3.2 HABITAT MANAGEMENT: THE EXPERIMENTAL FIELDS

3.2.1 Introduction

The importance of habitat quality in influencing feeding site selection by goose species has been well documented, with "quality" being measured in terms of food abundance, food availability and nutrient value (eg Drent et al 1979; Owen 1971, 1975; Ydenberg & Prins 1981). An analysis of the food ingested by Greenland White-fronted Geese wintering at the North Slobs, Co. Wexford, found that their diet consisted mainly of common ryegrass (Lolium perenne), although stubble grain and sugar beet were taken when available, and the birds probed for roots and stolons when on semi-natural grasslands (Mayes 1979). Mayes also investigated the energy budget of Greenland White-fronted Geese and concluded that the birds could not maintain their energy requirements in December and January by grazing alone. She indicated that the availability of stubble grain and sugar beet in arable areas, and of roots and stolons in natural habitats, therefore form a crucial part of the winter diet. Although the stolons had a fibre content comparable with grass leaves, it was thought that the rate of energy intake was improved by the ability of the birds to ingest stolons more rapidly than leaves, especially when on wet or flooded land.

To determine factors affecting feeding site selection by Greenland White-fronted Geese on Islay, and consequently the best means of managing habitat for the species, the distribution of geese over three experimental fields (SU22, AO35 and RK17) was monitored throughout the 1992-93 winter. Soil samples were analysed by the Scottish Agricultural College, and their recommendations on levels of fertilising and liming needed to bring the pastures up to a reasonable agricultural standard were adhered to. Each field was divided into sectors in the summer of 1992 and each sector received one or a combination of liming, fertilising and rush cutting treatments, as described below. The number of birds using the different sectors within the experimental fields was then recorded throughout the following winter.

The effect that management techniques such as liming and fertilising had upon plant species diversity was also assessed by recording species abundance within the treated areas, both before the treatments were applied, and again one year later. Food ingested by the birds was determined by faecal analysis. The extent to which the geese fed selectively upon the different types of vegetation available was determined by comparing food ingested, identified by the faecal analyses, with the relative abundance of the different types of vegetation in the field.

3.2.2 Methods

3.2.2.1 Treatment of the experimental fields

The first experimental field, Sunderland Farm field number 22 (SU 22), received a range of treatments including liming (at 3 tons/acre), fertilising (using Timac 0:15:10 at 2.5 cwt/acre), liming and fertilising and control sections which remained untreated. Denser sections of Juncus were cut to produce a fairly uniform distribution of Juncus across the experimental plots. The experimental area was marked out as a Latin Square of 16 plots, with the treatment given to each plot being randomised but constrained in that no strip was adjacent to another receiving the same treatment. Thus four plots were limed only (sectors 1A, 2C, 3B and 4D), four plots were fertilised only (sectors 1B, 2D, 3A and 4C), four plots were both limed and fertilised (sectors 1C, 2A, 3D and 4B) and four plots were untreated control areas (1D, 2B, 3C, 4A) - see Figure 3.2.2.1a. Each plot was c. 40x40m in size, and marked by small white pegs driven into the ground. The number of birds recorded in each of the 16 experimental plots on field SU22 at Sunderland farm recorded at regular intervals during the 1992-93 winter; the count data was log transformed for statistical analysis.

Prior to treatment the second experimental field, at Aoradh farm (AO35) on the RSPB Reserve, had an almost 100% cover of approximately 1m high rush Juncus effusus. Half the area of the field slopes away from the RSPB observatory; an area of some 270x200m on the flat (most easily visible) part of the field was used as the experimental plot. The field was divided into 72 experimental plots, consisting of 18 avenues where the Juncus had been cut (ranging from 5m to 30m in width, and each 200m in length), separated by 5m wide sections of uncut Juncus stands, and with four alternating fertilised and unfertilised sections within each avenue (Fig. 3.2.2.1b). The Juncus was cut in strips of differing breadths in order to assess the amount of Juncus-cutting favoured by the birds. The breadths of the cut bands were as follows:

Strip	Aim Width	Real Width	Strip	Aim Width	Real Width	Strip	Aim Width	Real Width
1	5	5	7	5	5	13	5	5
2	10	10	8	30	27	14	10	9
3	10	10	9	30	30	15	5	5
4	5	4.5	10	5	5	16	20	18
5	5	5	11	5	5	17	5	5
6	10	11	12	10	9	18	5	5

A grid of marker posts (ordinary fence posts with white paint on top) and pegs was used to identify the corners of each experimental plot. Half of each avenue was fertilised using organic nitrogen-free Timac fertiliser (N:P:K ratio of 0:15:10) at 3 cwt/acre. No lime was applied to this field as the RSPB wished to preserve the acidic nature of the land for botanical reasons. Cattle put out in the field in autumn and early winter grazed on the regrowing Juncus in areas that had been topped, which helped to re-define the cut:uncut areas. The grazing of re-growing Juncus by the cattle, combined with the presence of a malt-lick, also served to maintain the cattle in good condition in the field in early winter, thus saving on the cost of supplementary feeding. The number of Greenland White-fronted Geese recorded in each of the plots was recorded at regular intervals during the 1992-93 winter. The numbers of cattle and Barnacle Geese present were also recorded, and compared with the Greenland White-fronted Goose counts, since it was thought that grazing pressure from cattle or other goose species might influence the use of the field by Greenland White-fronted Geese. All count data was log transformed for statistical analysis.

The field at Rockside farm (RK 17), situated on a north facing slope, was both cut and fertilised with mineral phosphate at a rate of 5cwt/acre, but not limed. Liming had been intended but proved impossible due to wet conditions. The Juncus was cut in bands of 30m and 10m in width diagonally across the field, the broad bands alternating with the narrow bands and each strip separated by some 5-10m of uncut Juncus. Field RK17 was observed at regular intervals during the 1992-93 winter to determine the number of geese present, but the birds were more frequently seen on fields SU22 and AO35.

3.2.2.2 Habitat assessment in field SU22

Direct measurements of habitat variables were recorded in 12 of the 16 plots of Sunderland 22 field (the experimental field most extensively used by the geese) to obtain further information concerning factors affecting the birds' selection of a feeding site. These were recorded once a month for the months of February to April inclusive. The three habitat variables measured were the biomass of grass present in the plot, mean grass sward length and maximum sward length. The biomass of green grass was estimated by clipping a 25 x 25 cm plot to soil level, drying the live (green) vegetation at 100°C for 24 h and weighing the sample. The dead (brown) vegetation was also kept and dried separately to determine the total weight of vegetation in the 625-cm^2 plot. Mean surface height and maximum height of the sward was estimated by measuring, without stretching, blades of grass from earth to tip at ten random points in each plot (as described by Hodgson, McKie & Parker 1986).

3.2.2.3 Botanical surveys of the experimental fields and faecal analysis

Baseline botanical surveys were made in the three fields (SU22, AO35 and RK17) subjected to different management regimes, to determine whether the liming, fertilising and rush-cutting treatments had any short-term effect on the botanical nature of the site. The abundance of the different grass species present in the field was also compared with the proportion identified in the faeces to determine whether the birds are selective in their feeding habits. The relative abundance of individual plant species was estimated between the 19th and 22nd August 1992 (ie just before the treatments were applied), and again one year later in October 1993. Plant species composition and abundance was also estimated at field Sunderland 22 in February-March 1993 to compare the abundance of the different grass species present in winter with the proportion identified in the faeces. One or two permanent quadrats (2m x 2m in size) were positioned at random in the experimental plots, and marked in their south-west corner by white-topped wooden marker posts (Figures 3.2.2.1a,b). In 1993 botanical surveys were made at only a limited number of quadrats, however, since the remaining quadrats could not be re-located due to dense Juncus growth or the loss of marker posts during subsequent agricultural operations. Comparisons of vegetation cover in 1992 and 1993 therefore are made only between corresponding quadrats found in both years.

The cover abundance of all plant species was determined according to a Domin scale (see below). The mean Domin value for each predominant species was determined and converted into a corresponding range of percentage values representing cover abundance for each field. Mid-points of these ranges were then calculated and used for direct comparisons between years and faecal composition. Domin scale values of 1-3 were assigned relative mid-points 2-4 respectively, and mean values <1 were assigned a mid-point of 1, for figures illustrating variation in abundance. Constancy values (ranging from I to V) were compiled using Vespan utilities and communities were related to National Vegetation Classification (NVC) categories.

Domin Scale:

Range		Domin Value
91-100%	recorded as Domin:	10
76-90%		9
51-75%		8
34-50%		7
26-33%		6
11-25%		5
4-10%		4
	with many individuals	3
<4%	with several individuals	2
	with few individuals	1

Goose faeces were collected near the quadrats in the experimental fields (SU22 AO35 and RK17) between 21st January and 31st March 1993, and dried pending further analysis, with a view to assessing whether the birds ingested some grass species in preference to others. A representative sample from each quadrat position was taken and crushed using a cleaned pestle and mortar for each corresponding sample. A proportion of the resulting faecal matter was then diluted using water and mounted evenly for microscopical examination.

Ingested vegetation was identified from the cell structure of the epidermal layers viewed under a microscope (120X magnification). A sample of 50 cells were identified for each slide, selected systematically according to the positioning of the grid of the microscope to avoid any biasing the results. Unidentified plant cell structures, either non-specific or unfamiliar, were drawn and later compared to fresh live specimen drawings. Any 'miss-hits' were discounted as part of the sample size 50, and the next corresponding 'hit' (identifiable cell) was taken. Cell species classification was made by comparison with previously prepared slide-specimens or with live-specimen drawings of the main plant species present in the three experimental fields. Certain plant species were unavailable for direct comparison due to season (e.g. Equisetum fluviatile). Any universal cells (such as mesophyll) that could not be classified, were grouped into the 'other vegetation' category.

3.2.3 Results

3.2.3.1 **The effect of liming and fertilising treatments - field SU22.** Greenland White-fronted Geese were not seen in field SU22 until January, although regular checks were made during October, November and December. Marked variation from day to day in the maximum number of birds counted in the field from January onwards indicates that the birds did not have a fixed pattern for using the site (Fig. 3.2.3.1a). The geese made most intensive use of the field during March (60 to 90 days after 1st January in Fig. 3.2.3.1a), with a mean count of 42.6 geese each day (n=20), compared with mean daily counts of 19.6 geese in February (n=11), 1.4 in January (n=14) and 0.2 in April (n=12). A regression of the number of geese recorded in each plot with the total number of geese present in field SU22 on that day confirmed that there was a positive correlation between the two figures (r^2=0.29, df=876, P<0.001). Residual values were therefore used in subsequent analyses of the distribution of geese within the field to control for variation in the total number of geese present.

Two-way analysis of variance was used to test whether the distribution of geese at field SU22 was influenced by the different management regimes (liming, fertilising etc) or by the measured habitat variables (biomass and sward length). Results initially indicated a positive correlation between total biomass of vegetation and the number of geese counted in the plot (r=0.085, df=876, P=0.06), but after correcting for the total number of geese present in the field the association did not prove statistically significant (r=0.008, n.s.). There was no association between the different treatments and the numbers of geese using the plots (F=0.485, df=3,9, P=0.701, 2-way ANOVA). There was also no association between the numbers of geese in the plot and green ("live") biomass or sward height. There were differences between treatments in the biomass of vegetation present and sward height, but these did not appear to be systematic, and were not associated with goose numbers (Table 3.2.3.1a). The control plots tended to have the highest biomass of live vegetation, whereas the limed and fertilised plot had both the lowest amount of dead vegetation and of total vegetation (Table 3.2.3.1a), but this pattern was not consistent from month to month (Fig. 3.2.3.1b).

The results may be due to subtle or more extensive variation in the quantity and quality within the plots not identified by broad-brush measurements, or to the treatments having only limited effect on the vegetation within a single season. Also the lines of the drainage ditches may have spread lime and fertiliser beyond the treated plots. The mean biomass of green grass recorded each month, and the mean weight of vegetation present each month, at plots subjected to different treatments does indicate that the quantity of vegetation available to the birds was highest in March (Fig. 3.2.3.1b), which was when the birds spent most time feeding in SU22. The mean numbers of geese recorded each month on the limed, fertilised, limed+fertilised and control plots, given in Table 3.2.3.1b, and the percentage of birds seen each month on plots subjected to these different management regimes illustrated in Figure 3.2.3.1c., imply that the birds may use untreated plots in early or mid winter (January) and transfer to more intensively managed pasture later in the season, but sample sizes were small in both January and April so further research is necessary to clarify this point. It did seem, however, that areas of the field treated with lime but not with fertiliser were not selected by the birds.

Although there was no significant association between the number of geese counted and the biomass of vegetation available in each plot throughout the winter, further consideration of the data indicated a positive correlation between goose numbers and grass biomass in March, but not in February (Figure 3.2.3.1d), supporting the view that a more extensive study of the distribution of geese in relation to management techniques and habitat variables would help to confirm the ecological requirements of Greenland White-fronted Geese and the best ways of managing the land for the birds.

3.2.3.2 **The effect of Juncus-cutting and fertilising - Field AO35.**

Greenland White-fronted Geese seen in field AO35 in the months of November to April inclusive and, as for field SU22, variation in the number of birds counted in the field indicated that the birds did not have a fixed pattern for using the site (Fig. 3.2.3.2a). The geese made most intensive use of the field during November (1 to 30 days after 1st November in Fig. 3.2.3.2a), with a mean count of 36.9 geese each day (n=9), compared with mean daily counts of 20.8 geese in December (n=8), 21.2 in January (n=18), 15.2 in February (n=8), 14.2 in March (n=15) and 11.4 in April (n=8). Regression analyses confirmed a positive association between the number of geese recorded in each plot with the total number of geese present in field AO35 on that day, and also a negative association between the number of geese and count date, confirming that fewer birds were recorded later in the season ($F=136.26$, $df=4438,2$, $P<0.001$; Fig. 3.2.3.2a). Residual values were therefore used in subsequent analyses of the distribution of geese within the field to control for variation in the total number of geese present.

Two-way analysis of variance of the residual variation in the count data (ie adjusted for the total number of Greenland White-fronted Geese present, and for the time of year) was used to test whether the distribution of geese at field AO35 was influenced by the <u>Juncus</u> cutting and fertilising treatments, and by the numbers of cattle and Barnacle Geese using the site. Initial results indicated that there was a positive association between the number of Greenland White-fronted Geese in the avenue and the width of that avenue (F=6.17, df=4302,1 P=0.13), but not with a combination of avenue width and the use of fertiliser (F=0.31, df=4302,1, P=0.58). When the numbers of geese recorded in the strip were reconsidered in terms of density, however, thus allowing for the likelihood of wider avenues holding more birds merely because they covered a greater area, there was no evidence to suggest that wider avenues were more attractive to the geese (F=0.004, df=4302,1, P=0.95, Not Significant). There was still a bias in the distribution of birds across the experimental plot, however, with the birds concentrating at the south-eastern end (ie grid numbers <10, C and D, in Fig 3.2.3.2a), possibly because this included a wet area which may have provided better grazing for the geese (Variance ratio=1.29, df=71, P=0.052). Consideration of the percentage of the geese seen each month that were recorded in strips of different widths indicated that the birds may use wider avenues early in the winter and narrower avenues thereafter (Fig. 3.2.3.2b), but the biological reason for this pattern is not clear and further data is necessary to verify the results. The numbers of Greenland White-fronted Geese present in field AO35 was inversely related to the number of cattle present on that day (r=-0.053, n=2299, P<0.05, Pearson correlation) and positively associated with the numbers of Barnacle Geese (r=0.058, n=1935, P<0.05, Pearson correlation). The indication that the presence of cattle deters the geese from using the field may be due either to an increase in disturbance levels as the farmer checks his livestock, or to grazing by cattle reducing the biomass of grass available for the birds. The correlation between the Greenland White-fronted Goose and Barnacle Goose counts suggests that when conditions are suitable for one species at the site then they are also suitable for the other, although the precise factors affecting site selection by the birds remain unclear.

3.2.3.3 **Juncus cutting and fertilising continued - Field RK17.** Greenland White-fronted Geese were recorded in field RK17 on only 17 of the 34 days on which the field was checked during the 1992-93 winter. Moreover, they were seen feeding within the experimental plots on only 5 occasions. There was insufficient data, therefore, for an objective assessment of feeding site selection in relation to management techniques at field RK17, but changes in the botanical nature of the field associated with the different management regimes is considered in section 3.2.3.4 below.

3.2.3.4 **Botanical surveys of experimental fields subjected to different management regimes**

The abundance of different vegetative species before and after treatment for the treated and control plots in fields SU22 and AO35, and also for field RK17 which was neither limed nor fertilised, are given in Tables 3.2.3.4a,b,c. General descriptions of the vegetative composition of the three fields are given below. There was no major change in the abundance of different plant communities or sub-communities attributable to liming or fertilising the pasture (Figs. 3.2.3.4a,b,c; Tables 3.2.3.4a,b), but is thought unlikely that changes in management of the fields would have a major effect on species composition within just one year.

Field SU22 appeared to form an ill-defined mosaic of various community types ranging from open swards to dense Juncus clumps and including other communities associated with drainage channels (the latter was not studied in any detail). The high frequencies and constancy values of Anthoxanthum odoratum and Festuca rubra suggest close affinities to Festuca ovina-Agrostis capillaris-Galium saxitile grassland: Holcus-Trifolium sub-community. The high frequency of typically more mesotrophic species in the sward, such as Trifolium repens and Rumex acetosa probably reflects past grazing management and liming of the soil. However, areas of impeded drainage have led to the development of stands more typical of Rush pasture: the occurrence of Cirsium palustre suggesting some affinities to Juncus sub-community. The high frequency of Carex nigra is atypical of both these communities (K. Peberdy pers. comm.). Holcus lanatus was the predominant species in both the 1992 and 1993 surveys, with Anthoxanthum odoratum proving equally abundant in 1992, and slightly less prolific in 1993 (Table 3.2.3.4a, Fig. 3.2.3.4a). Carex nigra and Festuca rubra were also abundant in both years; the increase in Trifolium repens between 1992 and 1993 may perhaps be due to treatments of the experimental plots in 1992. A number of other grasses including Agrostis species were present in both seasons.

At field AO35 Juncus effusus, was the predominant species, with Holcus lanatus and Agrostis species the most abundant of the grasses (Table 3.2.3.4b, Fig. 3.2.3.4b). The prevalence of Juncus effusus suggests it fits most closely into the NVC category, Juncus effusus/acutiflorus-Galium palustre rush pasture: Juncus effusus sub-community, although the comparatively high frequencies of Anthoxanthum odoratum and Agrostis capillaris are somewhat atypical and reflect tendencies to some kind of Festuca-Agrostis-Galium grassland. Juncus dominance is associated with a somewhat more impeded drainage and a history of less intensive grazing; the drainage channels themselves were not studied (K. Peberdy, pers. comm.). There was no major change in the botanical nature of the field between years.

Experimental field RK17 suggested a co-dominance between Trifolium repens and Agrostis capillaris, followed by equal abundances of Ranunculus repens, Alopecurus geniculatus, Bellis perennis and Lolium perenne (Table 3.2.3.4c, Fig. 3.2.3.4c) This field also represents a complex mosaic of communities, resulting in poor definition of coefficients in the Match analysis. Here, all swards are markedly more mesotrophic, reflecting past fertilisation, both artificial and via stock. This is reflected in areas of impeded drainage, where Juncus communities show affinities more to Holcus lanatus-Juncus effusus rush pasture: typical sub-community, and communities on higher ground which grade into those more typical of Lolium perenne-Cynosurus cristatus pasture, indicating past re-seeding. This is reflected in the higher soil pH and low organic content (K. Peberdy pers. comm.).

3.2.3.5 **Faecal analysis**

The proportion of different grass or vegetative species identified in the faeces collected from different sites is given in Table 3.2.3.5a. Since faecal samples could not always be located in surveyed quadrats, comparisons are made between the 'mean' cover abundance (1992 and 1993) over the whole field (for each experimental field) and 'mean' occurrence of plant species in faecal samples collected over the whole field.

A comparison of the relative abundance of vegetation at field SU22 with the proportion identified in the faeces (Figure 3.2.3.4a), suggests that the geese mainly ingest Anthoxanthum odoratum and Festuca rubra, which are two of the predominant species of grass found in this field. These two species are generally associated with marshy areas, in habitats likely to be used by the geese. The most prevalent grass recorded in the field was Holcus lanatus, but the geese ingested only minimal quantities of this species. This may be attributed to the structure of the plant; although many grasses possess hair-like cells, Holcus lanatus has excessive epidermal hair-cells of a filamentous structure which may be unpalatable to the birds. Other species of anatidae have been found to avoid Holcus lanatus (Rees 1990). Trifolium repens was also abundant in the field but appeared to be selected in only small quantities by the birds. It is possible, however, that the fibrous stolons of Trifolium were ingested by the birds for their high protein content, but these would not be identified under the microscope. Stolons occur below the litter level and form the overwintering part of the plant. Faecal samples were taken during the winter, hence low occurrences of the more recognisable super-litter plant structures such as the leaves of Trifolium repens. Any selection of such material would be through passive-selection (K. Peberdy pers. comm.).

Figure 3.2.3c further suggests that Agrostis sp. were either selected in small quantities or apparently avoided. Agrostis is characterized by its creeping nature, however, and geese may feed mainly on the fibrous stems which would not be identified under the microscope. Moreover, certain vegetative species present in the faeces were not recorded in field SU22. It seems, therefore, that some species (eg Lolium) remain in the digestive system of the bird from previous grazing on surrounding fields, or that the geese fed in areas not covered in the botanical surveys. Field SU22 was surrounded by pastures containing Lolium perenne and other grass species. Carex nigra, which was present in the field, may have been overlooked in the faecal analysis since a sample of this sedge was not collected for comparison. The low proportion of unidentified vegetation recorded in the faeces, however, indicates that the geese do not select Carex nigra.

Botanical surveys of field AO35 demonstrate a predominance of Juncus effusus (average 63%), with Holcus lanatus having a cover abundance of approximately 42%. A selection of other plant species were observed in significant numbers including Agrostis stolonifera and Ranunculus repens (Fig. 3.2.3d). Examination of faecal samples, however, indicate that geese do not ingest Juncus (Figure 3.2.3d) and select small quantities (3.2%) of Holcus lanatus, confirming that unpalatable species such as Juncus rush and the hairy leaves of Holcus lanatus do not form part of the birds' diet. The majority of plant matter in faeces collected from AO35 fell within the "unidentified" category (33.4%), which suggests geese are grazing mainly on the more fibrous roots/stolons.

Anthoxanthum odoratum was the plant species most commonly identified in the faeces collected at AO35 (26.6%, Fig. 3.2.3d), although it did not appear to be particularly abundant in the field. It seems, therefore, either that the geese are grazing on localised areas of specific vegetation not covered by the botanical surveys, or that they are selecting Anthoxanthum odoratum from among other grass swards. Anthoxanthum odoratum is a characteristic species occurring on the edge of hollows (areas avoided during vegetation surveys). Alopecurus geniculatus also appeared to form a major part of the birds' diet (14.6% of vegetation ingested) but appeared to be less abundant in the field, suggesting that the birds may graze selectively for this species. A mosaic of other species, including Poa trivialis and Trifolium repens was identified in the faeces, although not in significant numbers, indicating the possibility of passive selection.

Analysis of droppings collected in field RK17 revealed a high proportion of unidentified plant material (49.1%), suggesting that the birds are mainly ingesting roots and stolons (Fig. 3.2.3e). A co-dominance of Trifolium repens and Agrostis capillaris was found in the botanical surveys. Only a small proportion of Agrostis species were identified in the faeces, however, thus supporting the analysis of vegetation ingested in field SU22, which found that Agrostis was not selected by the birds. Of the known species, Trifolium repens appeared to be the most abundant in the faeces (16.4% of vegetation ingested). The geese also ingested Ranunculus repens and Alopecurus geniculatus in proportions similar to the percentage cover recorded in the field (Fig. 3.2.3e). Both Trifolium repens and Ranunculus repens are stoloniferous species, with high starch levels, which might be attractive to grazing geese. Trifolium repens also has a high protein content, which would further increase its nutrient value to the birds, but Ranunculus species contain alkaloids that may deter geese.

3.2.3 Conclusions

1. There was no evidence to indicate that liming and fertilising the land, or cutting Juncus, in fields subjected to different management treatments, influenced the distribution of geese within these fields.

2. There was also no statistical evidence for an association between the numbers of geese in a plot and habitat variables measured in that plot (including sward height and the biomass of green vegetation), although consideration of the monthly variation in the biomass of vegetation did indicate that the quantity of vegetation available to the birds was highest in March, which coincided with the highest numbers of birds seen feeding in the field. Moreover, there was some

evidence for a positive correlation between goose numbers and grass biomass in March, but not in February.

3. Although there was some evidence to suggest that the liming and fertilising treatments affected the biomass of vegetation present, and also sward height, the relationship was not systematic and was not associated with goose numbers when data for the whole of the winter was included in the analyses.

4. The lack of an association between liming and fertilising treatments and the habitat variables measured in the field may be due to subtle or more extensive variation in the quantity and quality of vegetation within the plots not being identified by broad-brush measurements, or to the treatments having only a limited effect on the vegetation within a single season.

5. Monthly variation in the distribution of birds across the experimental plots suggests that the birds may use untreated plots in mid winter (January) and transfer to more intensively managed pasture later in the season, but sample sizes were small in some months and further research is necessary to clarify this point. It did seem, however, that areas treated with lime but not with fertiliser were not selected by the birds.

7. There was an inverse correlation between the numbers of Greenland White-fronted Geese counted and the number of cattle present in the field on the same day.

8. There was a positive association between the number of Greenland White-fronted Geese and the number of Barnacle Geese present at a site.

9. The birds appeared to feed selectively on different vegetation at different sites, but Anthoxanthum odoratum, Festuca rubra, Alopecurus geniculatus, and Trifolium repens appeared to form a major part of the diet.

10. There was no evidence for a major change in the botanical nature of the pasture attributable to different management techniques, but it was thought unlikely that the treatments would influence the relative abundance of the different types of vegetation in just one year.

11. A more extensive study of the distribution of geese in relation to management techniques and habitat variables would help to confirm the ecological requirements of Greenland White-fronted Geese and the best ways of managing the land for the birds.

Table 3.2.3.1a. Measurements of habitat variables made on treated and untreated plots in field SU22 from January to April inclusive, together with the results of 2-way ANOVAs testing for differences between treatments in the quantity of vegetation recorded.

Treatment	n	Mean Biomass live veg. (gm^{-2})	Mean Biomass dead veg (gm^{-2})	Mean Biom. Herbs (gm^{-2})	Mean Total Biomass (gm^{-2})	Mean Sward (cms)	Max Swd (cm)	Min Swd (cm)
Limed	108	30.69	81.82	3.05	114.90	1.70	3.21	0.71
Fertilised	126	29.70	90.16	4.28	122.33	1.69	2.77	0.87
Lime+Fert.	126	29.39	62.35	3.88	94.97	1.55	2.48	0.69
Control	126	34.54	83.55	4.26	120.56	1.80	3.03	0.78
F		3.92	21.07	0.37	15.48	49.76	44.66	18.51
df		482,3	482,3	484,3	482,3	650,3	650,3	650,3
P		0.009	<0.001	n.s.	<0.001	<0.001	<0.001	<0.01

Note: n.s. = not statistically significant (P>0.05)

Table 3.2.3.1b. Distribution of geese across plots in field SU22.

Note: Mean goose days includes days when no geese present
Mean count includes only days when geese were present

Month	Treatment	No.days Counted	No.days geese present	Total goose days	Mean goose days	Mean count
January	Lime	14	1	0	0	0
	Fertilised	14	1	0	0	0
	Lime+Fert.	14	1	0	0	0
	Control	14	1	20	0.36	20
February	Lime	11	7	44.6	1.01	6.37
	Fertilised	11	7	44.7	1.02	6.39
	Lime+Fert.	11	7	57.3	1.30	8.19
	Control	11	7	72.3	1.64	10.33
March	Lime	20	12	96.8	2.42	8.07
	Fertilised	20	12	196.6	2.46	16.38
	Lime+Fert.	20	12	280.5	3.51	23.38
	Control	20	12	156.9	1.69	13.08
April	Lime	11	1	0	0	0
	Fertilised	11	1	0	0	0
	Lime+Fert.	11	1	2	0.4	2
	Control	11	1	0	0	0

Table 3.2.3.4a Cover abundance of vegetation at permanent quadrats in field SU22 in 1992 and 1993.

Note: * = Fertilised plots
+ = Limed plots
*+ = Limed and fertilised plots
- = Untreated (control) plots

Constancy values indicate the percentage of plots in which each species was located (V=80%, IV=60%, III=40%, II=20%, I=0%), thus indicating the constancy of distribution of the species across the field.

		Cover abundance (domin scale) of main species																		
		D1	C1	B1	A1	D2	C2	B2	A2	D3	C3	B3	A3	D4	C4	B4	A4	Cons-tancy	Mean Domin	Range (%)
Plant species	Yr	-	*+	*	+	*	+	-	*+	*+	-	+	*	+	*	*+	-	Value	Value	
Anthoxanthum odoratum	92	7	5	7	7	8	7	5	7	8	6	7	6	8	8	8	8	V	7	34-50
	93	7	3	8	4	7	5	3	5	7	6	6	5	7	6	6	6	V	6	26-33
Holcus lanatus	92	4	8	6	8	4	8	7	8	8	8	5	5	5	6	7	7	V	7	34-50
	93	6	8	7	8	7	7	6	8	8	8	5	6	5	8	8	7	V	7	34-50
Trifolium repens	92	4	4	3	3	3	8	5	3	4	4	2	2	5	4	5	4	V	5	11-25
	93	6	6	5	6	7	4	7	5	7	5	5	6	7	7	7	6	V	6	26-33
Agrostis stolonifera	92	3	5	3	5	3	6	0	3	3	3	3	3	3	4	3	4	V	3	Many
	93	4	6	6	3	5	6	5	5	4	4	4	6	4	4	5	4	V	5	11-25
Agrostis capillaris	92	5	6	4	5	7	6	6	6	7	5	6	0	5	7	5	7	V	5	11-25
	93	4	6	6	3	5	6	5	4	5	6	6	4	6	7	6	7	V	5	11-25
Carex nigra	92	8	0	8	5	7	6	8	3	4	5	5	8	8	8	7	8	V	6	26-33
	93	8	6	7	5	6	5	8	5	3	6	6	8	8	8	7	7	V	6	26-33
Festuca rubra	92	6	5	5	6	6	4	4	0	5	5	8	8	5	5	7	5	V	5	11-25
	93	5	6	7	6	6	6	4	4	4	6	8	7	5	6	6	5	V	6	26-33
Rumex acetosa	92	0	6	2	2	3	4	3	4	6	4	5	4	3	4	4	3	V	4	4-10
	93	0	5	5	4	0	4	4	5	5	4	4	4	3	4	4	5	V	4	4-10
Cirsium palustre	92	4	6	0	5	4	2	2	4	4	5	0	2	2	2	4	2	V	3	Many
	93	5	4	0	2	4	0	4	4	4	2	5	4	0	2	0	2	IV	3	Many
Poa trivialis	92	3	0	4	0	0	4	0	0	3	0	0	0	0	0	3	2	II	1	Few
	93	0	5	0	0	0	6	0	0	0	0	0	0	0	0	4	0	II	1	Few
Ranunculus repens	92	0	5	0	3	2	4	0	0	0	0	0	0	0	0	0	4	II	1	Few
	93	5	5	0	6	3	6	0	4	5	3	2	0	0	2	2	0	IV	3	Many
Alopecurus geniculatus	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	93	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	I	<1	N/A
Lolium perenne	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.2.3.4b Cover abundance of vegetation at permanent quadrats in field A035 in 1992 and 1993.

Plant species	Yr	A2 *	C2 *	C7 *	D7 -	A11 *	B11 -	C11 *	D11 -	Constancy Values	Mean Domin Value	Range (%)
		Cover abundance (domin scale)										
Holcus lanatus	92	6	7	5	4	5	6	7	5	V	6	26-33
	93	8	8	7	7	6	7	8	7	V	7	34-50
Juncus effusus	92	8	9	9	9	9	8	9	8	V	9	76-90
	93	7	8	7	8	9	7	7	8	V	8	51-75
Ranunculus repens	92	4	4	4	4	5	4	0	5	V	4	4-10
	93	5	4	5	6	5	5	5	4	V	5	11-25
Agrostis stolonifera	92	5	4	4	4	5	4	0	5	V	4	4-10
	93	6	6	5	6	6	6	5	5	V	6	26-33
Agrostis capillaris	92	4	6	5	5	4	5	5	5	V	5	11-25
	93	2	5	6	4	4	4	5	4	V	4	4-10
Anthoxanthum odoratum	92	5	0	5	0	0	5	4	0	IV	2	<4%
	93	2	0	7	4	6	6	6	2	V	4	4-10
Equisetum fluviatile	92	2	0	5	0	0	5	4	0	IV	2	<4%
	93	3	4	3	2	0	4	0	3	V	3	Many
Carex ovalis	92	0	0	0	2	4	4	5	0	II	2	<4%
	93	0	5	4	5	4	6	6	6	V	5	11-25
Poa trivialis	92	3	0	3	0	0	0	0	0	II	1	N/A
	93	3	0	0	2	0	4	0	3	III	2	Several
Trifolium repens	92	4	4	0	0	0	5	4	0	II	1	N/A
	93	0	4	0	0	0	0	0	4	III	2	<4%
Alopecurus geniculatus	92	0	0	0	0	3	0	3	3	I	1	N/A
	93	0	0	0	3	4	3	5	7	IV	3	Many
Lolium perenne	92	0	0	0	0	0	4	0	3	I	1	Few
	93	0	0	0	0	0	0	0	0	0	0	0

Table 3.2.3.4c Cover abundance of vegetation at permanent quadrats in field RK17 in 1992 and 1993.

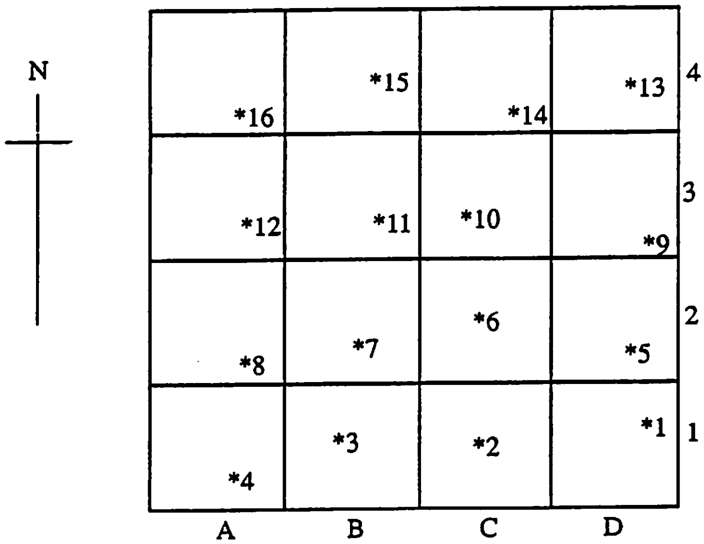
Plant species	Year	Cover abundance (domin scale) B5	D6	A7	A7	B7	A8	B8	D8	C3	C4	Constancy Value	Mean Domin Value	Range (%)
Ranunculus repens	92	4	3	3	5	6	5	5	4	3	4	V	4	4-10
	93	4	5	5	5	6	6	5	5	5	6	V	5	11-25
Trifolium repens	92	9	9	9	7	8	6	3	7	5	8	V	7	34-50
	93	8	7	9	6	6	6	0	6	6	8	V	6	26-33
Agrostis capillaris	92	0	5	5	6	6	6	4	7	4	5	V	5	11-25
	93	5	5	6	4	7	6	7	6	6	5	V	6	26-33
Alopecurus geniculatus	92	8	7	0	6	6	3	5	4	8	7	V	5	11-25
	93	6	7	0	0	5	6	6	5	6	6	V	5	11-25
Bellis perennis	92	4	4	4	3	4	3	0	4	4	5	V	4	4-10
	93	5	5	6	5	3	4	3	4	6	5	V	5	11-25
Lolium perenne	92	7	7	6	3	5	2	0	0	7	7	IV	4	4-10
	93	7	7	8	6	4	0	0	0	8	8	IV	5	11-25
Holcus lanatus	92	4	0	0	6	5	5	6	6	4	0	IV	3	Many
	93	4	0	0	6	5	5	6	6	4	0	IV	3	Many
Agrostis stolonifera	92	3	3	0	4	3	2	4	0	0	3	IV	2	<4%
	93	0	0	0	7	0	0	0	0	0	0	I	1	Few
Poa trivialis	92	0	0	0	2	2	2	0	0	3	0	III	1	Few
	93	0	0	0	0	2	0	0	0	0	0	I	1	Few

Table 3.2.3.5a. Proportion of different plant species recorded in goose faeces collected from different fields in the 1992-93 winter.

Plant Species	AO35	RK17	SU22	SU01	SU08	SU11	SU26
Anthoxanthum odoratum	26.6	1.85	30.2	0	29	34.8	12
Holcus lanatus	3.2	0.33	5	0	0	0	0
Lolium perenne	3.1	2.7	10.2	14	27.4	15.9	6
Trifolium repens	3.9	16.4	4.3	8	1.1	6.9	12
Unidentified sp.	33.4	49.1	6.6	64	24.5	27.5	62
Poa trivialis	4	0.8	6.8	2	2.1	0.95	0
Alopecurus geniculatus	14.6	10.6	3.7	10	4	2	6
Festuca rubra	7.7	3.3	27.7	0	4.1	4	0
Ranunculus repens	0.5	13.9	0.7	2	1	0	2
Agrostis stolonifera	1.1	1	5	0	7	9	0
Equisetum fluviatile (Y)	1.9	0	0	0	0	0	0

Figure 3.2.2.1a. The treatment of plots and location of permanent quadrats in Field SU22.

Quadrat Positions



* = Permanent quadrats

SU22 Field Plan

	A	B	C	D
4	C	LF	F	L
3	F	L	C	LF
2	LF	C	L	F
1	L	F	LF	C

C = Control
F = Fertilised
L = Limed
LF = Limed & Fertised

(No diagrams to scale)

Figure 3.2.2.1b. The treatment of plots and location of permanent quadrats in field AO35.

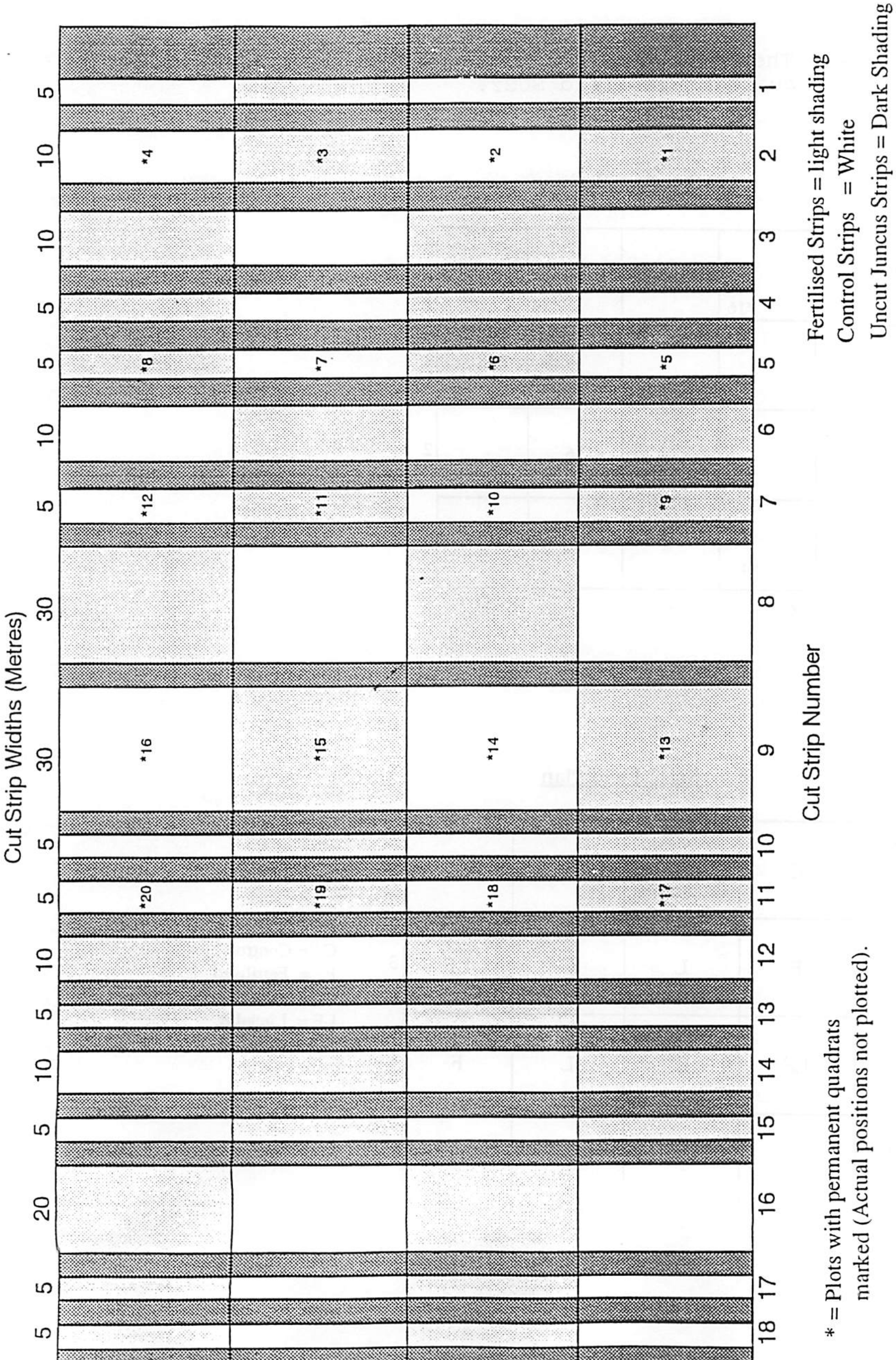


Figure 3.2.3.1a. Maximum counts of Greenland White-fronted Geese on Experimental Field SU22 (January to April inclusive).

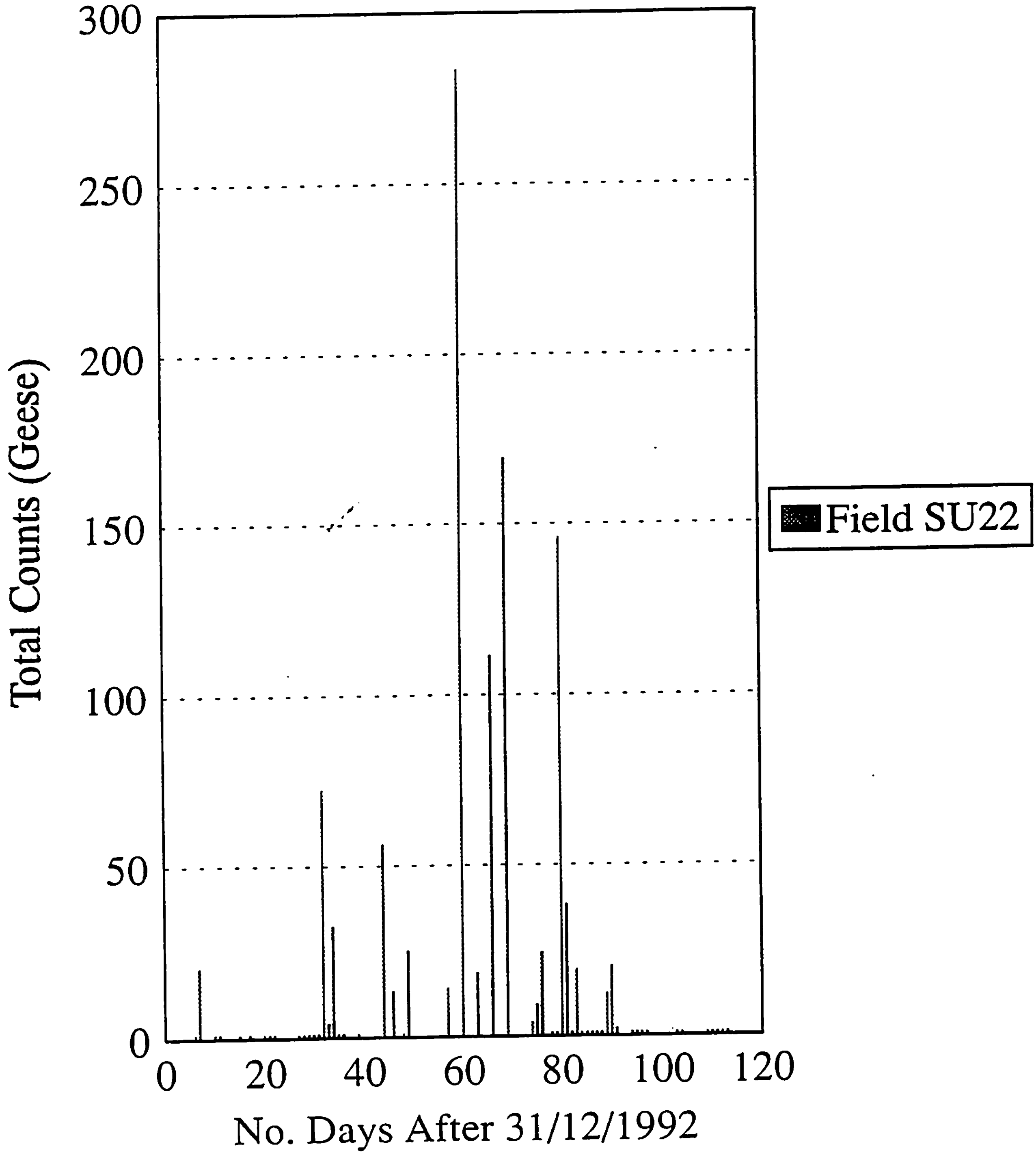
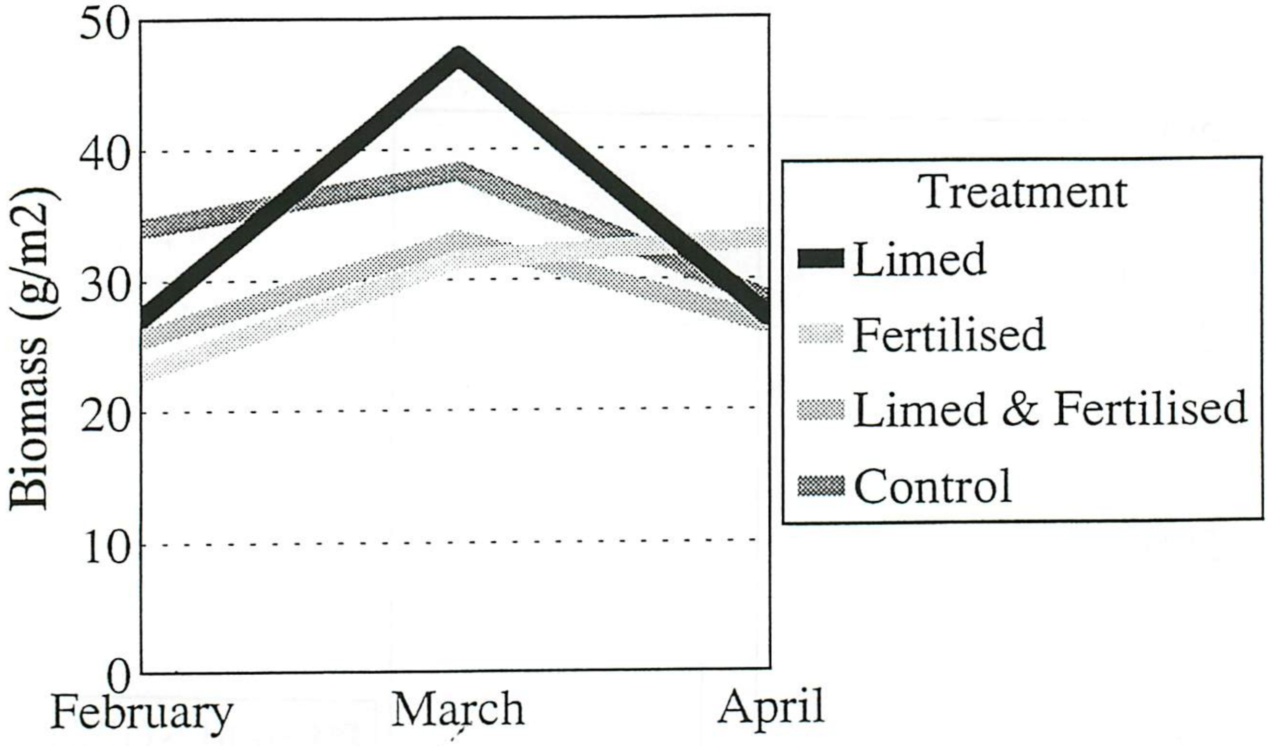
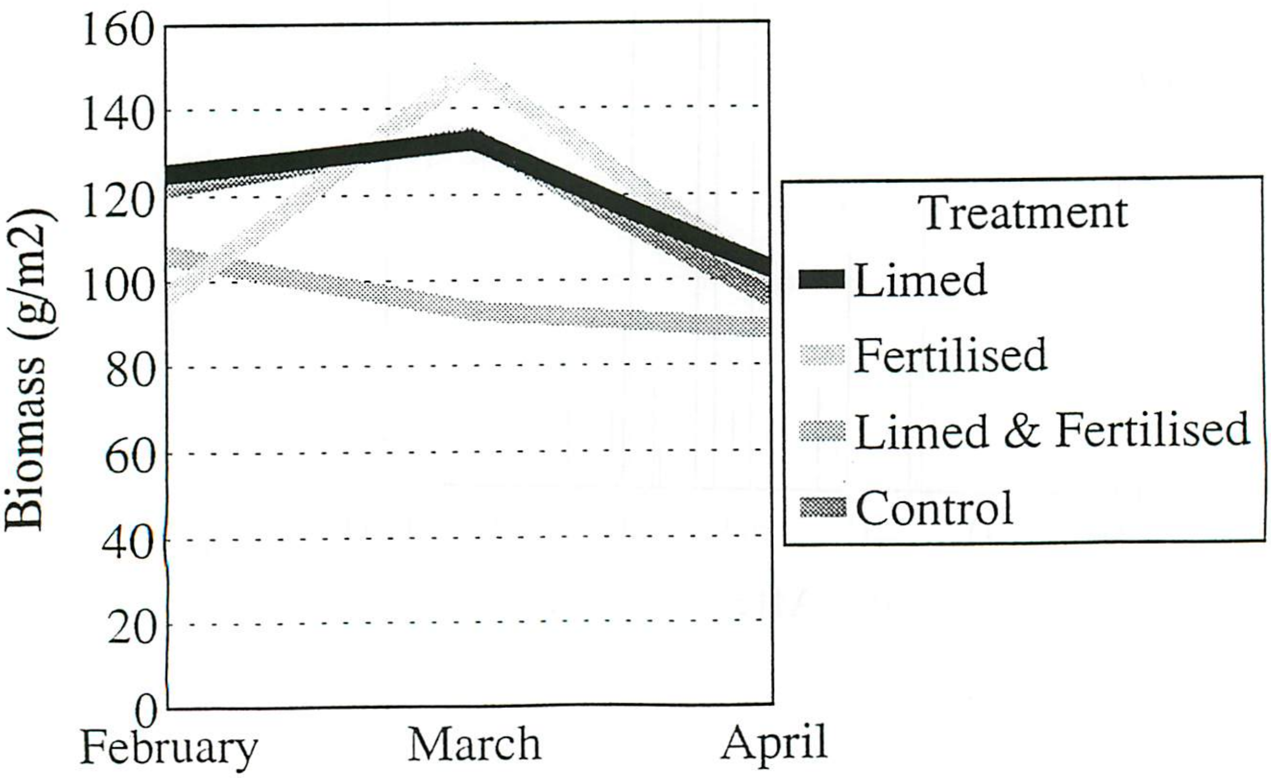


Figure 3.2.3.1b. Effects of the different management regimes on the biomass of vegetation in Field SU22 each month.



(a) Live Biomass



(b) Total Biomass

Figure 3.2.3.1c. Distribution of birds recorded in Field SU22 across plots subjected to different management treatments.

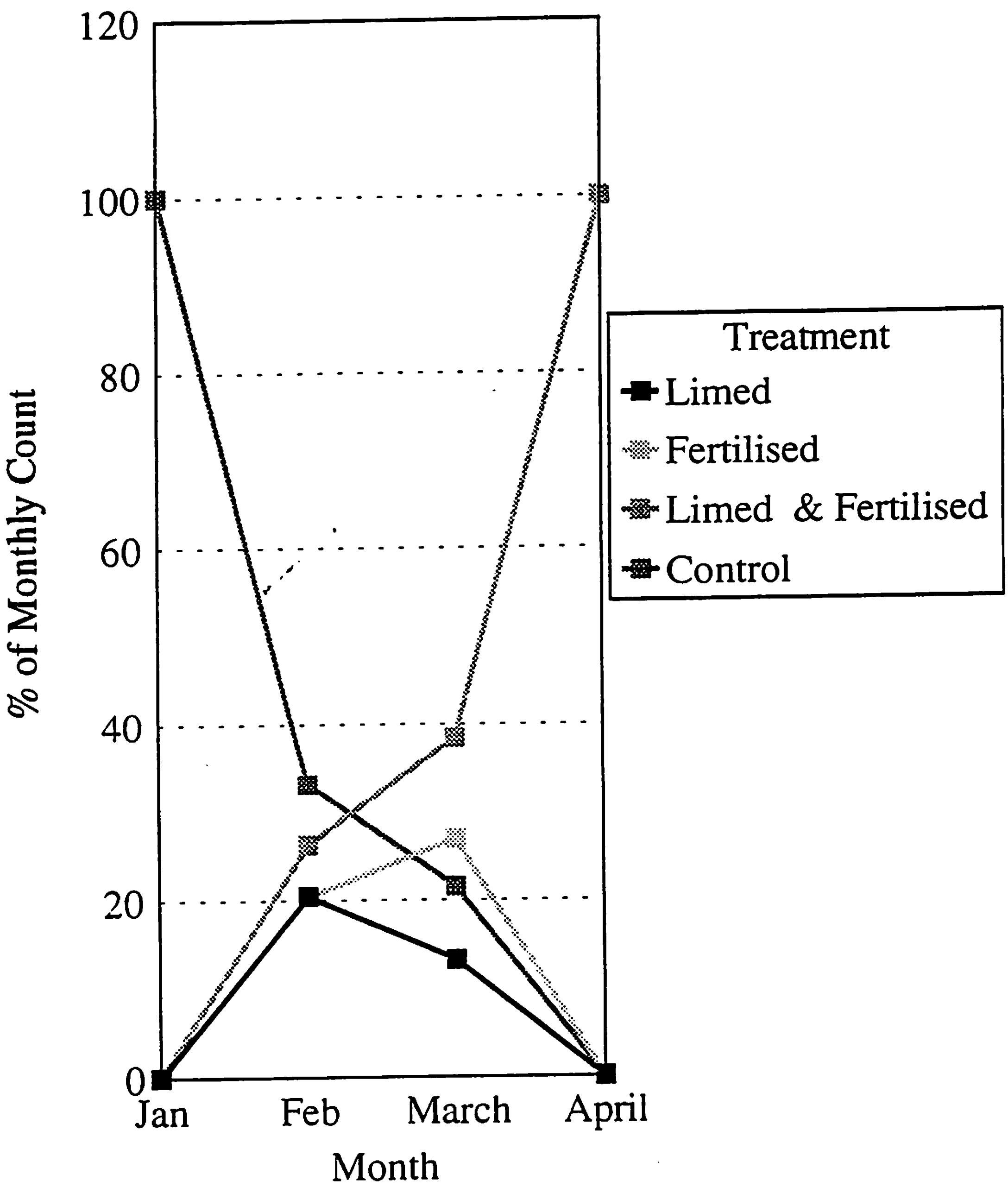
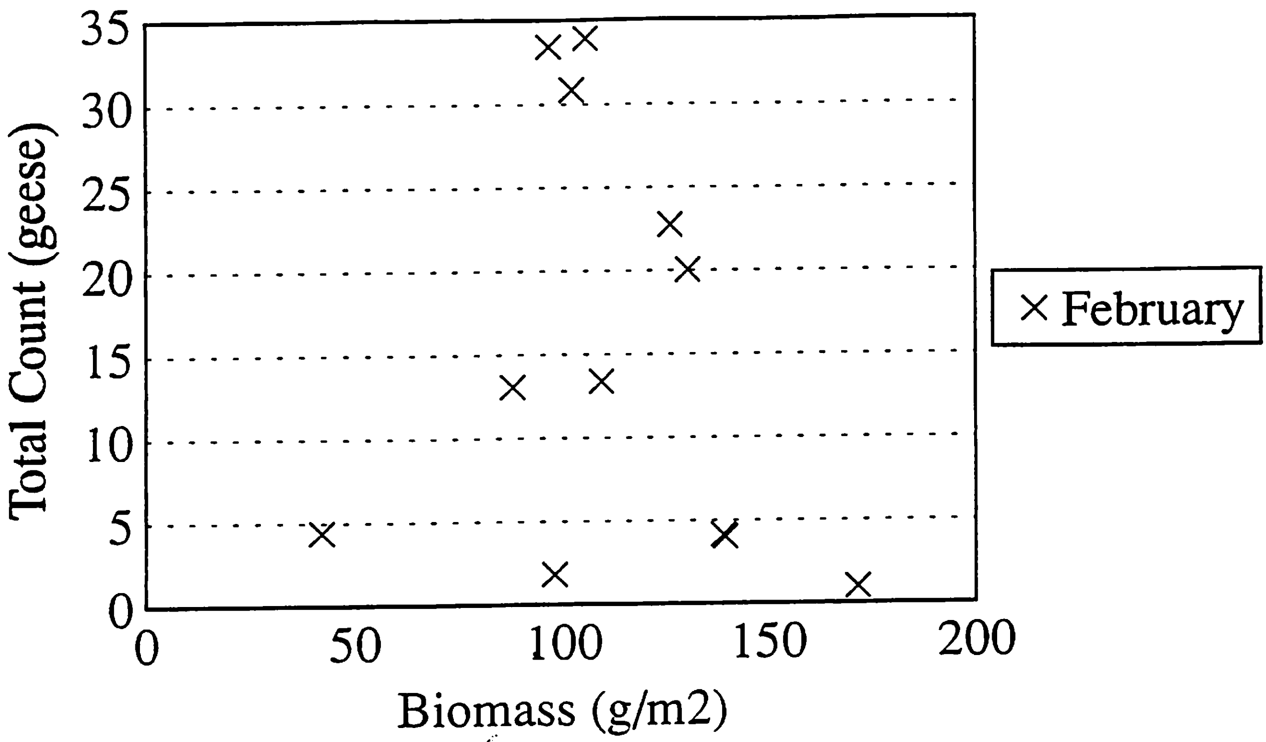


Figure 3.2.3.1d. Number of Greenland White-fronted Geese recorded on different plots in field SU22 in relation to the biomass of vegetation in the experimental plots.



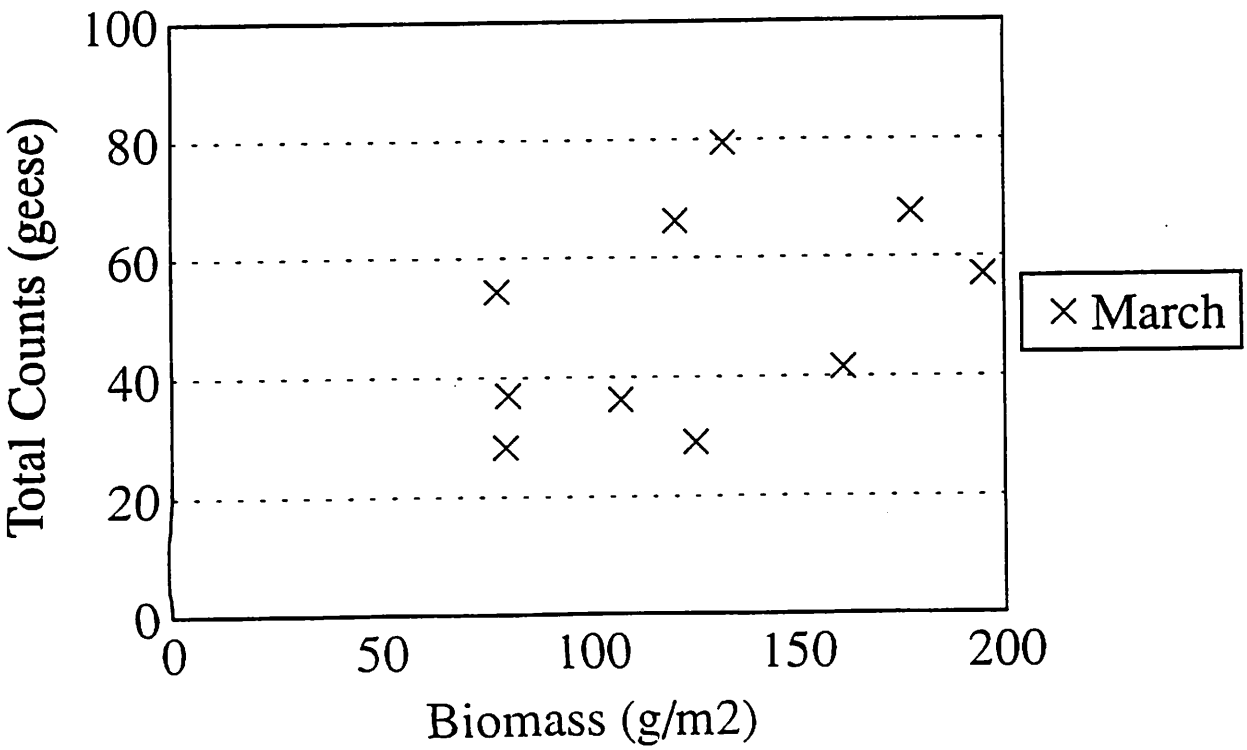


Figure 3.2.3.2a. Maximum counts of Greenland White-fronted Geese on Experimental Field AO35 (November to April inclusive).

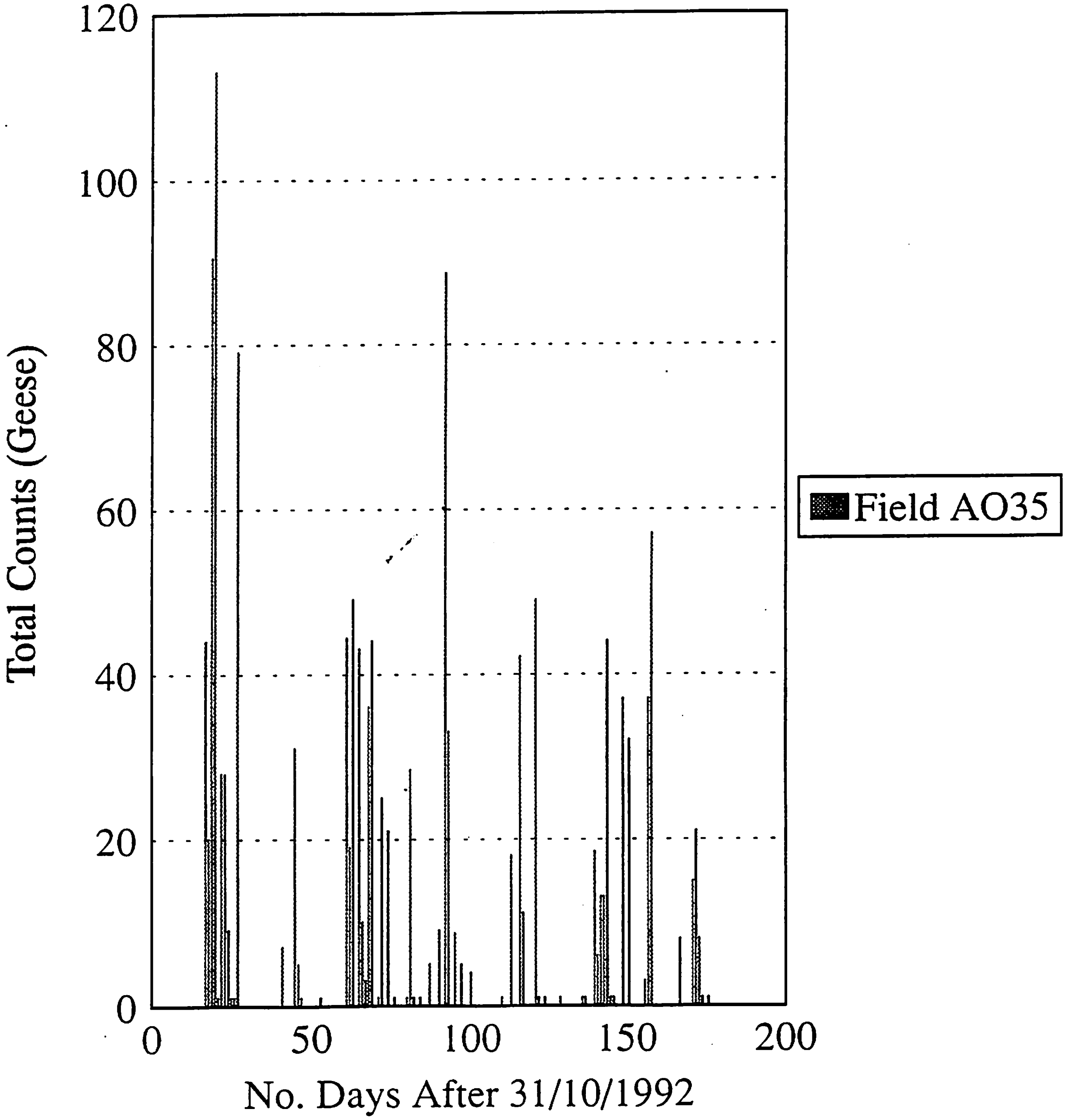
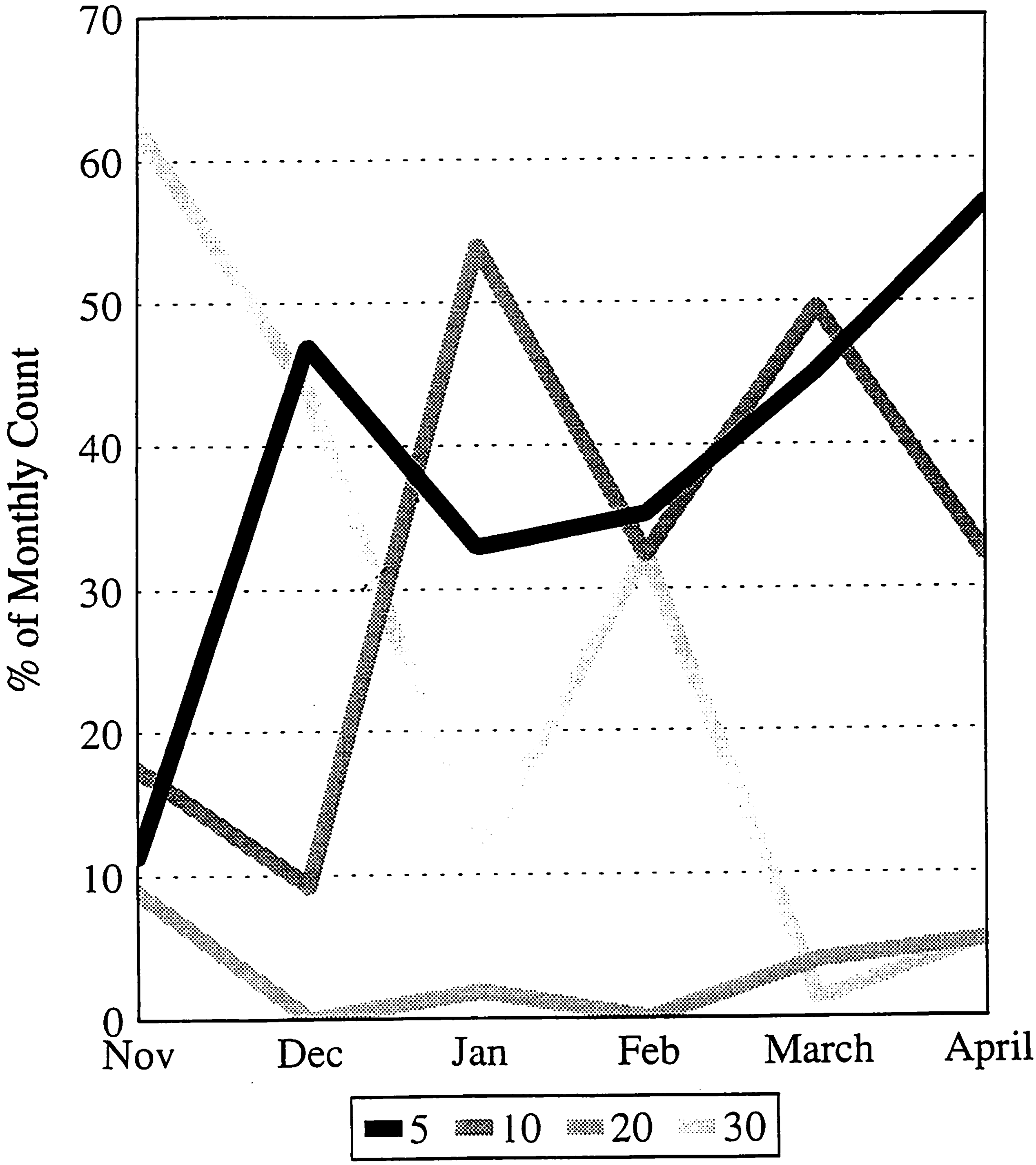
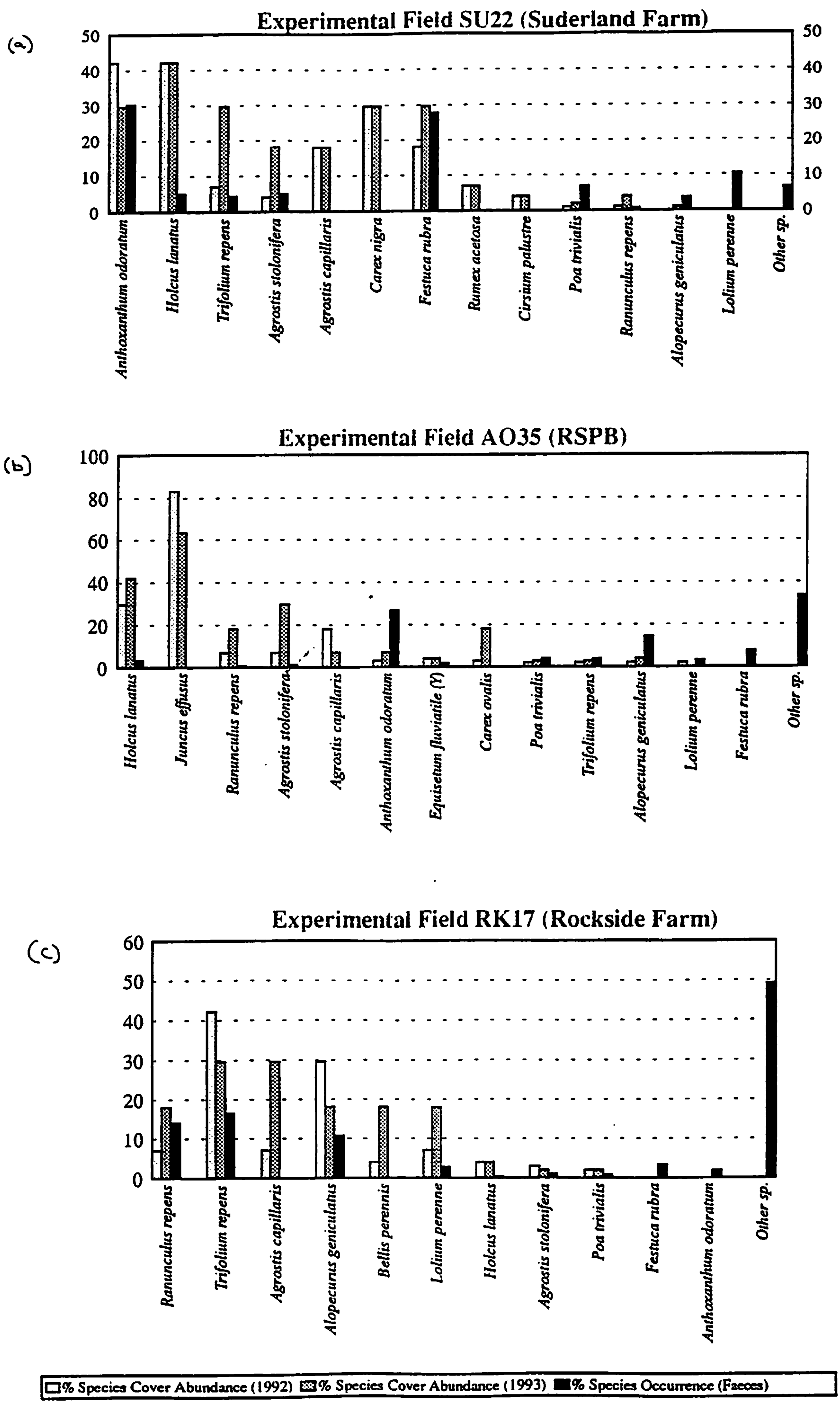


Figure 3.2.3.2b. Distribution of birds recorded in Field A035 in relation to the width of avenues of cut Juncus.



Figures 3.2.3.4a,b,c. Comparison of the abundance of vegetation and faecal composition for the three experimental fields.



3.3 FEEDING ACTIVITY AT DIFFERENT SITES AND DURING THE WINTER SEASON

3.3.1 Introduction

The proportion of birds actively feeding in each field was recorded during the routine counts of geese within the main study area during the 1992-93 winter (see Section 3.1.5). The type of feeding activity was also recorded to determine whether the birds were clipping the surface swards or digging for roots or stolons. Changes in the birds feeding activities during the winter and on different types of pasture were investigated, using the more detailed habitat classifications described in Section 3.1.5.

3.3.2. Results

The percentage of birds recorded as feeding during flock scans in each half month from late October to late April ranged from 51% (in late April) to 77% (in late November, Table 3.3.2a); on average some 65% of the birds seen during the flock scans were recorded as feeding throughout the winter season. Although feeding activity appeared to vary from month to month, there was no obvious increase or decline in the numbers of geese feeding during the course of the winter ($r=0.06$, $p>0.1$, Pearson Correlation). More detailed studies of the energetics of the species would be necessary to determine whether the low percentage of birds seen feeding in late April was due to the geese having accumulated sufficient nutrient reserves for spring migration by this late stage of the season. Excessive feeding might then then result in the birds carrying unnecessary weight during the migratory flight. The type of feeding activity changed during the winter; the proportion of birds seen pecking at swards increased, and the proportion seen tugging at roots or the base of the stem decreased as the winter progressed ($r=0.33$, $P<0.01$ for % pecking and $r=-0.34$, $P<0.01$ for % tugging, Pearson Correlations; Table 3.3.2b). This may indicate a tendency for the geese to select root systems with a high carbohydrate content in mid winter, and shooting vegetation with comparatively high protein levels in spring.

Several factors thought likely to influence feeding behaviour, such as sward length and flock size, varied with the time of year. A general linear model (GLM) therefore was used to separate the effects of the different variables. The results confirmed that the percentage of birds feeding varied between half months, which may perhaps be due to variation in weather conditions or to the timing of the observations since there was no obvious pattern to changes in feeding activity during the winter (Tables 3.3.2a,c). Sward length and flock size were also associated with feeding activity; a higher proportion of the geese were seen feeding when in larger flocks and on shorter swards (Table 3.3.2c). There was a tendency for more birds to be feeding in areas with medium to high _Juncus_ cover, but the results did not reach statistical significance. The broad habitat codes and green-ness of the sward did not appear to influence feeding activity

(Table 3.3.2c). Further consideration of whether the birds fed by pecking or tugging on different types of pasture indicated that they were more likely to dig for roots in fields abundant in Juncus, but that sward length, green-ness of that sward and flock size did not influence their feeding behaviour on pasture land (Table 3.3.2d).

3.3.3 Conclusions

1. Although the percentage of birds recorded as feeding varied from month to month, there was no obvious pattern to changes in total feeding activity during the winter.

2. The percentage of birds that fed by tugging for roots or stolons was higher in mid winter, and the percentage that fed by pecking at swards was higher in the spring. This may perhaps reflect a change in the nutrient requirements of the geese from a high carbohydrate diet in mid winter to higher protein levels prior to spring migration.

3. A higher proportion of geese seen in large flocks were recorded as feeding in comparison with geese feeding in smaller flocks. More detailed behavioural studies would be necessary to confirm whether this is due to birds in small flocks spending more time in being vigilant in order to minimise the chances of being predated.

4. A higher proportion of geese were also seen feeding when in fields with shorter swards, presumably because it takes the birds longer to ingest sufficient food to meet their energy needs when the biomass of vegetation is low.

5. There was comparatively little evidence to suggest that the tendency for the birds to feed by pecking or by tugging was influenced by habitat variables.

Table 3.3.2a Percentage of geese reorded as feeding in each half month during the 1992-93 winter. 1=first half of the month, 2=second half of the month.

Date	Oct 2	Nov 1	Nov 2	Dec 1	Dec 2	Jan 1	Jan 2	Feb 1	Feb 2	Mar 1	Mar 2	Apr 1	Apr 2
n	9	19	41	17	15	28	22	54	51	70	59	75	44
Mean % feed	67%	59%	77%	61%	64%	67%	73%	51%	73%	66%	65%	70%	51%
SD	32	42	31	37	29	31	30	34	26	29	35	24	31

Table 3.3.2b Mean percentage of geese recorded as pecking or tugging when during flock scans in each half month during the 1992-93 winter. 1=first half of the month, 2=second half of the month.

Date	Oct 2	Nov 1	Nov 2	Dec 1	Dec 2	Jan 1	Jan 2	Feb 1	Feb 2	Mar 1	Mar 2	Apr 1	Apr 2	TOT
No. scans (n)	0	0	0	1	1	1	15	36	45	44	33	34	22	232
% peck	-	-	-	100%	0%	0%	54%	79%	100%	96%	98%	94%	95%	91%
SD	-	-	-	0	0	-	47	33	0	18	9	16	21	26
% tug	-	-	-	0%	0%	100%	46%	19%	0%	0%	3%	0%	5%	7%
SD	-	-	-	-	-	-	47	32	0	0	17	0	21	24

Table 3.3.2c. Results of GLM analysis to determine variables influencing the percentage of geese in the flock that were known to be feeding.

Variable	F	df	Significance level	
Half month	2.31	12	<0.01	***
Habitat type	1.67	2	0.19	ns
Juncus abundance	3.71	1	0.06	x
Green-ness of sward	0.08	1	0.77	ns
Sward length	4.11	1	0.04	*
Flock size	5.22	1	0.02	*

Note: Probability levels *** = < 0.01
* = <0.05
x = <0.10
ns = not statistically significant

Table 3.3.2d. Results of GLM analysis to determine variables influencing the percentage of geese known to be feeding that were (i) pecking or (ii) tugging at the vegetation.

	(i) Pecking			(ii) Tugging		
Variable	F	df	P	F	df	P
Half month	7.11	6	<0.001	12.16	6	<0.001
Habitat type	0.04	1	ns	0.06	1	ns
Juncus abundance	6.77	1	<0.01	3.23	1	0.07
Green-ness of sward	1.19	1	ns	2.70	1	ns
Sward length	0.12	1	ns	1.50	1	ns
Flock size	0.69	1	ns	0.60	1	ns