The numbers of Pink-footed and Greylag Geese wintering in Britain: observations 1969–1975 and predictions 1976–1980

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One of the principal research objectives of the Wildfowl Trust has been to study the populations of geese wintering in the British Isles, in order to know what is happening to them and why, so that any necessary steps can be taken to care for the geese and for the interests of the many people who enjoy and prize geese and other forms of wildlife. The two most abundant stocks of geese to be found in Britain between October and April are the Pink-footed Geese *Anser brachyrhynchus* which breed in central Iceland and east Greenland and the Greylag Geese *Anser anser* breeding in lowland Iceland. Each is now found in winter chiefly in eastern Scotland and also in south-west Scotland and northern England.

Censuses of these two populations have been carried out in early November each year since 1960. The results for the first decade were reported and analysed by Boyd and Ogilvie (1969, 1972) and summarized by Ogilvie (1970) and Boyd (1973), following earlier studies going back to 1950. This paper is intended to accomplish four tasks: (1) report the results of the annual censuses in 1969–1975, together with observations on the recruitment of young in those years; (2) describe recent changes in regional distribution and examine trends in some areas; (3) present some alternative projections of population size in the years 1976–1980; and (4) discuss ways in which the future of these two stocks may be influenced by human activities in Britain and Iceland.

The censuses have been conducted by teams of observers visiting all the roosts of each species likely to be in use in autumn and counting the geese leaving the roost in early morning or returning to it in late afternoon: in many cases it is also possible to check the numbers at feeding areas during the middle of the day. The technique and its limitations have been discussed in earlier papers (especially Boyd & Ogilvie 1969, 1972). Those papers also listed the individual roosts. Here we use the regional groupings used in those papers, rather than site-by-site tabulations, chiefly to save space but also because in some regions it may be harmful to the interests of the geese to draw attention to the numbers at certain roosts. (Full details are deposited in the files of the Wildfowl Trust.)

The previous report on Pink-footed Geese ended with 1968, while that on Greylag Geese also included data for 1969–1971. Because a comparison between the fortunes of the two species is of special interest, we include here data for both for the seven years 1969 to 1975.

Observations in 1960–1975

Total numbers

The numbers of Pink-footed and Greylag Geese found in Scotland and England in early November in 1969–1975 are listed by regions in Tables 1 and 2. In some years, notably

Table 1. Numbers of Icelandic Pink-footed Geese found in major regions of Scotland and England in early November, 1970–1975, compared with quinquennial means in previous decade (from Boyd and Ogilvie 1969). Thousands of geese, to nearest 0·1.

Region	1960–64 mean	1965–69 mean	1970	1971	1972	1973	1974	1975	1970–75 mean
Moray	0·1	0·6	—	—	—	—	0·2	0·4	0·1
Aberdeen	2·6	13·2	2·2	3·7	5·5	8·9	13·7	16·8	8·5
Angus, Perth	16·7	24·3	37·8	21·0	27·1	39·2	33·2	21·9	30·0
Fife, Kinross	7·5	6·9	10·2	12·0	12·3	9·5	11·9	7·5	10·5
S.E. Scotland	12·5	13·6	13·2	18·5	22·1	13·4	15·2	9·8	15·4
Solway	4·8	4·1	4·2	2·5	0·5	0·3	1·9	2·0	1·9
Lancashire	3·3	4·2	3·6	6·3	4·1	9·8	11·9	13·9	8·3
Yorks, Lincs	8·4	3·2	0·6	1·1	1·1	1·3	1·1	0·9	1·0
Total	57·4	70·1	71·8	65·1	72·7	82·4	89·1	73·2	75·7
East-central Scotland as % of total	44·8	44·5	66·9	50·7	54·2	59·1	50·7	40·2	53·5

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Table 2. Numbers of Icelandic Greylag Geese found in major regions of Scotland and England in early November, 1970–1975, compared with quinquennial means in previous decade (from Boyd & Ogilvie 1972). Thousands of geese, to nearest 0·1.

Region	1960–74 mean	1965–69 mean	1970	1971	1972	1973	1974	1975	1970–75 mean
Moray	2·7	2·7	1·8	3·1	3·4	3·6	6·0	13·7	5·3
Aberdeen	2·3	6·4	6·4	9·4	9·8	10·7	5·2	14·6	9·3
Angus, Perth Kincardine	20·3	32·2	39·3	31·0	35·1	45·4	40·7	15·1	34·4
Fife, Kinross	2·0	2·1	2·2	5·6	3·7	2·8	3·9	4·5	3·8
S.E. Scotland	1·4	2·9	4·4	2·9	4·1	3·4	3·3	3·1	3·5
W. Scotland	0·5	0·7	1·3	1·8	1·4	1·2	2·0	1·0	1·4
Bute	1·5	3·3	1·2	1·6	1·1	2·7	1·1	2·2	1·6
Argyll	0·9	1·2	0·9	1·7	1·4	0·9	1·4	1·8	1·3
Solway	3·6	3·8	6·5	6·0	6·6	4·6	5·2	4·7	5·6
N. England	0·2	0·2	0·5	0·8	1·4	1·2	0·5	2·3	1·1
Total	35·4	55·5	64·5	63·9	68·0	76·5	69·3	63·0	67·5
East-central Scotland as % of total	63·0	61·8	64·3	57·3	57·1	63·0	58·7	31·1	56·6

1969 and 1973, fog, rain or wind made counting unusually difficult in some areas, requiring adjustments to be made on the basis of information obtained earlier and/or later than the census week-end. Such adjustments affect only a small proportion of the national totals. In all years the figures presented are 'conservative', in the sense that they are more likely to be lower than higher than the true totals, both because of the possibility that some geese were not found at all and because the majority of the observers taking part seem to under-estimate rather than over-estimate numbers in situations where bird-by-bird counting is impracticable. Although it would be desirable to attach estimates of the variance to each of the estimated annual totals we have found ourselves unable to do so in a consistent manner, because in some localities we are dependent on a single observation and in others, where geese from several different roosts mingle by day and do not segregate in the same way from one night to the next, we do not see how to estimate variances for the sub-regional totals. Nevertheless, because of the duplication of observations built into the system, we believe that the totals given here are most unlikely to be in error by more than 10% in even the worst year and that most of the regional and national totals are within ±5%. By the standards appropriate to counting flocks of birds in the wild the accuracy and precision attained seem reasonable. Unfortunately, as will emerge below, the year to year changes that are being looked for are quite often little greater than the likely limits of error. Even with the best efforts of a practised team of observers (and most of the people taking part have done so for many years and know their districts well) it seems impossible to place great reliance on the estimated difference in total number of either species between any consecutive pair of years. Changes over a run of years are thus more useful than individual values.

Figure 1 is a graph of the national totals of each species in November for the years 1960–1975, the data for 1960–1968 being taken from earlier papers. The general picture is of an upward trend in both populations. The rate of gain has been greater for the Greylag, which in 1960 was only about half as numerous as the Pinkfoot and by 1971 had almost reached equality. The pattern of year-to-year change has been similar for the two species in 12 of the 15 intervals, with net gains in 8 and losses in 4. In two cases the Pinkfoot declined while Greylags increased. From 1973 to 1974 the Pinkfoot gained markedly while the Greylag dropped. From 1974 to 1975 both dropped, the Pinkfoot very sharply, following one of the worst breeding seasons recorded since 1950.

Recruitment

Table 3 summarizes the information from observations on the proportion of first-winter birds and on brood-size each autumn from

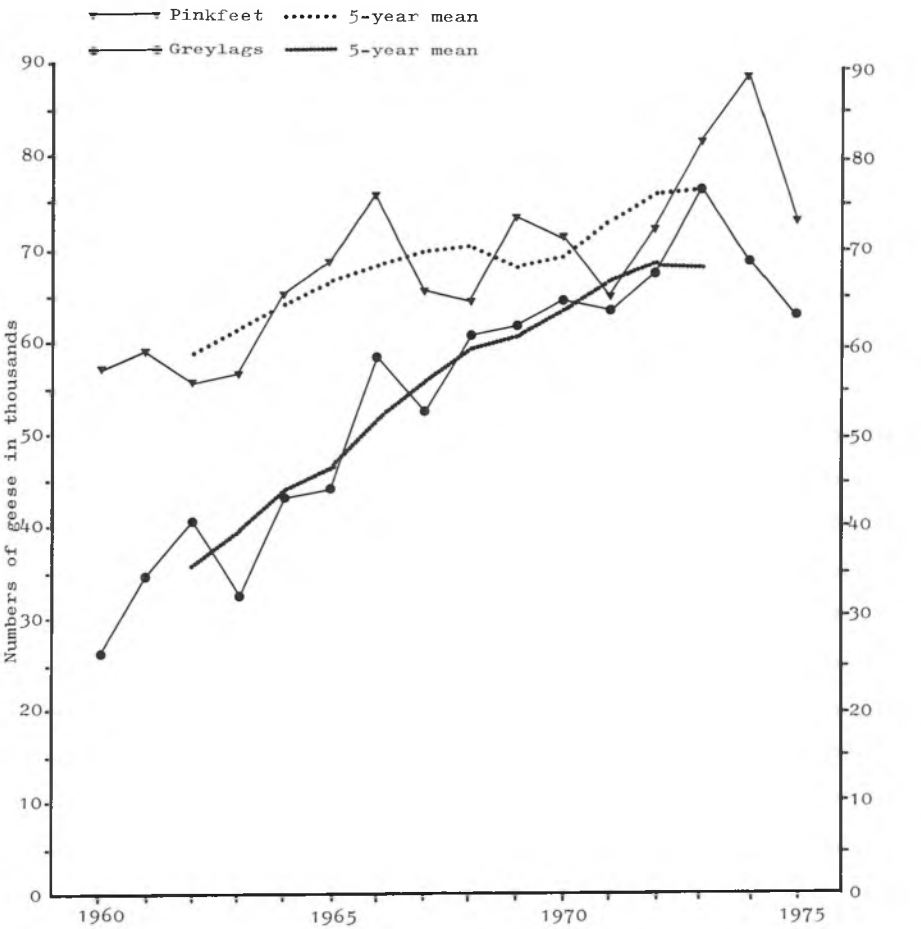

Figure 1. National totals of Pinkfeet and Greylags, 1960–1975, together with five-year means.

1969 to 1975 and compares the annual values with the means for the two previous 5-year periods. For both species the latest period produced similar results: low production in 1972 and 1975 and high in 1973, with period means close to the low values of 1965–1969 rather than the high values of 1960–1964. Thus the downward trend in recruitment during the 1960s has been halted and has given way to fluctuations without clear trends in the early 1970s. As in the previous decade, both the proportion of young geese and the mean brood-size were slightly higher for the Greylag than for the Pinkfoot.

Losses

No direct measure of losses is available. They can only be estimated by difference (Table 4). There is only one wholly implausible estimate, that the total losses of Pinkfeet from 1971 to 1972 amounted to only 500 birds. Perhaps the most likely explanation is that the estimated total of Pinkfeet in 1971 (N_t = 65·0) was too low. If so, that would also suggest that the estimated mortality rate for 1970–1971 is too high. The annual 'mortality rates' of each species vary rather widely and are not closely in phase with each other. Given the vulnerability of the method of estimation to the effects of errors in counting, the consistency of the results is probably more remarkable than their vagaries. The 6-year mean mortality rate of 18·4% for the Pinkfoot does not differ appreciably from that in the preceding 5 years, although lower than the mean rate of 22·2% for 1960–1964. The period means for the Greylag differ more

Table 3. Recruitment of Pink-footed and Greylag Geese as estimated from sample counts of proportion of first-winter birds and brood-sizes in late October and early November, 1969–1974.

Year	proportion of 1st w. birds			brood-size		
	birds in sample	1st w. total	95% limits	identified	mean size	s.e. mean
		j			b	
Pink-footed Goose						
1969	1605	·244		43	2·14	
1970	1635	·231		85	2·18	
1971	1717	·222		125	1·87	
1972	1442	·114		69	1·67	
1973	1427	·305		71	2·35	
1974	2155	·176		109	2·16	
1975	1577	·056		60	1·43	
period mean		·192			1·97	
mean 1965–1969		·178			1·95	
mean 1960–1964		·253			2·72	
Greylag Goose						
1969	581	·238		60	1·97	
1970	830	·251		33	2·36	
1971	1618	·175		127	1·84	
1972	1370	·151		98	1·77	
1973	1763	·303		83	2·56	
1974	1394	·188		86	2·16	
1975	1811	·076		92	1·51	
period mean		·197			2·02	
mean 1965–1969		·167			1·98	
mean 1960–1964		·322			3·09	

Table 4. Annual recruitment ($Y_t = j\,N_t$) and losses ($L_t = N_t - [N_{t+1} - Y_{t+1}]$) of Pink-footed and Greylag Geese in 1969–1974, estimated from total counts (N_t) and proportion of first-winter birds (*j*): expressed as thousands of geese, to nearest 0·1. Crude mortality rate $d_t = L_t/N_t$.

	Pink-footed Goose				Greylag Goose			
	N_t	Y_t	L_t	d_t	N_t	Y_t	L_t	d_t
1969	73·8	18·0	18·5	·251	61·8	14·7	13·5	·218
1970	71·9	16·6	21·3	·296	64·5	16·2	11·9	·184
1971	65·0	14·4	0·5	·008	63·8	11·2	6·1	·096
1972	72·8	8·3	15·5	·213	68·0	10·3	15·3	·225
1973	82·4	25·1	9·1	·110	75·6	22·9	19·6	·259
1974	89·1	15·7	19·9	·224	69·3	13·0	9·9	·143
1975	73·2	4·1			63·0	4·9		
mean mortality rate 1969–1974 $\bar{d}$				·184				·188
1965–1969				·180				·125
1960–1964				·222				·220

widely, the estimate having reached the remarkably low value of 12·5% in 1965–1969, but having returned to about 19% in 1969–1974.

Balances between recruitment and losses

If only because of the method of calculating losses, it is to be expected that the mean rate of gain in population size should correspond fairly closely with the excess of the rate of recruitment over the mortality rate. It is more interesting to look at the correspondence between the various rates in different years (Figure 2). There is a close resemblance between the proportion of juveniles recruited

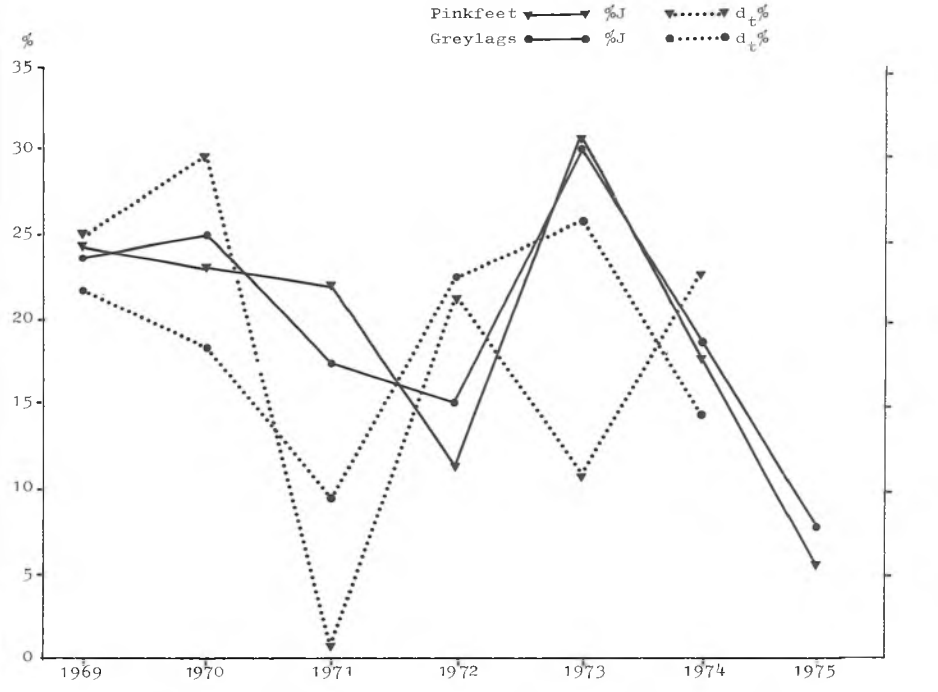

Figure 2. Recruitment (% juveniles) and losses (d_t%) of Pinkfeet and Greylags, 1969–1975.

by each species in each year. Though the resemblance between the estimated rates of loss is less close, there is a tendency for losses to be greater in years with more young and less in years when recruitment was low, as would be expected given the evidence from recoveries of ringed geese, first demonstrated for Pinkfeet by Boyd (1953), that first-winter geese are more vulnerable to shooting than older geese. For British-ringed Pinkfeet ringed in October or early November, the chance of recovery in the first winter of a young goose was about 1·42 times greater than that of older geese (unpublished mean value for 1950–1959; cf. Boyd's original estimate of 1·27 for the years 1950–1952). Amongst British-ringed Greylags the corresponding mean 'vulnerability quotient' in the period 1952–1963 was 1·15. The range of annual variation in juvenile vulnerability is itself considerable and seems to be inversely related to juvenile abundance.

When using the census data in order to see what may happen in the years ahead, it is important to keep in mind the probability that annual mortality is at least as variable as recruitment, even after errors of estimation have been reduced.

Regional distribution

The tendency shown in the previous decade for the greatest growth in numbers to be in eastern Scotland persisted until 1975 in Aberdeen, the numbers in east central Scotland having receded from the peak of 48,700 reached in 1973. The only flourishing group of Pinkfeet elsewhere is that in Lancashire, discussed in a later section. No striking redistribution of Pinkfeet or Greylags occurred in Scotland between 1970 and 1974, although the numbers in the principal area, Angus and Perth, fluctuated widely from year to year. That was apparently due to differences in the state of the stubble fields after the barley harvest. With a growing tendency amongst farmers to plough very soon after harvesting, in those years when a dry autumn allowed an early and complete pick-up in east central Scotland, Pinkfeet tended to aggregate in the south-east. However, when those conditions recurred in east-central Scotland in 1975, increased numbers were found in north-east Scotland and in Lancashire, while there were fewer in south-east as well as in east-central Scotland.

Numbers in east-central Scotland, 1960–1975

About three-fifths of all the Icelandic Pinkfeet and Greylags in Britain in early November are to be found in east-central Scotland—defined as the counties of Angus, Kincardine, Perth, Fife and Kinross (with single roosts of Pinkfoot in Stirling and Clackmannan added in). This proportion has remained relatively constant for Greylags since 1960. For Pinkfeet less than half were in the region in 1960–1964, but they rose to a peak in 1970 when the region held two-thirds of the population.

The importance of the concentration lies in the conflicts with agriculture that have been developing in recent years. Most importantly we are concerned with the implications of a possible counter-attack by farmers with the object of driving away or killing many of the geese. Bailey *et al.* (1972) and Hamilton and Stanley (1975) have reported on several massive examples of poisoning of both Greylags and Pinkfeet with agricultural chemicals in 1971 and 1974, while a further incident occurred in November 1975 in Fife in which not less than 400 Pinkfeet died. It seems unlikely that all these occurrences were wholly accidental. There has further been a vociferous campaign to have both these species of goose declared as pests in the counties of Angus, Perth, Fife, Kinross, Stirling and Clackmannan, so that there would no longer be a closed season for them. After proposing a Statutory Order to this effect the Secretary of State for Scotland finally bowed to the strength of the objections and protests from both wildfowling and conservation bodies and withdrew his Proposal.

The present recommended policy is to try to disperse the larger concentrations of geese by disturbing their roosts but so far this has not been tried and its effects are unknown. However it is worth trying to consider what the impact of an intensified attack by farmers, whether by shooting, poison, trapping or roost disturbance, might be, not just locally but on the entire stocks of the two species.

One way of examining the role of east-central Scotland (hereafter ECS) in the dynamics of the two species is to set up a model, summarized in Table 5, to see how far changes in regional abundance are due to immigration and emigration, in addition to deaths and the recruitment of young birds. The model used assumes that the ECS stocks are subject to the same rates of recruitment by births and of mortality as the rest of the population. This assumption is reasonable for the proportion of first-winter birds because most of the sampling of age-ratios is carried out in the region. The assumption about mortality rates cannot be supported by independent evidence for recent years: but a comparison based on recoveries of geese ringed between 1950 and 1963 gave no indication of differences in survival between geese that had been ringed in ECS and those ringed elsewhere in Britain (Boyd, unpublished).

The I columns in Table 5 provide estimates of the extent to which immigration or emigration of adults between one year and another may have accounted for the variations in required numbers, given the assumptions about deaths and recruitment. We ignore here shifts during the winter, which do occur (see Boyd (1955) for evidence from ringed Pinkfeet and Boyd (1959) and Boyd and Ogilvie (1972) for that from ringed Greylags), but which may not be decisive in determining whether geese living in ECS one November return there the next November, if they survive.

Perhaps the most remarkable feature of the numbers in the I columns is that many of them are small (less than 10% of the corresponding E values). Given the obvious imprecision of the calculations, this suggests that for most of the time the ECS stocks of both species could be considered as closed groups. This is consistent with the earlier evidence from ringing recaptures and recoveries showing a marked tendency for geese ringed in one region in autumn to be found there again in later years, especially at the corresponding season (Boyd 1955).

Only five years produced evidence of large-scale shifts by Pinkfoot: influxes corresponding to about one-third of the returning adults in 1961 and 1970, an egress of the same order in 1971, and two smaller ones in 1973 and 1974. The largest flux in adult Greylag numbers was the apparent loss in 1974 of nearly half the adults assumed to be surviving, while in 1969 two-fifths of the adults did not reappear. In both years there was little spilt grain in the area. In three other years (1965, 1966, 1970) there were estimated additions equal to about one-quarter of the adult stock.

The lack of any trend towards growth by immigration in ECS is perhaps an encouraging sign in the context of any proposal for a massive and sustained assault intended to reduce the numbers of geese, as formulated in those parts of Perth and Fife where complaints are most insistent, because it suggests that the removal of some geese may achieve the desired effect without the undesirable consequence of immediate immigration of

replacements.

Table 5 suggests that annual losses (from all causes and not only during the winter), of adult and first-winter geese from the ECS stocks have averaged 5,500 to 6,000 for each species. Though the relationship between winter shooting losses and those from other causes is quite unknown in recent years, earlier work suggests that 60–85% of these deaths were probably due to shooting, mostly within the region. A campaign to wipe out geese at the places where they are most disliked would probably require the annual kill within the region to be at least doubled. This would certainly be feasible for the Greylag, perhaps harder to accomplish for the Pinkfoot, due to differences in their responses to shooting.

A doubled regional kill would be sadly wasteful, if continuation of the present prohibition on the sale of dead wild geese meant that most of the additional kill would not be used for food. But the available evidence suggests that the impact on the entire Iceland populations would be small.

Pink-footed Geese in Lancashire in November, 1961–1975

One of the most interesting changes in distribution in the last few years has been a surge since 1972 in the number of Pinkfeet found in Lancashire in November. The earlier history of changes there is somewhat confused by arguments about the completeness of counts prior to 1970 although in any event it has long been true that numbers in early November were much smaller than those found later in the winter. Analysis of early ringing results suggested that this was due chiefly to im-

Table 5. Population models for Pink-footed and Greylag Geese in east-central Scotland (ECS) in November, 1961–1975.

Year	Pink-footed Geese						Greylag Geese					
	N	Y	A	S	I	I/A%	N	Y	A	S	I	I/A%
1961	25·3	4·5	15·8	19·0	+ 5·5	35	22·0	8·8	13·2	17·4	+ 1·1	8
1962	28·9	6·1	22·9	23·5	+ 3·9	17	25·7	8·2	17·5	15·0	+ 0·1	1
1963	25·4	5·1	20·2	21·4	— 3·3	16	22·8	6·3	16·5	22·3	+ 1·5	9
1964	31·0	8·3	22·8	26·0	+ 1·4	6	26·1	7·2	18·9	14·7	— 3·4	18
1965	27·8	5·8	22·0	24·1	— 4·0	18	23·7	5·0	18·7	23·3	+ 4·0	21
1966	35·0	7·6	27·4	26·9	+ 3·3	12	40·3	10·0	30·3	32·5	+ 7·0	23
1966	35·0	7·6	27·4	26·9	+ 3·3	12	40·3	10·0	30·3	32·5	+ 7·0	23
1967	29·2	3·2	26·1	25·5	— 0·8	3	35·8	3·9	31·9	38·3	— 0·6	2
1968	32·0	3·8	28·3	27·6	+ 2·8	10	41·8	2·5	39·3	32·4	+ 1·0	3
1969	31·6	7·7	23·9	23·7	— 3·7	15	30·1	7·2	22·9	23·5	— 9·5	41
1970	48·0	11·1	36·9	33·8	+13·2	36	41·5	10·4	31·1	33·9	+ 7·6	24
1971	33·0	7·3	25·7	32·8	— 8·1	31	36·6	6·2	29·5	32·3	— 4·4	15
1972	39·4	4·5	34·9	31·0	+ 2·1	6	38·8	5·8	32·9	30·0	+ 0·6	2
1973	48·7	14·9	33·8	43·3	+ 2·8	8	48·2	14·6	32·6	35·7	+ 2·6	8
1974	45·1	7·9	37·2	35·0	— 6·1	16	44·6	8·4	36·2	38·2	+ 0·5	1
1975	29·4	1·6	27·8	—	— 7·2	26	19·6	1·5	18·1	—	—20·1	111
means												
1961–65	27·7	7·0	20·7			18	24·1	7·1	17·0			12
1966–70	35·2	6·7	28·5			15	37·9	6·8	31·1			17
1971–75	39·1	7·2	31·9			17	37·6	7·7	29·9			19
1961–75	34·0	7·0	27·0			17	33·2	7·2	26·0			16

Assume proportion of 1st-winter birds (j) and crude death-rate (d) to be those of entire populations (see Tables 3 and 4).

N = total count of geese in ECS, in thousands, rounded ω 0·1

Y = estimated number of 1st-winter birds in ECS

A = (N-Y) = estimated number of full-grown geese in ECS

S = E(1-d) = expected number of survivors from N_t in following November, assuming death-rate for entire population.

I = $A_t - S_{t-1}$ = estimated number of full-grown geese in ECS in year t minus expected number of survivors from number in ECS a year earlier. Positive or negative numbers imply immigration or emigration respectively (though small scorings may merely be due to errors in counting or estimation).

I/A is an index of the scale of immigration/emigration, ignoring sign.

migrations from haunts around the Humber and the Wash (Boyd 1955). This delayed build up is still occurring: after the record of nearly 14,000 in early November 1975 the total rose to around 20,000 in December 1975 and January 1976. The protection of Martin Mere after its acquisition by the Wildfowl Trust in 1972 has had a considerable effect. The geese now use it quite regularly as a roost, as well as a feeding area, instead of roosting on the sands of the Ribble estuary.

The declining use of the former major haunts north and south of the Humber and around the Wash seemed to result from the practices of straw-burning and ploughing immediately after harvesting, leaving little food available in November and December. In the vicinity of Martin Mere the prevailing practice is to disc-harrow the fields once or twice after harvesting the barley. This effectively sows many spilt grains which, in the mild wet conditions on the west coast, promptly sprout several inches. The fields are then left untouched until the spring, offering the geese excellent grazing.

While arithmetic is less instructive than observation and ecological insight it is of some interest to applying the modelling approach used in the preceding section to the Lancashire numbers (Table 6). As few observations on family-size and proportions of young were made in Lancashire before 1973 it is necessary to use the 'national' estimates of those parameters rather than local ones, which would be preferable. The most striking feature of the Lancashire model, in contrast to that for East Central Scotland, is the much higher I/A ratio in Lancashire, throughout the whole period. This demonstrates that the population is far from being closed, as was indeed inferred from the ringing results 20 years ago.

Table 6. Population model for Pink-footed Geese in Lancashire in November 1961–1975. Assumptions and column-headings as in Table 5, (numbers to 0·01 to reduce rounding errors).

Year	N	Y	A	S	I	I/A%
1961	4·70	1·76	2·94	3·53	+0·81	28
1962	3·55	0·74	2·81	2·88	−0·72	26
1963	1·53	0·31	1·22	1·29	−1·66	136
1964	3·48	0·93	2·55	2·91	+1·26	49
1965	2·50	0·53	1·97	2·16	−0·94	48
1966	3·50	0·76	2·74	2·69	+0·58	21
1967	1·50	0·16	1·34	1·31	−1·35	101
1968	8·06	0·94	7·12	6·93	+0·19	3
1969	5·62	1·37	4·25	4·21	−2·68	63
1970	3·61	0·83	2·78	2·54	−1·43	51
1971	6·31	1·40	4·91	6·26	+2·37	48
1972	4·10	0·47	3·63	3·23	−2·63	72
1973	9·80	2·99	6·81	8·72	+3·58	53
1974	11·98	2·11	9·87	9·30	+1·15	12
1975	13·89	0·78	13·11		+3·81	29
means						
1961–65	3·15		2·30			47
1966–70	4·46		3·65			34
1971–75	9·21		7·67			35
1961–75	5·61		4·54			38

It is obviously much harder to guess what might happen in Lancashire than in the east of Scotland if the number of adult geese returning to Lancashire in November is not closely tied to the number of survivors from a year earlier with local early season attachments. This contrast provides a convenient point of departure for a consideration of possible changes in numbers and distribution, nationally and regionally, in the next few years.

Projected changes in 1976–1980

Total numbers

Early in 1969 we made two alternative predictions about the size of the Pinkfoot population in the autumn of 1969 and in the years up to 1975 (Boyd & Ogilvie, 1969). These predictions derived from simple extrapolation of two linear regressions fitted to the total counts for 1950–1968 and for 1966–1968 respectively. The long-period regression line indicated continued growth, to 74,900 in 1969 and 89,000 in 1975. The short-period regression line indicated a fall to 48,800 in 1969 and to 34,900 in 1971. The observed value of 73,800 in 1969 agreed quite closely with the value expected from the long-run regression and led to the rejection of the hypothesis of continuing rapid decline based on the counts in 1966–1968. It is, of course, not at all surprising that a projection from counts in only three years should prove very misleading.

Figure 5 records the results of fitting least-square linear regressions to the November counts of Pinkfeet and Greylags in the seven years 1969–1975 and of extrapolating the fitted lines to forecast numbers in the years 1976–1980. The results suggest that the rate of increase from 1969 to 1975 was rather greater for Pinkfeet than for Greylags and that the annual values for Pinkfeet were scattered more widely around the expected values.

Comparing the numbers of Pinkfeet found annually in 1969–1975 with those expected from the regression equation for 1950–1968, six of the seven values fall below expectation,

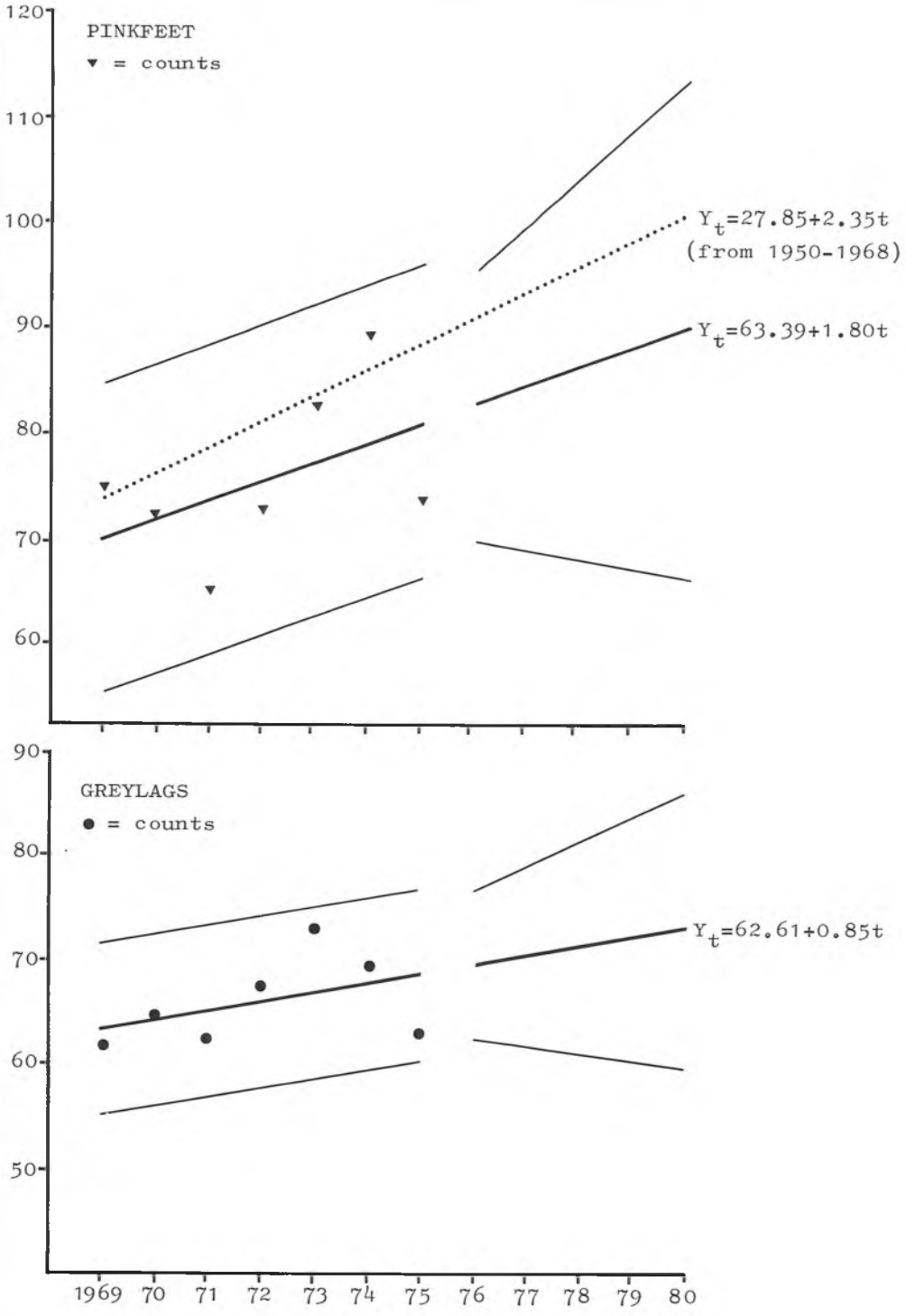

Figure 3. Fitted least-square linear regressions for totals of Pinkfeet and Greylags, 1969–1975, with 95% limits, plus extrapolations to 1980 with 90% limits.

confirming that the rate of increase has diminished in recent years. Looking ahead to 1980 the projections from 1950–1968 and from 1969–1975 are about 100,700 and 89,800 respectively. The latter figure is only a little above the highest number yet recorded, 89,100 in 1974.

For the Greylag a rather similar result obtains, a projected total of 72,800 in 1980, compared with a recorded maximum of 73,200 in 1973. Thus there is no indication from counts in recent years that any substantial increase in the total number of either population is to be expected between 1976 and 1980, unless there is some important change from the circumstances prevailing in the last seven years.

Regional changes

The regional totals for Pink-footed and Greylag Geese recorded in Tables 1 and 2 can be treated in the same way as the national totals, fitting least-squares lines to the data for 1969–1975 and using those trend lines to predict numbers in the years ahead. The results are summarized in Table 7. They indicate slow growth in total numbers, as did Figure 5 based on national totals, with continuing redistribution between regions.

The Pinkfoot is expected to continue to gain, absolutely and relatively, in Aberdeen and Lancashire, to disappear as an 'early November bird' from the Solway and will probably decrease in south-east Scotland. It is hard to guess what may happen in Angus and Perth: the very low value of the coefficient of determination r^2 indicates that in 1969–1975 there was little correlation of the observed numbers with a linear equation. The number fluctuated widely from year to year and the periodicity of the swings seemed to increase. It may be guessed that in 1976 the numbers will return to or above the least-squares estimate, but there seems no way of judging how close the observations in 1980 are likely to be to the forecast of 32,700. The very low value of r^2 for Yorkshire and Lincolnshire is not due to wide fluctuations but reflects the fact that the fitted line is no better than a line of zero slope for forecasting: i.e. the mean for 1970–1975 is as good an estimator for 1976 and 1980 as the trend line projections (calculated as 1·03 and 0·99 respectively).

The Greylag is expected to continue to gain substantially in Moray and to decline in Angus and Perth and in south-east Scotland. The very low values of r^2 for Aberdeen, Angus and Perth and the Solway and northern England are due in the two northern

Table 7. Expected numbers of Pink-footed and Greylag Geese in different regions of Scotland and northern England in November in 1976 and 1980, estimated from linear least-squares trend lines fitted to data for 1969–1975. Numbers of geese in thousands.

Region	Mean number observed, 1970–75	Coefficient of determination r^2	Estimated numbers		% of national total		
			1976	1980	1970–75	1976	1980
Pink-footed Goose							
Aberdeen	8·5	0·314	14·8	20·6	11·2	18·0	22·4
Angus, Perth	30·0	0·019	30·7	32·7	39·6	37·3	35·6
Fife, Kinross	10·5	0·241	9·1	7·5	13·9	11·0	8·2
S.E. Scotland	15·4	0·181	12·4	9·3	20·3	15·0	10·1
Solway	1·9	0·507	0·1	0	2·5	0·1	0
Lancs.	8·3	0·75	14·3	20·7	11·0	17·4	22·5
Yorks, Lincs.	1·0	0·008	1·0	1·0	1·3	1·2	1·1
Total	75·6		82·4	91·8			
Greylag Goose							
Moray	5·3	0·655	11·0	17·2	7·9	15·6	23·2
Aberdeen	9·3	0·003	9·8	9·4	13·8	13·9	12·7
Angus, Perth	34·4	0·027	30·5	27·4	51·0	43·3	37·0
Fife, Kinross	3·8	0·212	4·6	5·7	5·6	6·5	7·7
S.E Scotland	3·5	0·556	2·4	0·9	5·2	3·4	1·2
West Scotland[1]	4·3	0·530	5·3	6·4	6·4	7·5	8·6
Solway, N. England	6·7	0·020	6·8	7·0	9·9	9·7	9·4
Total	67·3		70·4	74·0			

[1] West Scotland here includes Bute and Argyll.

Table 8. Comparison of forecasts of total populations of Pink-footed and Greylag Geese in November in 1976 and 1980 by linear extrapolation of trend lines for data of 1969–1975 for (a) national totals and (b) regional totals, summed.

	Estimated number in 1976		Estimated number in 1980	
	Pinkfoot	Greylag	Pinkfoot	Greylag
Extrapolated national totals	82,700	69,400	89,800	72,800
Extrapolated regional totals	82,400	70,400	91,800	74,000

areas to wide annual fluctuations in 1969–1975 and in the south to a complete lack of trend.

Table 8 shows that the projected national totals obtained by summing the regional projections are close to those derived from the past national totals, with a difference of only 2·2% in the worst of the four cases. This is somewhat surprising, even though it must be true that, if the size of the population entering Britain each autumn is determined by the action of events in Iceland on the geese leaving Britain in spring, and if growth in total number is small, gains in one region must be accompanied by losses from elsewhere.

Discussion

The scope of this report has been deliberately limited so as to focus on changes in abundance, as perceived nationally and regionally. The relative importance of factors in Britain, as compared with those in Iceland and Greenland, in determining why so small a proportion of the potential breeding population brings young birds to Britain and how the population fluctuations are kept damped down requires fuller analytical treatment, to be reported elsewhere.

Perhaps the most important principles which emerge from this progress report and from the primitive modelling applied to the situations in eastern Scotland and Lancashire are these. There is a need for international and national perspectives, concerned with the total stock size and its determinants. That need does not seem great in cases such as the two discussed here where the total numbers of geese occurring at present are high relative to those believed to have existed in the past, even if small in comparison with those of many species and stocks in other countries. Because goose-shooting is still an unpopular pastime in Iceland the question of allocation of kill between countries is unimportant. Within Britain sport hunting of grey geese is now, perhaps to a greater extent than ever before, under private control, because the geese themselves have largely withdrawn from estuarine roosts and feeding areas in favour of inland roosts. In so doing they have put themselves under the protection of landowners and farmers whose interests are served by severe restriction on public access to land: and have thereby aggravated the hostility of those farmers who find or believe that the present of large numbers of geese is harmful to their cropping and grazing plans.

In choosing to discuss distribution at a 'regional' level we may have obscured rather than clarified the issues to be faced in conserving geese in Britain, by interposing an abstraction between consideration of the welfare of the species as a whole and the problems of conflict at local level. To demonstrate that some regional groupings are more nearly closed than others, at just one time of year, is of very limited value, as compared for example with intensive local studies throughout the period of residence of geese in Britain. The study of the impact of these two species in the vicinity of Loch Leven, Kinross (Newton and Campbell 1973) should be repeated in other areas of concern. The chief value of this 'regional' study may be in suggesting that: (1) the most serious difficulties in eastern Scotland may be in process of resolution, without the need to move towards more extreme courses of action such as large-scale destruction; (2) there may well be similar complaints to deal with in the north-east; (3) the upsurge of Pinkfeet in Lancashire may provide the first example of an effective answer to 'short stopping' (in North American usage), the choice by geese to winter further north in the range and to abandon, more or less completely, former strongholds in the south. The situation there will be watched closely in the coming years.

Even if it proves too expensive to conduct prolonged investigations in such troubled areas as east Fife and the Isla valley there is probably much still to be learned from detailed study of the distribution by roosts in November about the capacity of the geese to find their own solutions to crowding and competition and about the ways in which those

solutions are influenced by human activities of various kinds.

The view of Newton and Campbell (1973) that 'Other things being equal, these geese will probably not reach the limit of their resources in Britain for a long time' seems to be appropriate. The same is probably also true in respect of grazing resources in the lowlands of Iceland, which are extensive and slowly being improved by human action, despite a recent worsening of climate (Fridriksson 1972). The first pressure from the habitat may be a shortage of nesting areas for Pinkfeet, especially as the principal colony in Thjorsarver, central Iceland, shows signs of being overcrowded: Gardarsson (1972) suggested that 'natural goose populations are not necessarily in short-term balance with summer grazing conditions'. Alternative areas used by Pinkfeet in Iceland and Greenland are very limited in extent (Bulstrode and Hardy 1970; Kerbes, Ogilvie and Boyd, 1971). The Greylag Geese, nesting at lower altitudes and more closely in contact with farm stock and cultivated grasslands, are more likely than Pinkfeet to be affected by changes in farming policy and the tactics and attitudes of Icelandic farmers. Yet the marked coincidence of annual variations in recruitment of the two species suggests that as breeding birds both are chiefly affected by the weather, either directly or through its effects on the quantity or quality of food plants.

Despite the evidence of yearly variations in recruitment, the most striking features of the population budgets of these two species are the successful damping down of fluctuations in total numbers and the evidence of a large breeding potential far from fully deployed in recent years. The capacity of Pink-footed and Greylag Geese to live well within their means in this way merits further investigation. Unfortunately, the funding of science, like journalism, seems to respond to crisis, disaster and sensation rather than to quiet success, so that probably the only way to find out why the grey geese are so successful will be to wait until something seriously damaging occurs, whether it be the long-threatened inundation of Thjorsarver for power development or a massive attack by farmers in Scotland.

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Summary

Greylag Geese *Anser anser* breeding in lowlan Iceland and Pink-footed Geese *Anse brachyrhynchus* breeding in central Iceland an east Greenland arrive in Scotland and norther England in October. A series of censuses of gees at all known autumn roosts made in earl November each year since 1960 has shown tha from 1969 to 1975 the number of each species con tinued to increase, though more slowly than in th previous decade. There were 89,100 Pinkfeet i November 1974 but the total fell back to 73,200 i 1975, after one of the poorest breeding season known. The highest number of Greylags ye reached was 76,500 in November 1973; there wer 63,000 in November 1975. In 1970–1974 recruit ment of young geese was at a higher rate than i 1965–1969 but well below that of 1960–1964. Th large number of geese of both species in east central Scotland have caused some concern t farmers. It appears that the geese visiting there i autumn form a relatively closed group, augmente occasionally by 'immigrants' but in 1975 seen i unusually small numbers. The reduction wa probably due to a temporary comparative scarcit of food in the region due to exceptional harves conditions but may also have been affected by ac tion taken by farmers in the previous winter Numbers in north-east Scotland have grown mor rapidly than those elsewhere, apart from a resurgence of Pink-footed Geese in Lancashire one of the few recent examples of geese building u in the south of the wintering range. The Lancashir birds seem to form a much more open group tha those in east-central Scotland. Projections o trends during 1969–1975 suggest that i 1976–1980 it is comparatively unlikely that either stock will increase to above the peaks they have already reached.

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