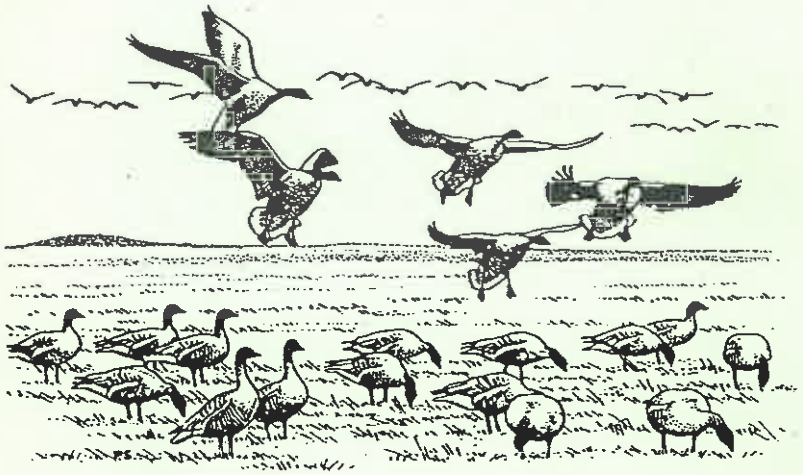
THE WILDFOWL & WETLANDS TRUST

RESEARCH REPORT

Goose distribution and feeding around Loch Leven NNR

Richard Hearn & Carl Mitchell



Saving wetlands and conserving their wildlife

Richard Hearn

Goose Distribution and Feeding around Loch Leven NNR

Report to Scottish Natural Heritage
by
The Wildfowl & Wetlands Trust
Slimbridge, Gloucester, GL2 7BT, UK

Contract No. 94/19

Richard Hearn & Carl Mitchell

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Contents

1 Executive summary

1) This report details the results of a project undertaken between December 1994 and April 1995, to investigate the numbers and distribution of Pink-footed and Greylag Geese which use the Loch Leven area of eastern Scotland.

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) Compared to the late 1960s, Loch Leven now supports a larger proportion of the annual autumn population estimate. Loch Leven also supports a larger proportion of the autumn regional total than it did thirty years ago, although the regional total as a proportion of the total population estimate is decreasing. There has, however, been a shift in the peak arrival time from November to October.

4) During December to March, the mean number of roosting Pink-footed Geese counted at Loch Leven during midwinter was 5790 and in spring was 4395 .

5) Relatively small numbers of roosting geese were recorded at the time of a full moon (mean of 1363) compared with those recorded at the time of a new moon (mean of 6436).

6) The mean number of feeding Pink-footed Geese counted during daily searches in the study area during midwinter was 5144 and in spring was 6607.

7) The study area surrounding Loch Leven was *c.*140 km^2 of primarily farmland and comprised of approximately 47% improved grassland, 21% ploughed land, 14% winter cereals and 13% stubbles.

8) Pink-footed Geese were highly selective of the fields available within the study area. Of 1474 fields checked for feeding geese on 74 count days during the study period 14% were used by Pink-footed Geese and 3% were used by Greylag Geese. There was a tendency for more fields to be used by Pink-footed Geese from winter to spring.

9) Overall, Pink-footed Geese showed strongest preferences for improved grass fields, the few potato fields available and those containing cereal stubbles. From December to March preferred feeding in improved grass fields remained at a similar level, feeding in stubble and unimproved grass fields declined whilst feeding in winter cereals increased.

10) Certain fields held a disproportionately large number of geese. Three fields accounted for 10% of counts of feeding Pink-footed Geese, and ten fields held 25%. On 75% of fields in which Pink-footed Geese were seen once, they were seen a second time, and on 90% of fields in which they were seen twice they were seen again.

11) During 1994-95, Pink-footed Geese primarily fed in broadly similar areas to those in which they were recorded feeding during 1968-70.

12) Flock sizes of Pink-footed Geese are now more homogenous than during 1968-70 with fewer medium size flocks and a greater proportion of smaller flocks and larger flocks.

13) Pink-footed Geese were recorded feeding at night on three out of the seven nights when observations were made, and were recorded in six out of the 204 fields checked. The proportion of geese counted during the day which were recorded in the same checked fields at night was approximately 23% overall.

14) Over 1000 sightings of 263 individually-marked Pink-footed Geese were obtained during the study. Of the Pink-footed Geese caught at Loch Leven in October over 70% subsequently moved away from the study area. Of 39 Pink-footed Geese marked in October which were subsequently seen wintering further south, 44% were recorded back at Loch Leven during the spring passage.

15) Marked Pink-footed Geese which spent most of the winter months at Loch Leven were seen in broadly similar areas to unmarked geese, however individual geese showed strong preferences for certain fields within the study area.

16) Three radio-tagged Pink-footed Geese were monitored between December and March. Overall, they were recorded roosting on 39% of the nights and 46% of the days when checks were made.

17) A highly significant association between dropping counts and goose-day totals was obtained. Large numbers of droppings and large mean goose day totals in each of the principal crop types demonstrated the attractiveness of individual fields rather than crop type.

18) 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 (60%) than was estimated from live capture methods (39%) and age assessments in the field (14.8%).

19) Disturbance to feeding flocks of geese was mostly unintentional (65%) although deliberate disturbance by farmers and through shooting was 100% effective at causing the geese to move away from the area. Objects left in fields in order to deter geese were often transient in nature and their effectiveness was minimal. Six observations of decoy geese left in fields during the shooting season were made and one was known to have resulted in successful hunting.

20) A detailed general discussion provides a synthesis of the separate aspects of this study.

2 Introduction

2.1 General background

Both Pink-footed Geese *Anser brachyrhynchus*, which breed in Iceland and Greenland, and Icelandic-nesting Greylag Geese *Anser anser* winter in Britain and feed almost exclusively on farmland (Owen *et al.* 1986). About 225000 Pink-footed and 100000 Greylags currently winter in Britain (Mitchell 1994). Both species are present from late September to early May, but Pink-footed Geese generally arrive 3-4 weeks earlier and depart 2-3 weeks later than most Greylags. The distribution of both species is patchy and centred on a number of roosts, estuaries, large lakes and reservoirs, from which the birds fly each day to feed. The different roosts are not self-contained and movements of some birds from roost to roost around the country have been confirmed by counts and ringing (*e.g.* Fox *et al.* 1994).

Feeding flocks of Pink-footed Geese frequently consisting of several thousand densely packed birds, are amongst the most wary of geese, generally keeping away from hedges and other shelter that may hide potential predators. Before deforestation the farmland now used by the birds for grazing was not available, and Pink-footed Geese were restricted to coastal saltmarshes (Owen 1976). Their wariness and rather nomadic nature is adapted to this habitat, which is still important to some flocks in spring. Grain from barley stubbles currently constitutes the main food in autumn and early winter, followed by an increasing proportion of grass as the winter progresses. In some areas, unharvested potatoes and carrots are a major food source as are harvested sugar beet tops in Norfolk. In the late winter and spring, improved grasslands are heavily used by geese, though feeding can occur on winter-sown cereals and some grain may be gleaned from the surface of newly sown fields.

In Britain, the Pink-footed Goose is protected under Schedule 2 of the Wildlife & Countryside Act (1981); Annex II/2 of the E.C. Birds Directive and Appendix III of the Berne Convention. Greylag Geese are also protected under Schedule 2 of the Wildlife & Countryside Act (1981) except in the Outer Hebrides, Wester Ross, Sutherland and Caithness where they come under Schedule 1 part II of the Wildlife & Countryside Act (1981); Annex II/2 of the E.C. Birds Directive and Appendix III of the Berne Convention.

Loch Leven in east central Scotland, a National Nature Reserve since 1964, covers some 14km^2 and is the largest natural eutrophic lake in Britain with two fifths of its area no more than 3m deep. The loch is renowned for its wildfowl, and was one of the first 13 sites designated by the United Kingdom under the Ramsar Convention (Owen *et al.* 1986). It holds the largest concentration of breeding ducks in the country, is an extremely important wintering site for a wide variety of wildfowl (*e.g.* Waters & Cranswick 1994), and is one of the top eight sites for wintering Pink-footed Geese in Britain (Mitchell 1994).

Regular winter wildfowl counts did not start at Loch Leven until 1966, but there is a complete series of counts available since then. The loch forms a major autumn arrival point for Pink-footed Geese and, in most years, the counts are highest in the early autumn, falling to a lower, though fluctuating level for the rest of the

winter. The surrounding farmland provides large feeding areas for these and the Greylag Geese, though variations in harvest success and types of crops grown cause variations in the numbers of geese and how long they stay. A study made during 1968-70 of the Pink-footed and Greylag Geese wintering at Loch Leven by Newton & Campbell (1973) described in detail their numbers, distribution and feeding preferences.

A recent review by The Wildfowl & Wetlands Trust (WWT) showed that the numbers of Pink-footed Geese counted at Loch Leven in the autumn have increased at a faster rate than the national average, whilst Greylag Goose numbers have fallen dramatically, despite a nationally stable population level (Boyd *et al.* 1994). With this background, co-inciding with an increasing emphasis on land-use strategies, a new examination of the numbers and distribution of feeding geese around Loch Leven was timely.

2.2 The work of this project

The project was carried out between 1 December 1994 and 15 April 1995, and this report presents the findings of the work. The study had the following objectives:

a. To assess Loch Leven's role and importance for Pink-footed Geese in a local and national context.

b. To assess the feeding distribution of geese from the Loch Leven roost in relation to agriculture, shooting pressure and other relevant influencing factors.

c. To assess the degree of winter site fidelity and movements of Pink-footed Geese both to and from Loch Leven.

d. To determine the age and sex structure of the Pink-footed Goose population.

In order to address the objectives outlined above, eight areas of study were undertaken;

1. **Field use** was determined in order to investigate relationships between crop types and goose distribution.

2. **Co-ordinated Roost Counts** were carried out weekly from 12 December 1994 to 8 April 1995 to provide estimates of the numbers of Pink-footed and Greylag Geese roosting on Loch Leven, to monitor changes during the study period at different phases of the moon and to allow comparisons to be made with the numbers of geese counted during daytime searches.

3. **Daytime searches for geese** were carried out on four days of each week between 6 December 1994 and 31 March 1995 on approximately 140 km^2 of farmland surrounding Loch Leven. These provided estimates of the number of Pink-footed and Greylag Geese feeding close to the loch and examination of the crop preferences of each species during the study period.

4. **Nocturnal searches for geese** were carried out on seven nights between 30-31 January and 22-23 March 1995 using an image intensifier to estimate the extent and distribution of night-feeding by the geese.

5. **Movements of individually-marked Pink-footed Geese** were recorded throughout the study period to investigate the timing and extent of movements both within and beyond the study area.

6. **Movements of radio-tagged Pink-footed Geese** were examined between 20 December 1994 and 8 March 1995 for five marked geese. The use of radio transmitters complemented diurnal observations by allowing roost occupancy to be quantified and checks to be made for marked geese in areas where neck collars may have been difficult to read.

7. **Droppings** from ten fields were counted systematically each month during the study period to investigate more fully goose use when compared to daytime counts of geese.

8. The **age and sex structure of the Pink-footed Goose population** was determined through examination of Pink-footed Geese shot at Loch Leven during the hunting season, age counts of flocks of feeding geese and examination of birds caught with cannon-nets.

A synthesis of the studies is used to provide an overall discussion (Section 6).

3 Study area

The study area lies in east-central Scotland, in the 10 km squares NT90, NT91, NT92, NO00, NO01 and NO02, and was centred on Loch Leven (Figure 1). The boundaries of the study area were agreed by SNH, on the basis of existing knowledge of the localities used by both Pink-footed and Greylag Geese.

The study area covers approximately 140 km^2 of farmland and its altitude varies from *c.*100m near Auchmuirbridge to *c.*230m near Glenlomond. It lies within the Perth & Kinross District of Tayside Region. The main geographical features are the loch itself, the valleys of the River Eden, River Leven and Cairney Water with associated farmland, and the edges of high ground of the Ochil Hills, Cleish Hills, Benarty Hill and the Lomond Hills.

Diurnal searches for feeding geese were undertaken over an area of approximately 140 km^2, divided into 1474 fields (Figure 2). Most fields were of 3-6ha, separated by wire fences, walls or hedgerows and occasionally by windbreaks of small trees. The area also contains several large woodlands, many farmsteads and an aerodrome. An inner study area, bounded by roads and, in 1994-95, divided into 324 fields, covered approximately 20km^2 of farmland around the loch (Figure 2). This inner study area co-incided with the area used by Newton & Campbell (1973) during their 1968-70 study.

For the purposes of this report the term 'study area' includes all 1474 fields, unless specific references to, or comparisons with, the 1968-70 study are mentioned. At the start of the study in December 1994, the grass had stopped growing, and most of the cereals had been harvested. By the end of the study in the first week of April, some fields had been ploughed and some had been sown with winter cereals. Thus, for most of the early part of the study, goose food supply was gradually diminishing, as grass was eaten or shrivelled by frost, and harvest waste was eaten or ploughed under. Towards the end of the study, however, grass had begun to grow.

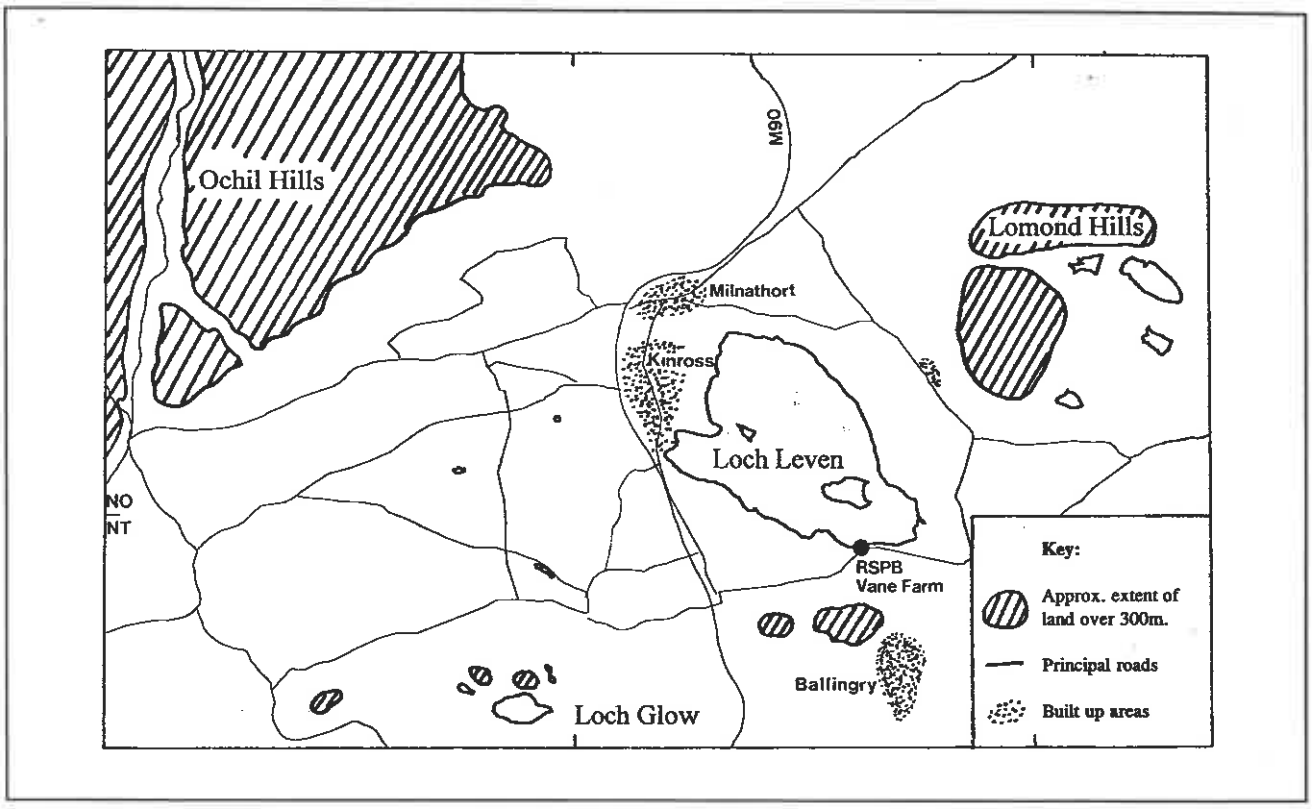

Figure 1. *The Loch Leven study area showing the main geographical features.*

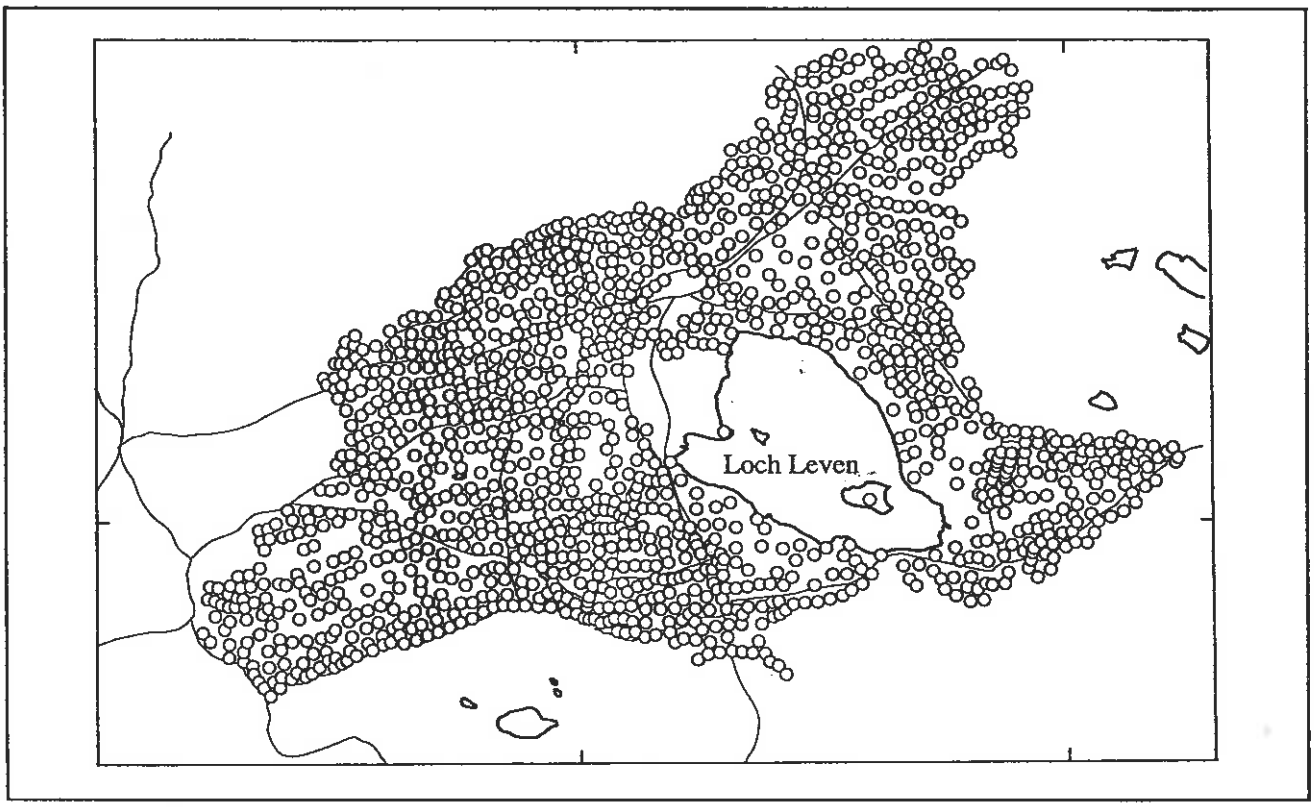

Figure 2. *Loch Leven study area showing the location of 1,474 fields checked for feeding geese (each circle is located at the centre of the field).*

4 Methods

4.1 Field use

Each of the 1474 fields within the study area was checked in April 1995 and the crop type determined (including ploughed land and miscellaneous, *e.g.* golf course).

4.2 Co-ordinated roost counts

Counts of roosting geese have been undertaken by SNH each month between September and March since 1966. The counts are collated under the Wetland Bird Survey (WeBS) and were made available to the project for analysis.

Dawn counts of roosting geese were made at Loch Leven, approximately once weekly throughout the study period from 12 December 1994 until 8 April 1995. The direction of flight from the loch was also recorded. Counters were positioned at three points around the loch to ensure that the coverage was as comprehensive as possible (see Figure 3). The three vantage points offered excellent views over the loch and have been used on previous roost counts at the site. A total of 15 roost counts were undertaken and these have been compared with counts made on the nearest day whilst undertaking diurnal field searches (see section 4.3).

4.3 Daytime searches

Daily searches for geese were undertaken throughout the study area on four days each week between 5 December 1994 and 31 March 1995. A total of 74 field searches were made. Two routes were used (A and B, Figure 3), with each route alternated daily between morning and afternoon visits to reduce systematic bias in the time of day each field was visited. Both routes allowed full visual access to all fields within the study area. Whenever Pink-footed or Greylag Geese (or both) were encountered the following details were recorded:

- time of day
- field code (Using a 1:25000 Ordnance Survey map, which showed field boundaries, each individual field was assigned a unique code prior to counts being undertaken)
- flock size of each species present
- crop type (using the same types identified in 4.1)
- presence of stock
- position of flock within the field
- the extent of human disturbance activities or efforts to deter geese (*e.g.* gas guns, scaring devices).

Additionally, any marked birds seen were recorded and, during December and January, a sample of the age composition of the flock was recorded (see section 4.8.2).

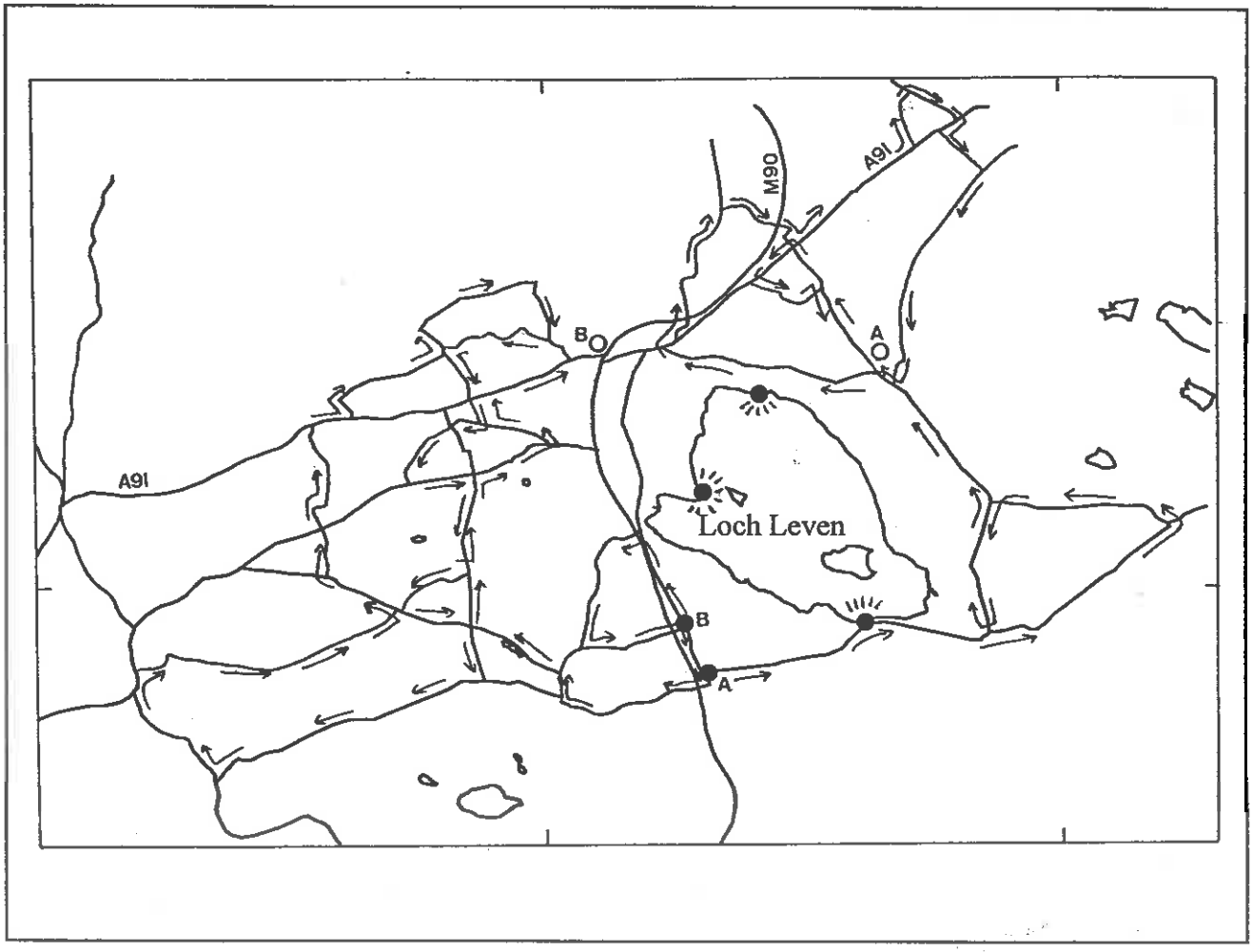

Figure 3. *Loch Leven study area showing daily count routes and the three roost observation points. The start (●) and end (○) of each of the two routes (A and B) are also shown.* ✺ *indicate the roost observations points.*

4.4 Nocturnal searches

Approximately once weekly, from 30 January until 22 March, an image intensifier was used to make searches for geese feeding at night on fields within, and close to, the inner study area. Of the fields contained within this area, 204 could be adequately checked from the roadside. In addition, areas adjacent to the inner study area, where geese had been observed feeding earlier that day were also checked, but not systematically. Two visits were undertaken each night; one 2-3 hours after sunset and one 1-2 hours before dawn. Similar data were recorded as for day-time observations in addition to the state of the moon. Identification of the species present was not possible using the image intensifier although all flocks encountered were identified by call. A comparison was made between the estimated number of geese recorded on the 204 checked fields during the night and the number of geese counted during the day in the same fields.

4.5 Movements of individually-marked Pink-footed Geese

Since January 1987, over 1500 Pink-footed Geese have been caught and marked by WWT at Martin Mere, Lancashire and at several localities in Scotland (see Fox *et al.* 1994 for details). Each has been fitted with a metal British Trust for Ornithology (BTO) ring and a white plastic leg ring engraved with three letters, which can be read with a telescope at up to 300m. Renewed effort into marking Pink-footed Geese at Carden Point, Loch Leven started in spring 1994 and most of the geese ringed there have been fitted with a metal BTO ring and a grey plastic neck collar engraved with two letters. These can be read with a telescope at up to 800m and allow individual recognition when the goose is sitting, resting on water or in long vegetation. Individually marked Pink-footed Geese were checked during routine diurnal counts, and additional *ad hoc* searches were specifically made for marked birds. When time permitted, searches were made for geese in surrounding areas. This primarily involved Strathearn (Tayside) to the north of Loch Leven and the Loch Gelly area (Fife) to the southeast. Additional searches were made to Cameron Reservoir (Fife), Blairdrummond Moss (Central), the upper Earn Valley and Auchterarder area, Strathmore and Montrose Basin (Tayside), Meikle Loch and Loch of Strathbeg (Grampian). Sightings of marked geese were also reported to WWT by local birdwatchers and reserve wardens from other sites within the wintering range.

4.6 Movements of radio-tagged Pink-footed Geese

At a cannon-net catch on 20 December 1994, radio transmitters were attached to five Pink-footed Geese, under a licence issued by the BTO. Each transmitter was glued to a 5cm diameter piece of tarpaulin using contact adhesive. The tarpaulin was then attached to the mantle and down feather on the birds' back using '*superglue*' (a fast acting bonding adhesive). The location of these birds were monitored during the daily searches using a radio receiver. Feeding flocks were scanned during the daily searches (but see below) to establish if any radio-tagged geese were present. Scans were also made from high vantage points along the daily count route to check a wider area than was visible with binoculars. The presence of radio-tagged geese roosting on Loch Leven was checked each evening from the three roost count points. Monitoring of the radio-tagged birds did not take place between 24 December 1994 and 8 January 1995. Checks for radio-tagged geese feeding at night in fields in the study area were not made.

4.7 Dropping counts

In investigating the relationship between the intensity of goose-use and field type it is important that the amount of goose use can be measured accurately for a specific field. Goose use is readily measured by counting the density of droppings in the study fields (*e.g.* Owen 1971, Bedard and Gauthier 1986, Fox 1993 *etc.*). For example, a strong correlation between daytime count data and dropping densities ($r=0.76$, $P<0.001$) was found in Barnacle Geese *Branta leucopsis* on Islay, Strathclyde (Percival 1988). Pink-footed Geese defecate every 5-6 minutes whilst feeding (WWT unpubl.), so the number of droppings accumulated per unit area can be used to help assess the accuracy of the diurnal counts.

Ten fields were selected for dropping counts within the inner study area in early December 1994. The crops in the selected fields were improved grass (two), set-aside grass (two), stubble (four) and winter cereals (two). Across each field a diagonal transect was established with sample points located at intervals of 50 paces. The number of points varied from six to 16. At each point droppings were counted within an area of $5m^2$. Each transect was surveyed once monthly in the last week of the month. Droppings were removed from each sample point in December and after counting in subsequent months so that no duplication arose.

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

Field observations of the proportions of first-winter birds and family groups has been used for many years as an indicator of productivity (*e.g.* Ogilvie & Boyd 1976) and has now become a standard research tool in monitoring goose population dynamics. The age and sex structure of Pink-footed Geese wintering at Loch Leven were sampled by three methods: 1) age assessments in the field; 2) age and sex of geese shot at the reserve (hunting bag) and 3) age and sex of geese caught during cannon-netting attempts.

4.8.1 Age assessments in the field

During December and January age assessments of flocks were undertaken in the field. Settled flocks were chosen when viewing from the road since these allowed close inspection of contour and wing feather shape. To avoid duplication no flock was knowingly assessed more than once in any two week period.

Under favourable light conditions experienced observers with a telescope could distinguish adult and first-winter Pink-footed geese at distances of up to 300m. First-winter geese could be separated from adult geese by examination of the size and shape of the mantle and breast feathers and upper wing coverts. Additional field age assessment data, collated by WWT, were available for regional and national comparisons. Due to the late commencement of this study, age assessments undertaken in the field close to Loch Leven were, however, later than those carried out in other parts of Britain.

4.8.2 Hunting bag

During the study period there were three periods of organised goose shooting at Loch Leven. These were 5-9 December, 9-13 January and 23-27 January. After each organised shoot, dead Pink-footed Geese were examined and the following data were collected:

- Age - determined by examination of plumage characteristics
- Sex - determined by eversion of the cloaca
- Biometrics: wing length - total flattened chord (mm); tarsus length (mm); total head and bill length (mm) and body weight (g).

4.8.3 Capture data

During the 1994/95 winter, a total of seven cannon-net fires were made at Carden Point on the southern shore of Loch Leven. On each occasion two full-size nets were fired. The site was pre-baited with grain for 7-10 days prior to the catch. The same data collected from the hunting bag samples were recorded for geese caught with cannon-nets.

4.9 Disturbance

The causes of disturbance to goose flocks were recorded during daily routine searches when these events were observed. Responses of the disturbed geese were categorised as alert, fly and return to the same field and fly and not return. Additionally, the presence of devices, such as gas guns, intentionally positioned to scare geese was noted, whether geese were present or not. Minor disturbance events that only resulted in some geese becoming alert were not recorded. This is a daily occurrence for feeding geese and is not thought to significantly alter their distribution.

5 Results

5.1 Field use

In April 1995, about a half of the farmland was under grass of various ages, another quarter was under cereals (mainly barley and including stubble fields), a further fifth had been ploughed and the remainder was predominantly sown to brassicas, with a very few fields having been planted with potatoes and turnips (Table 1). There was no significant difference between the proportion of fields of different crop types within the whole and inner study area ($\chi^2_{16}=7.2$, ns).

Table 1. *Total and percentage crop type of Loch Leven study area (assessed in April 1995).*

Crop	Total no. of fields	Proportion of study area	No.of fields within inner study area	Proportion of inner study area
Improved grass (IG)	688	46.7	137	42.3
Unimproved grass (UG)	25	1.7	6	1.8
Winter cereal (WC)	210	14.2	53	16.4
Stubbles [1] (ST)	194	13.2	43	13.3
Bare soil (plough, BS)	306	20.7	68	21.0
Brassica (BR)	29	2.0	6	1.8
Potatoes (PO)	7	0.5	2	0.6
Turnips (TU)	3	0.2	1	0.3
Miscellaneous [2]	12	0.8	8	2.5

Note: [1] *includes stubbles of cereals (SC), brassicas (SB) and rape (SR).*
[2] *includes maize (1 field), hay (1), raspberry (2), strawberry (1), mixed fields (2) and scrub (5).*

The distribution of the principal field types is shown in Figure 4. The distribution of individual crop types are presented as figures in Appendix 1. Since field use was determined at the end of the study period the amount of ploughed land was over represented. However, of the 306 fields recorded in this category only 21 (7%) ever held geese, and of these, at the start of the study six were already ploughed, seven were cereal stubble fields, four were harvested potato and four sown with improved grass. The preference of geese for particular fields is determined in Section 5.3 and although this anomaly should be borne in mind, the very low proportion of geese using 'ploughed' fields should not effect the interpretation of the results.

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. Usually the geese left the roost over a period of about one hour in single species flocks of varying size. Complete data are given in Appendix 2 and are summarised in Table 2.

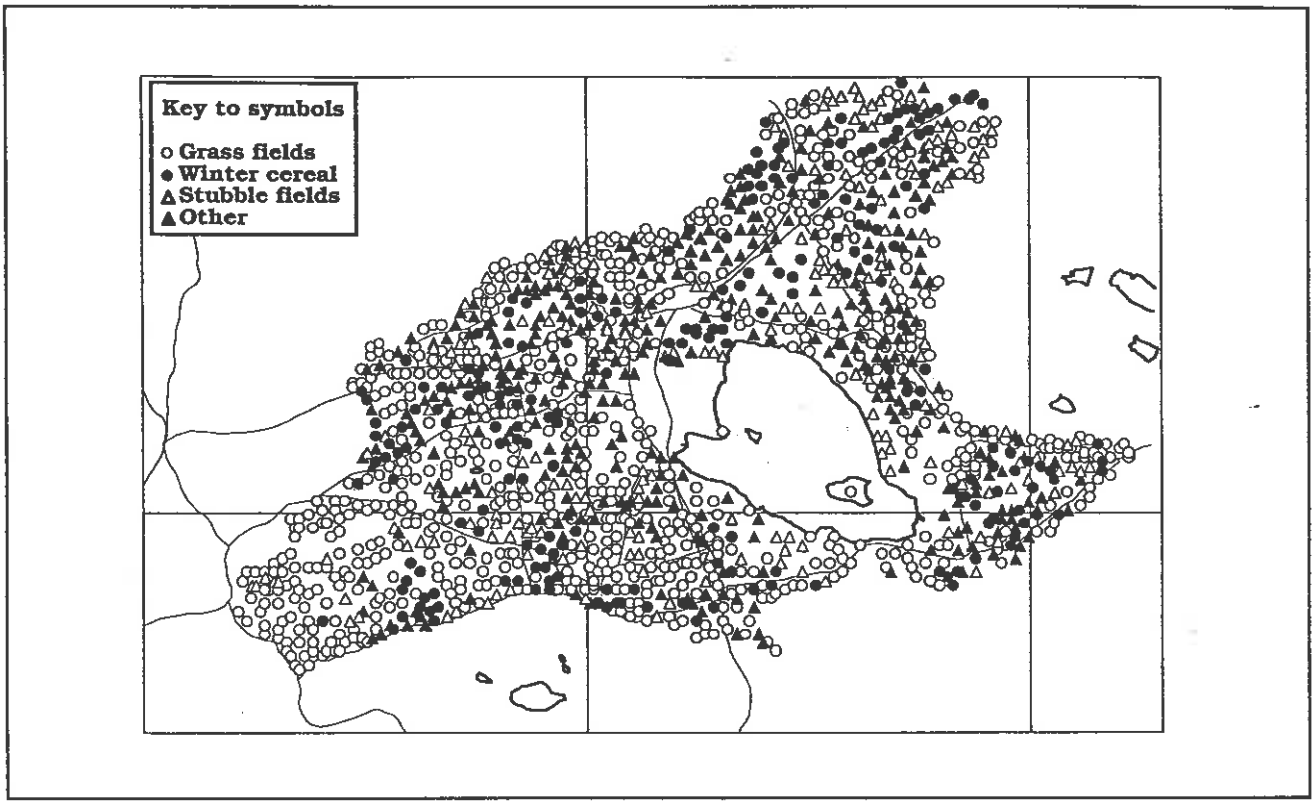

Figure 4. *The distribution of principal field use types in the Loch Leven area in April 1995 (for a complete breakdown of field types see Appendix 1)*

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

Date	Roost count total	Field count total	Field counts as a % of roost count	State of moon	Cloud cover (oktas)
6 December 1994	No count	4989	-	New	-
12 December	7911	6361	80	first quarter	5
23 December	3289	4180	127	last quarter	8
12 January 1995	6971	5627	81	last quarter	4
19 January	1204	5010	416	Full	5
25 January	5452	3853 [1]	71	last quarter	7
28 January	9912	5990 [1]	60	New	1
9 February	6447	3480	54	first quarter	1
16 February	935	5351	572	Full	7
23 February	2527	8113	321	last quarter	1
2 March	6778	12694	187	New	6
9 March	6153	6692	109	first quarter	7
16 March	1951	6520	334	Full	2
27 March	4311	5338	124	last quarter	1
31 March	2618	4667	178	New	8
8 April	7849	No count	-	first quarter	1

Note: [1] field count total is from the day previous to roost count.

The mean number of roosting birds during midwinter (December and January) was 5790 (n=6) and in spring (February and March) was 4395 (n=9). There appeared to be no correlation between the diurnal counts of geese in the study area and roosting Pink-footed Geese flighting from the loch (r_{14} = 0.18, ns). The number counted in the fields expressed as a proportion of those roosting varied between 54% and 572% (mean = 194%). On most count days (n=9), more birds were recorded in fields than could be accounted for by the roost counts.

Relatively small numbers of roosting geese were recorded on 19 January, 16 February and 16 March (mean 1363) at the time of a full moon compared with those recorded on 28 January, 2 March and 31 March (mean 6436) at the time of a new moon (Table 2 and Figure 5) although lack of sufficeint data precluded statistical analysis. Geese were also observed roosting and/or feeding along The Cut (NO9000) during full moon periods (see Section 5.4).

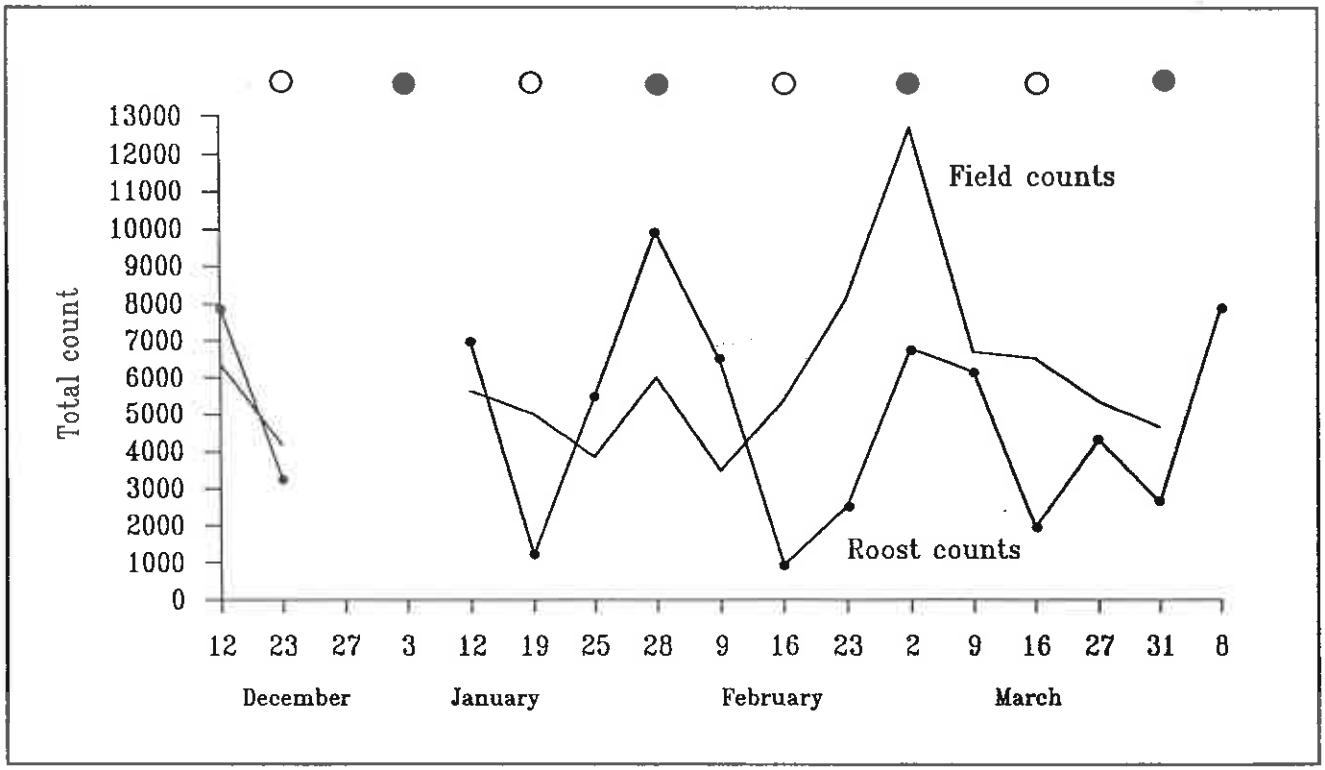

Figure 5. *Roost counts and field counts of Pink-footed Geese at Loch Leven between 5 December 1994 and 8 April 1995.* ○ = *full moon,* ● = *new moon.*

The monthly roost counts (October to March) of Pink-footed Geese from 1966-67 to 1993-94 are shown in Figure 6. By far the biggest increases in the numbers of Pink-footed Geese roosting at Loch Leven have been recorded during the early autumn. In the early 1970s, approximately 5000-10000 Pink-footed Geese were recorded in October but by the early 1990s this has increased to 16000-22000. Although counts from each month have shown some increase, most have been modest, although January counts show an increase from less than 3000 in the early 1970s to 5000-9000 in the early 1990s.

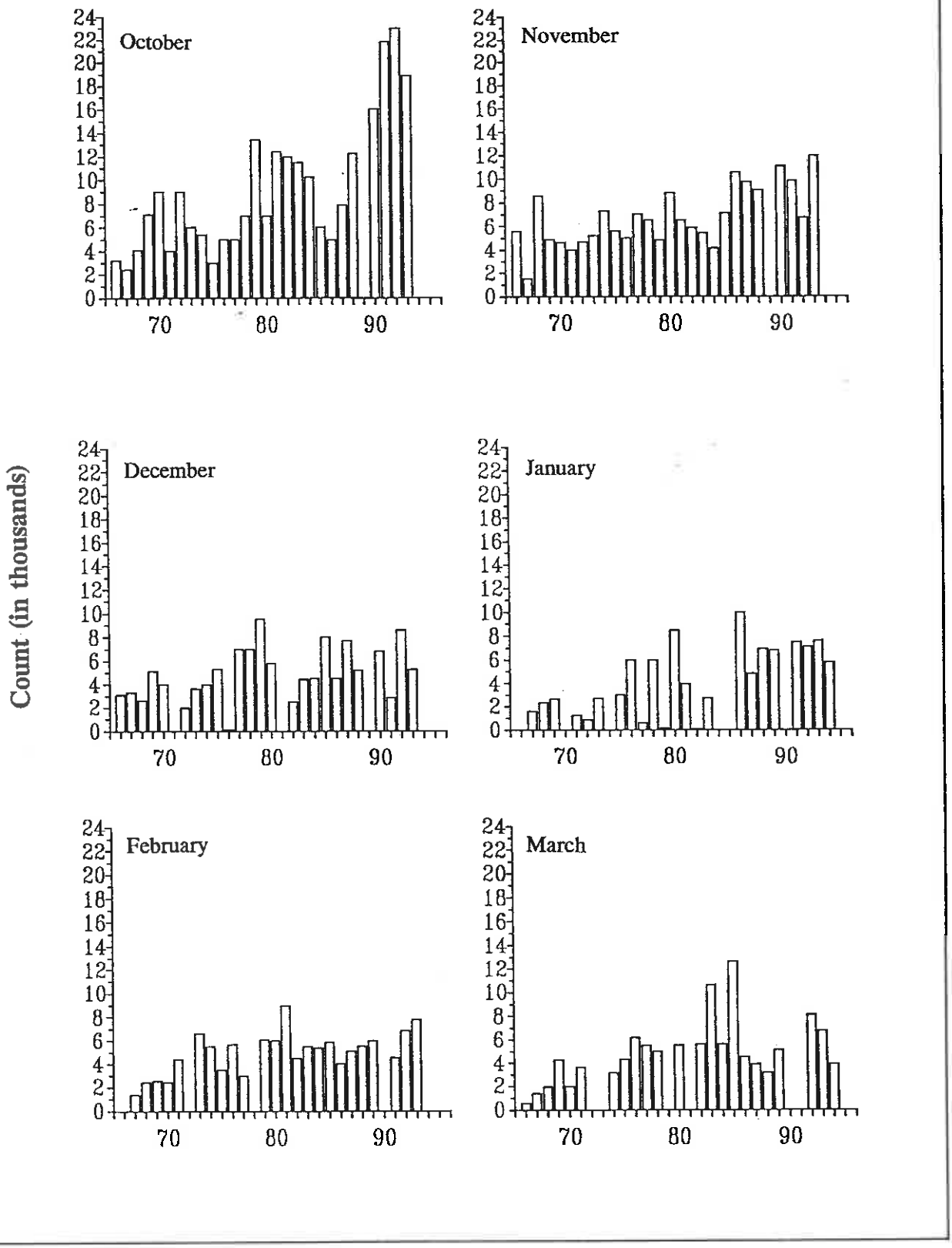

Figure 6. *Monthly roost counts of Pink-footed Geese at Loch Leven from 1966/67 to 1993/94*

Expressed as a proportion of the British wintering population (based on November WWT roost counts) the number of Pink-footed Geese counted at Loch Leven in October shows a slight increase which is greater than the overall population increase (Figure 7, October). It does, however, vary considerably from year to year with a very low proportion supported between 1984 and 1987. Counts of Pink-footed Geese in other months expressed as a proportion of the annual population all show slight declines except in January (although none are statistically significant) (Figure 7, November - March).

Counts of Pink-footed Geese at Loch Leven in November expressed as a proportion of the total number counted in Perth & Kinross and Central (the count region into which Loch Leven lies) show a statistically significant increase (Figure 8a). However, November counts of Pink-footed Geese within Perth & Kinross and Central expressed as a proportion of the total population estimate show a statistically significant decline (Figure 8b).

Organised roost counts throughout the Pinkfoot's winter range were recently started during mid-winter and spring (from 1993/94, *e.g.* Stenhouse & Mitchell 1994). However, the overall mid-winter counts (both in January) accounted for only 72% of the autumn 1993 population estimate and 56% of the autumn 1994 population estimate. The mid-winter counts of Pink-footed Geese at Loch Leven in 1994 (5778) and in 1995 (9912) were 3.6% and 6.6% of the overall total counted. Overall, the spring counts accounted for only 56% of the autumn 1993 population estimate and 38% of the autumn 1994 population estimate. The spring counts of Pink-footed Geese at Loch Leven in 1994 (5778) and 1995 (9912) were 6.9% and 9.8% of the overall total counted.

Since the late 1960s, there has been a dramatic decline in the number of Greylags roosting at Loch Leven despite a nationally stable population level (*e.g.* Boyd *et al.* 1994). Numbers have never been high in the early autumn (the period of increase for Pink-footed Geese) but November counts have fallen from 2500-5000 in the mid-1970s to less than 300 in the early 1990s. Average midwinter counts in December and January in the early 1970s were 3000-5000. By the late 1980s these too had fallen to 1000-2000 and in the two most recent winters (since 1991-92) less than 500 Greylags have been recorded at Loch Leven. A proportion of the winter stock are thought to be of feral origin and could be found at Vane Farm RSPB reserve, on the south shore of the loch, with great regularity. It would seem likely that only a small number of Icelandic Greylags are now frequenting the Loch Leven area over the whole winter period. This is in contrast to the national trend, where Greylag numbers have gradually increased from *c.*50000 in the late 1960s up to *c.*100000 in the late 1980s since when the population has apparently stabilised (Mitchell 1994).

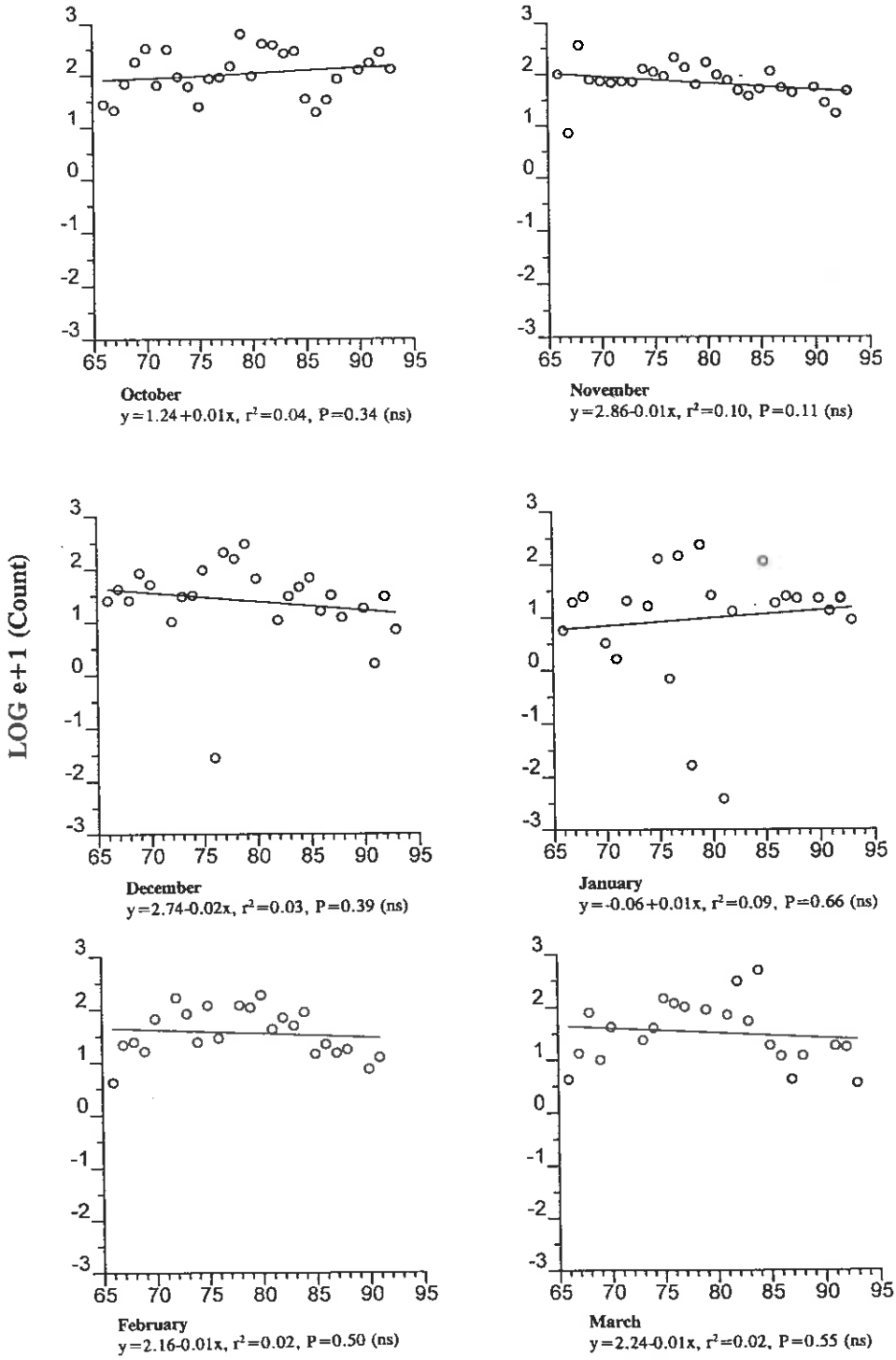

Figure 7. *Counts of Pink-footed Geese at Loch Leven in October to March expressed as a proportion of the annual (November) population estimate.*

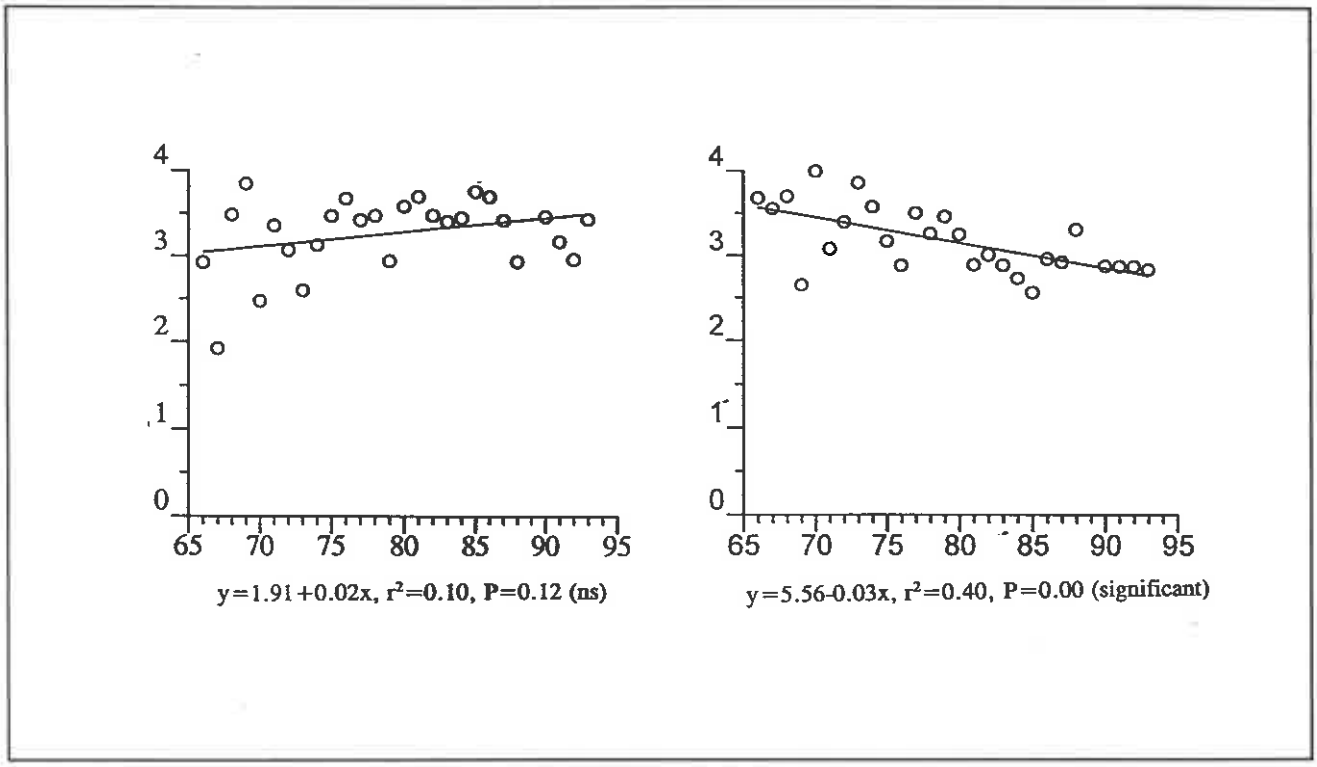

Figure 8. *November counts of Pink-footed Geese at Loch Leven expressed as a proportion of the regional total (8a) and the regional total expressed as a proportion of the annual (November) population estimate (8b)*

5.3 Daytime searches

During the study period all 1474 fields were checked once for feeding geese on each count day (n = 74). Of the fields checked, 209 (14.2%) were utilised by feeding Pink-footed Geese and 43 fields (2.9%) were used by Greylag Geese (Table 3). There was a tendancy for more fields to be used by Pink-footed Geese from winter (3.4% of those available in December) to spring (8.1% in March). Because of the low number of Greylag Geese present this trend was not apparent. Summing the number of geese counted during the field searches resulted in a total of 292734 bird days for Pink-footed Geese (mean = 3956 geese per count day) and a total of 4116 bird days for Greylags (mean = 56 birds per count day). The distribution of all the fields used by Pink-footed Geese is shown in Figure 9.

Table 3. *Number of fields used by Pink-footed and Greylag Geese during December 1994 to March 1995.*

Species	Number of fields used (% of those available)					
	December	January	February	March	Total used	Total not used
Pinkfoot	50 (3.4)	85 (5.8)	94 (6.4)	120 (8.1)	209 (14.2)	1265 (85.8)
Greylag	16 (1.1)	13 (0.9)	9 (0.6)	17 (1.2)	43 (2.9)	1431 (97.1)
Either	54 (3.7)	85 (5.8)	96 (6.5)	122 (8.3)	**215 (14.6)**	1259 (85.4)

Note: Total number of fields available = 1474

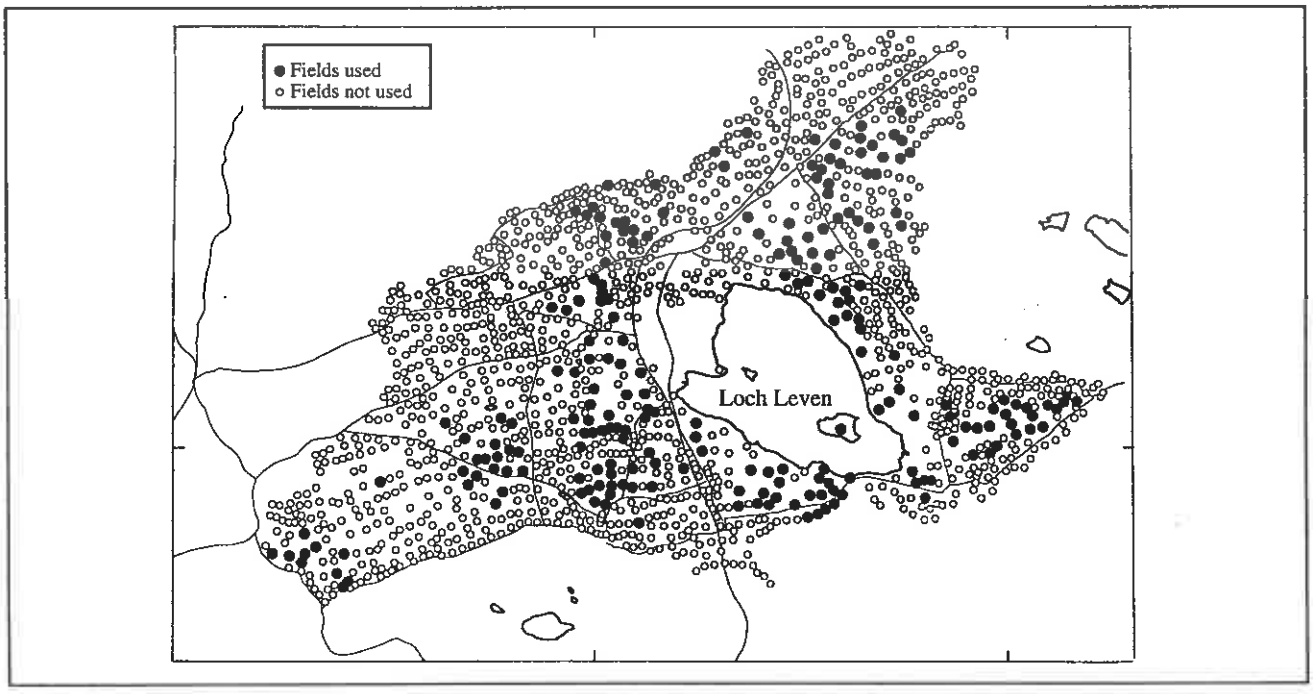

Figure 9. *The Loch Leven study area showing all fields used by Pink-footed Geese, together with those fields in which Pinkfeet were never recorded.*

The field types in which Pink-footed Geese were recorded from December to March and the extent to which geese fed selectively, rather than randomly, over the study area is shown in Table 4. An index (c) was produced by comparing the percentage composition of the field types available (from Table 1) with the percentage composition of the feeding records obtained overall. The index (c) reflects the degree of preference for particular field types (see Table 4 key for explanation). Some fields were used in proportion to their availability in the area (*e.g.* winter cereals), some were preferred (improved and unimproved grass, stubbles and potatoes), and others were avoided to some extent (bare soil and miscellaneous), Whilst some were avoided altogether (brassicas).

Table 4. *Total bird days for Pink-footed Goose in different crop types during winter 1994-95.*

Crop	December		January		February		March		Overall	
	a (b)	c	a (b)	c	a (b)	c	a (b)	c	a (b)	c
Improved Grass	21671 (56)	1.2	48125 (61)	1.3	52383 (61)	1.3	64145 (53)	1.1	186324 (57)	1.2
Unimproved Grass	2792 (7)	4.2	1860 (2)	1.4	1300 (2)	0.9	140 (0)	0.1	6092 (2)	1.1
Winter cereal	3847 (10)	0.7	11883 (15)	1.1	8764 (10)	0.7	25109 (21)	1.5	49603 (15)	1.1
Stubbles	9219 (24)	1.8	16003 (20)	1.5	19124 (22)	1.7	18515 (15)	1.2	62861 (19)	1.5
Bare soil	43 (0)	0.0	920 (1)	0.1	2820 (3)	0.2	12528 (10)	0.5	16311 (5)	0.2
Brassicas	0 (0)	-	0 (0)	-	0 (0)	-	0 (0)	-	0 (0)	0.0
Potatoes	1210 (3)	6.2	617 (1)	1.6	2050 (2)	4.8	0 (0)	-	3877 (1)	2.4
Miscellaneous	0 (0)	-	0 (0)	-	0 (0)	-	290 (0)	0.3	290 (0)	0.1

Key: a - Total number of Pink-footed Geese recorded (bird days). (b) - expressed as a percentage. 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.

From December 1994 to March 1995 preferred feeding in improved grass fields remained at a similar level, feeding in stubbles, unimproved grass and potato fields declined whilst feeding in winter cereals increased. Overall, Pink-footed Geese showed strongest preferences for improved grass fields, the few potato fields available and those containing stubbles. Yet despite these preferences very few of the available fields were used - of the 688 improved grass fields available within the study area only 118 (17%) were used, and of these, 10 fields accounted for 31% of observed feeding within that crop type.

Certain fields held a disproportionately large number of geese. Thus, three fields (C97, I2 and I38) accounted for 9.8% of counts of feeding Pink-footed Geese, and ten fields held 24.6% (Table 5). The distribution of the 28 fields which, overall, held more than 1% of the total number of bird days (*i.e.* >2927) is shown in Figure 10.

Table 5. *The 28 fields which held more than 1% of observed Pink-footed Geese*

Field Number	Total number of birds days	Proportion of overall total
C97	13775	4.6%
I2	7425	2.5%
I38	7397	2.5%
R78	6440	2.2%
I41	6401	2.1%
P84	6317	2.1%
N47	6276	2.1%
H107	6150	2.1%
C26	6140	2.1%
I58	5812	1.9%
I49	4591	1.5%
I53	4528	1.5%
P105	4415	1.5%
G27	4185	1.4%
I37	4063	1.4%
I4	4050	1.4%
H91	3985	1.3%
E39	3872	1.3%
S1	3837	1.3%
G90	3700	1.2%
R5	3654	1.2%
I45	3653	1.2%
C63	3561	1.2%
I51	3462	1.2%
C3	3440	1.2%
H62	3380	1.1%
R55	3330	1.1%
J14	3288	1.1%

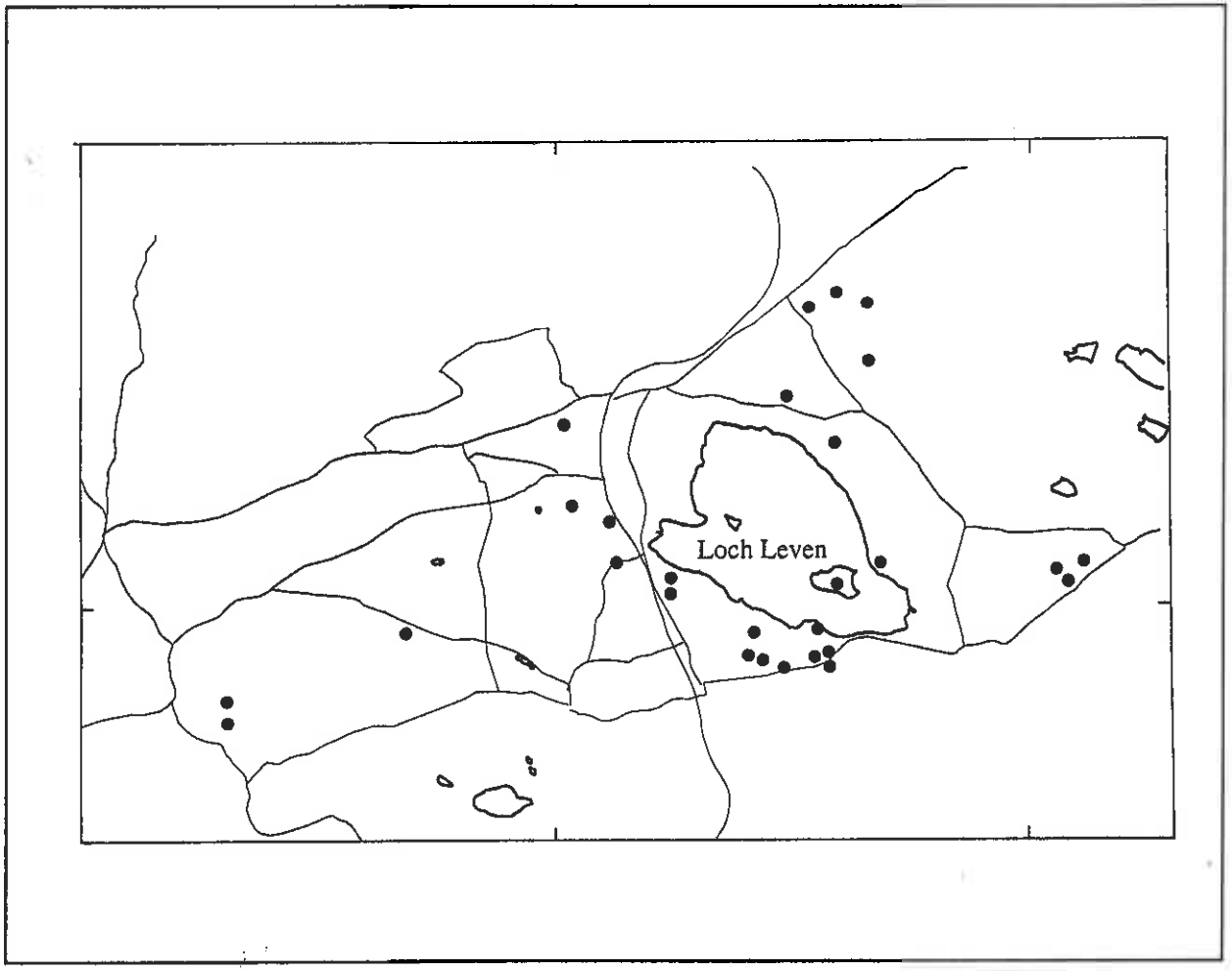

Figure 10. *The distribution of the 28 fields in which greater than 1% of the total number of Pinkfeet (bird days) were recorded.*

Overall, Pink-footed Geese did a quarter of their observed feeding in only 5% of the 209 fields used, a half in 15%, and three quarters in 32%. Greylag Geese did a quarter of their observed feeding in only 3% of the 43 fields used, a half in 8%, and three quarters in 19% (Figure 11).

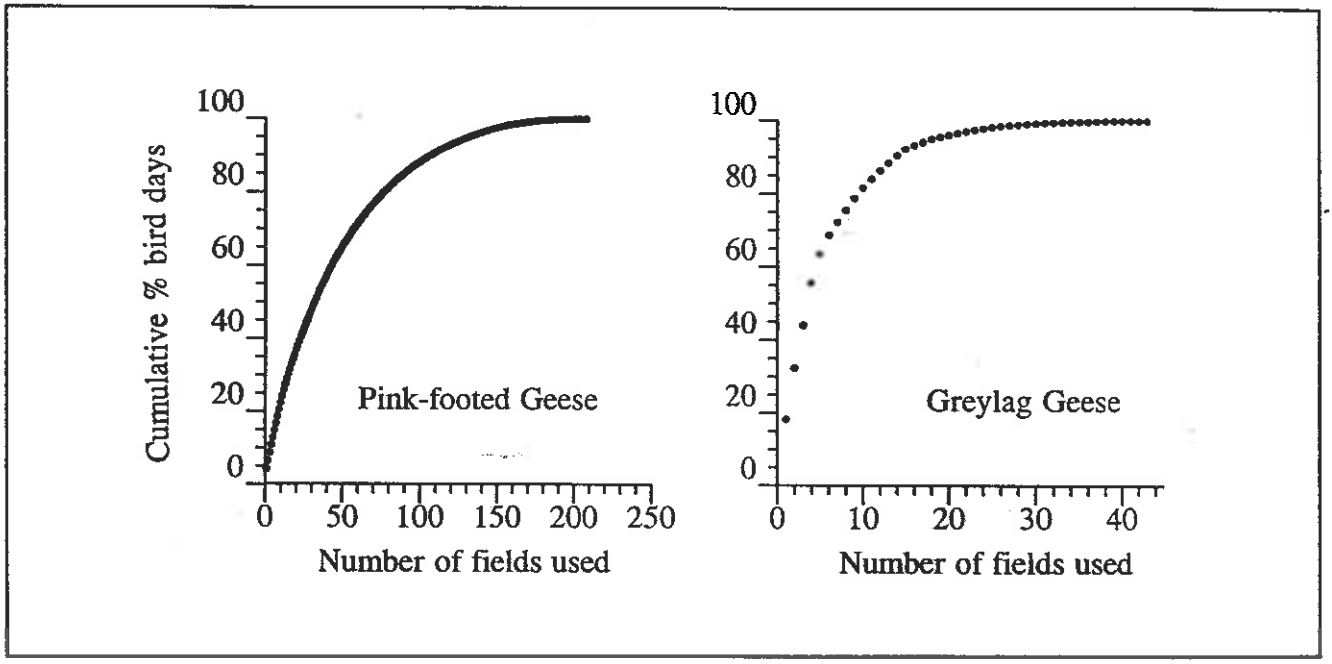

Figure 11. *The intensity of feeding by Pink-footed (left) and Greylag Geese (right) in different parts of the study area, 1994/95.*

Despite geese selectively choosing to feed in some crop types and not in others, the fidelity for particular fields was remarkable (Figures 10 and 11). The tendency of geese to return to where they had already fed safely contributed to certain fields being used much more than would be expected from the food they contained. On 75% of fields in which geese were seen once, they were seen a second time, and on 90% of fields in which they were seen twice they were seen again.

The diurnal distribution of sightings of Pink-footed Geese made during this study could not be directly compared with those obtained during the 1968-70 study. However, Figure 12 visually compares the principal feeding areas used by Pink-footed Geese in 1968-70 together with the fields in which Pink-footed Geese were recorded in 1994-95. The degree of similarity is remarkable despite some changes in the agricultural make-up of the land.

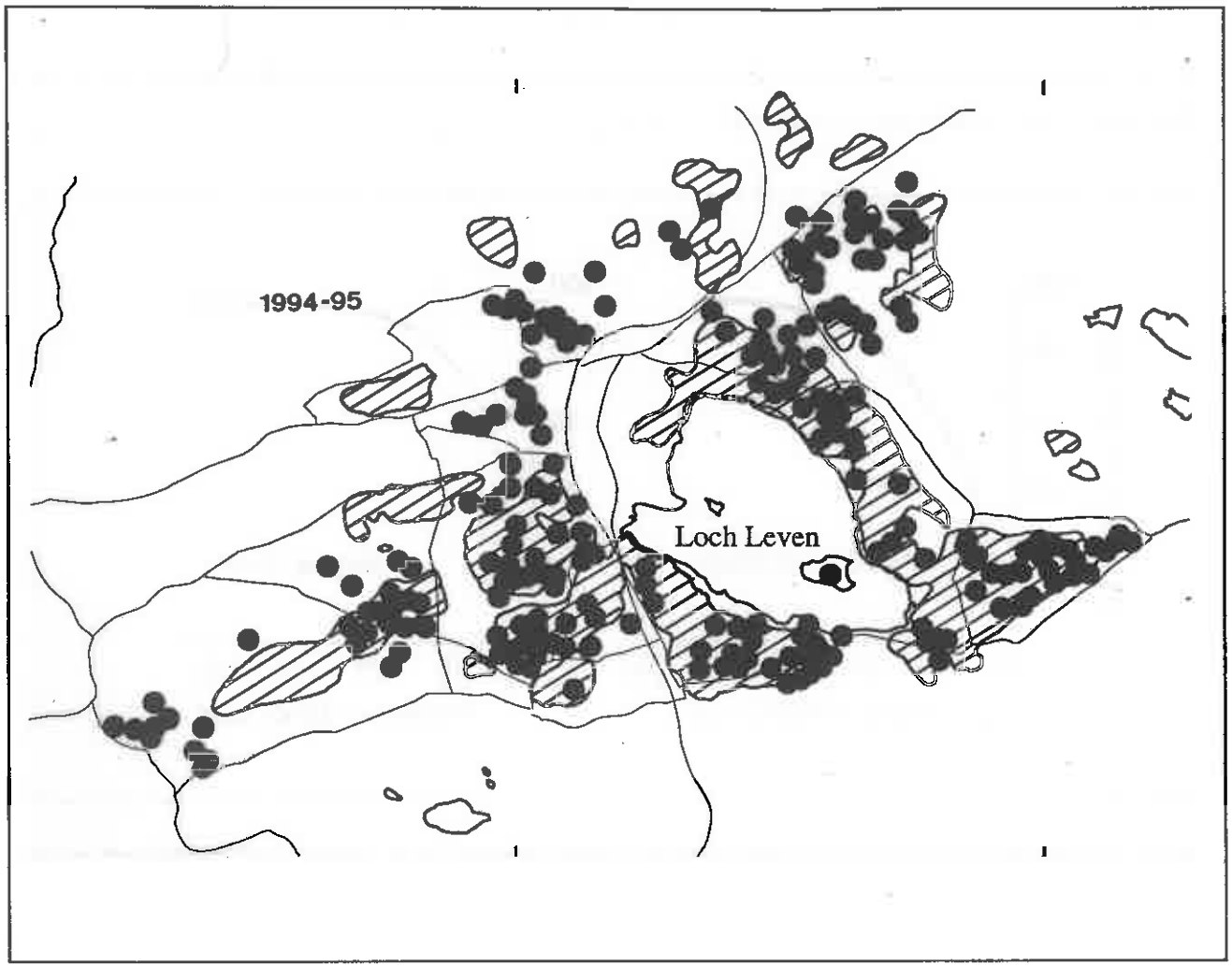

Figure 12. *The principal feeding areas used by Pink-footed Geese in 1968-70 (cross-hatched) shown together with the fields in which Pinkfeet were recorded in 1994/95 (closed circles).*

A comparison of the mean flock size of Pink-footed and Greylag Geese recorded during the present study with those counted in 1968-70 is shown in Figure 13.

Flock sizes of Pink-footed Geese are now more homogenous than during 1968-70 with less medium sized flocks (101-500 geese) and a greater proportion of smaller flocks (*e.g.* 1-20 geese) and larger flocks (*e.g.* more than 1000 geese). Flocks of more than 1000 birds have risen from 3% to 15%, reflecting the increase in numbers wintering at Loch Leven over the last 20 years. By contrast, Greylag Goose flock size has decreased, with no flocks larger than 500 birds recorded during winter 1994/95, while 6% of flocks were larger than 500 birds during the 1968-70 study period.

Although Mean flock sizes of Pink-footed Geese recorded from December to March did not change considerably, although there was a tendency for the proportion of smaller flocks to decrease and flocks of over 1000 birds to increase slightly as winter progressed (Figure 14).

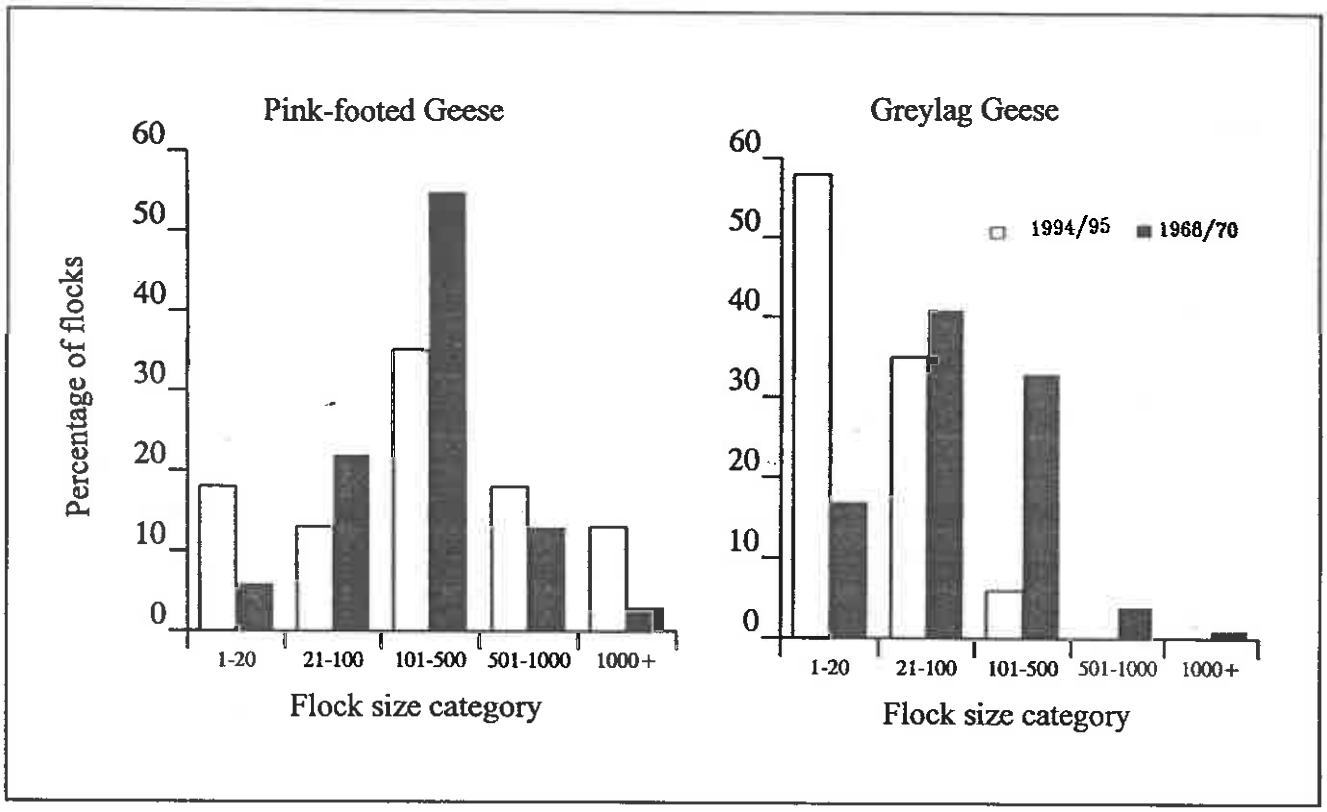

Figure 13. *Mean flock size of Pink-footed and Greylag Geese recorded in 1994/95 shown together with those recorded in 1968/70 (from Newton & Campbell 1973).*

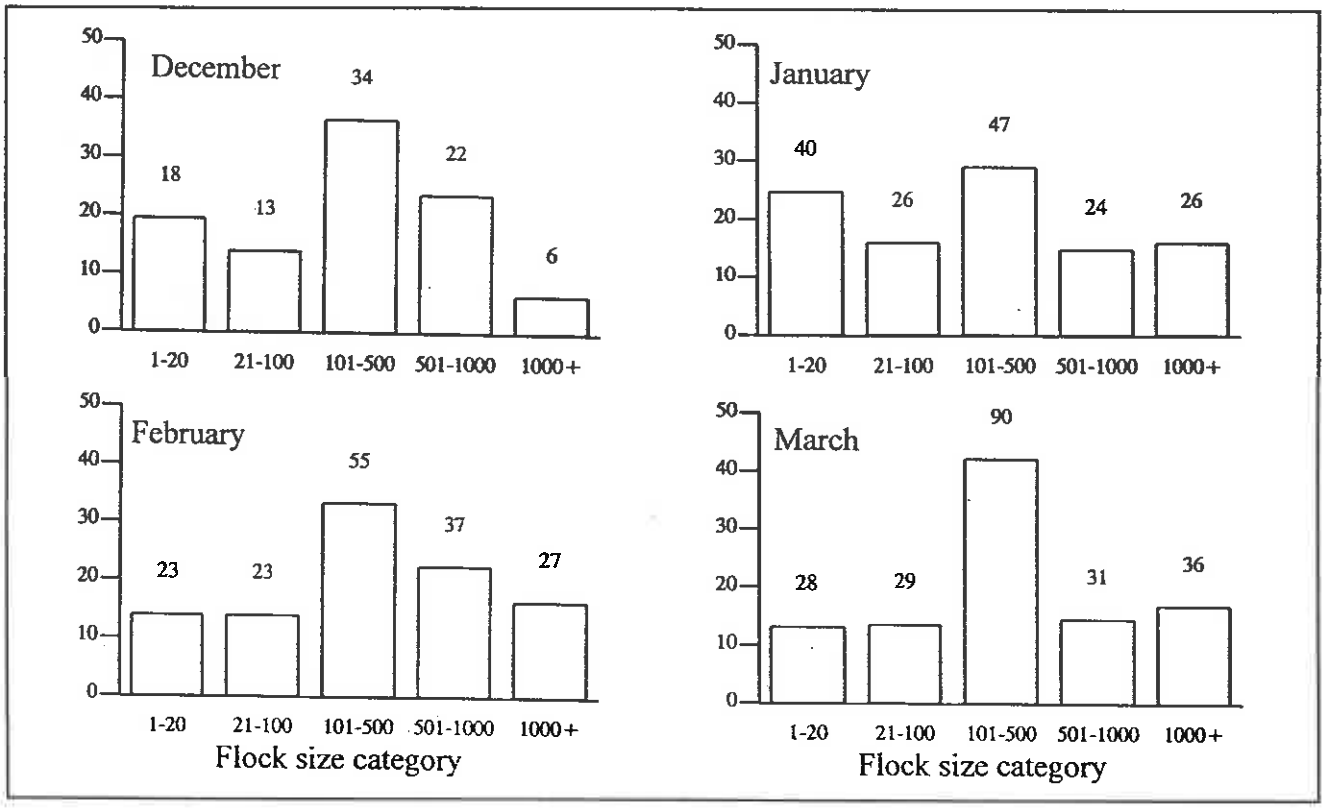

Figure 14. *Percentage flock size of Pink-footed Geese recorded in each month, December 1994 to March 1995 (sample sizes shown above bars).*

5.4 Nocturnal Searches

Pink-footed Geese were recorded feeding at night on three out of the seven nights when observations were made (Table 6). No Greylag Geese were recorded feeding at night. Overall, a total of 5411 Pink-footed Geese were counted in seven separate flocks (mean flock size = 773). Pink-footed Geese were recorded in six out of the 204 fields checked (Figure 15).

Additional checks away from the inner study area but made at the time of the weekly counts, revealed Pink-footed Geese feeding in a field at night 5.5km from Loch Leven. During the period of full moon in mid-February up to 3000 Pink-footed Geese roosted in large fields (especially H89 and H91) along The Cut (NO9000). The geese fed in this area during the day and on 15 March continued to feed in the early evening (until at least 2100h), but at 0440h that night the majority were resting/sleeping.

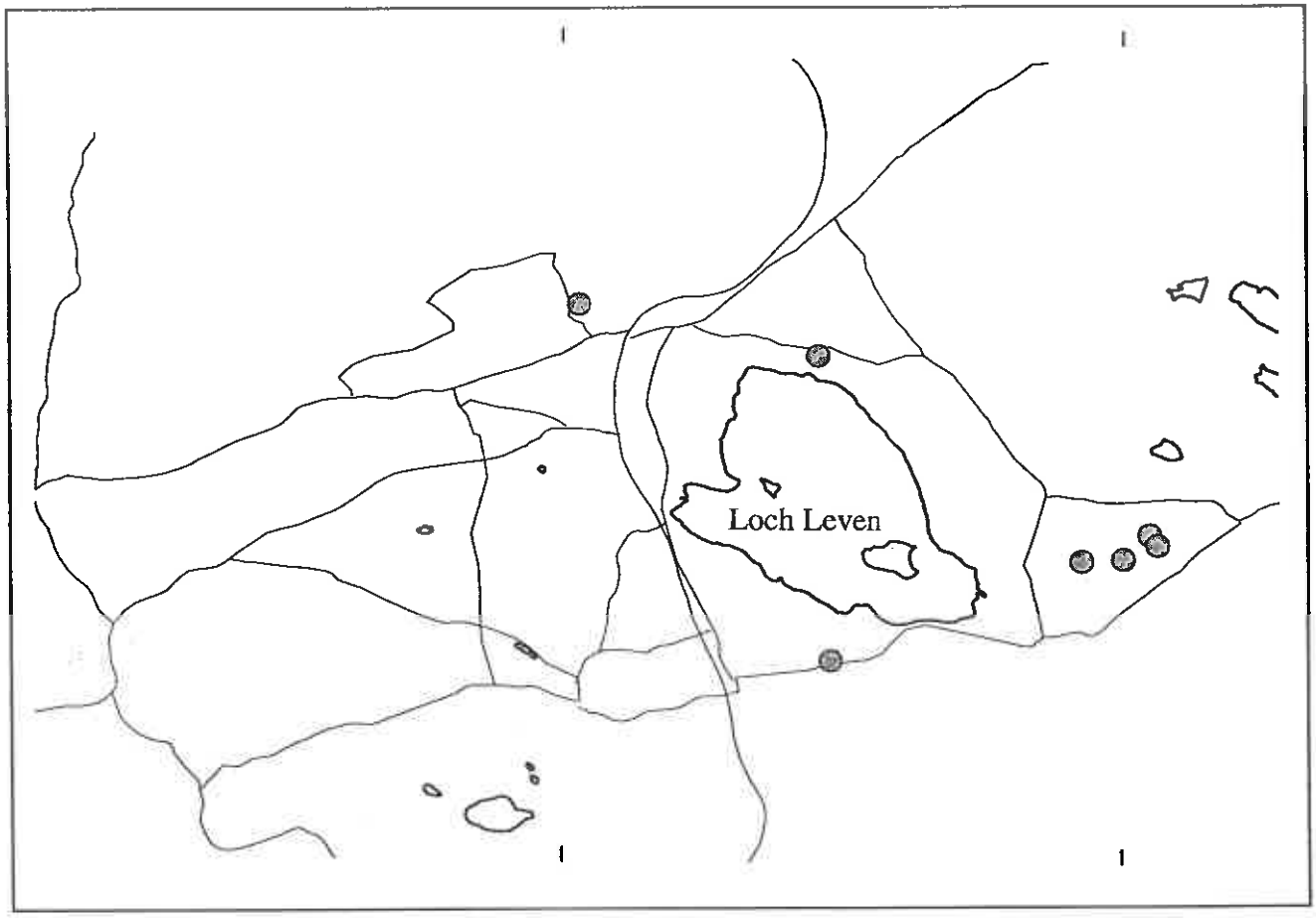

Figure 15. *The distribution of fields in which Pink-footed Geese were recorded night feeding between January and March 1995.*

Table 6. *The extent of night feeding recorded in 204 checked fields near Loch Leven (30-31 January - 22-23 March 1995). Also shown is the number of geese recorded in the checked fields during the day preceding night counts.*

	Nocturnal observations							Daytime observations	
Date	State of Moon	Cloud cover (oktas)	No. of fields with geese (%)	Field	Flock size	Time	Crop type	Daytime count	No. of fields with geese (%)
30-31 January	new	1	0 (0%)	-	-	-	-	4896	4 (1.96%)
9-10 February[1]	first quarter	1	1 (0.49%)	G9	1200	2100	IG	1060	2 (0.98%)
15-16 February	full	7	1 (0.49%)	I45	11	2045	SR	3201	0 (0%)
23-24 February	last quarter	3	0 (0%)	-	-	-	-	4057	7 (3.43%)
3-4 March	new	1	0 (0%)	-	-	-	-	5285	5 (2.45%)
15-16 March	full	2	5 (2.49%)	H53	450	2100	WC	4098	8 (3.92%)
				H91	100	2100	WC		
				H89	450	2100	WC		
				H87	3000	0440	WC		
				H53	200	0440	WC		
22-23 March	last quarter	4	0 (0%)	-	-	-	-	486	4 (1.96%)

Note: [1] An additional flock of 500 Pink-footed Geese were recorded at 21.30h on 9 February in an improved grass (IG) field outside of the inner study area.

On the seven daily counts made on the day immediately preceding the night time observations a total of 23083 Pink-footed Geese were recorded (mean = 3297; range 486 - 5285) in the 204 fields checked at night (Table 6). Overall, this represented 60% of the total number of Pink-footed Geese counted during those seven daily counts (*i.e.* from all fields within the study area). The proportion of geese counted during the day which were recorded in the same checked fields at night was approximately 23% overall (range 0%-113%). On two occasions (9-10 February and 15-16 March) the number of Pink-footed Geese recorded at night exceeded those counted in the checked fields during the day. In all cases except one (15-16 February), the number of fields used by Pink-footed Geese during the day was larger than the number of fields in which Pink-footed Geese were recorded at night.

Nocturnal feeding by geese was not confined to the period of full moon and cloud cover is clearly an important factor in determining the number of geese that fed at night. On 9-10 February a total of 1700 Pink-footed Geese were observed feeding after dark, this occurred a week before full moon on a night with little cloud cover (1 okta). The following week, when the moon was full but cloud cover was nearly complete (7 oktas) only 11 Pink-footed Geese were recorded feeding.

On several occasions large numbers of Pink-footed Geese were seen flighting into Loch Leven at dawn from the south of Benarty Hill (southwest Fife). These birds had presumably been feeding outside of the study area during the night. No nocturnal searches for geese were made outside of the study area (*i.e.* to the area south of Benarty Hill) since no birds were ever located there during the day.

Artificial lighting did not seem to attract nocturnal feeding flocks; the area around Balado Poultry Farm, which was regularly used during the day, is extremely well lit every night due to the presence of a military installation. However, no geese were observed feeding there at night during the study period.

5.5 Movements of individually-marked Pink-footed Geese

Over 1000 sightings of 263 individually marked Pink-footed Geese were obtained from the Loch Leven study area during December 1994 to March 1995. Of the individuals identified, 201 had been marked at Loch Leven since October 1994, 46 had been marked at Martin Mere (Lancashire), six were ringed near Caerlaverock (Dumfries), six ringed near Meikle Loch (Grampian) and four had been caught at Loch Eye (Highland).

In October 1994, 134 Pink-footed Geese were caught and ringed at Carden Point, Loch Leven. Over 40% of these were not seen again. It is highly unlikely that these birds wintered in the study area since virtually all the marked geese present were identified. A further 14% were first seen locally and then, later in the season, they were sighted away from Tayside. Twenty Pink-footed Geese (15%) were subsequently only seen at sites away from Tayside. The remaining 38 marked Pink-footed Geese (28%) were seen at least once during the study period within the study area (but not seen elsewhere). The distribution of sightings of Pink-footed Geese caught at Loch Leven in October 1994 and seen away from the study area is shown in Figure 16.

None of the Pink-footed Geese caught in subsequent months (December, February or March) was seen away from Tayside (Table 7) but most were seen locally within the study area. Assuming that the Pink-footed Geese caught at Loch Leven were representative of those roosting on the loch in October, over 70% of these subsequently moved away from the area. This strengthens the suggestions from count data (*e.g.* Figure 6) that Loch Leven is a major autumn staging area for Pink-footed Geese in Britain.

Table 7. *Sightings of Pink-footed Geese ringed at Loch Leven from October 1994.*

Month of ringing	Number ringed	Never seen (%)	Only seen within Tayside (home)	Only seen away from Tayside (away)	Seen both home and away
October 94	134	57 (43%)	38 (28%)	20 (15%)	19 (14%)
December 94	15	2 (13%)	13 (87%)	0	0
February 95	19	0	19 (100%)	0	0
March 95	117	28 (24%)	96 (76%)	0	0

Of the 39 Pink-footed Geese marked in October 1994 at Loch Leven which were subsequently seen in wintering areas primarily further south, 44% (n = 17) were recorded back at Loch Leven during February and March (*i.e.* during the spring passage).

The distribution of sightings of marked individuals within goose flocks together with the distribution of flocks of geese containing no marked birds is shown in Figure 17. Marked birds were located amongst flocks in

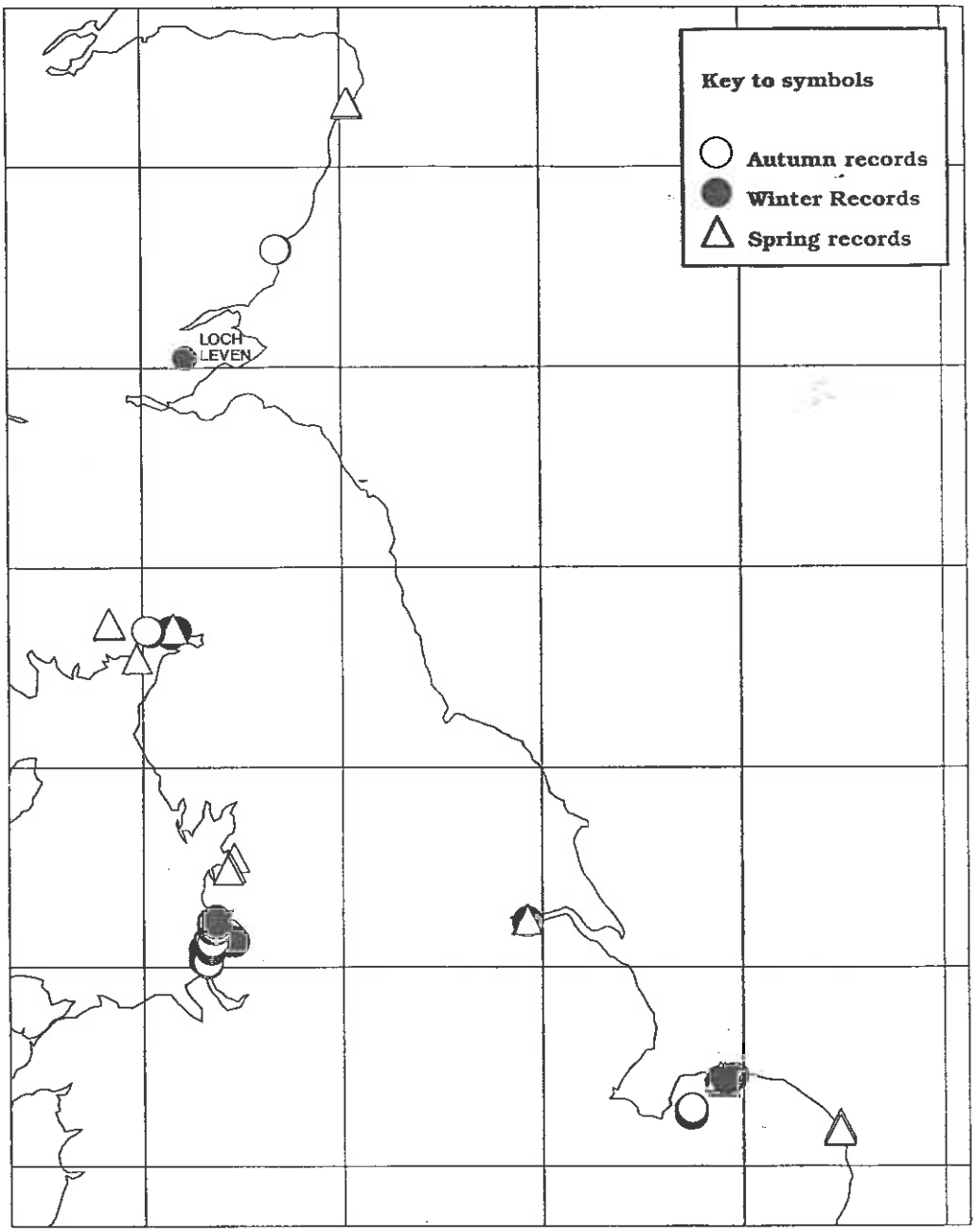

Figure 16. *Sightings of Pink-footed Geese ringed at Loch Leven in October 1994 and seen away from the study site.*

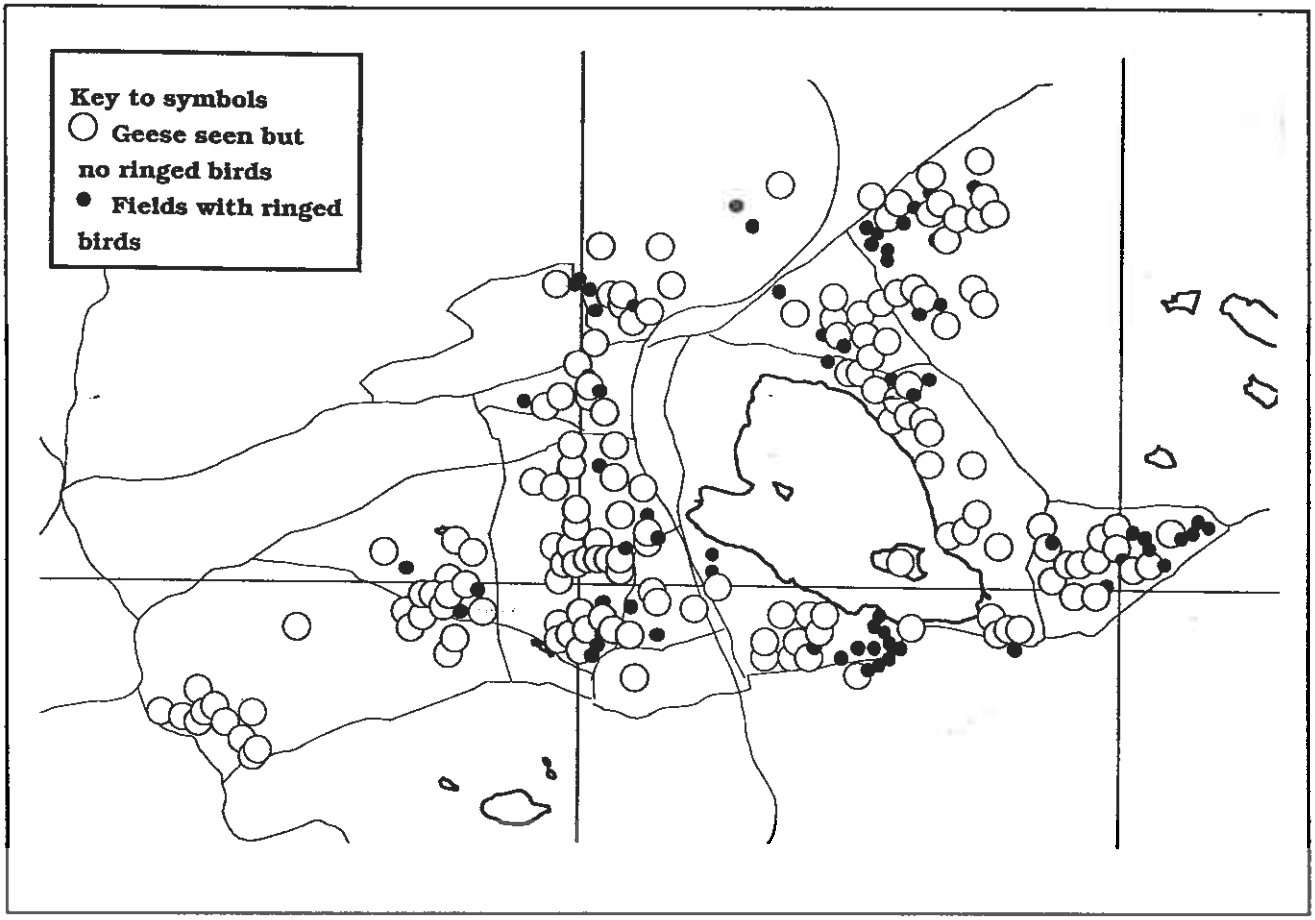

Figure 17. *The distribution of flocks of geese which contained ringed Pink-footed Geese (closed symbols) shown together with flocks which contained no ringed geese (open symbols).*

similar areas to those frequented by flocks of un-marked birds indicating that geese caught at Carden Point wereprobably representative of the geese using the study area during the winter. However, a suite of fields to the extreme west of the study area (based around Wester Aldie Farm, NT0397) never contained Pink-footed Geese marked at Carden Point. It is probable that these geese were from the Loch Leven roost (although this was not confirmed during the study) since the nearest alternative roosting site is probably Skinflats (17km to the southwest).

The clustered nature of sightings of marked geese is shown in the distribution of multiple sightings (Figure 18). Some individual geese showed strong preferences to certain fields within the study area (Figure 19). All marked birds had visited the Carden Point area at some point since this was the site of capture. Other than sightings at Carden Point some individuals were only ever seen along The Cut (*e.g.* FV), others were only ever seen in fields to the west of Loch Leven (*e.g.* BS), and some were only ever seen to the north of Loch Leven (*e.g.* IJ). Other birds were recorded in more than one area, for example CZ was seen to the west and to the north of Loch Leven. The records shown in Figure 19 are presented as examples only since small sample sizes obtained during the study period precluded statistical analysis of fidelity to seasonal ranges.

No geese were ever located outside the study area to the southeast of Loch Leven (south of Benarty Hill) despite reports from local farmers (and other observers) of feeding flocks and the fact that flocks of geese were regularly observed leaving the study area and flying in that direction. Flocks of Pink-footed Geese were occasionally seen flighting into the Loch Leven area from the southeast on some mornings.

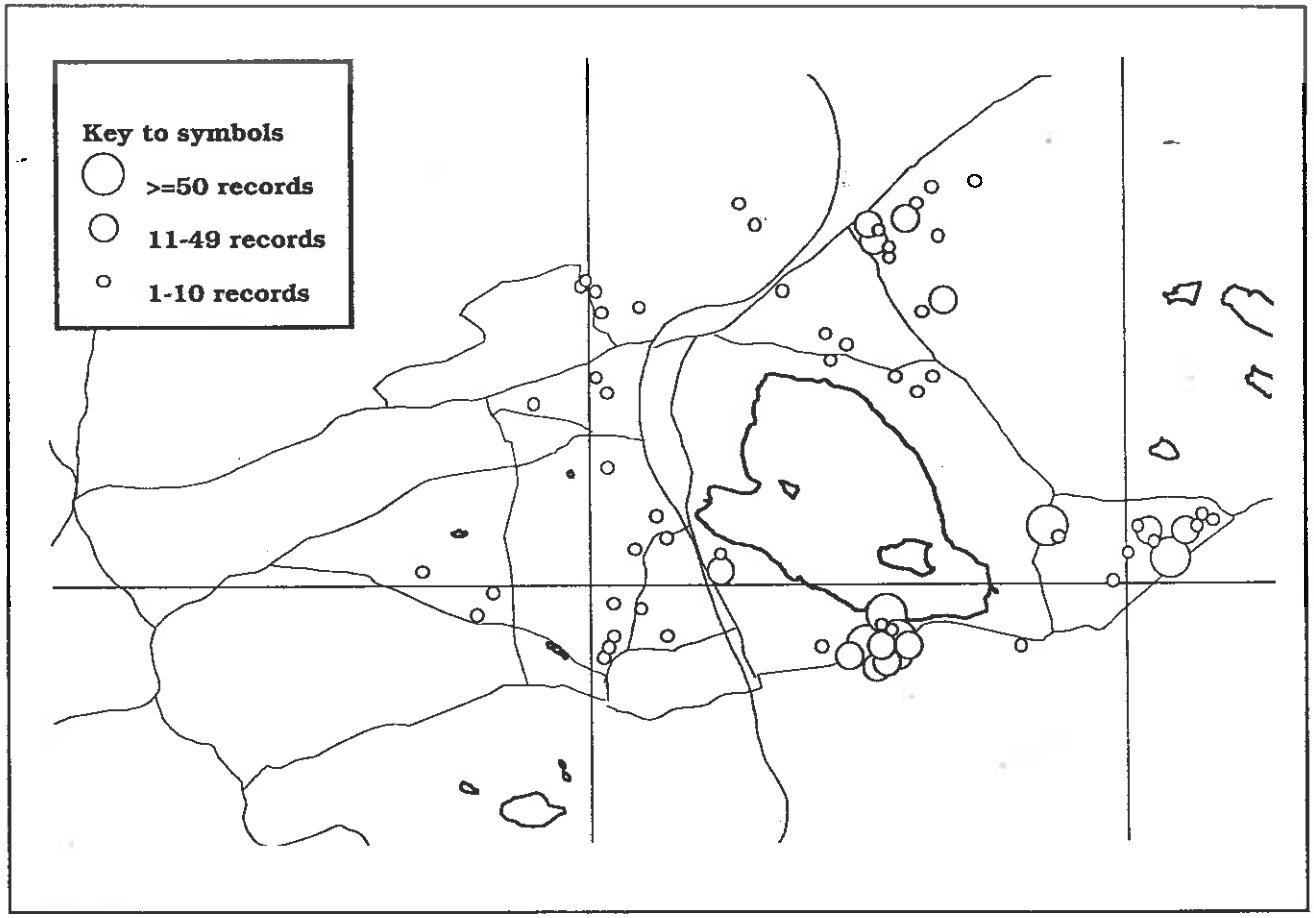

Figure 18. *The distribution within the study area of all sightings of Pink-footed Geese ringed at Carden Point.*

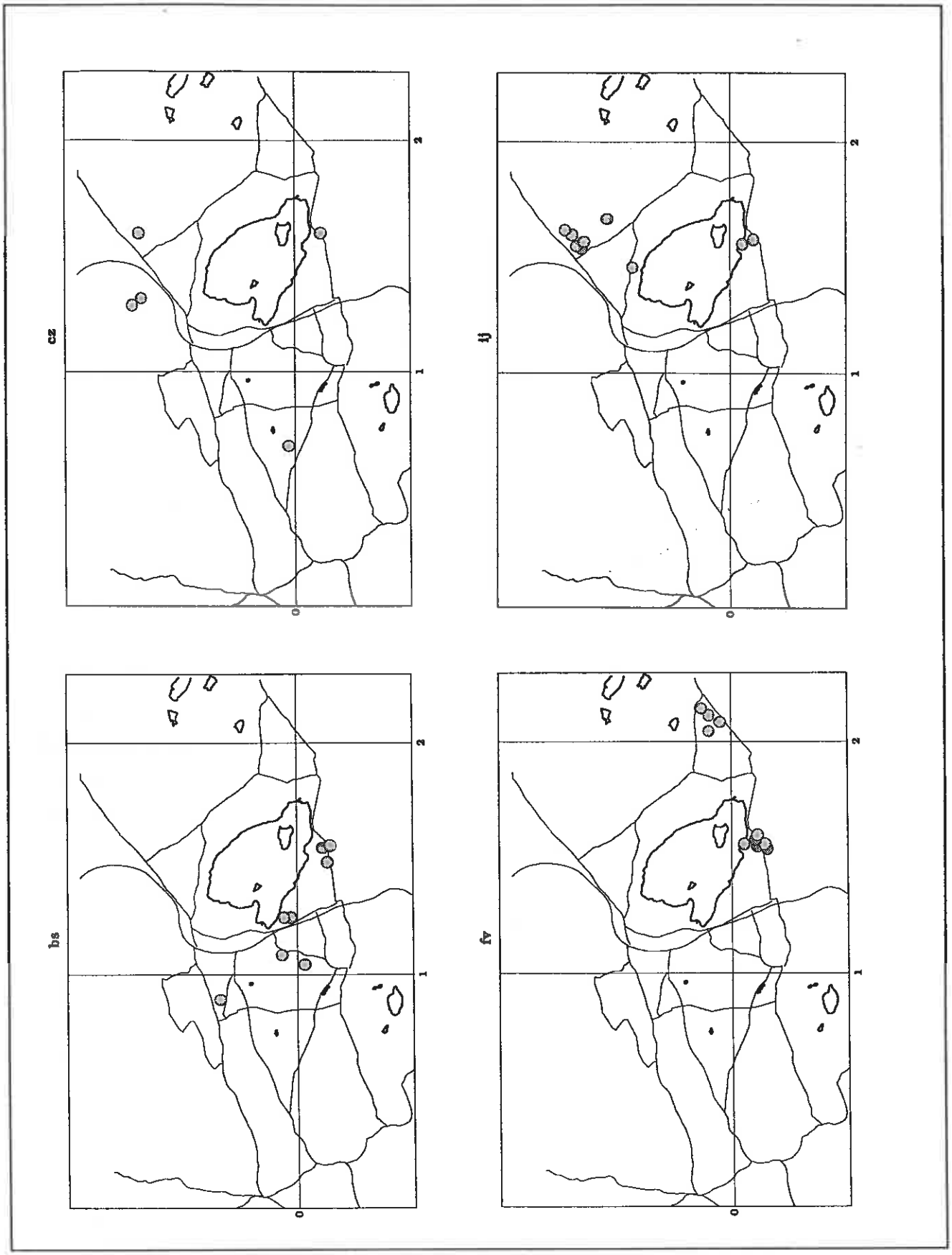

Figure 19. *Sightings of four individually marked Pink-footed Geese.*

5.6 Movements of radio-tagged Pink-footed Geese

Checks for radio-tagged Pink-footed Geese were made throughout the study area each day and at Loch Leven each night from the day of attachment (20 December 1994) until 24 December (4 days), then from 8 January until 8 March 1995 (59 days).

The five transmitters remained attached for a mean period of 23 (±9) days. However, this included two transmitters which had become detached within four days of attachment - these have subsequently not been included in the analysis. Thus, the three other transmitters remained attached for a mean period of 37 (±7) days. By 19 January however, (30 days after capture) no geese provided radio signals from within the study area, although four of the geese were still present (the use of neck collars during this study enabled individuals to be located during the day when transmitters had become detached). The remaining transmitter was still attached but the bird was located 19km NNW in Strathearn. Daily monitoring of its movements and roost choice was not possible in Strathearn but checks continued to be made day and night within the Loch Leven study area until 8 March in case the bird returned to that area. The number of times each radio-tagged Pink-footed Goose was recorded is shown in Table 8 and individual summaries are given in Appendix 3.

Checks for any transmitter signals were made for a total of 63 days and 63 nights (a potential of 378 opportunities for signals to be received). However, taking account of either the date at which these transmitters were known to have become detached or the date at which one goose left the study area, an adjusted figure of 56 potential opportunities was calculated and overall, 24 signals (43%) were received (Table 8). Roosting at Loch Leven by the three radio-tagged geese was monitored for 7, 12 and 9 nights respectively. Overall, they were recorded roosting there on 39% of the nights (mean 3.6±0.9 days). Daytime use of the Loch Leven study area was also monitored for 7, 12 and 9 days respectively. Overall, they were found feeding on 46% of the days (mean 4.3±0.3 days)

Table 8. *Outcome of radio transmitter signals for three Pink-footed Geese.*

		December 1994						January 1995													
collar		21	23	25	27	29	31	2	4	6	8	10	12	14	16	18					
ID	daytime	●	○	●	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	○	●	○	●
	night	●	○	○	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	○	○	○
IJ	daytime	○	○	●	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	○	○	○	●	●	-	-	○	●	○	●
	night	●	●	●	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	○	●	○	○	○	-	-	○	○	○	○
IN	daytime	●	○	○	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	○	●	●	●	●	-	-	○			
	night	●	○	●	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	●	●	○	●	○	-	-	○			

Key: ● signal received from Loch Leven roost (night) or from the study area (daytime). ○ no signal received. - not checked

Notes: ID was thought to have left the study area on 13 January. IJ was seen without its transmitter on 20 January. IN was seen without its transmitter on 17 January

5.7 Dropping counts

The crop type, mean dropping counts and total number of goose days for each of the sampled fields from January to March are shown in Table 9. There was a statistically highly significant association between dropping counts and goose day totals (Figure 20). However, on nine occasions droppings were recorded (albeit few) when geese had not been seen during the previous month indicating that dropping counts do reveal the presence of geese when counts may not, particularly when small numbers of birds are involved.

Overall, dropping counts were greatest in one of the two improved grass fields (I53), one of the two winter cereal fields (H91), one of the two set-aside grass fields (I48), followed by one of the three stubble fields (I38). No geese were recorded during the daytime field searches in three of the four stubble fields (I31, G33 and H100) although low mean dropping counts were found in two of them (I31 and G33). The large overall dropping counts and large mean numbers of goose days in one field of each of the principal crop types demonstrates the attractiveness of individual fields rather than crop type.

The difference between Pink-footed and Greylag Goose droppings could not be determined in the field. However, only five of the study fields ever held Greylags (I38, I46, I48, I51 and I53) and four of these had less than 70 birds days in total over the three months. A total of 495 Greylag Goose days were recorded in field I53.

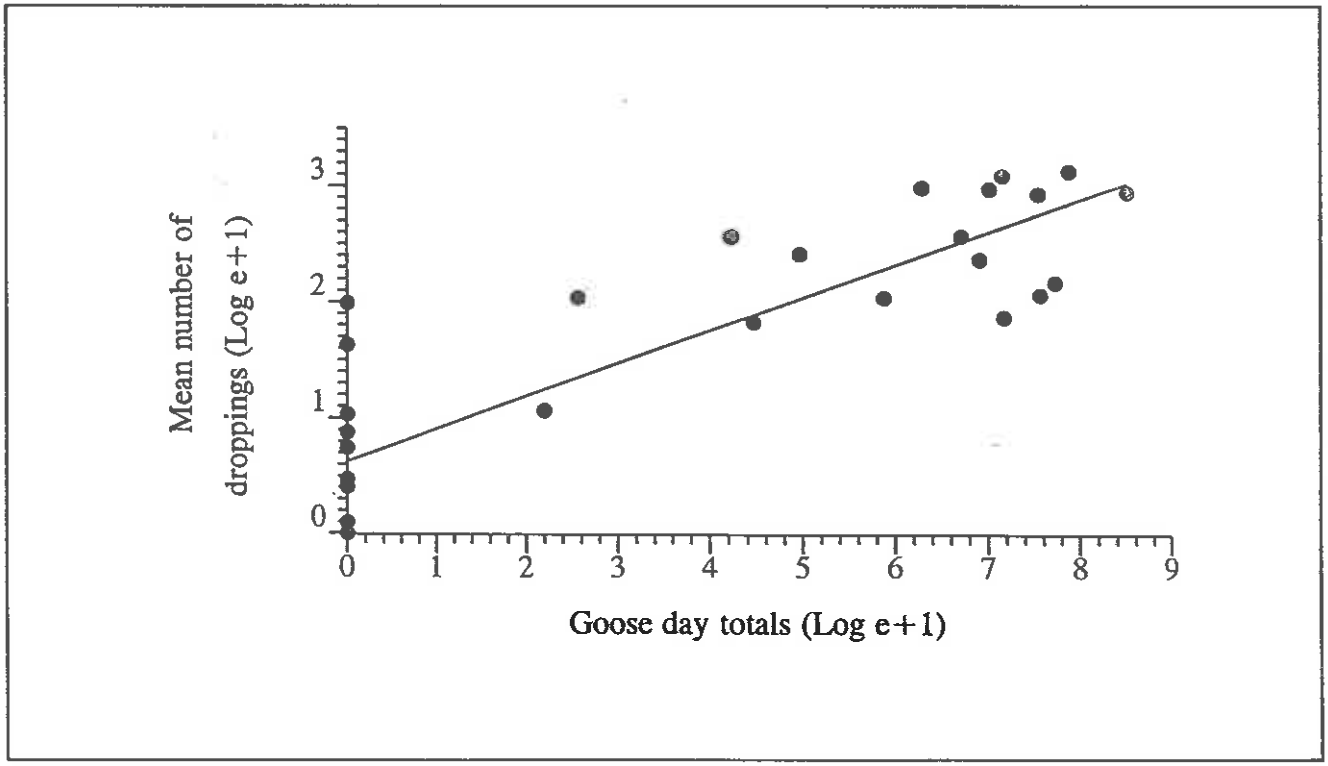

Figure 20. *The relationship between mean number of droppings and monthly total goose days. Fitted regression line* $r^2=0.43$, $P<0.001$.

Table 9. *Crop type, number of sample points, mean dropping counts and goose-day totals in dropping sample fields.*

Field	Crop type	Sample points each month	January		February		March		Overall	
			Mean number droppings	Total goose days	Mean number of droppings	Total goose days	Mean number of droppings	Total goose days	Mean number of droppings	Mean no. goose days
I46	Set-aside grass	14	17.9	1893	0	0	1.9	8	10.6	633
I48	Set-aside grass	10	12.0	68	6.3	0	6.7	356	15.7	141
I51	Improved Grass	9	10.2	143	6.7	12	5.2	86	10.4	80
I53	Improved Grass	7	18.7	1113	21.1	1281	6.9	1929	20.0	1441
I31	Stubble	14[1]	0.1	0	0.5	0	1.1	0	1.3	0
I38	Stubble	6	18.2[2]	4955	9.7	1000	12.1	822	15.0	274
G33	Stubble	15[1]	1.4	0	4.1	0	0.1	0	2.6	0
H100	Stubble	13[1]	0	0	0	0	-	0	0	0
H89	Winter cereal	16	0.6	0	5.5	1300	7.8	2270	5.0	1190
H91	Winter cereal	11	1.8	0	18.9	540	22.0	2654	16.2	1064

Note: [1] *In March some stubble fields had been completely or partially ploughed resulting in new sample sizes : G33 n=12, I31 n=14, H100 n=0.*

[2] *The January count in field I38 (18.2 droppings per sample point) is less than would have been expected for this field as 4955 goose days were recorded there that month. This is partly because geese consistently fed at the back of the field and rarely used the area across which the sample transect ran. Goose grazing or foraging had been supposed to be uniform across the study fields such that it was unnecessary to randomize the design - however field topography clearly plays a role in where the geese fed. On flighting into a field geese tend to land in the centre and gradually feed towards the edges. In the case of field I38 feeding pressure was clearly higher at the back of the field (nearer the roost) than in the centre.*

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

5.8.1 Age assessments in the field

Between 5 December and 17 January, a total of 5539 Pink-footed Geese were aged in the field of which 4721 (85.2%) were adults and 818 (14.8%) were young (Table 10).

Table 10. *Summary of age assessments of Pink-footed Geese wintering at Loch Leven during winter 1994/95.*

Date	Flock	No.Aged	No.Adults	No.Young	% young
05.12.94	700	344	241	103	29.9
07.12.94	930	343	265	78	22.7
07.12.94	381	182	145	37	20.3
08.12.94	1500	600	482	118	19.7
13.12.94	200	105	82	23	21.9
13.12.94	2800	434	358	76	17.5
13.12.94	740	384	328	56	14.6
15.12.94	2180	634	534	100	15.8
12.01.95	1120	526	481	45	8.6
12.01.95	450	296	275	21	7.1
13.01.95	670	372	334	38	10.2
16.01.95	750	489	441	48	9.8
16.01.95	810	464	436	28	6.0
17.01.95	450	366	319	47	12.8
Total	13681	5539	4721	818	14.8

Note: Some age assessments were carried out before the study began (1 December). Of 712 Pink-footed Geese aged in October, 155 (21.7%) were young.

Table 10 reveals a decrease in the overall proportion of young during the winter, from a mean figure of 19.5% young in December to 9.0% in January. The low proportion of young recorded in January emphasises the limitations of undertaking age assessments in the latter half of the winter. Greater mortality among young accounts for some of this difference, but the suggested mortality is unlikely to be as great as it appears; rather the majority of young Pink-footed Geese become very hard to distinguish from adults. This was clearly shown by some marked individuals present in the study area that were known to be young but were indistinguishable from adults when observed in the field after the turn of the year. In addition, some families may have left the area during the autumn passage, suggesting that successfully breeding pairs may winter further south than east Scotland. Age assessments made during December indicate that the proportion of young recorded at Loch Leven (19.5%) is close to that obtained in October and November in east-central Scotland (20.7%, Table 11).

Table 11. *Regional comparisons of the proportion of young in Pink-footed Goose flocks, October - November 1994 inclusive. (WWT data).*

Area	Total aged	Adults	Young	% Young
north Scotland	500	407	93	18.6
northeast Scotland	4100	3157	943	23.0
east-central Scotland	8387	6655	1732	20.7
southeast Scotland	500	385	115	23.0
southwest Scotland	1646	1239	407	24.7
northwest England	2309	1588	721	31.2
Total	17442	13431	4011	23.0

In winter 1994/95, the proportion of young recorded in different regions increased further south. North Scotland contained the lowest percentage (18.6%), followed by northeast Scotland (23.0%), southeast Scotland (23.0%) and east-central Scotland (20.7%), southwest Scotland (24.7%) and the southernmost region for which there are data (northwest England) supported as many as 31.2% young. Unfortunately no data are available for winter 1994/95 from east England, however data from previous winters' in east England suggest high concentrations of young in that region, the most southerly of all British wintering populations of Pink-footed Geese (*e.g.* Mitchell 1994). These regional trends may be biased by the timing of assessments. Those from northwest England, where the largest proportion of young occurred, were carried out earliest in the year, the majority being completed during September. By contrast, assessments in Grampian and Highland were undertaken during November. In addition, the sample from Highland is very small, with just a single flock of 500 birds having been aged.

5.8.2 Hunting Bag

A total of 84 Pink-footed Geese were examined during the study period. The age and sex of these birds is shown in Table 12 and biometric data are presented in Appendix 4. The overall proportion of young present in the shot sample was 59.5%. The sample comprised 48.6% males and 51.4% females (12 geese were not sexed).

5.8.3 Capture Data

During the winter 1994/95 a total of 286 Pink-footed Geese was caught (mean = 41 Pink-footed Geese per catch). The age and sex of these birds is shown in Table 13. Overall, there was 38.8% young in the sample. The sample comprised 53% males and 47% females (one goose was not sexed).

Table 12. *Summary of age and sex ratios of Pink-footed Geese shot at Loch Leven from December 1994 to January 1995.*

Week	Adult male	Adult female	Young male	Young female	Un-sexed adult	Un-sexed Young	% Young
5-9 December	9	12	9	11	0	10	58.8
9-13 January	1	2	4	1	1	1	60.0
23-27 January	6	3	6	8	0	0	60.9
Total	16	17	19	20	1	11	59.5

Table 13. *Summary of the age and sex structure of Pink-footed Geese trapped at Loch Leven during winter 1994/95.*

Date	Adult male	Adult female	Young male	Young female	Un-sexed adult	Total	% young
3 October 94	8	5	13	7	0	33	60.1
12 October 94	30	24	24	23	0	101	46.5
20 December 94	2	3	4	4	0	13	61.5
23 December 94	1	1	0	0	0	2	0
8 February 95	4	6	2	7	0	19	47.4
14 March 95	25	27	11	8	1	72	26.3
21 March 95	22	16	5	3	0	46	17.4
Total	92	82	59	52	1	286	38.8

A comparison between the proportion of young obtained from each of the three methods is given in Table 14. The largest proportion of young was found amongst the geese shot during organised hunting weeks although the sample size was small in comparison with other methods. The proportion of young from capture data (38.8%) was less than that obtained from shot birds but over twice as high as that obtained from age assessments in the field. The observed difference in the ratios of males to females between the shot sample and the captured sample was not statistically significant ($\chi^2_1 = 0.44$, ns).

Table 14. *Summary of age assessments from different sampling techniques.*

Method	Total aged	No. Adults	No. Young	% Young.
Age assessments in the field	5539	4721	818	14.8
Estate shoot bag	84	34	50	59.5
Cannon-netting	286	175	111	38.8

5.9 Disturbance

A total of 49 disturbance events were observed while conducting routine field searches. These involved a total of 49310 geese of which 45747 (92.8%) were disturbed in some way. The majority of disturbance events were not intended to scare geese from fields. Of the 49 events, 32 (65%) were unintentional, and most of these events did not cause the geese to leave the field (Figure 21). Although intentional disturbances were fewer (35%) they were more effective at scaring the birds away from the fields. Farmers intentionally scared geese from their fields on 14 occasions, and on each occasion all geese left the area. Shooting, both where geese were the target and where a farmer was shooting corvids (unintentional, n = 1) caused all geese present to take flight and leave the area. Aircraft (small planes and helicopters) and various activities of the public, such as walking alongside fields containing feeding geese, caused some disturbance. Aircraft disturbed 88.5% of 12320 birds of which 36.0% (4435 birds) left the field. The public caused 89.2% of 9085 birds to be disturbed of which 61.8% (5615 birds) left their chosen field.

A total of 57 fields contained objects positioned to scare geese away from fields. This comprised 3.8% of the fields within the study area. The objects typically consisted of sacks on poles, barrels, or gas guns. However, these objects were often transient in nature and their effectiveness in scaring geese was rather minimal. Typically, the objects would deter geese from using a field for a brief spell after being sited, but geese apparently soon become accustomed to them and returned to feed in that field.

Six observations of decoy geese were made during the shooting season (*i.e.* up to 1 February) and one was known to have resulted in successful hunting.

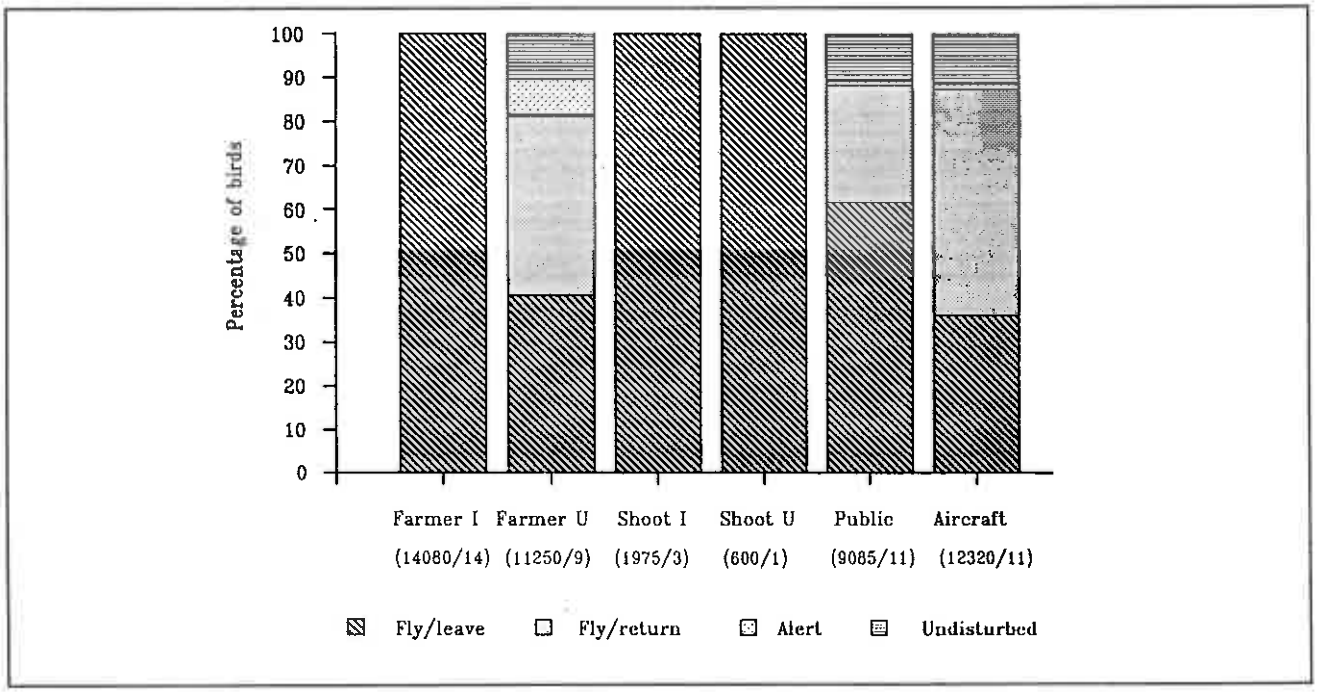

Figure 21. *The proportion of responses of Pink-footed Goose flocks to disturbance events recorded within the study area during daily field searches, December 1994 to March 1995. Key: I = intentional, U = unintentional, bracketed figure = (number of geese recorded/number of disturbance events).*

6 General Discussion

6.1 Loch Leven's role and importance for Pink-footed Geese in a local and national context.

The world population of Pink-footed Geese numbered some 260000 in 1993 (Madsen & Mitchell 1994) and their world range is limited, with the majority (85%) breeding in Iceland and Greenland and wintering exclusively in Britain. Every year since 1960 a census of Pink-footed Geese in Britain has been carried out in early November. Distribution data based on these censuses are therefore biased towards the autumn concentrations, when a greater proportion of the population is in northern and inland areas than later in the winter and in spring. Pink-footed Geese can show major shifts in distribution according to feeding conditions in autumn, both on a local and regional scale.

The main winter habitat used to be saltmarsh but in recent decades the species has increasingly moved inland to feed on arable crops, taking advantage of reservoirs and other freshwaters for roosting (Owen 1976). Of 25 major Pinkfoot roosts in east-central Scotland only six were coastal and those geese moved inland to feed (Owen *et al.* 1986). The proportion of birds in various areas of Britain over the last thirty years has changed (*e.g.* Ogilvie & Boyd 1976). Not only are there annual fluctuations in different areas but also trends over longer periods. The most striking is the importance of east-central Scotland in the 1960s - attributed to the increase in barley growing there (Kear 1963). More recently there has been an increase in the importance of Norfolk during midwinter. This area now supports up to a third of the winter population and this has been attributed to an adequate coastal reserve network and inland feeding on waste sugar beet tops (*e.g.* Cross 1994)

The way in which distributional changes occur, in view of the traditional habits of geese, is not well understood. Analysis of recovery and sightings data by Fox *et al.* (1994) showed that a proportion of the population moved south through the traditional autumn concentrations to ultimate wintering sites in Lancashire and Norfolk. There then follows a gradual move north through areas such as the Fylde, Solway, Lothians, east-central Scotland, Grampian Region and Moray Firth as a response to grass growth in late winter. Throughout most winters, there remains some relatively sedentary Pink-footed Geese which spend the winter months at individual sites within the traditional winter range. Recovery and recapture data from ringing in the 1950s suggest that this pattern is long established.

Wintering Pink-footed Geese have increased in Britain 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 over the past 20-25 years. Major concentrations of Pink-footed Geese (over 10000 birds) were present at three sites (Loch Leven, Strathearn and Strathallan), though 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 in range is continuing. Based on the long-term November counts, during the 1960s and 1970s the numbers 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.

Most sites in east-central Scotland hold their peak in October or November and Dupplin Loch (NO0320) has been identified as a key site when the geese first arrive in Britain, regularly achieving peaks of over 30000 in late September and early October with 62000 counted there on 2 October 1994 (Bell & Newton 1995, Bell pers comm.), accounting for a quarter of the population in that year. Regular counts show that the autumn peak at Loch Leven is usually around the second or third week of October, a week or two after the peak at Dupplin Loch --thus it seems likely that more Pink-footed Geese are 'arriving' at Dupplin Loch than at Loch Leven but the latter site probably supports some of the Dupplin birds a few weeks later.

Regular autumn counts (traditionally carried out in November) have shown a gradual increase in the number of Pink-footed Geese counted at Loch Leven, but this number as a proportion of the census total, is gradually declining. This has been more than compensated for by the large increase in numbers counted in October (up to peaks of over 20000) which as a proportion of the census total is increasing (Figure 7). Thus, it appears that Loch Leven is just as important today, as an autumn gathering point for Pink-footed Geese, as it was thirty years ago, but there has been a shift in the peak arrival time from November to October. Clearly substantial numbers of birds use the loch as a staging area, with over 70% probably leaving after October (*e.g.* Table 7). Typically, 5000-8000 now remain through the winter decreasing in April as birds move north.

Pink-footed Goose counts for the mid-winter and spring period have, until 1993/94, not been adequately monitored. WeBS counts usually take place after geese have left a roost site and field searches invariably miss flocks. Loch Leven is unique therefore, in that an unbroken run of winter monthly counts of roosting geese has been collected since 1966. Hhowever, it is not possible to adequately reflect the importance of Loch Leven in a local and national context (outwith the autumn census period) until there are more data from throughout the Pink-footed Goose winter range. The values of 3-7% of the mid-winter counts and 7-10% of the spring counts are, therefore, preliminary assessments and probably slight overestimates since not all of the wintering geese are recorded.

Dawn counts (rather than evening flight counts) at the time of a new moon are the most effective method of obtaining accurate estimates on the number of Pink-footed Geese using the roost (*e.g.* Kirby 1990). Under suitable moon and weather conditions geese will often feed in fields after sunset returning to the roost during darkness. On clear, moonlit nights geese may roost on, or close to, standing water on fields or return to the roost in the evening, only to leave for fields at some time during the night to continue feeding. When night feeding occurs, diurnal field searches will produce a higher count of geese. However, field searches are time consuming and may be limited by the mobile nature of geese flighting between fields. During the present study, diurnal field searches sometimes produced an underestimate of geese in the study area, as can be seen by comparing the relatively high roost counts with the corresponding field count of that day (*e.g.* 25 January, 9 February).

To complicate counting estimates further, geese often roosted at Loch Leven and flew out of the study area to feed during the day. This was particularly apparent to the southeast and out of the of the study area from where geese were regularly observed flighting into Loch Leven at dawn or late afternoon/evening.

In the present study the positive association between dropping counts and goose-day totals is encouraging and diurnal field counts probably adequately reflect field use. Percival (1988) found a few fields where a discrepancy between counts (low) and dropping counts (high) was considerable and attributed this to birds being hidden in undulating fields and therefore being missed during the counts. Secondly, counts were made in daylight, taking no account of night-time feeding. The former factor is not a major aspect in this present study since geese in the study fields were easily counted (but see below). No fields were recorded with a very large dropping count and few geese recorded during daytime counts. However, field G33 was partly surrounded by trees and the presence of a very small number of geese may have gone undetected during the day; this is the only field where this situation may have arisen (see Table 9). Night-time feeding was assessed for the study fields (see section 5.4) although no birds were ever recorded using these fields at night. Differences between the droppings of Pink-footed and Greylag Geese could not be separated in the field, however goose use by Greylags, as indicated by daytime field searches, was very low in comparison to Pink-footed Geese.

6.2 The feeding distribution of geese from the Loch Leven roost in relation to agriculture, shooting pressure and other relevant influencing factors.

Some areas of east-central Scotland are now less suitable for wintering geese than in the 1960s and 1970s. Changes to autumn sown cereals and oilseeds in the 1980s left less stubble available in autumn and early winter and geese feeding on freshly sown cereals brought conflict with farmers (Bell & Newton 1995). Within the Loch Leven study area, however, the type of crops available to the geese in 1994/95 were not dissimilar to those available in the late 1960s, although there has been an increase in the proportion of improved grass and winter cereals available and a corresponding decrease in potatoes and stubble fields.

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 (Figure 12). However, the intensity of goose use has changed somewhat. In the late 1960s and early 1970s, most feeding occurred within a few kilometres of the loch, within the area bordered by the inner study area perimeter roads. Today, away from Vane Farm, larger numbers of geese tend to flight further from the loch, feeding primarily beyond the perimeter roads often several kilometres west towards Powmill, northeast towards Strathearn, and east towards Glenrothes. Deliberate localised disturbance by farmers probably accounts for most of the shift in distribution away from the areas close to the loch shore and undoubtedly the controlled shooting activities during the autumn and winter discourage geese from using this area. Figure 12 is intriguing since despite the shift in feeding pressure the geese have moved to areas where they formerly fed (albeit in smaller numbers) 20 years ago.

Newton & Campbell (1973) suggested that the need for safety, a good all round view and minimum disturbance were important factors 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 birds preferred the same general areas in each of the two winters even though the foods these contained differed. The present study identified a greater than expected preference for grass, stubble and potato fields while brassica, bare soil, turnip and miscellaneous fields were avoided. However, the overall fidelity to certain areas remains today as it did in 1968-70.

In the present study it was not possible to correlate the preference of geese for particular fields with food abundance since observations started in December when some stubble fields had been ploughed in or much of the spilled grain had been eaten. There were too few potato fields to make comparisons of potato abundance as Newton & Campbell (1973) did. Despite their influence on distribution it appears that neither habitat nor food have yet limited the number of Pink-footed Geese using Loch Leven. Much apparently suitable habitat close to the loch is still unoccupied.

Observations of individually marked Pink-footed Geese within the study area provided further evidence of the traditional nature of the feeding ranges (Figure 17). Overall, Pink-footed Geese used a small numbers of fields available to them, yet within those 'core' feeding areas some individual geese only fed in a small suite of fields (*e.g.* Figure 19). In terms of conservation management, the protection of important wintering areas, and if possible the enhancement of conditions there, are of particular importance (see Wilson *et al.* 1991). The high site loyalty may have implications for management to reduce conflict with agriculture.

Organised shooting disturbance is strictly controlled on St. Serfs Island and the foreshore. This disturbance undoubtedly affects roost use to some degree (Figure 5) although this was difficult to quantify. Unfortunately, the present study commenced too late in the hunting season to allow comparisons of roost counts between shooting periods and non-shooting periods.

Uncontrolled shooting activity was not encountered to any great extent during this study. Shots were regularly fired at Pink-footed Geese leaving the roost from Classlochie Farm, and great effort was made to disturb feeding geese from the fields within this farm during the day. The disturbance was successful at inhibiting goose use but was localised and probably had little impact on overall distribution. Although the number of geese shot at Classlochie Farm was not determined, the loss in terms of overall goose numbers was probably small. Interpretation of the impact of hunting disturbance at the roost must therefore be treated with caution given the limited data available here and the influence of the moon on roost counts.

The amount of effort put into scaring geese by farmers varied greatly over the study area, with Classlochie and Glenlomond/Balgedie being the most disturbed areas, and Powmill and Vane Farm being the least disturbed of the areas regularly used by geese. However, despite the relative security at Powmill, geese did not noticeably select this site for feeding over more disturbed areas that were closer to Loch Leven. Classlochie was consistently utilised for feeding despite geese being forced to leave the area on a regular

basis; they would often return to the point of disturbance within hours. The proximity of the totally secure area at Vane Farm is probably an influencing factor with birds flighting to the reserve after disturbance events. Other areas of high disturbance levels such as Balgedie did not receive the same amount of pressure so soon after a disturbance event, however it was typical that the birds would not move far and would be back in the field from which they had been disturbed the next day.

The objects placed in fields were generally unsuccessful in keeping geese out of a particular field for more than a few days after being positioned. However, certain types of object were clearly more successful than others. The only objects that detered geese completely were vehicles. For example, field I2 was heavily used by Pink-footed Geese, with 5765 bird-days in February (making it the most heavily used field that month) and 7425 bird days during the study period (making it the second most used field overall). When an old tractor was placed in the centre of the field geese immediately stopped visiting the field and no geese were recorded in I2 during March. Nine other fields contained cars or trucks during the winter and none supported geese. Four of these (C103, L81, R72 and R74) were immediately adjacent to areas regularly utilised by geese and C103 and L81 contained favoured crops (improved grass and winter cereal respectively).

Other objects, such as small sacks on poles and scarecrows, were typically unsuccessful in deterring geese. For example, field C97 contained around 15 objects and was also the most disturbed field in the study area with five disturbance events observed (10.2%). These resulted in 6130 birds being disturbed, of which 4450 (72.6%) left the area. Yet C97 was the most heavily used field over the study period with a total of 13775 bird-days (mean = 3444 bird-days per month). Pink-footed Geese therefore appear highly tolerant of some objects left in particular fields if other factors are desirable.

Newton & Campbell (1973) did not make observations of feeding geese at night but did record when geese were seen or heard in fields at night by local people. They concluded that no more than 15% of the Pinkfoot's total winter feeding was at night and that most night feeding occurred close to the period of full moon. Despite observations being made on fewer days during the present study, systematic checks of a sample of fields with an image intensifier showed that night feeding occurred on just less than half of the nights when observations were made and, on average, 23% of the total number of Pink-footed Geese counted in the same checked fields during the day fed at some time during the night. Pink-footed Geese were however, recorded in fewer fields at night than during the day.

That geese can feed at night in the weeks either side of the full moon effectively means they are able to feed on 75% of nights providing that enough moonlight exists. They may fly off the loch during the night if the moon appears later in the night once they have already begun to roost. At any stage of the moon cycle, however, geese may not feed if it is too cloudy.

The roost count data obtained in this study in relation to the phases of the moon has implications for future roost monitoring. The annual national censuses in October and November must avoid periods of full moon so that any underestimation of numbers due to night-time feeding is minimised.

6.3 The degree of winter site fidelity and movements of geese both to and from Loch Leven.

In accord with many migratory goose species Pink-footed Geese show a high rate of reappearance at familiar wintering areas (*e.g.* Greenland White-fronted Geese, Warren *et al.* 1992, Canada Geese *Branta canadensis maxima*, Raveling 1979). 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 areas with disturbance-free roosts.

The site faithfulness of wintering Pink-footed Geese has been demonstrated by Boyd (1955) and, more recently, by Fox *et al.*(1994). Marking of Pink-footed Geese with individually recognisable rings in Lancashire revealed a 69% return rate to the point of capture between winters. However, in addition, 34% were known to move between two sites or more within a winter.

Some of the individually-marked Pink-footed Geese caught in Lancashire in the late 1980s and early 1990s were recorded at Loch Leven prior to the commencement of this study. For example, of 1331 marked birds, 9% had been recorded in the Loch Leven area, and of these nearly one third had been shot. The remainder were of ringed birds seen alive and included six which were seen on several occasions between winters (mostly in successive springs). Thus, despite a very low observer effort at that time, there were indications that some Pink-footed Geese that wintered in Lancashire were site faithful, in the spring at least, to the Loch Leven area. Other Lancashire-ringed Pink-footed Geese exhibited extreme site faithfulness (down to individual fields) in successive seasons during the northward spring migration in other areas too (*e.g.* Dumfries & Galloway, Grampian Region).

The sightings of individually marked Pink-footed Geese during the present study confirm much of the findings of Fox *et al.* (1994) with many of those marked in October being seen in traditional wintering areas further south. Several marked Pinkfeet moved south to Lancashire and Norfolk and were later seen back at Loch Leven in the spring. Thus, evidence of site fidelity to staging areas, both autumnal and on spring passage has been confirmed for some of the ringed birds.

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. Based on sightings of Pink-footed Geese caught in October 1994, this study has revealed that probably in excess of 70% do move on, yet a proportion caught in early autumn (up to 30%) remain close to the roost throughout the winter (*e.g.* Table 7). There is no obvious spring passage revealed by numbers roosting at Loch Leven (*e.g.* Bell & Newton 1995), yet clearly some Pink-footed Geese that have staged there during the autumn pass through Loch Leven again during the spring. Unfortunately, we can say little of the 57 marked Pink-footed Geese which were not seen after capture other than they almost certainly did not winter in the Loch Leven area. Yet of the 39 Pink-footed Geese that were seen away from Loch Leven after capture, 44% were recorded back there during the spring passage. Their movements through the area must be staggered over February and March (and probably into April), indicating a slower passage north during the spring - some marked individuals remained for only a few days

in either month (in contrast to sedentary wintering birds, some of which were seen almost daily). This finding is similar to that of Fox *et al.* (1994 see Figure 6) who suggest the movement north in spring follows a gradual gradient of grass growth.

The results of count data and sightings of individually marked Pink-footed Geese suggest that the Pink-footed Geese recorded at Loch Leven comprise of three main components. Loch Leven is one of the top eight most important autumn gathering roosts for Pink-footed Geese in Britain - although as demonstrated earlier (Figure 7) its importance later in the autumn (i.e. by November) is declining. Counts in October contain a large proportion of passage birds that move to winter either within east-central Scotland or further south. It appears that some Pink-footed Geese are using Loch Leven in October in larger numbers than the 1970s and 1980s but are moving through the area quicker than before. Certainly the declining proportion of Pink-footed Geese counted at Loch Leven in November supports this. Secondly, some of the Pink-footed Geese already at Loch Leven by October stay throughout the winter (up to 30%, Table 7), although these may make temporary or longer term movements to other areas within eastern Scotland. The sightings collated from one season have shown that by late January and certainly into February, a third component, Pink-footed Geese that have wintered further south in Norfolk and southwest Lancashire (which may or may not have passed through Loch Leven), are beginning their migration north through northern Lancashire, Dumfries, southeast and east central Scotland.

Recent ringing of Pink-footed Geese at Loch Leven has greatly improved the understanding of timing of passage, destination of autumn caught birds and local site fidelity of individually marked geese. This study has also suggested that within the study area itself some individual geese may exhibit discrete 'activity ranges' (*e.g.* Figure 19). This has not been quantified since sample sizes are relatively small (most < 10) and clearly needs further study. There appeared to be considerable overlap among individual ranges especially in the vicinity of the loch itself, yet we suspect that the distribution departed from uniformity indicating the presence of centres of activity and fidelity to some sites (i.e. fields) within their activity ranges. Extreme site fidelity within an area has already been demonstrated for Greenland White-fronted Geese wintering at Wexford, Ireland (Wilson *et al.* 1991). In other studies, Barnacle Geese tended to be faithful to their feeding sites within a winter and even between years (Percival 1991). Radio-tagged Pink-footed Geese in northeast Scotland also showed centres of activity within activity ranges which covered 21 - 69 km^2 (Giroux & Patterson 1995). Lorenzen & Madsen (1985) reported that, in Denmark, different feeding sites were visited sequentially by Pink-footed Geese. In northeast Scotland, Giroux & Patterson (1995) reported that Pinkeet returned to the same $1km^2$ on average every 24 days but no fixed sequence was observed. In terms of conservation management, the protection of important areas, and if possible, the enhancement of conditions there, are of particular importance. Fox *et al.* (1994) demonstrated some degree of between-winter site fidelity amongst Pink-footed Geese caught at Martin Mere, although sightings were too infrequent to attach significance to fidelity within an area. However, some individual geese were seen in broadly similar locations (within 10km) at spring staging areas, suggesting that Pink-footed Geese used traditional sites year after year. Observations during this study confirm the within-site fidelity of some individuals and this will be valuable when considering management for such a mobile species. Areas such as key feeding sites will be obvious candidates

for management prescriptions.

The results of the checks made for the three radio-tagged Pink-footed Geese revealed that they roosted on Loch Leven for approximatly 40% of the period studied and were recorded feeding in the study area for approximately the same amount of time. However, failings in the attachment technique (for two other marked Pink-footed Geese) and small sample sizes obtained from the three geese studied precluded detailed analysis of roost site loyalty over more than three to four weeks. Giroux (1991) trapped and fitted radio transmitters to 11 Pink-footed Geese near the Ythan Estuary, Grampian in the mid-1980s, in order to investigate movements of individual geese among roosts in northeast Scotland. Pink-footed Geese changed their roosting sites approximately every ten nights between December and April, and, on average, each bird visited 3.4 roosts returning to the same sites on many occasions. Some shifts followed disturbances at the roosts resulting from shooting and other human activities, other shifts took place during periods of harsh weather or while geese were field feeding at night during a full moon. Despite few data, the present study suggests that some Pink-footed Geese do not roost at Loch Leven continously. Either other local roost sites are used, although these were not identified during the present study, or the geese regularly fed at night away from the loch.

Of the 11 Pink-footed Geese marked by Giroux (1991), one (9%) provided no radio signals at all, and five geese (45%) disappeared after 33 $\pm$ 16 (se) days of tracking, and it is possible that these radios could have ceased to transmit or were lost. The remaining five geese (45%) were followed for 86 $\pm$ 16 days, until spring migration. Giroux (1991) fitted the transmitters to the two central tail feathers using cable ties and contact adhesive. This method was not successful for two Greenland White-fronted Geese *Anser albifrons flavirostris* caught on Islay, Strathclyde. Within two weeks the geese had bitten through the shafts of their tail feathers, effectively removing the radios. Back-mounted transmitters have been effectively used on other wildfowl (*e.g.* see Kenward 1987) although radio loss decreased with the use of a securing harness. Future attempts to radio-track Pink-footed Geese should consider using the tail-mounting technique, or back-mounted with the addition of a securing harness.

In summary, Pink-footed Geese staging at Loch Leven in the autumn show a high degree of site fidelity during the return spring migration. Within the study area, individual or cohorts of marked geese probably exhibit centres of activity and fidelity to some fields within their activity ranges. Despite high site loyalty to an area during the winter months some Pink-footed Geese may seek temporary alternative roost sites or feed at night away from the loch. A sample of over 200 individually marked Pink-footed Geese will form the basis for investigating between-winter site fidelity; other studies have suggested that this occurs.

6.4 The age and sex structure of the population.

The present study commenced too late in the season to make meaningful comparisons of the age composition of flocks with those obtained in other areas of northern Britain. Where comparisons are made using autumn assessments obtained outwith this study, the proportion of young in feeding flocks at Loch Leven (22%) was

very similar to the national average obtained in October and November by WWT (23%). Thus, there is no indication that Loch Leven supports an unrepresentative portion of the wintering population. By December, the proportion of young had decreased slightly to 19.5%, and by January the value had decreased to less than 10%.

Although hard to quantify for Pink-footed and Greylag Geese, it is reasonably well established that the first goose flocks to arrive in Britain in autumn contain a higher proportion of families than later arrivals (M.A.Ogilvie & H.Boyd *in litt.*). This has been demonstrated for Russian-nesting Brent Geese *Branta b.bernicla* (*e.g.* Lambeck 1990); the percentage young in The Netherlands in autumn declines as migration proceeds, *i.e.* some families are amongst the first geese to leave for the final wintering areas. In these areas, early winter counts would overestimate the proportion of young. However, for both Pink-footed Geese and Greylags, mass gatherings at traditional sites in October (*e.g.* Loch Leven) presumably dilute this effect and may promote homogeneity of flocks.

Age assessments carried out at Loch Leven complement the findings of Stenhouse & Mitchell (1994) who also recorded (in 1993-94) a decline in the proportion of young as winter progressed. Certainly ageing gets progressively harder during the winter since the young geese 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 (and probably higher numbers) of young being shot during the shooting season.

With winter food supplies adequate in most years, shooting in autumn and winter accounts for the majority of losses in Pink-footed Geese and Greylags (Fox *et al.* 1989). Wright & Boyd (1983) showed that, at Loch Leven, young of both species were more vulnerable to shooting. 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 corresponding percentages observed amongst live geese in the field in November (mean 16.8% $\pm$ 6.7%). This concurred with the findings of other studies of hunted species where first-winter mortality was higher than that for adults (*e.g.* Gitay *et al.* 1990). Wright & Boyd (1983) also noted that the proportion of young in the kill of Pink-footed Geese was much higher in late October and early November (44%) than in late November and December (33%) and January (25%), yet in the Greylag bag the proportion of young remained close to the mean (41.5%) throughout the season.

The current study provides complementary data to Wright & Boyd (1983) and although the sample size from the three periods of shooting (n = 84) is smaller than almost all of the samples examined in their study the proportion of young in the bag (60%) is higher than for any year between 1966 and 1980.

A larger proportion of young Pink-footed Geese were caught with cannon-nets (38.8%) than were present in the wintering population. Boyd (1955) suggested that the proportion of young Pink-footed Geese caught in the 1950s with rocket nets was not dissimilar to that present in the population, largely because the nets were very well hidden in stubble fields and no baiting was involved. Baiting at the Loch Leven capture site is on

a grass field on the loch edge and probably attracts more families who tend to dominate this food resource. Catches of Pink-footed Geese at Martin Mere, Lancashire regularly consist of more young (thus presumably families) than the population average (WWT unpubl. data).

The proportion of young in caught samples (38%, cannon-nets) and those shot (60%) was far greater than those obtained through field age assessments. This has been documented elsewhere (*e.g.* Wright & Boyd 1983) and demonstrates the bias inherent in these sampling techniques. However, our interpretation of the data is limited by the late commencement of this study.

7 Recommendations for further work

The results presented in this study reflect observations from December to March, part of one winter season, and as such are of limited value in isolation. In order to better understand the following:

- timing of the autumn arrival of individually marked Pink-footed Geese at Loch Leven
- feeding distribution of geese from the Loch Leven roost during September to December
- age and sex structure of Pink-footed Geese gathering at Loch Leven in the autumn
- degree of between-winter site fidelity of Pink-footed Geese marked at Loch Leven in winter 1994-95
- activity ranges and centres of activity of individually marked Pink-footed Geese at Loch Leven
- Identification of local alternative roost sites

The following work is recommended:

- Daily counts (including searches for geese, marked individuals *etc.*) of the route undertaken in this study be carried out three to four times per week from 15 September to 30 November (11 weeks). The crop type in each field in the study area to be determined at the start and end of the study.
- Roost counts one day per week during the 11 week study period
- Cannon-netting is undertaken on at least two occasions during the 11 week period, ideally once in early October and once in mid-November. Birds caught are to be marked with plastic neck collars.
- Shot birds and those caught with cannon-nets are examined, and opportunistic flock scans of feeding geese to be carried out in order to determine the age and sex of individuals using Loch Leven.
- Observations of individually marked geese to be undertaken in order to better understand the activity ranges and centres of activity of Pink-footed Geese at Loch Leven
- Visits to suitable local roost sites at night to check for the presence of roosting geese
- A report to be written summarising data obtained during the December 1994 to March 1995 study and the September 1995 to December 1995 study. This to include analysis of all aspects of the crop type preferences, field type preferences and distribution and activity ranges of Pink-footed Geese using Loch Leven.

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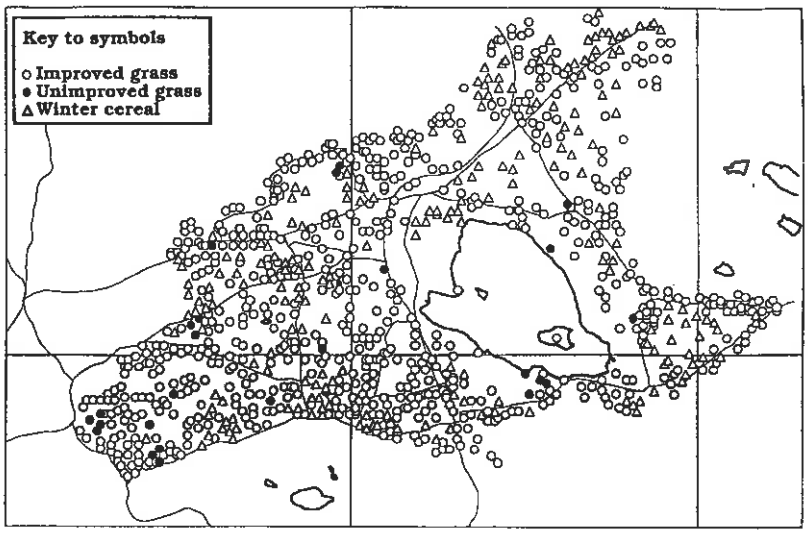
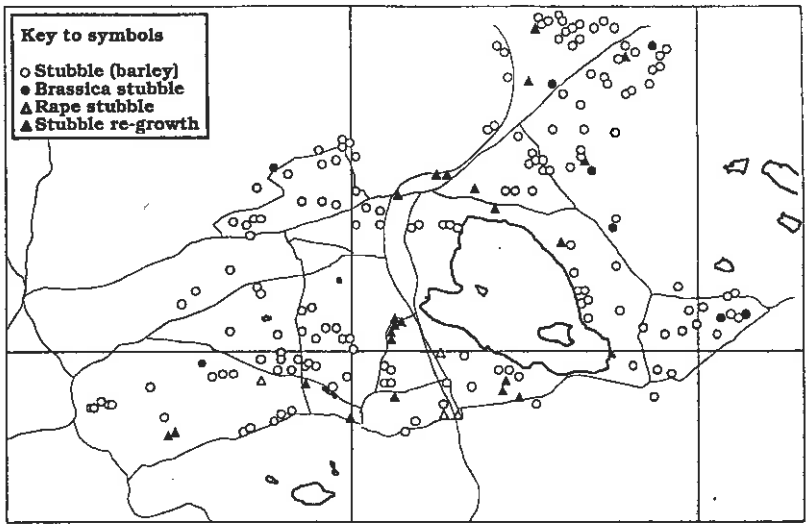
10 Appendices

Appendix 1 - *Distribution of field types within Loch Leven study area.*

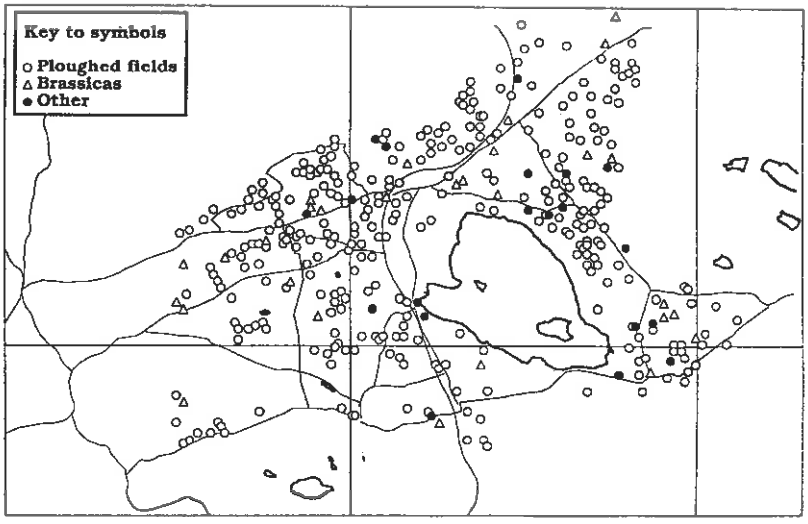
Grass fields



Stubble fields



Other field use



Appendix 2 - *Roost Count Data*

Date	Time	Vane Farm	Old Manse	Kirk Gate	Total
12.12.94	0745-0830	5816	647	1448	7911
23.12.94	0825-0905	1905	91	1293	3289
12.01.95	0740-0900	1869	1055	4047	6971
19.01.95	0745-0900	960	39	205	1204
25.01.95	0755-0900	440	3315	1697	5452
28.01.95	0730-0900	4558	1147	4207	9912
09.02.95	0710-0820	1281	2246	2920	6447
16.02.95	0735-0830	0	5	930	935
23.02.95	0655-0900	708	35	1784	2527
02.03.95	0620-0725	1267	2221	3290	6778
09.03.95	0605-0730	2675	1782	1696	6153
16.03.95	0535-0630	447	862	642	1951
27.03.95	0600-0705	1702	1444	1165	4311
31.03.95	0615-0705	92	865	1661	2618
08.04.95	0540-0645	5170	1471	1208	7849

Note : Data were recorded for time and direction of flight for each individual flock as it left Loch Leven. This is not presented here but is available on request.

Appendix 3 - *Summary histories of individually radio-tagged Pink-footed Geese*

Neck collar ID - Adult male, transmitter frequency 266

ID was recorded roosting at Loch Leven on 20 December. It was seen in field I49 the next day and the presence of its transmitter was confirmed visually. On 23 December its signal was received from a flock of 600 Pink-footed Geese in field G90. By 9 January the bird was still present in the Loch Leven area; it was seen in field C70 that day and was roosting on the loch by 1800h that evening. The next day a strong signal was received from a flock of 290 Pink-footed Geese in field C31 but again the bird was not seen. On 12 January a weak signal was received from the Grahamstone area (around G90) but no geese were seen. ID was next located in Strathearn (NO0919) on 31 January, where it remained until at least 8 March. However, the transmitter was retrieved from the same field where the bird was initially observed on 8 March, approximately 4km ESE of Dupplin Loch. Thus the transmitter remained attached to ID until at least 9 February (52 days/7.4 weeks), when a check of Strathearn did not reveal the presence of the transmitter from where it was retrieved.

Neck collar IJ - Adult female, transmitter frequency 315

IJ was recorded roosting off St. Serf's for the first three nights after capture. It was also seen in field I49 on 21 December and 23 December. On the evening of 10 January at 1840h a weak signal was received from the Kirkgate area of Loch Leven. Two days later a strong signal was received from a flock of 520 Pink-footed Geese in field C3. IJ continued to frequent this area for the next eight days at least. On 13 January IJ was in field C24 with 670 Pink-footed Geese, on 17 January it was in field C3 with 460 Pink-footed Geese and on 19 January it was in field C5 with 1650 Pink-footed Geese. The presence of IJ was not visually confirmed during any of these records and throughout this period it was not recorded roosting on Loch Leven. However, on the 20 January the bird was seen in C26 but no signal was received. A check with the receiver over the C5 area where the bird was recorded the previous day did not reveal the presence of the transmitter. It is therefore assumed to have lost it at roost the previous evening. IJ continued to be seen in the Loch Leven area for the remainder of the winter.

Neck collar IL - Adult male, transmitter frequency 257

IL was the least recorded of all five transmitter birds. On 20 December it was roosting on Loch Leven, just off St. Serf's Island. It was not recorded again until 17 January when its neck collar was read by G.Wright in field C3. Earlier that day this flock had been checked with the receiver and no signal was received. On 19 January IL was observed in field I53 and the loss of its transmitter was confirmed. IL continued to frequent the Loch Leven area until the end of the study.

Neck collar IN - Adult female, transmitter frequency 347

IN was recorded roosting on Loch Leven on the evening after capture, just off St. Serf's Island. The next day a strong signal was received from field I49 but the bird was not seen. On 22 January the bird was again recorded roosting on the loch close to St. Serf's Island. On 9 January IN was still using the area and was recorded roosting on the loch, this time in the Carden Point area. The next day a weak signal was received from the Glenlomond area (near field D40) but no birds were seen. That evening the bird was again roosting off Carden Point/Kirkgate. On 11 January IN was seen in I49 by A.Lauder who suspected that no transmitter was present. Over the next day two weak signals were received from the Classlochie area but no geese could be seen and it began to look as though the transmitter was lying there. However, on 13 January a signal from 112 Pink-footed Geese in G88 and G91 was received, although IN was not confirmed visually. The bird was then not recorded for a few days until on the 17 January it was seen in field I53 when it was definitely not carrying a transmitter. IN also continued to frequent the area, particularly the Vane Farm fields, for the remainder of the winter.

Neck collar IP - Adult female, transmitter frequency 285

It is possible that IP lost its transmitter on the evening after catching, however it is most likely to have happened towards the end of the month. A strong signal was often received in late December in the evening from the eastern end of St. Serf's Island where the bird was assumed to be roosting. It was recorded there on the evenings of 20 and 22 December and a weak signal from the Grahamstone area (field G90) was received on 23 December. By 9 January a strong signal was recorded regularly from St. Serf's Island and on 19 January IP was finally seen in field I51 when a signal was still coming from St. Serf's. IP remained in the Loch Leven area until the end of the study period.

Appendix 4 - *Summary Biometric Data from shot birds. Mean (± standard deviation) given above range.*

	Young male	Young female	Adult male	Adult female
Sample size	15	16	12	7
Mass (g)	2565 (±342)	2307 (±378)	2885 (±436)	2582 (±441)
	1900-3275	1625-2875	2225-3500	2125-3150
Wing (mm)	427 (±14.2)	416 (±14.2)	449 (±8.0)	441 (±14.5)
	398-458	400-447	436-459	419-465
Tarsus (mm)	72.7 (±4.3)	70.2 (±4.5)	74.5 (±4.3)	73.1 (±3.3)
	66-80	64-80	69-84	67-77
Head & Bill (mm)	106.7 (±3.5)	101.3 (±4.8)	107.9 (±3.0)	106.7 (±5.9)
	100-112	95-111	104-113	98-114

The Wildfowl & Wetlands Trust, founded by Sir Peter Scott in 1946, works to save wetlands for wildlife and people. More than 30 scientists, based largely at WWT's headquarters at Slimbridge in Gloucestershire, provide the scientific basis for wetland conservation, specialising in: wildfowl and wetland ecology, wetland processes and functions, and practical wetland restoration, management and conservation. Professional consultancy services for wetlands are provided by WWT's Wetlands Advisory Service.

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