

Goose Feeding and Distribution around Loch Leven NNR

Report to Scottish Natural Heritage

by

**The Wildfowl & Wetlands Trust
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1. Executive summary

- 1) This report presents the results of fieldwork undertaken between October 1995 and November 1995 inclusive, to investigate the numbers and distribution of Pink-footed Geese which use the area surrounding Loch Leven National Nature Reserve.
- 2) Loch Leven is one of the top eight sites in Britain for Pink-footed Geese regularly supporting over 10000 geese in the autumn (with peak counts in excess of 20000). Typically, 5000-8000 now remain through the winter decreasing in April as birds move north.
- 3) There has, however, been a shift in the peak arrival time from November to October. The number of Pink-footed Geese counted at Loch Leven in October now forms a larger proportion of the annual autumn population estimate than it did in the 1960s. Conversely, the proportion counted in November appears to have declined slightly. Loch Leven also supports a larger proportion of the autumn regional total than it did thirty years ago, although the regional total expressed as a proportion of the total population estimate appears to be decreasing.
- 4) There is no strong evidence ^{of} ~~for~~ any stabilisation of either local or regional populations in relation to the national population. The slope for Loch Leven v. regional is just significantly less than 1, suggesting that population growth is slightly slower locally than regionally, but the fit is poor and firm conclusions cannot be drawn from this analysis.
- 5) During the study, the number of roosting Pink-footed Geese counted at Loch Leven decreased from (17898 in late September) 13500 in October to 8915 in late November.
- 6) The mean number of feeding Pink-footed Geese counted during daily searches in the study area was 2767 in October and 1836 in November.
- 7) The study area surrounding Loch Leven was c. 140 km² of primarily farmland and comprised, in October, of approximately 47% improved grassland, 28% cereal stubbles, 7% ploughed land, and 3% winter cereals. By the end of November the proportion of cereal stubbles had fallen to 21% and planted winter cereals had increased to 13% of farmland.
- 8) Pink-footed Geese were highly selective of the fields available within the study area. Of 1495 fields checked for feeding geese on 26 count days during the study period, 5% were used by Pink-footed Geese and 1% were used by Greylag Geese. Certain fields held a disproportionately large number of geese. Three fields accounted for 33% of counts of feeding Pink-footed Geese, and nine fields held 50%.
- 9) Overall, Pink-footed Geese showed strongest preferences for newly re-sown grass fields, and cereal stubbles. During 1995/96, Pink-footed Geese primarily fed in broadly similar areas to those in which they were recorded feeding during 1994/95 and 1968/70.

- 10) A total of 324 sightings of 79 individually-marked Pink-footed Geese were obtained during the study. Overall, of the 375 Pink-footed Geese recorded (either caught or seen alive) in the field within the study area during 1994/95, 162 (43%) were seen again during the 1995/96 winter.
- 11) Marked Pink-footed Geese were seen in broadly similar areas to unmarked geese, however individual geese showed strong preferences for certain fields within the study area.
- 12) Age assessments in the field showed that the Pink-footed Geese wintering at Loch Leven contained a similar proportion of young as those wintering in other areas. A higher proportion of young were shot (59%) than was estimated from live capture methods (29%) and age assessments in the field (21.1%).
- 13) A detailed general discussion provides a synthesis of the separate aspects of this study.

2. Introduction

2.1 General background

From December 1994 to March 1995, the daily distribution of feeding Pink-footed Geese *Anser brachyrhynchus* and Greylag Geese *A. anser* around Loch Leven NNR was examined (Hearn & Mitchell 1995). A standard count route was undertaken four days per week. Once weekly dawn roost counts recorded the number of birds using the loch. The study indicated that Loch Leven is one of the eight most important sites in the UK for Pink-footed Geese and over the last 25 years the proportion of the UK autumn population estimate that the loch supports has increased. Loch Leven also now supports a greater proportion of the regional population although south-east Scotland (as a region) is decreasing in importance as a wintering area for Pink-footed Geese. Autumn counts in previous years revealed that Loch Leven is an important staging site for Pink-footed Geese when they first arrive in late September and October. Resightings of individually marked birds have shown that many birds wintering in Lancashire and, to a lesser extent, Norfolk pass through Loch Leven during autumn and spring.

In 1994/95, c.5000-8000 geese were recorded through the mid-winter period. The feeding Pink-footed Geese were found to be highly selective in their distribution over the surrounding area. Only 14.2% of 1492 fields checked were used by Pink-footed Geese, while Greylag Geese were recorded in just 2.9% of the fields. This resulted in a total of 14.6% fields used by both species over the whole study period. Of the 209 fields used by Pink-footed Geese, three supported 10% of all bird days and ten held 25%. In 90% of fields in which Pink-footed Geese were observed feeding on two occasions they were seen again.

The distribution of winter feeding by Pink-footed Geese was found to be very similar^{to} that recorded during 1968-1970 (Newton & Campbell 1973), despite some significant land-use changes in these areas during the intervening 25 years. In 1994/95, improved pasture supported the majority of feeding Pink-footed Geese, with 57% of all birds observed in this crop. However, potatoes and cereal stubble, had a greater degree of preference than improved pasture. Unimproved pasture and winter cereals were also selected in greater proportion than their availability in the study area. Despite this strong preference for improved pasture, Pink-footed Geese were only recorded in 17% of the fields of this crop type.

Over 1000 sightings of 263 marked Pink-footed Geese were made during the 1994/95 study. Of the Pink-footed Geese caught at Loch Leven in October 1994, 72% subsequently moved away from the area. Thirty-nine of these birds were seen wintering further south, and 44% of these were seen back at Loch Leven during the spring. Of those birds caught during December and February, 94% were only seen within the study area and the remaining 6% were never seen again. This indicates the large turnover of birds at Loch Leven during the autumn, and relative winter site fidelity of those birds caught during the winter months.

The 1994/95 study was not initiated until December and consequently, the feeding distribution of Pink-footed Geese when they first arrive at Loch Leven in late September and October was not determined. This is the period when the highest numbers of geese are present in the area, with up to 25000 in recent years (A Lauder pers. comm.). Sightings of colour-marked birds caught at Loch Leven during this period have shown that a large number of birds using the loch during this period spend the majority of the winter

further south, especially in Dumfries & Galloway, Lancashire and Norfolk. A large proportion move north again in February or March passing through the Loch Leven area.

2.2 Aims and objectives

The fieldwork was undertaken between 1 October and 30 November 1995. The study had the following objectives:

- 1) To assess Loch Leven's role and importance for Pink-footed Geese in a local and national context during the autumn.
- 2) To assess the feeding distribution of geese from the Loch Leven roost in relation to agriculture and other relevant influencing factors in the early season period.
- 3) To assess the degree of within-winter and between-winter site fidelity.
- 4) To determine the age and sex structure of the population.
- 5) To collect data in order to develop activity ranges and centres of activity of individually-marked birds.

To address these objectives the following areas of study were undertaken:

- 1) Co-ordinated roost counts at approximately weekly intervals.
- 2) Crop type was determined before and after the study.
- 3) Field searches for feeding geese 3-4 times per week along the route used in the previous winter.
- 4) Checking each feeding flock for the presence of marked individuals.
- 5) Examination of estate shooting bag and cannon-net catches to determine age and sex of a sample of birds.
- 6) Field age counts with a target of 6000 birds to be aged.

3. Study Area

The study area is located in east-central Scotland, within the district of Perth & Kinross, Tayside Region, in the 10 km squares NT90, NT91, NT92, NO00, NO01 and NO02 and is centred around Loch Leven NNR (Figure 1). It covers some 140 km² of modern agricultural land, interspersed with pockets of woodland. The altitude varies from c. 100 m near Auchmuirbridge in the east to c. 230 m near Glenlomond. The main geographical features are the loch itself, the valleys of the River Eden, River Leven and Cairney Water and the edges of the surrounding high ground of the Ochil Hills, Cleish Hills, Lomond Hills and Benarty Hill. The study area is essentially the same one used in 1994/95 (Hearn & Mitchell 1995). The study area boundary remained the same, however, slight changes in individual field boundaries resulted in a total of 1495 fields being checked - an increase of 21 fields compared with 1994/95.

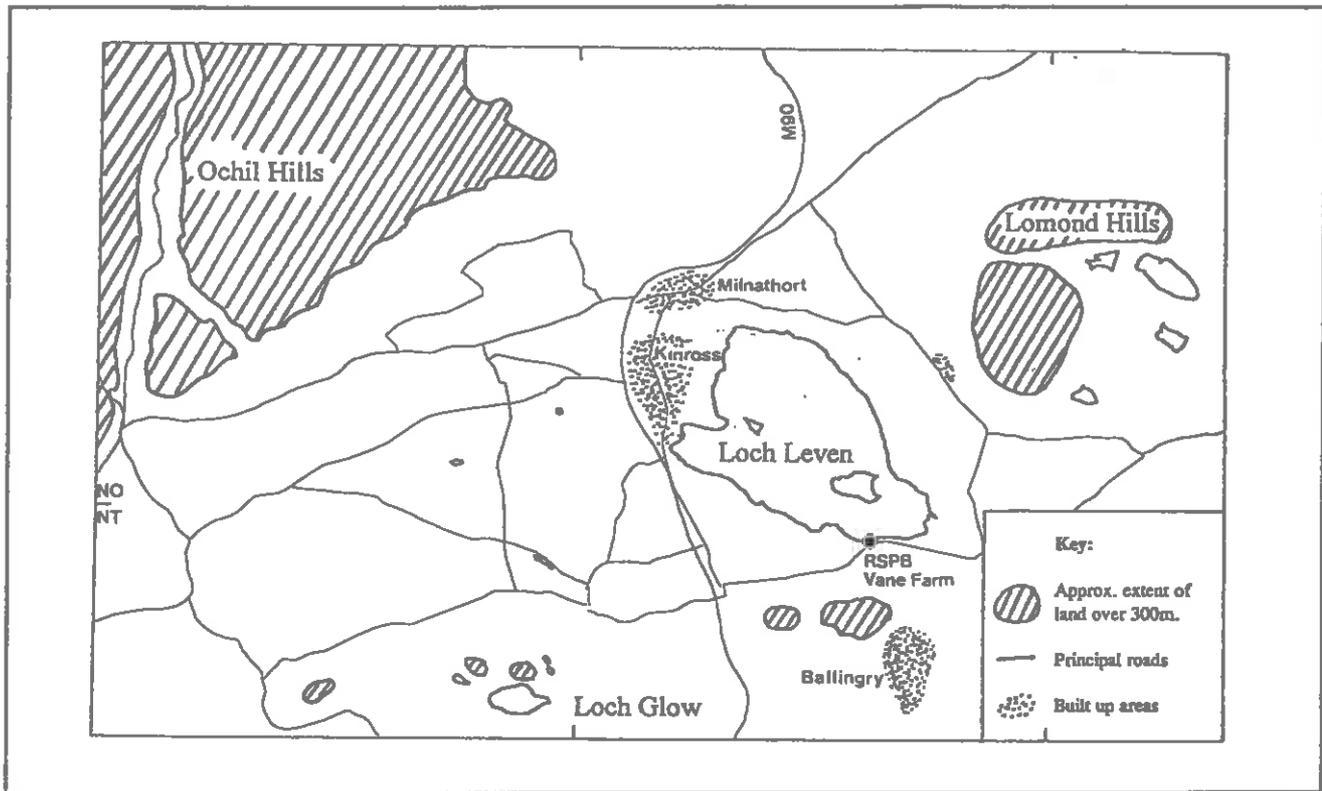


Figure 1. The Loch Leven study area showing the main geographical features.

4. Methods

4.1 Crop Types

The crop type of each of the 1495 fields was determined prior to the study in late-September 1995 and again after the study in mid-December 1995. Each field was categorised into one of the following field types:

Improved pasture
Cereal stubble
Bare soil/Ploughed
Winter brassica
Carrots

Unimproved pasture
Stubble regrowth
Winter cereal
Brassica tops
Fallow

Newly-sown grass
Rape stubble
Winter grass
Potatoes
Miscellaneous

4.2 Co-ordinated Roost Counts

Dawn counts of roosting geese were made at Loch Leven approximately once weekly. The direction of flight from the loch was also recorded. Counters were positioned at three points around the loch to ensure that coverage was as comprehensive as possible (Figure 2). The three vantage points offered excellent views over the loch and have been used for previous roost counts at the site.

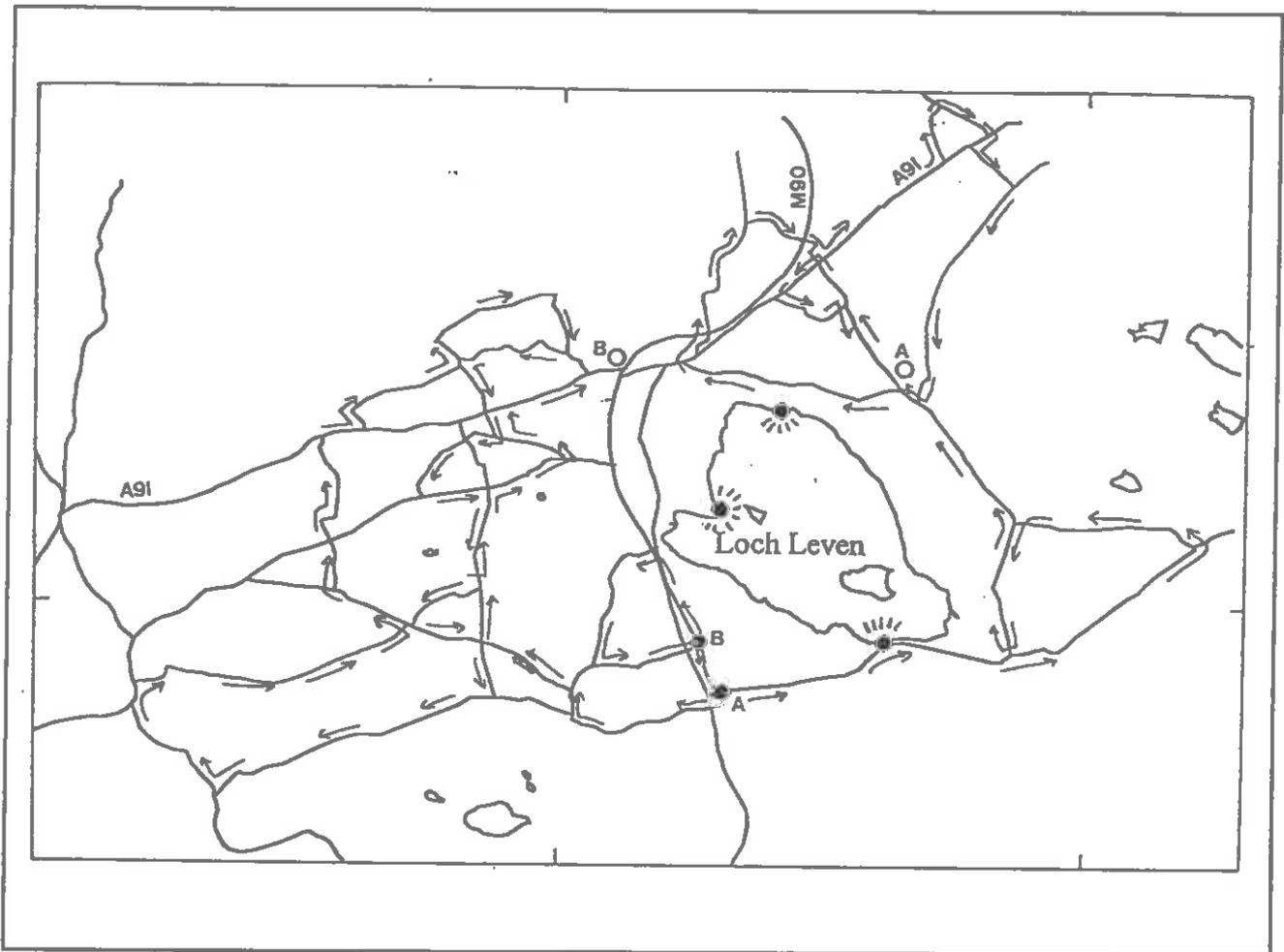


Figure 2. *Loch Leven study area showing the daily count routes and the three roost observation points. ☀ indicates the roost observation points.*

4.3 Daytime Field Searches

Daily searches for geese were undertaken on a minimum of three days each week. Days were chosen at random and took into consideration the availability of field staff and weather conditions. Two routes (A and B) were followed on each survey day (Figure 2). These were modified slightly from the previous routes used during 1994/95 to take into account the improved knowledge of the distribution of Pink-footed Geese around the loch. Whenever geese were encountered the following details were recorded:

- a) time
- b) field code and crop type
- c) flock size of each species present
- d) presence of livestock
- e) presence and identification of marked birds

4.4 Movements of individually marked Pink-footed Geese

At the start of the study, a total of 338 Pink-footed Geese had been marked at Loch Leven (238 with neck-collars and 100 with engraved leg rings), of which 12 were known to have been recovered dead. In addition, a further 41 birds (36 collars and five rings) were caught on 11 October 1995. A total of 1548 Pink-footed Geese have been marked at 12 other locations in the UK and Iceland, of which 248 are known to have been recovered dead. Thus the total number of marked birds that could potentially have been seen during the study period was 1679.

During both daily field searches and whenever additional time permitted, marked Pink-footed Geese were observed to obtain the identification of the individuals present. Searches for geese in areas adjacent to the study area were also made whenever possible. Sightings of marked Pink-footed Geese from other parts of the country were also reported to WWT by bird watchers and reserve wardens. The sightings obtained within the Loch Leven study area were supplemented by *ad hoc* observations of marked individuals collected opportunistically up to April 1996. These additional sightings enabled tentative investigation into the distribution patterns₄ and activity centres at the individual level.

4.5 Age and sex structure of the Pink-footed Goose population

4.5.1 Age assessments in the field

Field age assessments of Pink-footed Geese within the study area were undertaken to determine the productivity of the 1995 breeding season. Observers chose flocks where all geese could be aged, thus minimising bias inherent in checking birds only on the flock edge. No flock was knowingly checked twice as ageing was undertaken in four concentrated periods, with no flock in the same location being examined more than once during each of these periods. Additional age assessment data, collated by WWT, from other parts of Britain were available for regional and national comparisons.

4.5.2 Hunting Bag

During the study period there were three weeks of organised goose shooting at Loch Leven NNR. These were during weeks starting 16 October, 30 October and 13 November 1995. Data from a further week commencing 6 January 1996 were also examined for this report. After each shoot, dead Pink-footed Geese were aged (by examining plumage characters) and sexed (by eversion of the cloaca).

4.5.3 Capture Data

During winter 1995/96, a total of three cannon-net fires were made at Carden Point on the southern shore of the loch. Two full-size nets were fired on each catch, after the site had been pre-baited with grain for 7-10 days beforehand. Caught birds were also aged and sexed.

Findings?

5. Results

5.1 Crop Type

The number of fields (1495) was a slight increase on the number contained within the study area in 1994/95 (1474). The boundary of the study area was not altered and this increase is a result of field boundary changes within the study area.

Improved pastures formed nearly half of the study area in September and cereal stubbles accounted for 28.2% of the fields. By December, the proportion of fields planted with winter cereals increased (from 2.8% to 13%). The proportion of fields containing cereal stubbles fell between September to December (from 28% to 20%) as the stubbles were ploughed in. The distribution of the principal crop types (in September) is shown in Figure 3.

Table 1. Total and percentage crop type of the Loch Leven study area, before and after the study period.

Crop type	September		December	
	No. of fields	%	No. of fields	%
Improved grass	701	46.9	686	45.9
Unimproved grass	46	3.1	45	3.0
Newly sown grass	18	1.2	47	3.1
Cereal stubble	422	28.2	308	20.6
Stubble regrowth	9	0.6	28	1.9
Rape stubble	24	1.6	10	0.7
Ploughed ground	100	6.7	75	5.0
Winter cereal	41	2.8	194	13.0
Brassicas	45	3.0	51	3.4
Brassica tops	18	1.2	12	0.8
Potatoes	54	3.6	22	1.5
Carrots	2	0.1	0	0.0
Fallow	10	0.7	11	0.7
Miscellaneous ¹	5	0.3	6	0.4

Note : ¹ includes raspberry (2), leek (1), turnips (1), and scrub (2).

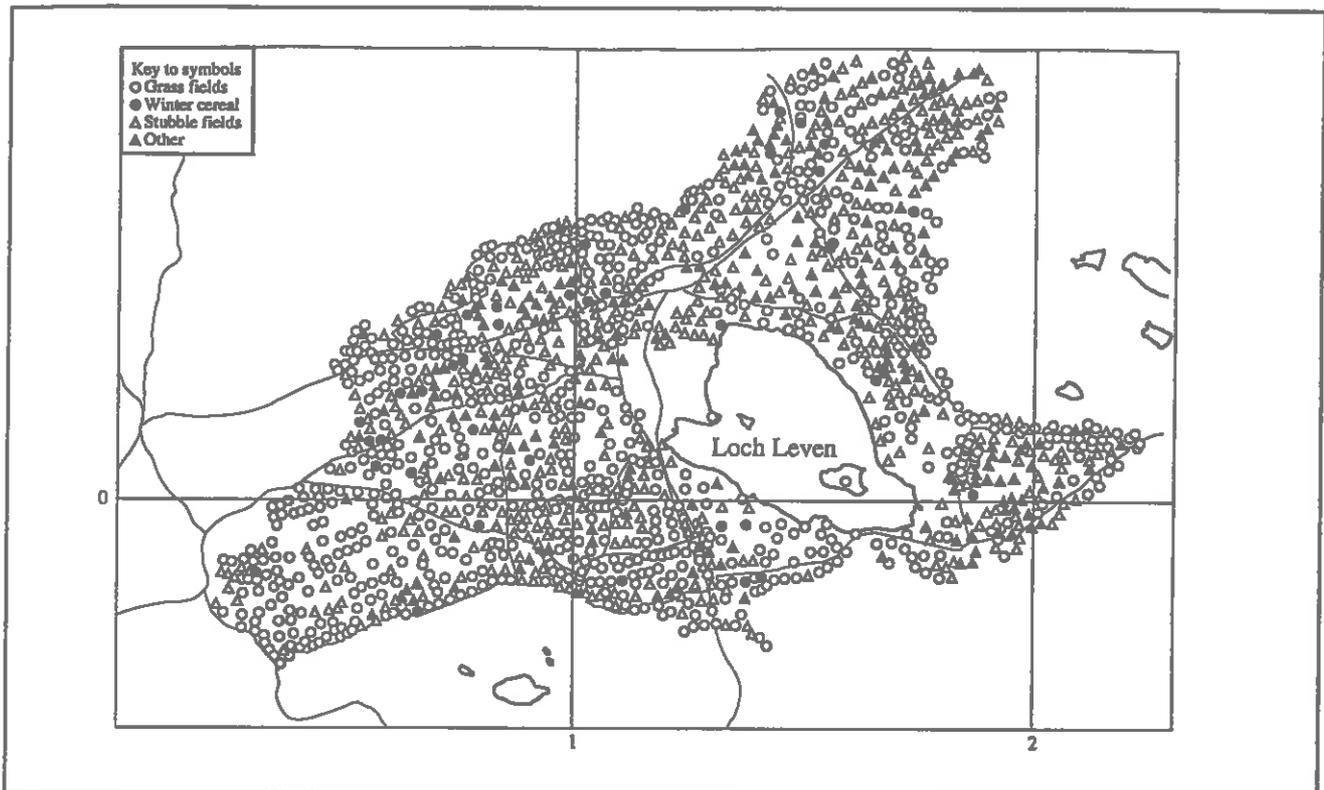


Figure 3. *The distribution of principal field use types in the Loch Leven area in September 1995.*

Between September and December, the predominant crop types, with the exception of improved grass, changed quite markedly in their representativeness within the study area. At the start of the study period when crop type distribution was first assessed, 10.7% of fields had already been harvested, ploughed and sown with a winter crop. This pattern continued through the study period so that significantly less cereal stubble and potato fields were present by December. Both of these crop types are important as food for Pink-footed Geese during the autumn, consequently this food supply gradually diminished over the autumn. The most preferred food type however, improved grass, remained fairly constant, with just 15 fields (2%) being ploughed. Although the ploughing of fields, particularly those containing stubble, continued throughout the study period the proportion of fields containing bare soil decreased as a result of increased growth in winter cereals and newly sown grass.

5.2 Co-ordinated Roost Counts

Reasonably good weather on each roost count date allowed an accurate estimation of the total number of geese flighting from the loch to be made. The peak number of geese recorded roosting at Loch Leven was 17898 on 30 September (Table 2, Figure 4), after which the number roosting at the loch gradually declined. The mean count in October being 12774 and in November, 9372. The number of geese counted further declined during the autumn to 8915 recorded on 25 November.

The number of Pink-footed Geese counted during the daily field searches were, on average, 28% of the number counted at roost, suggesting that a large proportion of the roosting birds fed outwith the main study area. This is in contrast to the December to March study period in 1994/95 when, on average, the mean roost count accounted for 51% of those counted during the daily field searches.

Table 2. Summary of roost counts of Pink-footed Geese at Loch Leven and corresponding field counts.

Date	Roost count	Field count (date, if not on same day as roost count)	Field count as a proportion of roost count
30 September	17898	2436 (2 Sep)	13.6%
7 October	13500	5320 (8 Oct)	39.4%
8 October	12900	5320	41.2%
13 October	11200	4827 (14 Oct)	43.1%
15 October	13498	4827 (14 Oct)	35.8%
16 November	9830	3570	36.3%
25 November	8915	2500 (22 Nov)	28.0%

Within the Perth & Kinross and Central region, Loch Leven held the largest number of Pink-footed Geese during the 14/15 October 1995 national census, and nationally, held the fourth largest number of geese (Mitchell 1996).

The Monthly roost counts (October and November) of Pink-footed Geese from 1967/68 to 1993/94 are shown in Figure 5. There have been large increases in the number of Pink-footed Geese roosting at Loch Leven during these two months. In the early 1970s; approximately 5000-10000 Pink-footed Geese were recorded in October but by the early 1990s this had increased to 16000-22000.

Expressed as a proportion of the wintering population estimate (based on November WWT roost counts) the number of Pink-footed Geese counted at Loch Leven in November shows a very slight decrease (Figure 6). It does however, vary considerably from year to year. Counts of Pink-footed Geese at Loch Leven in November expressed as a proportion of the total number counted in Perth and Kinross and Central (the WWT count region in which Loch Leven lies) show an apparent increase (Figure 6). However, November counts of Pink-footed Geese within Perth & Kinross and Central expressed as a proportion of the total population estimate shows an apparent decline (Figure 6).

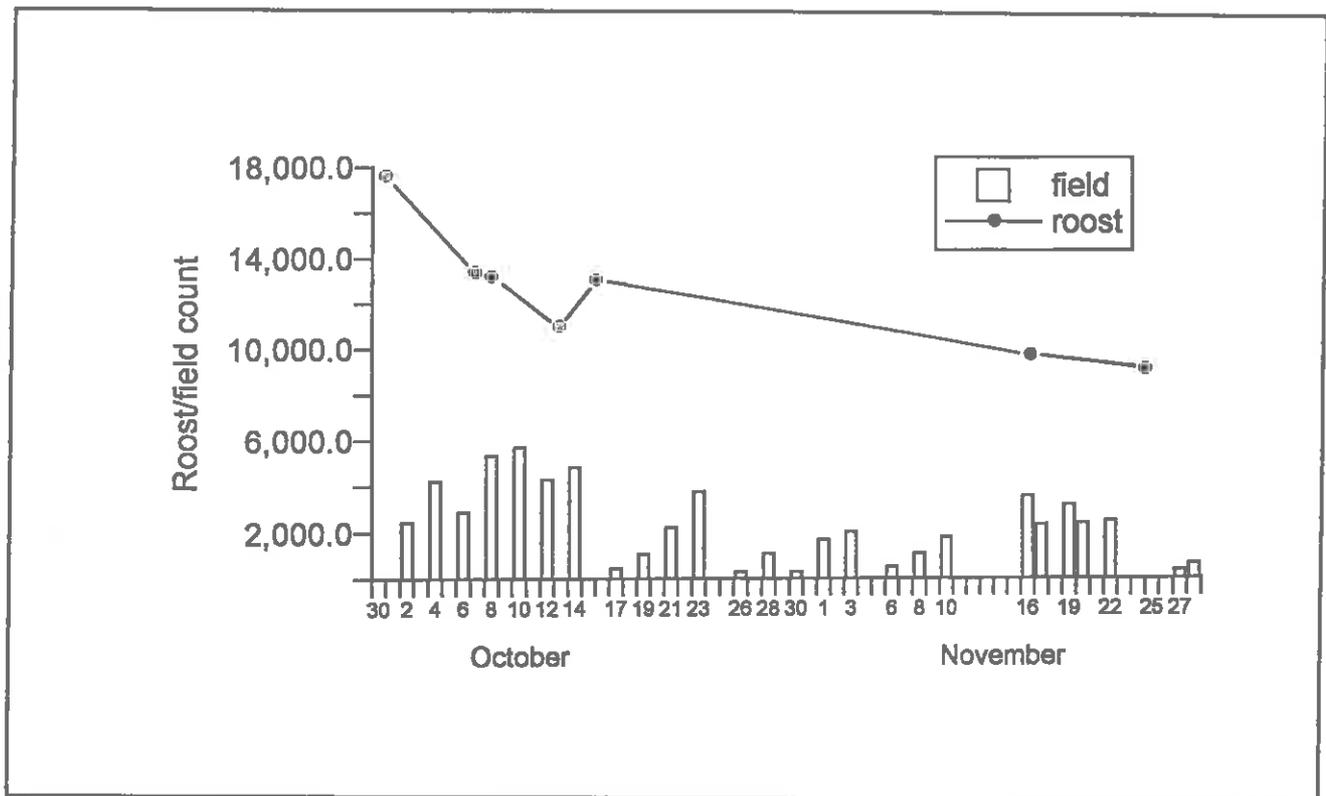


Figure 4. Roost counts and field counts of Pink-footed Geese at Loch Leven between 30 September and 25 November 1995.

In order to assess whether the local (Loch Leven) or regional counts of Pink-footed Geese are approaching a natural limit to the numbers which can be supported, a buffer effect analysis was carried out. The buffer effect (Brown 1969) applies to increasing populations, in which preferred sites are filled first, with less favoured sites only filling when the former have reached some kind of density-dependent limit to numbers. This limit may be equated to the carrying capacity of the site. Where this process operates, whether a site is approaching carrying capacity can be assessed by comparing the local rate of increase with the total population rate, achieved by fitting curves to log-transformed data for the local population plotted against those for the wider population. In such a relationship, asymptotic or flat responses indicate that carrying capacity has been reached, while a linear relationship with a slope of less than one indicates that population growth is slower in the local than in the wider population. Such analyses can be applied to buffer effects in terms of either habitat type (Ebbinge 1992) or geographical area (Moser 1988).

Table 3. Summary of the best fit lines for local v. regional v. total population counts. The significance values for tests of difference between the slope and one are given.

Comparison	Best fit	r ² (%)	Slope	Slope diff. from 1
Loch Leven v regional	linear	25.9	0.502	p < 0.05
Loch Leven v national	linear	52.1	0.833	N.S.
regional v national	linear	30.4	0.693	N.S.

Data from November roost counts at Loch Leven, for the whole of the Perth & Kinross and Central region, and for the wintering population estimate were used. Counts were log-transformed. Two alternative models were tested for the model - a linear fit or an asymptotic fit (see Rowcliffe & Mitchell 1996).

There is no strong evidence ^{of} any stabilisation of either local or regional populations in relation to the national population. The slope for Loch Leven v. regional is just significantly less than 1, suggesting that population growth is slightly slower locally than regionally, but the fit is poor and firm conclusions cannot be drawn from this analysis.

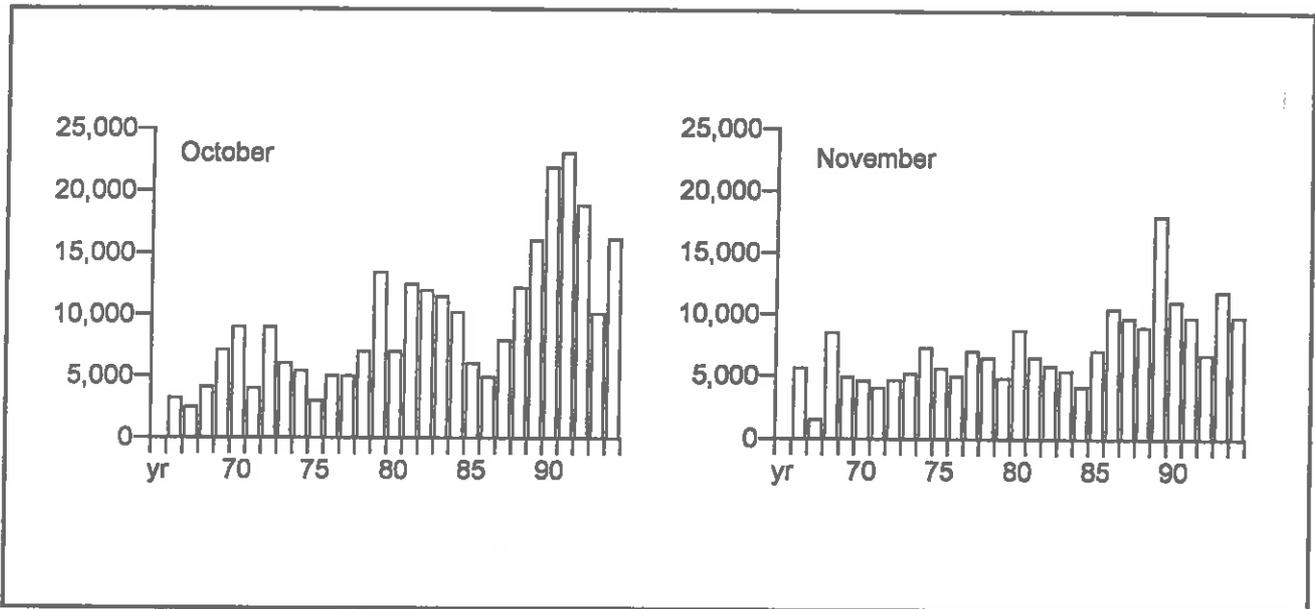


Figure 5. Monthly roost counts of Pink-footed Geese at Loch Leven in October and November from 1966/67 to 1994/95.

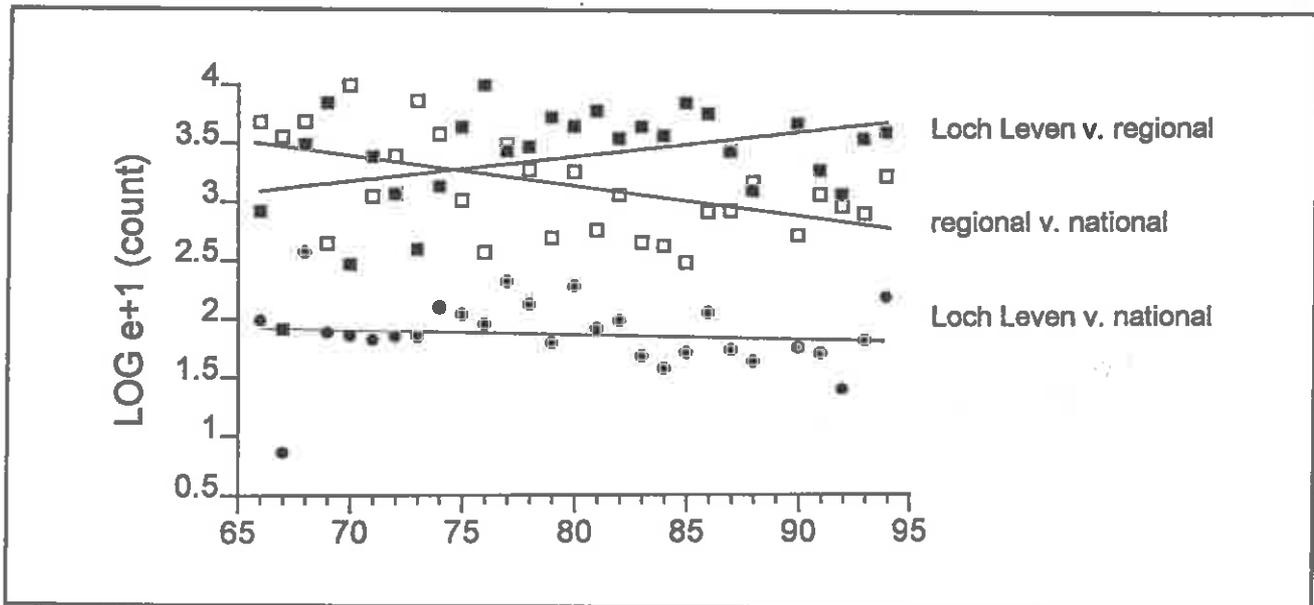


Figure 6. November counts of Pink-footed Geese at Loch Leven expressed as a proportion of the regional total (■); expressed as a proportion of the total population estimate (●) and the November regional total expressed as a proportion of the total population estimate (□). Linear regression lines have been fitted.

5.3 Daytime Field Searches

Field searches were made on a total of 26 days. The total number of geese recorded during the field searches ranged from 5673 on 10 October to 281 on 26 October (Figure 4). The proportion of birds that were found feeding in the study area, expressed as a proportion of those counted roosting on the loch ranged from 13.6% to 43.1% (mean 34%, Table 2).

Of the fields checked, 77 (5.2%) were used by feeding Pink-footed Geese and 15 (1%) were used by feeding Greylag Geese. During October and November, Pink-footed Geese were recorded in 52 fields (3.5%) and 29 (1.9%) fields respectively. Pink-footed Geese were recorded in four fields during both October and November (D26, H108, P50 and R51). A total of 60768 bird days were recorded for Pink-footed Geese and 251 birds days recorded for Greylag Geese. A total of 12 fields contained greater than 2% of all bird days for Pink-footed Geese (Table 3). Twelve fields also supported more than 2% of all Greylag Goose bird days. Of these last 12, eight fields also supported more than 1% of the Pink-footed Goose total bird days. The distribution of all the fields used by Pink-footed Geese is shown in Figure 7.

Table 3. *The twelve fields that supported more than 2% of observed Pink-footed Geese.*

Field Number	Number of days when geese were recorded	Total number of bird days	Proportion of overall total
D26	4	10670	17.6%
C4	3	5776	9.5%
N39	3	3726	6.1%
B36	3	3085	5.1%
H53	1	2100	3.5%
A65	2	1795	3.0%
P50	3	1738	2.9%
L88	2	1690	2.8%
C97	2	1460	2.4%
I53	3	1410	2.3%
I46	2	1400	2.3%
R51	2	1315	2.2%

Table 4. *The twelve fields that supported more than 2% of observed Greylag Geese.*

Field Number	Number of days when geese were recorded	Total number of bird days	Proportion of overall total
P23	3	58	23.1%
P3	2	30	11.9%
I46	2	26	10.4%
P9	1	24	9.6%
O80	1	21	8.4%
I49	2	18	7.2%
P10	2	18	7.2%
D26	4	15	6.0%
I53	3	15	6.0%
H91	2	8	3.2%
C4	3	7	2.8%
O88	1	6	2.4%

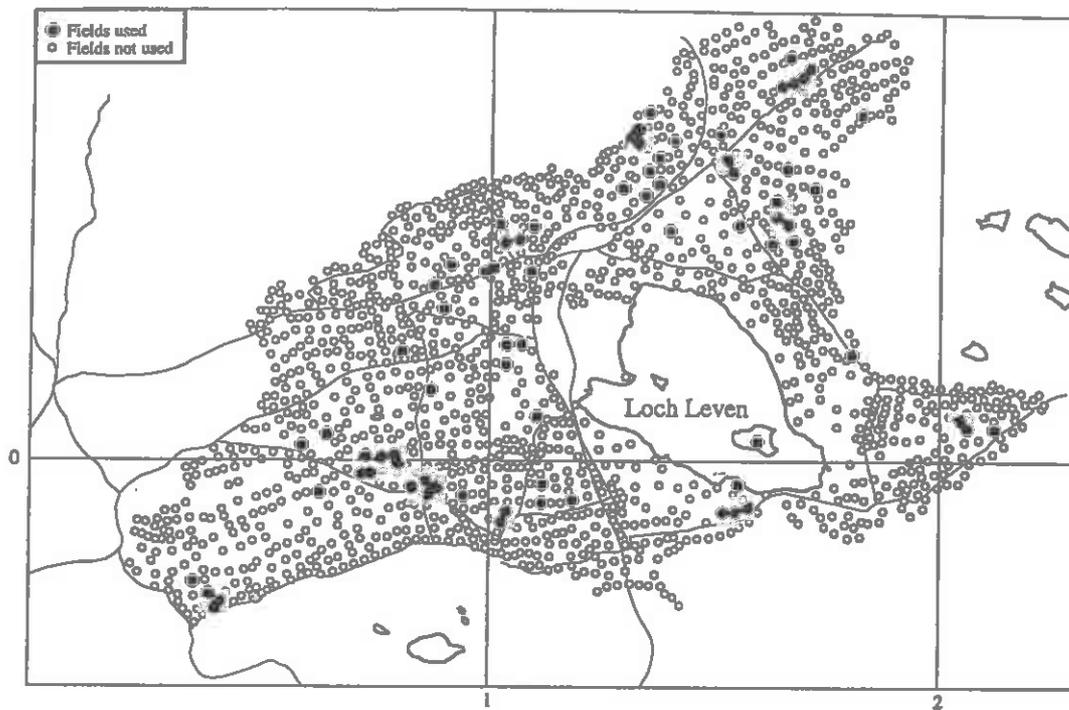


Figure 7. The Loch Leven study area showing all fields in which Pink-footed Geese were recorded, together with those fields in which Pinkfeet were never recorded.

In October, a total of 38735 Pink-footed Goose bird days (63.7% of study period) and 134 Greylag Goose bird days (53.4%) were recorded. Twenty-seven fields supported more than 1% of the total number of Pink-footed Geese and nine fields supported more than 1% of Greylag Geese. In November, a total of 22033 Pink-footed Goose bird days (36.3% of study period) and 117 Greylag Goose bird days (46.6%) were recorded.

Table 5. Total Pink-footed Goose bird days in each crop type during autumn 1995.

Crop type	October		November		Overall	
	a (b)	c	a (b)	c	a (b)	c
Improved grass	7513 (19.4)	0.4	11420 (51.8)	1.1	18933 (31.2)	0.7
Newly sown grass	9150 (23.6)	19.7	2356 (10.7)	8.9	11506 (18.9)	15.7
Unimproved grass	0 (0)	-	1400 (6.4)	2.1	1400 (2.3)	0.7
Cereal stubble	19484 (50.3)	1.8	4293 (19.5)	0.7	23777 (39.1)	1.4
Stubble regrowth	0 (0)	-	370 (1.7)	2.8	370 (0.6)	1.0
Winter cereal	200 (0.5)	0.2	310 (1.4)	0.5	510 (0.8)	0.3
Potatoes	275 (0.7)	0.2	550 (2.5)	0.7	825 (1.4)	0.4
Brassicas	0 (0)	-	960 (4.3)	1.4	960 (1.6)	0.5
Rape stubble	526 (1.4)	0.9	0 (0)	-	526 (0.9)	0.6
Bare soil	1587 (4.1)	0.6	374 (1.7)	0.3	1961 (3.2)	0.5

Key: a - Total number of Pink-footed Geese recorded (bird days). (b) - Expressed as a percentage for each month. c - Degree of preference for particular field types. An index of 1 indicates that a particular field type was visited in exact proportion to its availability in the area, more than 1, that it was visited more than expected, less than 1, that it was visited less than expected and 0, that it was avoided altogether.

Twenty-three fields supported more than 1% of the total number of Pink-footed Geese and five fields supported more than 1% of Greylag Geese. The crop types contained in those fields selected by Pink-footed Geese for feeding are shown in Table 5.

Newly sown grass fields were the crop type most preferred by Pink-footed Geese (degree of preference = 15.7), although these only formed 1.2%-3.1% of the fields in the study area (Table 1). In addition, Pink-footed Geese showed a strong preference for cereal stubbles, and stubble regrowth was used in proportion to its availability. Yet despite these preferences very few of the available fields were used. For example, of the 308 cereal stubble fields available within the study area only 25 (8.1%) were used. Carrots, brassica tops, fallow and miscellaneous were avoided altogether (i.e. geese were not recorded using fields that contained these crops).

Flock size of Pink-footed Geese was similar to that recorded during winter 1994/95. Although mean flock sizes of Pink-footed Geese recorded from October to December did not change considerably (Table 6), there was a tendency for the proportion of smaller flocks (21-100 birds) to decrease and flocks over 1000 birds to increase slightly as autumn progressed.

Table 6. Mean flock size of Pink-footed Geese recorded in 1995/96

Flock size	October	November	Overall
1-20	4 (5.1%)	6 (14.3%)	10 (8.3%)
21-100	14 (18.0%)	5 (11.9%)	19 (15.8%)
101-500	41 (52.6%)	19 (45.2%)	60 (50.0%)
501-1000	10 (12.8%)	5 (11.9%)	15 (12.5%)
1000+	9 (11.5%)	7 (16.7%)	16 (13.4%)

For Greylag Geese, the small number of birds present in the study area was reflected in the flock size - 82.6% of flocks were of 1-20 birds, whilst the remainder (17.4%) were of between 21 and 100 birds. No flock of more than 100 Greylag Geese was recorded.

5.4 Movements of individually-marked Pink-footed Geese

A total of 324 sightings of 79 individuals was made during the study period in a total of 38 different fields. Of the 79 individuals seen, 56 (71%) were seen on more than one occasion, 44 (56%) were seen more than twice and 28 (35%) were seen five or more times. Eight birds were seen ten or more times during the study period. On average, each marked bird was seen 4.1 times.

The most frequently seen individual was IN, seen on a total of 14 occasions. Only three of the 79 marked geese had been originally ringed away from Loch Leven (at Martin Mere, Lancashire). In addition, two birds were recorded (dead) in the study area which had originated from elsewhere. Of the remaining 76 marked geese, four were ringed during winter 1992/93, 59 during winter 1994/95 and 13 during winter 1995/96. A further 22 newly-ringed individuals were not observed in the field again after ringing, and one newly-ringed bird was recovered (dead) at Loch Leven (before it had been seen alive in the field).

The proportion of Pink-footed Geese marked at Loch Leven ^{SITE} which have never been seen is, on average 17% (Table 7), although most of these were marked in spring 1993 and autumn 1994 - both times of peak passage at the sight. In addition, 46% of the marked birds have only been seen at Loch Leven with the most sit-faithful birds being caught in winter 1993/94 and winter 1994/95. Of those marked Pink-footed Geese only seen away from Loch Leven most were marked during the autumn. Approximately the same proportion of marked geese (on average 25%) have been seen both away from Loch Leven and at the site regardless of when the geese were caught.

Table 7. Sightings of Pink-footed Geese ringed at Loch Leven NNR from Spring 1993 to Spring 1995.

Ringling period	Number ringed	Never seen (%)	Only seen within Loch Leven (%)	Only seen away from Loch Leven (%)	Seen both home and away (%)
Spring 1993	47	14 (30%)	16 (34%)	4 (8%)	13 (28%)
Winter 1993/94	4	0 (0%)	3 (75%)	0 (0%)	1 (25%)
Autumn 1994	134	35 (26%)	35 (26%)	30 (23%)	34 (25%)
Winter 1994/95	34	2 (6%)	28 (82%)	0 (0%)	4 (12%)
Spring 1995	117	6 (5%)	72 (62%)	6 (5%)	33 (28%)
TOTAL	336	57 (17%)	154 (46%)	40 (12%)	85 (25%)

Certain fields held a disproportionate number of marked geese - fields I51, I53 and I46 (all on the RSPB Vane Farm reserve) supported a large number of marked individuals (being close to the capture point at Carden Point), however field H108 near Auchmuirbridge (c. 6km from Carden Point) supported 18 marked individuals (Table 8).

Table 8. *The fields used by marked Pink-footed Geese*

Field number	No. marked individuals recorded	No. observations
I51	30	35
I46	29	82
H108	18	29
I53	18	24
P50	13	16
L124	10	14
P51	10	10
I48	9	9
P49	9	9
C97	8	8
P95	7	7
O88	6	14

Note: Marked individuals were recorded in a further 26 fields.

Within-winter sightings of individually marked geese were examined. A total of 77 Pink-footed Geese were either newly ringed ($n = 41$) or seen for the first time in October 1995. Of these, 29% were not seen again. It is unlikely that these birds wintered within the study area since virtually all the marked geese present were identified. A further 18% were first seen within the study area, and then later in the season, they were reported away from the study area. The remaining 33 marked Pink-footed Geese (43%) were subsequently only seen within the study area (and not seen elsewhere). The distribution of sightings of individually-marked Pink-footed Geese recorded at Loch Leven in October or November 1995 and subsequently seen outwith the study area is shown in Figure 8.

Sightings of individually marked geese were examined between winters. Overall, of the 375 Pink-footed Geese recorded (either caught or seen alive) in the field within the study area during the 1994/95 winter, 162 (43%) were seen again during the 1995/96 winter. For all birds which had been recorded in both winters, the period (autumn, winter or spring) in which it was first caught in 1994/95 was compared with the month in which it was first recorded in 1995/96 (Figure 9). Some of the sightings were within the same period - thus, it appears that not only are many geese returning to the Loch Leven area in subsequent winters (between-winter site fidelity) but some arrive there at similar times each year. There is evidence too that autumn caught geese pass through the site and return during the spring months. Thus, Pink-footed Geese marked in the autumn of

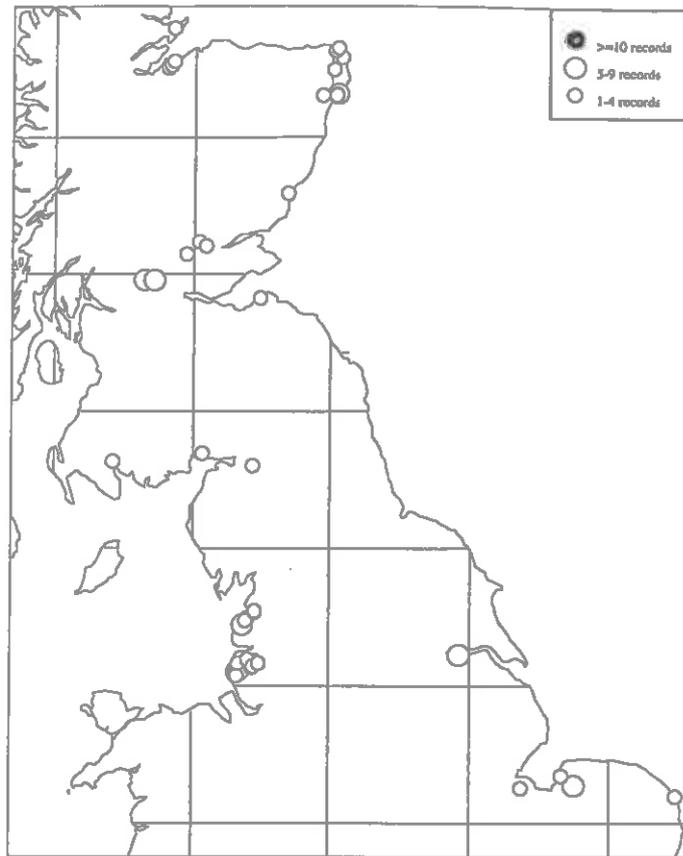


Figure 8. *The distribution of sightings of individually-marked Pink-footed Geese recorded at Loch Leven in October or November 1995 and subsequently seen outwith the study area.*

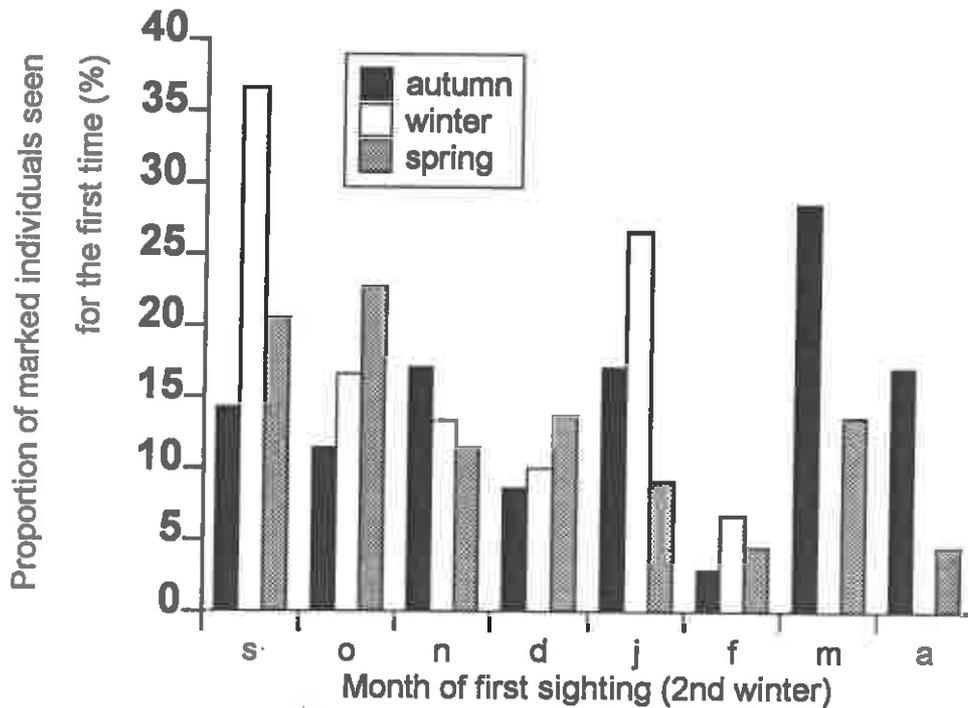


Figure 9. *The month of sightings and proportion of marked individuals seen for the first time at Loch Leven in the year after ringing.*

1994/95 appeared for the first time at Loch Leven in 1995/96 in most months of the winter with a pronounced peak in March. Those marked in mid-winter in 1994/95 appeared for the first time in 1995/96 throughout the autumn and mid-winter period, but none was recorded for the first time after February. Most geese caught in the spring were recorded for the first time the following year in either the autumn or spring.

The distribution of sightings of marked individuals within goose flocks together with the distribution of flocks of geese containing no marked individuals is shown in Figure 10. Marked birds were located amongst flocks in similar areas to those frequented by flocks of unmarked birds indicating that geese caught at Carden Point were probably representative of the geese using the study area during the autumn.

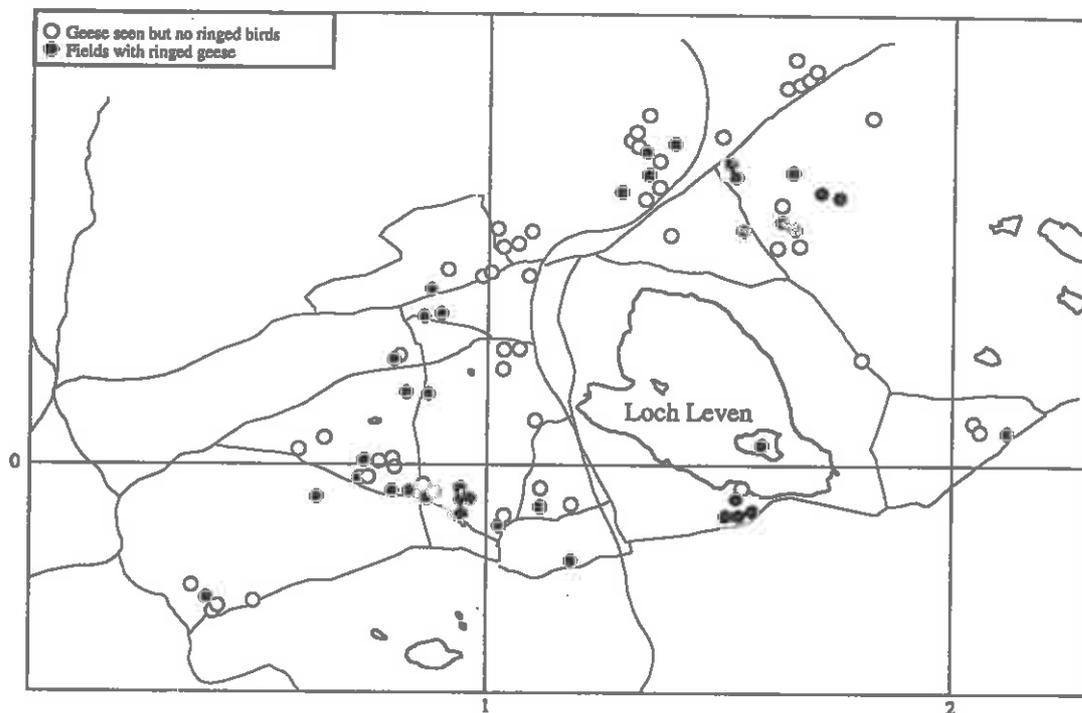


Figure 10. *The distribution of sightings of marked individuals within goose flocks together with the distribution of flocks of geese containing no marked individuals.*

Preliminary examinations of the pattern of sightings both within an autumn and between winters are based on sightings of individually-marked geese. The clustered nature of sightings of some marked geese within October and November 1995 is shown in Figure 11. However, some individual geese showed strong preferences to certain fields within the study area. All marked birds had visited the Carden Point area at some point since this was the site of capture (Figure 12). Other than sightings in this area, some individuals were only ever seen north of Loch Leven (O); others only to the west of the loch (Δ, Δ₁). FOR X

There is strong evidence from the patterns of sightings of marked birds that some individuals return to the same fields between winters. Figure 13 shows two examples - examples of individuals that returned to the same areas as they had been reported in previous years, and examples of individuals that were seen in different areas in previous winters.

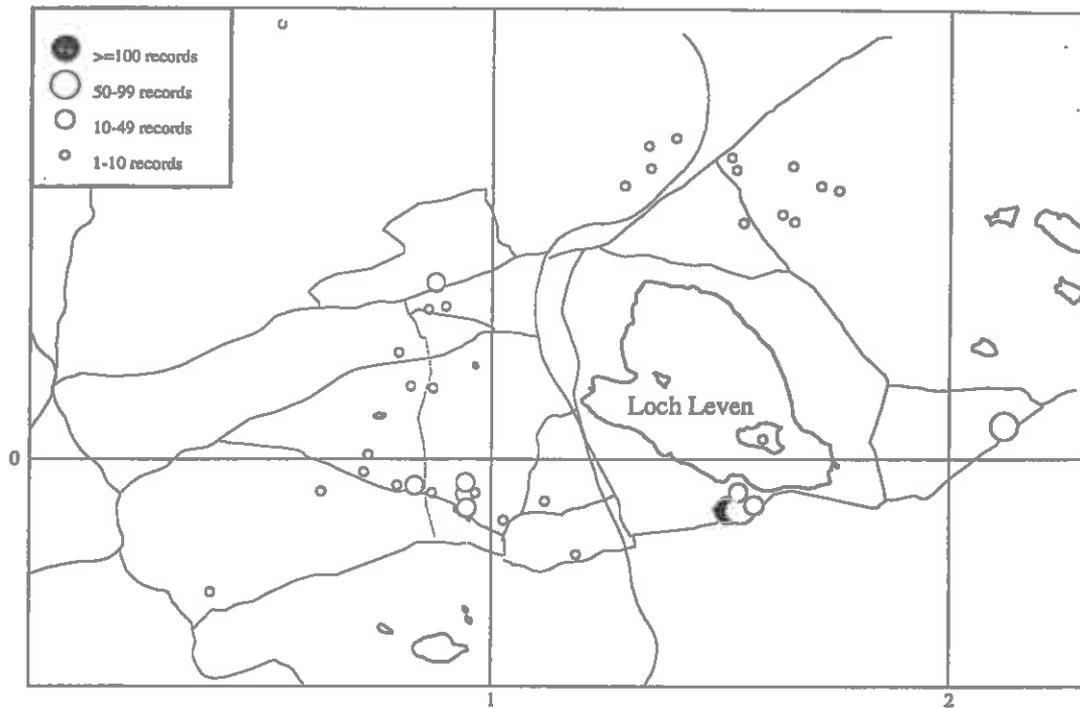


Figure 11. *The clustered nature of the distribution within the study area of all sightings of Pink-footed Geese.*

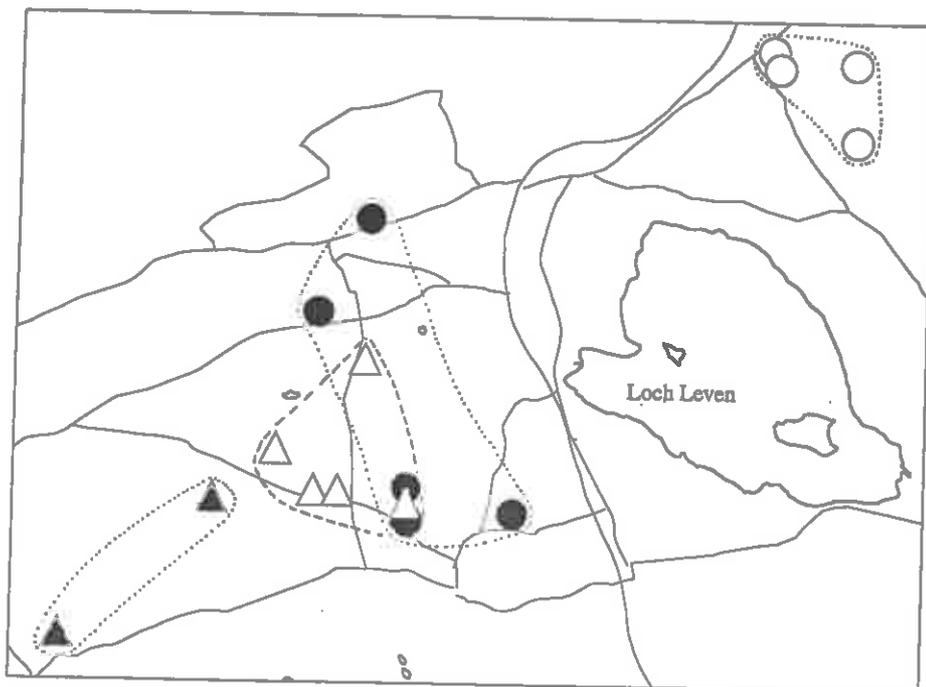


Figure 12. *Within-winter sightings of individual Pink-footed Geese showing affinity to certain fields.*



Figure 13. *Two examples of between-winter sightings of individually-marked Pink-footed Geese at Loch Leven. Sightings of the two birds are represented by solid symbols (high degree of between-winter site fidelity) and open symbols (low between-winter site fidelity) respectively.*

5.5 Age and sex structure of the Pink-footed Goose population

5.5.1 Age assessments in the field

Between 26 September and 10 December a total of 3882 Pink-footed Geese was aged in the field within the study area (Table 9). Overall, 3064 (78.9%) were adults and 818 (21.1%) were first-year birds.

Table 9. All age assessments of Pink-footed Geese from Loch Leven study area during winter 1995/96.

Date	Flock size	No. aged	No. adults	No. young	% young
26.09.95	1500	294	201	93	31.6%
27.09.95	318	318	238	80	25.1%
27.09.95	688	688	514	174	25.3%
27.09.95	2500	494	394	100	20.2%
29.09.95	452	452	335	117	25.9%
12.10.95	127	127	98	29	22.8%
12.10.95	237	237	197	40	16.9%
12.10.95	84	84	70	14	16.7%
12.10.95	263	263	212	51	19.4%
09.11.95 *	2500	600	529	71	11.8%
10.12.95	150	98	86	12	12.3%
10.12.95	385	227	190	37	16.3%
Total	9204	3882	3064	818	21.1%

* - see Table 10.

Table 9 shows that there is considerable variation in the age composition of Pink-footed Goose flocks at Loch Leven (range: 31.6% to 11.8% young). The proportion of young Pink-footed Geese declines as the autumn progresses, due either to families moving through the area earlier and/or a higher proportion of young Pink-footed Geese being shot.

In a national context, overall, the mean proportion of young recorded during the main sampling period for age counts in the rest of northern Britain (last two weeks of October and the first two weeks of November - 11.8%) is similar to that recorded for the rest of Britain (13.8%, see Table 10)

The data confirm Hearn & Mitchell's (1995) findings that since Loch Leven is a major autumn arrival point for Pink-footed Geese, a greater proportion of families may pass through the area during the early autumn. The range of age ratios during winter 1994/95 also showed higher proportions of young in southern areas of Britain, however the range was more homogenous than in winter 1995/96 and the overall proportion of young birds was greater (23.0%).

Table 10. Regional age assessments of Pink-footed Geese, September - November 1995. (WWT data).

Region	Total aged	Adults	Young	Proportion of young
north Scotland	1700	1500	200	11.8
north-east Scotland	2800	2503	297	10.6
east-central Scotland *	4700	4078	622	13.2
south-east Scotland	600	499	101	16.8
south-west Scotland	1232	952	280	22.7
east-central England	238	179	59	24.8
Total	11270	9711	1559	13.8

* - sample contains 600 birds aged at Loch Leven on 9 November 1995 (11.8% young, from Table 9)

5.5.2 Hunting Bag

A total of 50 Pink-footed Geese were examined during the winter 1995/96. Forty-six (92%) were from shooting weeks during the study period. The age and sex of these birds are shown in Table 11.

Table 11. Age and sex ratios of Pink-footed Geese shot at Loch Leven NNR from October 1995 to January 1996.

Week starting	Adult male	Adult female	Young male	Young female	% young
16 October 1995	1	1	1	4	71.4
30 October 1995	5	7	11	7	60.0
13 November 1995	1	5	1	2	33.3
6 January 1996	0	1	2	1	75.0
Total	7	14	15	14	59.9%

5.5.3 Capture data

During winter 1995/96, three catches of Pink-footed Geese were made resulting in a total of 152 individuals being caught. The overall proportion of young recorded in captured birds was 29.2% (Table 12).

Table 12. *Summary of the age and sex structure of Pink-footed Geese trapped at Loch Leven during winter 1995/96.*

Date	Adult male	Adult female	Young male	Young female	Unaged female	Total	% young
11 October 1995	8	11	6	5	0	30	36.7
15 December 1995	4	5	6	2	0	17	47.0
20 March 1996	43	31	13	10	1	98	23.7
Total	55	47	25	17	1	145	29.2%

Table 13 shows the variation in the proportions of young recorded using the three techniques. Both cannon-netting and shooting show a higher proportion of young compared to that present in the population (21.1% obtained from field assessments). These data are similar to those obtained during the winter 1994/95 study (Hearn & Mitchell 1995), even though the proportion of young birds was less during that period. The observed difference in the male to female ratios obtained from cannon-netting and shooting was not statistically significant ($\chi^2_1 = 1.86$, ns).

Table 13. *Summary of age assessments from different sampling techniques.*

Method	Total aged	No. adults	No. young	% young
Field assessments	3882	3064	818	21.1
Estate shoot-bag	50	21	29	58.0
Cannon-netting	144	102	42	29.2

6. Discussion

1) Loch Leven's role and importance for Pink-footed Geese in a local and national context during the stated period.

The world population of Pink-footed Geese numbered some 260000 in 1993 (Madsen & Mitchell 1994) and their world range is limited, with the majority (c.85%) breeding in Iceland and Greenland and wintering exclusively in Britain. The number of Pink-footed Geese wintering in Britain has increased from nearly 70000 in the late 1960s to over 200000 in the early 1990s (Mitchell 1994). At a regional level (east-central Scotland), large changes in the status and distribution of Pink-footed Geese have occurred in the past 20-25 years. Major concentrations (over 10000 birds) were present at three sites (Loch Leven, Strathearn and Strathallan), although Pink-footed Geese roosted regularly at 21 sites and were recorded feeding in 466 one km squares (Bell & Newton 1995). A number of new roosts have been occupied in the last decade and an expansion of range is continuing. Based on the long term November counts, during the 1960s and 1970s the number of Pink-footed Geese in the area reflected the national trend and showed a steady increase, but the large expansion of the population since then has not been reflected in east-central Scotland and it appears that the area may have reached carrying capacity.

There has, however, been a shift in the peak arrival time from November to October. The number of Pink-footed Geese counted at Loch Leven in October now forms a larger proportion of the annual autumn population estimate than it did in the 1960s. Conversely, the proportion counted in November appears to have declined slightly. Loch Leven also supports a larger proportion of the autumn regional total than it did thirty years ago, although the regional total expressed as a proportion of the total population estimate appears to be decreasing. Modelling of the trends using a buffer effect analysis, however found the trends to be weak and no firm conclusions could be drawn from them.

Within the Perth & Kinross and Central region, Loch Leven held the largest number of Pink-footed Geese during the 14/15 October 1995 national census, and nationally held the fourth largest number (Mitchell 1996).

2) The feeding distribution of geese from the Loch Leven roost in relation to agriculture in the early season period from arrival to the end of November 1995.

More Pink-footed Geese are visiting Loch Leven during the autumn and are wintering there than in the late 1960s, yet despite these increases, the overall distribution of feeding geese has remained remarkably similar between the two periods. The intensity of goose use has changed somewhat between the two periods. Most Pink-footed Geese tended to feed within a few kilometres of the loch shore in the late 1960s, yet in recent years, away from Vane Farm, larger numbers of geese tend to flight further from the loch (Hearn & Mitchell 1995). Newton & Campbell (1973) suggested that the need for safety, a good all round view and minimum disturbance were important in determining where Pink-footed Geese fed. They found that the preference of geese for particular fields could not be correlated with food abundance and that in 1968-70 geese preferred the same general areas in each of the two winters even though the foods they contained differed.

The present study identified a greater than expected preference for cereal stubble, and in particular, newly sown grass in the autumn while other crop types were not used in relation to their availability. The attraction to newly sown grass may not be unexpected. Hearn & Mitchell (1995) showed improved grass (and stubbles) to be preferred greater

than its availability during December to March - a time when autumn-sown grass would be indistinguishable from 'improved grass'. Comparisons with data collected in 1994/95 do show some differences. Using the two tables showing degrees of crop preferences (Table 5, this report and Table 4 from Hearn & Mitchell 1995) stubbles were preferred more in the autumn; potatoes more in mid-winter; grass (including newly-sown) was preferred throughout both periods; winter cereals were preferred more in the spring and the remaining crop types were used less than they were available.

Certain fields held a disproportionately large numbers of birds - Pink-footed Geese were recorded in 5.2% of the fields available, yet the general distribution of geese in autumn 1995 was similar to the distribution recorded in the previous winter/spring.

It would appear that Pink-footed Geese at Loch Leven prefer to use the same traditional areas throughout the period September to March, but switch fields (and crop types) within those cores areas as different food types become available.

3) The degree of within-winter and between-winter site fidelity

In accord with many migratory goose species, Pink-footed Geese show a high rate of reappearance at familiar wintering areas. This is presumably as an evolutionary response to a stable habitat resource, the successful exploitation of which enhances survival and reproductive output. Returning to familiar wintering sites combines knowledge of safe and profitable feeding with disturbance-free roosts. The site faithfulness of wintering Pink-footed Geese has been demonstrated by Boyd (1955), Fox *et al.* (1994) and Hearn & Mitchell (1995).

Loch Leven supports peak numbers during the autumn passage, thus the majority of birds are expected to move on to more southerly areas as the autumn progresses. The sightings of individually marked Pink-footed Geese during the present study confirm much of the findings of Hearn & Mitchell (1995) with probably in excess of 57% of Pink-footed Geese moving on, yet a proportion (up to 43%) was only recorded within the study area throughout the winter. The proportion remaining within the study area (43%) is higher than in 1994/95 (30%).

Sightings of individually-marked geese between winters suggest that a minimum of 65% of those recorded at Loch Leven in 1994/95, returned to the study area during 1995/96. This is remarkably high considering that Pink-footed Geese have an estimated annual survival rate of between 75% (juveniles) and 85% (adults) (Bell *et al.* 1995). In addition, at times of passage at the site (autumn and spring) some marked geese recorded in 1994/95 may have been missed in 1995/96.

4) The age and sex structure of the population

The overall proportion of young in feeding flocks at Loch Leven (21%) was higher than the national average obtained in October and November by WWT (13.8%). Throughout the autumn the proportion of young gradually decreased. The sample obtained during the same period as data collected elsewhere in Britain was similar (11.8%). There is no indication that Loch Leven supports an unrepresentative portion of the wintering population. This apparent decline in the proportion of young has been noted before (e.g. Stenhouse & Mitchell 1994). Certainly ageing gets progressively harder during the winter since the young undertake a body moult which makes them superficially more like adults. However, there appears to be a genuine reduction in the proportion of young largely due

to a higher proportion of young being shot during the shooting season.

Wright & Boyd (1983) showed that, at Loch Leven, young of Pink-footed Geese were more vulnerable to shooting than adults. Based on data obtained between 1966 and 1980, they found that the proportion of young in the bag (mean 34% \pm 9.0%) was much higher than the proportion of young observed amongst live geese in the field in November (mean 16.8% \pm 6.7%). Hearn & Mitchell (1995) showed that, at Loch Leven, the proportion of young in the bag in mid-winter 1994/95 was 60% compared with 23% recorded in the field.

A larger proportion of young Pink-footed Geese were caught with cannon-nets (30%) than were present in the wintering population. Baiting at the Carden Point capture site is on a grass field on the loch edge and probably attracts more families who tend to dominate this food resource.

In summary, the proportion of young in field samples declined during the autumn at Loch Leven. No difference in the age ratios of young at Loch Leven, compared with a national average, could be detected during the same sampling period in autumn 1995. Approximately 1.4 times more young were cannon-netted and approximately 2.75 more young were shot compared with the proportion aged in the field.

5) Collecting data to develop activity ranges and centres of activity of individually marked birds.

Recent ringing of Pink-footed Geese at Loch Leven has greatly improved the understanding of the timing of passage, destination of autumn caught birds and local site fidelity of individually-marked geese. The current study has also suggested that within the study area itself some geese may exhibit discrete 'activity ranges' (e.g. Figure 12). Activity ranges and centres of activity have been described for Greenland White-fronted Geese *Anser albifrons flavirostris* (Wilson et al. 1991) and for Pink-footed Geese in Aberdeenshire (Giroux & Patterson 1995) where seasonal activity ranges were within the range 16-69km². Identification of the size and range of daily and seasonal activity ranges is important when considering the potential for crop damage and has implications for the long term efficiency of scaring programmes.

Sample sizes are still small (most c.4 sightings per bird) and more sightings data are needed to facilitate analysis. There appeared to be some overlap among individual ranges especially within the vicinity of the loch itself, yet the distribution probably departed from uniformity, indicating the presence of centres of activity and fidelity to some fields within the activity ranges. In terms of conservation management, the protection of important areas, and, if possible, the enhancement of conditions there, are of particular importance. Observations during this study confirm the within-site fidelity of some individuals and this will be valuable when considering management options for such a mobile species.

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