surveyed	None surveyed
	561 ¹ (100.0)	90 ²	82 ³

Notes:

¹ - 561 1km squares were considered on Mainland because 8 1km squares were thought to hold Greylag Geese in late summer ('known' sites, see above).

² - a target rate of 16% (90/561) was set.

³ - an actual sampling rate of 14.6% (82/561) was achieved in two days.

Appendix 2

The land area and calculated area of selected habitat types on Orkney islands.

Table 8. The land area and calculated area of selected habitat types on Orkney islands.

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 Grimbister 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).

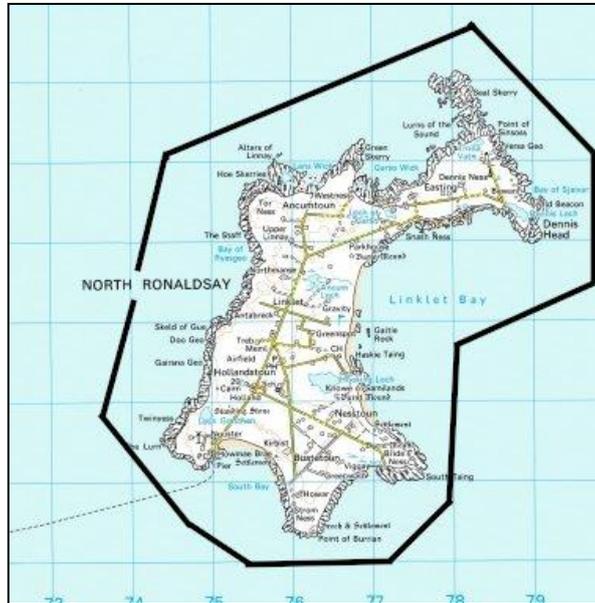
² – Agricultural land defined as arable and improved grassland combined.

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

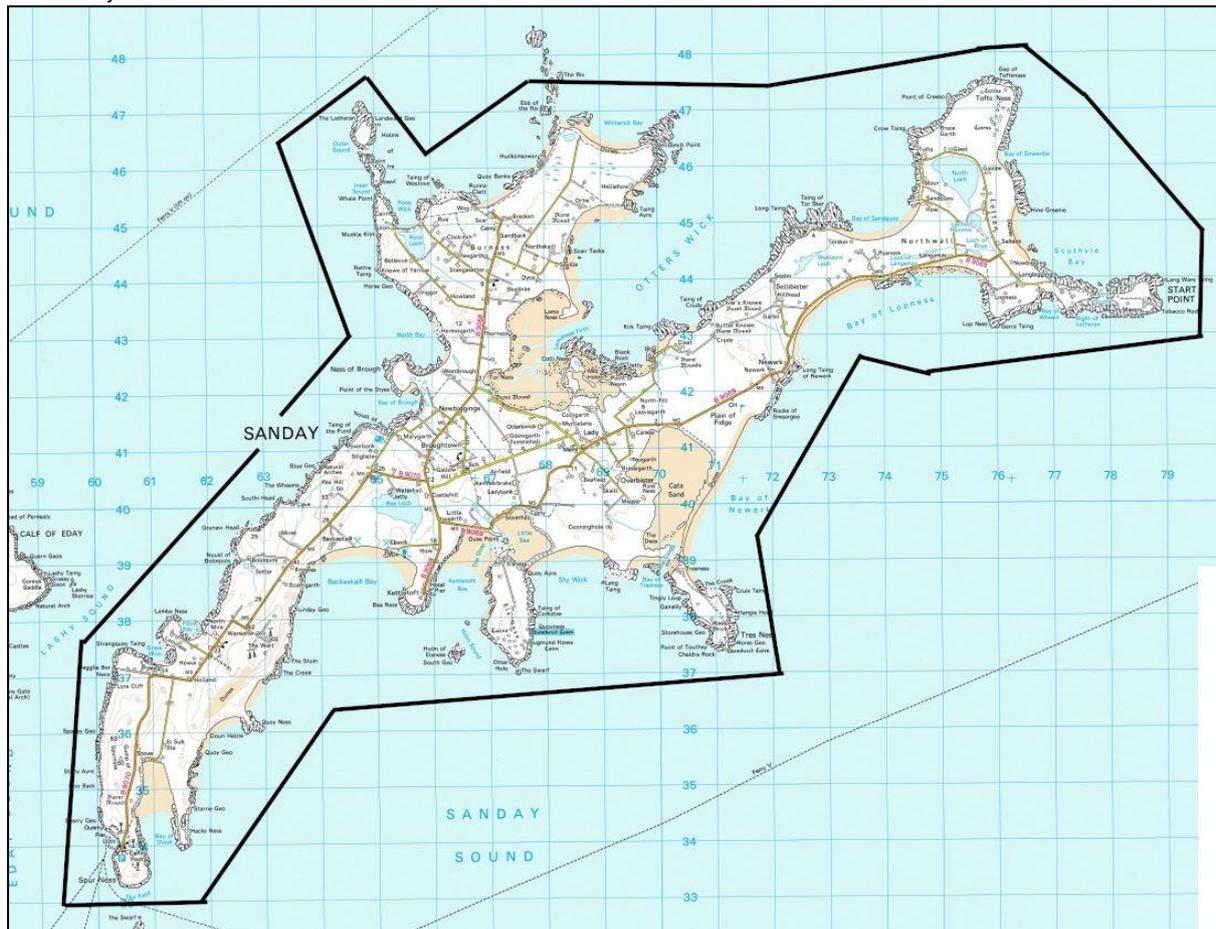
Appendix 3

Base maps of islands in Orkney showing areas of coverage.

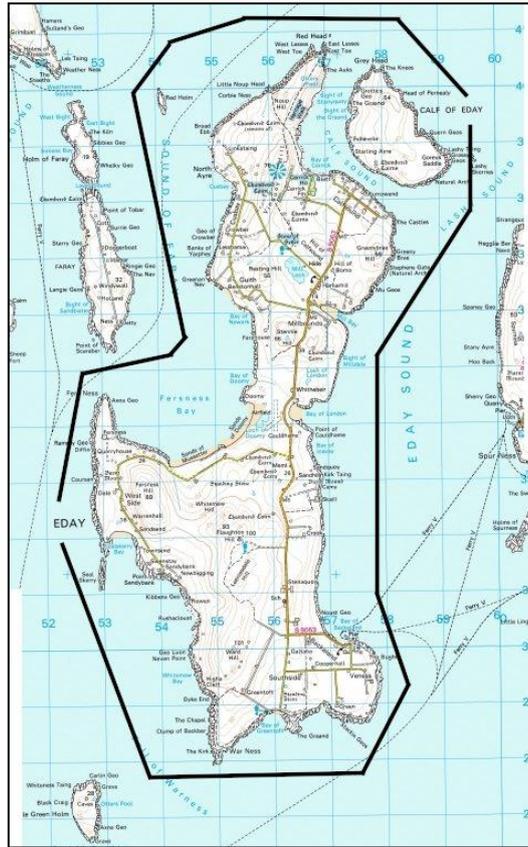
1. North Ronaldsay



2. Sanday



4. Eday



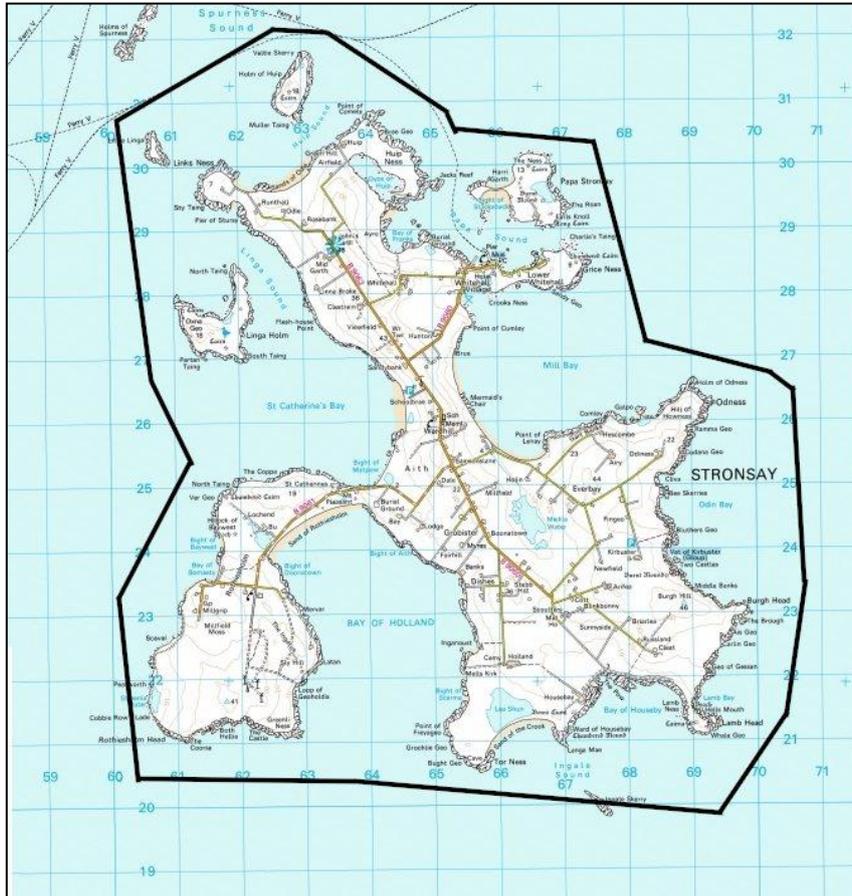
5. Rousay, Egilsay and Wyre



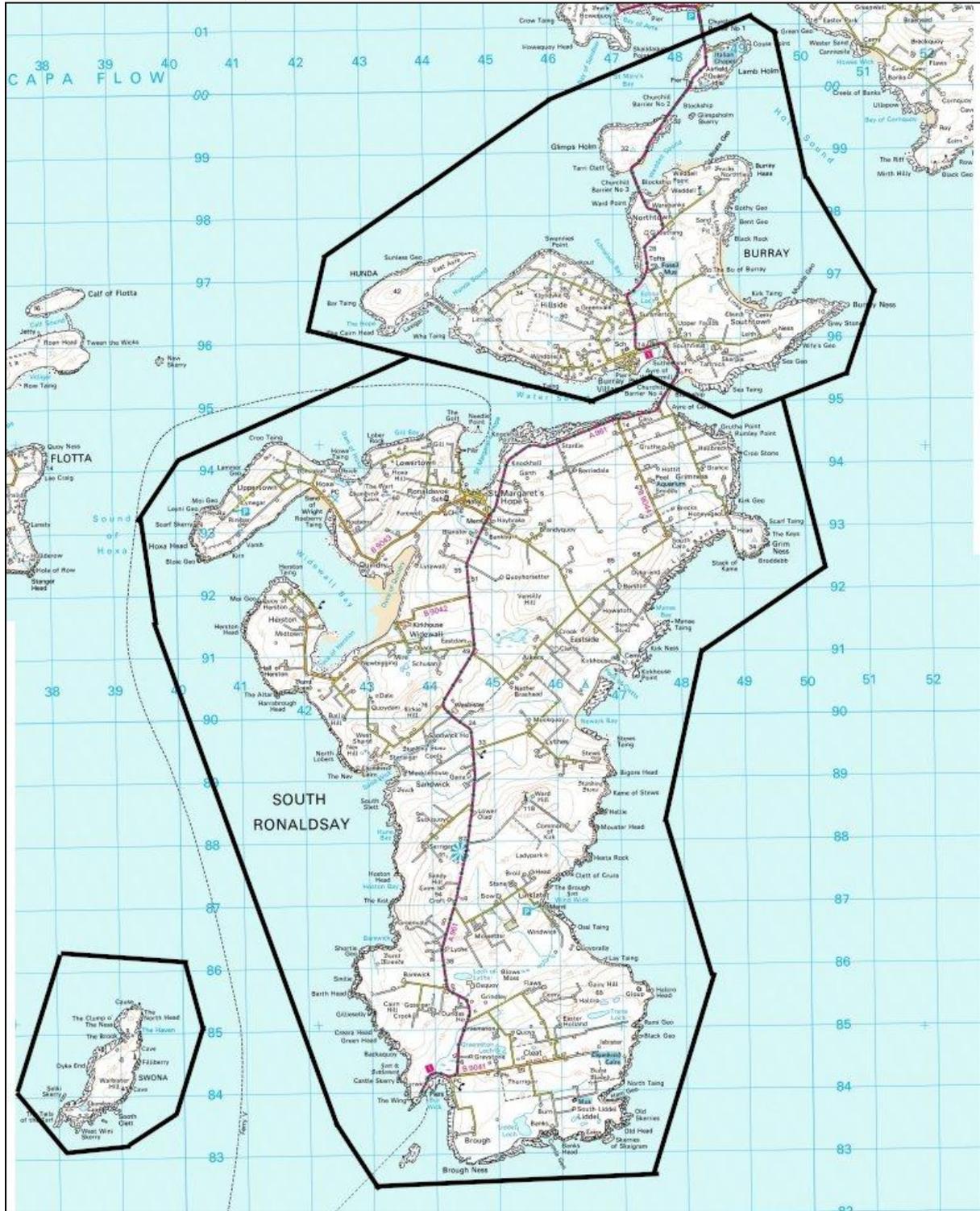
6. Shapinsay and Gairsay



7. Stronsay



8. South Ronaldsay, Burray and Swona



9.Hoy, Graemsay and Flotta



10. Mainland

