AN ASSESSMENT OF THE ECONOMIC IMPACT OF CANADA GOOSE GRAZING ON GRASMERE STATION USING A FARM MANAGEMENT MODELLING TECHNIQUE

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ABSTRACT

Estimates are made of the quantities of various pasture and crop types consumed by Canada geese (Branta canadensis maxima) at Grasmere Station over two years. The costs incurred by the farmer as a result of such feeding are then calculated on the basis of displaced stock units using a computer-based farm management modelling technique.

INTRODUCTION

This paper follows two recent Centre for Resource Management papers on Canada geese (Branta canadensis maxima Delacour, 1951) in New Zealand by White (1986) and Leathers and Costello (1986). The latter study was mainly concerned with estimating costs incurred by 21 runholders in the South Island high country as a result of goose grazing. Because of the scope of the task and study deadlines, the authors were forced to base their assessments on approximate food consumption data derived mainly from information on goose numbers supplied by the farmers. The various cost calculations were therefore deemed by the authors to be of preliminary value only. Runholdings were not identified in the report.

The main value of the Leathers and Costello paper was in the method, and in particular the application of a farm management modelling technique to evaluate goose consumption data. Essentially a feed budget modelling approach enabled the authors to interpret goose consumption data in terms of displaced stock units.

The present study is an extension of this approach, focusing on a single farm - Grasmere Station - where specific effort was made to quantify the extent and type of feeding carried out by geese over two years.

Assessing costs associated with birds feeding on pastoral farmland, has long been recognised as one of the most difficult areas of research within the field of avian economic ecology. Many potential studies falter at the initial stage of obtaining good information on food consumption. (Ebbinge et al. (1975) stated that the investigation of food intake by unrestrained animals in the field is one of the blind spots of ecology.) Having obtained the basic consumption information, the challenge is to interpret it within the context of a dynamic farming economy - bearing in mind that a quantity of food consumed by birds at any one time does not necessarily imply competition with livestock for a limited resource. It is in this latter interpretive phase that quite sophisticated methods of farm management modelling analyses are called for.

STUDY AREA

This study refers to feeding by Canada geese on the developed part of a single sub-leasehold contained mainly within the boundaries of Grasmere Station. The sub-lease is outlined and shown in Figure 1.

The developed section of the largely tussock covered sub-lease is shown in relation to Lake Grasmere (63 ha) in Figure 2. The unshaded paddocks are those contained within the sub-lease under study.

Pasture (grass/clover) dominated the developed area, although some turnips, oats and barley were grown during the study period. Descriptions of the various paddocks, made by MAF inspection in March 1984, are given in Appendix 2.

Lake Grasmere - a wildlife refuge - serves as a roost for Canada geese. The geese feed both within the lake (on aquatic macrophytes) and on the adjoining developed farmland.

METHODS

The methods fell into two main categories: (1) field observations of geese and estimations of their food consumption and; (2) analysis of these data in terms of stock displacement and hence costs incurred by the farmer.

1. Estimation of food consumed by geese on farmland

Estimates of food consumption were based on data obtained both directly and from secondary sources. Direct information was obtained on time spent feeding. Secondary information was used to estimate actual food consumed.

Time spent and location of feeding

Daytime (hour to hour) feeding activity counts were done over three to five days per month from April 1984 to March 1986. One of the aims was to determine the mean number of birds feeding within the roosting lake (Lake Grasmere) and on various paddocks each day.

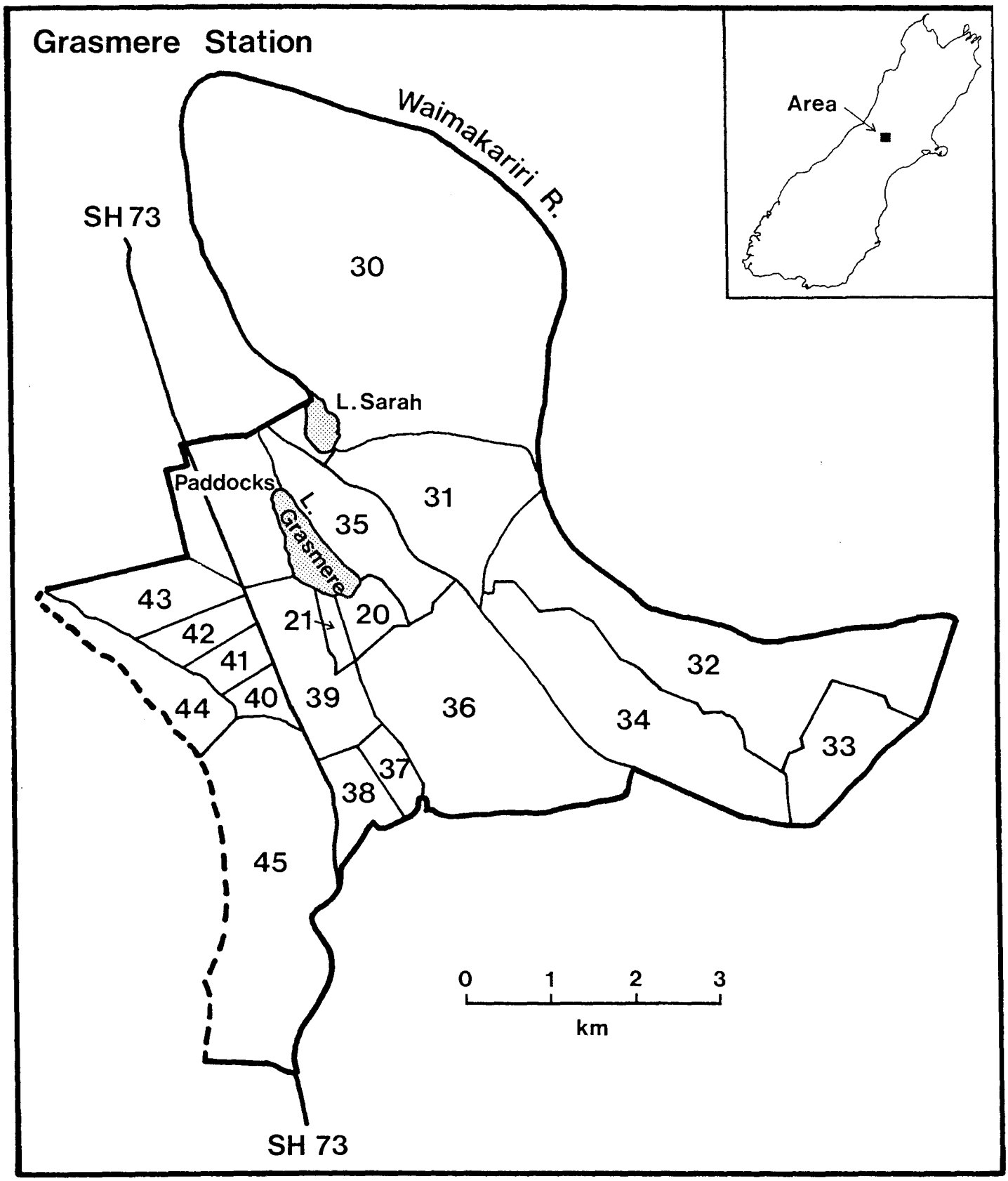

Figure 1. Grasmere Station.

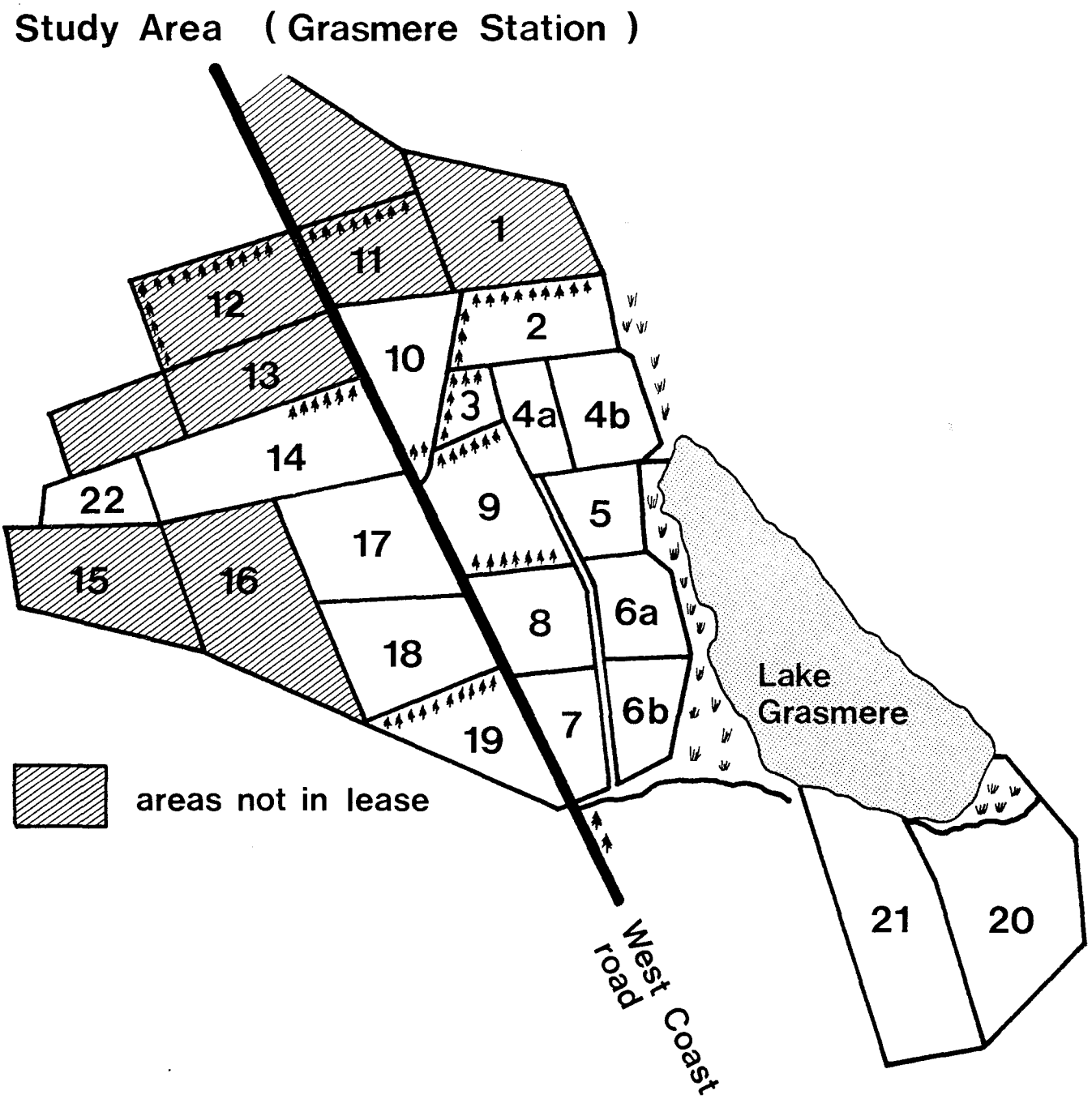

Figure 2. Study area Grasmere Station.

The feeding ecology of the geese was studied intensively by K.J. Potts between April 1984 and March 1986 (report in prep.). This work, from which the feeding data analysed in the present report are derived, showed that almost all of the terrestrial feeding undertaken by the birds roosting on Lake Grasmere occurred on the adjacent developed area. Only once in several hundred systematic observations were significant numbers of geese seen to feed on tussockland in the near-vicinity. Approximately 75% of the feeding recorded on the farmland occurred on lakeside pasture paddocks 5 and 6. No feeding was recorded on the shaded paddocks shown in Figure 2.

Numbers of geese at Grasmere Station were lowest in the late spring-late summer period, coinciding with breeding and brood rearing in the hills and river flats outside of the general vicinity.

Estimates of intake

An estimate of the amount of food actually consumed was calculated using daily intake information derived from secondary sources.

No estimates of daily intake are known for Branta canadensis maxima in the wild, but a best average estimate for New Zealand conditions and foods is 0.3-0.4 kg DM per bird per day (White, 1986). The estimate is six to eight percent of body liveweight and is based on studies of intake, egestion and energy balance for wild geese of various weights.

For the purposes of calculation 0.35 kg DM per bird per day was assumed.

Estimates of food quantities consumed in particular paddocks over the course of each month were calculated in the following manner.

(i) The mean number of birds feeding over the course of an average day (dawn to dusk) in the three to five day counting period per month was determined from direct observation.

(ii) This figure was then multiplied by the number of days in the month and expressed as 'goose feeding days' per month.

(iii) Monthly consumption estimates were determined by multiplying goose feeding days per month by 0.35 kg DM.

Margins for error and sensitivity testing

Whilst no quantitative data were available on the extent and pattern of night feeding, the possibility of considerable night feeding was not overlooked in the quest for reasonable 24-hour consumption estimates. The method of calculation outlined assumes that the number of birds feeding on particular paddocks during the day reflected the feeding pattern over 24 hours.

The method of calculation outlined is likely to overestimate rather than underestimate 24-hour consumption i.e. of all foods combined. Underestimation could only occur if the level of night consumption exceeded that of the day, which is unlikely.[1] Once stock displacement figures are calculated, the results are subjected to sensitivity testing i.e. projections are made to establish the level of stock displacement which could be expected if goose consumption was halved, doubled or otherwise changed.

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[1]Feeding on farmland has been shown to be mainly a daytime activity for geese in North America and Europe (see e.g. Owen, 1980). Only on moonlit nights does significant feeding appear to occur in these places. This may be related to some degree to the presence of foxes and other large ground predators, and the consequent unwillingness of the birds to venture onto land when vision is poor. Because predators may not pose the same problem in New Zealand, feeding may occur at night to a somewhat greater degree. In fact, at Grasmere the indications are that it is quite significant. However, it is unlikely to occur more than in the daytime, unless heavy hunting disturbance occurs in the latter period. Overall daytime feeding figures obtained at Grasmere indicate that geese fed on average about 60-70% of the time. This appears to be only slightly less than average figures reported for geese feeding in North America and Europe where daytime feeding is the norm. If it turned out that geese at Grasmere fed 60-70% of their time over the entire 24-hour period it would be surprising - particularly given the fact that food quality is high and long energy-sapping flights to obtain it were unnecessary.

In conclusion, the consumption data as calculated are considered to provide a reasonable basis for assessing the economic impact of goose grazing at Grasmere Station. The assessment is based on an average of the two years consumption data (see later) and therefore is the area of cost likely to be incurred by the farmer at current goose population levels.

2. Analysis of food consumed by geese in terms of stock displacement

All Grasmere Station forage and livestock data collected in preparation for input into the feed budget model are presented in Appendices 2-5. These data include:

Pasture/fodder resources of Grasmere Station for season 1985/86
Livestock numbers by class
Grazing management chart for Grasmere Station during 1985/86
Monthly, total and proportional livestock loading for each pasture of Grasmere Station.

The analysis is based on an average of the two years of goose consumption data given in Tables 1 and 2. The modelling approach used to analyse the data is described in detail by Leathers and Costello (1986) and summarised below.

Feed budgeting model

A computer-based feed budgeting model developed by P.S. Harris, and used in more basic form by Whitby (1979), was the main tool used to calculate sheep numbers displaced by geese. Given a particular feed resource, the model derives the carrying capacity of the run. The model, described by example in Appendix 1, is essentially a supply and demand accounting system which has as its primary output the determination of maximum sustainable carrying capacity. The main demand inputs are the classes of livestock which are carried throughout the year, along with their daily metabolisable energy requirements, taking into account desirable growth rates, culling rates, lambing percentages, lambing dates, weaning dates, prescribed liveweights and environmental factors.

Food supply inputs are seasonal patterns of pasture and crop production, herbage quality and estimates of the efficiency of utilisation of the pastures and crops. The latter accounts for the significant differences between the amount of herbage actually grown and that actually consumed by the livestock.

Using a computer programme these feed demand and supply schedules are reconciled to produce the potential stock carrying capacity of a given run or grazing management unit. The results for particular runs may indicate that they are over or understocked. The procedure is described in Appendix 1.

To establish how many extra livestock could be carried in the absence of geese, the model is re-run including monthly DM weights of different foods consumed by the geese.

Costs associated with stock displacement due to goose grazing are determined on the basis of gross margin data.

Methods of collecting and adjusting farm-related model data

Personal interviews were arranged with the runholder to obtain information on the extent and pattern of stock grazing in the year 1 July 1985 to 30 June 1986 as well as descriptions of all paddocks and blocks on the station.[1]

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[1]Whilst the data on stock grazing were not collected in the exact time period as the goose consumption data (various practical considerations precluded this), they nonetheless represent the pattern of annual stock grazing during the period of data collection. For this reason it was considered unlikely that the slight difference would introduce a significant source of error in the overall analysis.

The runholder's descriptions of each paddock or block were supplemented by notes supplied by the Wildlife Service and the M.A.F. As a base for the interview a topographic map in the NZMS1 series and a large scale Wildlife Service map of the paddocks were used. Areas of the blocks and the paddocks were calculated from these base maps. Grazing in some blocks had to be assumed as the interview material was incomplete. Extra sheep had to be added to the model to account for the fact that up to two thirds of the hay produced in the area was sold. The few cattle on Grasmere Station (18) were omitted because their movements were inconsistent and did not contribute any information to the model.

An annual pasture growth curve was calculated. Pasture utilisation and quality figures were assigned for each paddock. The pasture utilisation figure is that part of the herbage which would be harvested by the animal. It is dependent on the number of animals per hectare and the pasture quality - the latter characteristic being defined in terms of metabolisable energy content of pasture DM. The model and initial pasture production/ quality estimates were tested after the hay sold was deducted from the total hay resource.

The resulting carrying capacity was encouragingly within five percent of the actual stocking level. This five percent deviation was reduced by adjusting the percentage of herbage utilisation on the paddocks and blocks. As a final step the hay sold was added to the crop resource and the model was run again. The final result was a carrying capacity above the stocking level maintained by the farmer. The adjusted stocking level assumes that all the hay was consumed on the property.

The food consumed by the geese was then added to the feed available in each paddock according to the month and the model re-run. The resulting increase in carrying capacity was attributed to the removal of available DM by goose grazing. The model was run twice more with the existing geese consuming different daily DM intakes to test the effect on Grasmere Station stock numbers.

Turnips were grazed once in the seedling stage in November. A simple

experiment was conducted to calculate the ratio of seedling weight to mature turnip weight. A conservative ratio of 1:500 was established. The model was run again, this time with the goose grazing effects on the turnips removed.

RESULTS

1. Goose feeding and food consumption estimates

Population change and the broad pattern of feeding in Lake Grasmere and on adjacent farmland

Figure 3 shows the seasonal pattern of population change at Lake Grasmere and the relative extent of feeding recorded in the lake and on the land. Monthly histograms in Figure 3(a) show the mean number of geese recorded per day (over three to five days per month) in dawn to dusk feeding activity counts. Figure 3(b) indicates the relative extent of feeding on lake and land as percentages. The 95% confidence limits in relation to percentage feeding on the land (vertical bars) assume that the results obtained over the days counted were typical for the month.

Estimates of monthly pasture and crop consumption

Table 1 gives estimates of pasture and crop consumption by geese based on counts of feeding activity obtained over three to five days per month. The consumption estimates given in part (c) of Table 1 only summarise the nature of the food types consumed. The various paddocks used were recorded. Hence under 'pasture', for example,. information was collected on species composition, quality and growth stage. This was taken into account in the subsequent economic analysis.

Cuticle analysis of droppings collected from various pastures indicated that the geese consumed the clover and grass components roughly in proportion to availability in the sward (Potts, in prep).

Pasture accounted for 92 percent of overall consumption, grain stubble seven percent, and oversown and topdressed forage (OSTD) and turnips less than one percent each.

Table 1. Goose usage and food consumption estimates for Grasmere Station April 1984 - March 1986.

	1984 A	M	J	J	A	S	O	N	D	1985 J	F	M	A	M	J	J	A	S	O	N	1986 D	1986 J	F	M
(a) Mean number of geese feeding on farm per day over 3-5 days per month ± 95% confidence interval	14.3 ±49.2	29.0 ±47.8	12.3 ±31.8	4.5 ±14.4	66.5 ±79.3	25.2 ±18.6	4.4 ±5.7	10.2 ±11.0	11.0 ±12.8	3.9 ±8.9	60.2 ±23.0	287.7 ±347.7	8.2 ±13.7	19.5 ±35.5	0 ± 0	27.2 ±41.4	8.8 ±9.6	137.0 ±41.4	8.5 ±16.8	29.9 ±15.8	7.0 ±5.2	9.3 ±17.1	55.2 ±35.9	155.2 ±45.7
(b) Estimated goose feeding days per month (mean(a) x days in month	464	899	369	140	2062	756	136	306	341	121	1684	8733	246	605	0	843	273	411	264	897	217	288	1546	4811
(c) Estimated consumption per month assuming intake of 0.35 kg dry matter per bird per day (White 1986) (b) x 0.35 kg	Pasture 156	241	129	49	722	265	48	101	119	42	589	2448	21	212	0	295	96	144	92	314	76	101	541	1684
	Stubble* 6	3										608	65											
	Turnips							6																
	OSTD +	71																						

*Stubble is waste therefore not input into the model

+Oversown and topdressed

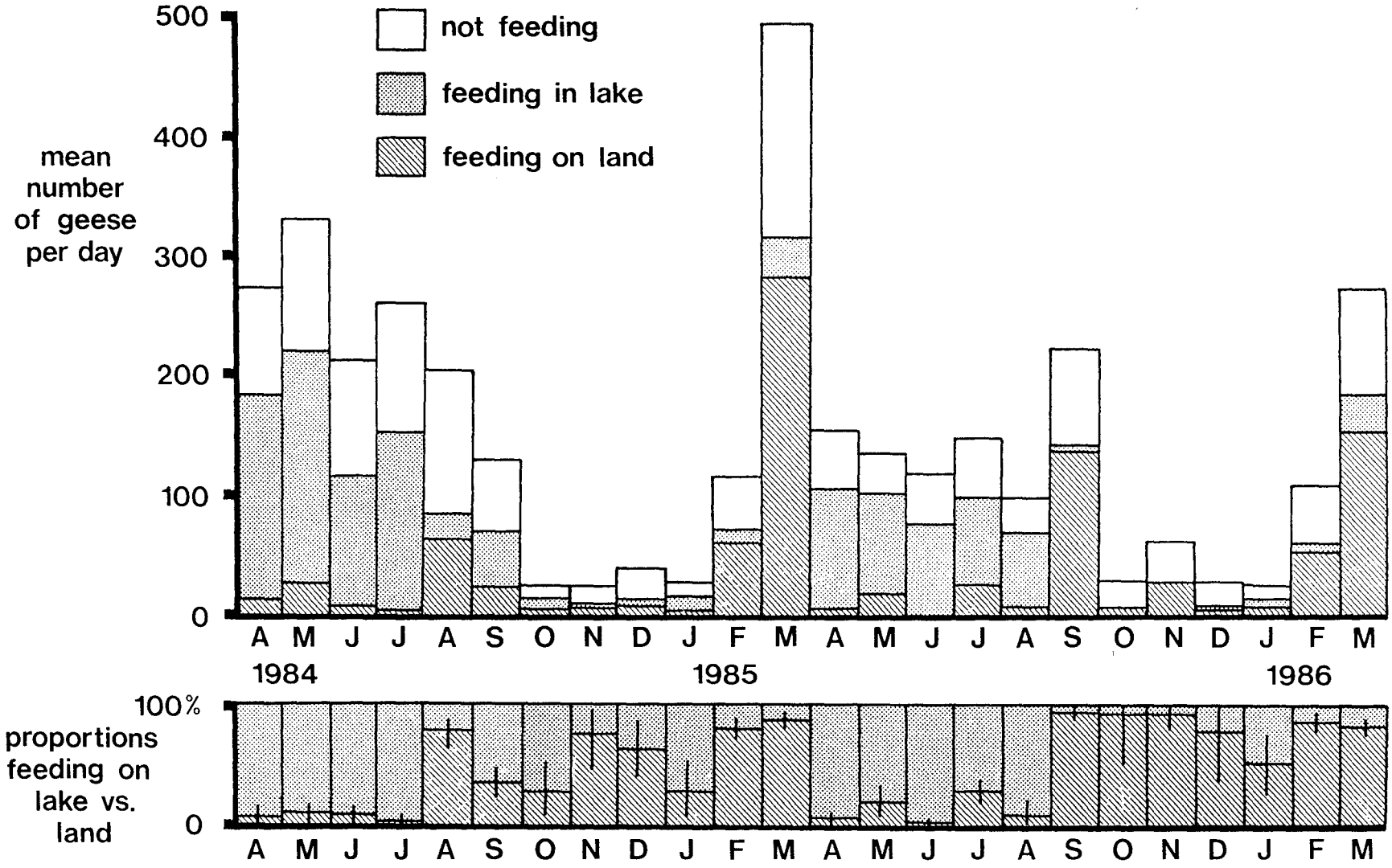

Figure 3. Seasonal pattern of population change at Lake Grasmere and relative extent of feeding in the lake and on the land.

Table 2 summarises goose consumption per month based on an average of the 1984/85 and 1985/86 data. The level of consumption is expressed in terms of DM per unit area of the various paddocks exploited. Estimates are given for the efficiency with which geese would be expected to utilise the relevant herbage. These figures denote the difference between the amount of herbage actually grown and that actually consumed by the geese.

Table 2. Goose consumption per month (kg DM/ha).

Paddock number	Herbage utilisation	J	A	S	O	N	D	J	F	M	A	M	J
2	0.75								12	17	1		
4a	0.60									31		12	1
5	0.75	3	44	16					30	123			6
6a	0.60	21	2	10	10	29	7	7	12	73	11	3	
7	0.80								8				
20	0.55						3	1				1	
21[1]	0.92				108								
43[2]	0.50										1		

[1] Turnips

[2] O.S.T.D.

Table 3. Summary of feed supply per paddock/block (kg DM/ha), average quality and percentage utilisation.

Past/Crop	kg/ha	AvQual	ha	Util
PAST 2	3849	9.5	16	75.0
*HAY 2	7347	8.5	16	60.0
PAST 4a	3705	9.6	12	60.0
*HAY 4a	1478	7.5	12	60.0
*BARLEY 4b	1881	12.5	16	92.0
PAST 5	3162	9.4	12	75.0
*HAY 5	5120	8.0	12	60.0
PAST 6a	4455	9.4	12	60.0
*HAY 6a	1414	8.0	12	60.0
PAST 6b	4667	9.4	13	60.0
*HAY 6b	1478	8.0	13	60.0
PAST 7	788	10.2	13	80.0
PAST 8	4497	9.4	12	75.0
*HAY 8	6122	8.5	12	60.0
LUCERNE 9	2165	10.2	17	75.0
*HAY 9	9462	8.8	17	60.0
PAST 10	3495	9.4	13	70.0
*HAY 10	5120	8.0	13	60.0
PAST 14	5495	9.6	16	80.0
PAST 17	7496	9.6	16	75.0
PAST 18	7496	9.6	14	75.0
PAST 19	8095	9.6	13	55.0
PAST 20	6490	9.6	31	55.0
*TURNIP 21	4338	13.0	36	85.0
*HAY 37	5788	8.3	18	60.0
BLOCK 30	1995	8.6	885	46.0
BLOCK 31	2996	8.6	160	34.0
BLOCK 32	3195	8.6	365	52.0
BLOCK 33	2497	8.6	104	52.0
BLOCK 34	2497	8.6	208	56.0
BLOCK 35	3495	8.6	104	41.0
BLOCK 36	2497	8.6	365	35.0
BLOCK 38	2996	8.5	18	51.0
BLOCK 39	2996	8.5	104	52.0
BLOCK 40	3295	8.5	60	52.0
BLOCK 41	3295	8.5	70	52.0
BLOCK 42	2996	8.5	70	52.0
BLOCK 43	3293	8.5	100	51.0
BLOCK 44	2497	8.5	100	46.0
BLOCK 45	2996	8.5	260	46.0
EXTRA	2996	8.5	200	46.0

* denotes that quantity of annual production removed as hay.

Table 4. Estimated significance of blocks and paddocks subjected to goose damage (1985/86).

Block/ Padd.	Area (ha)	Use	Grazing importance[1]	Cropping/Hay importance[2]
2	16	Grz/Hay	1	12
4a	12	Grz/Hay	2	2
5	12	Grz/Hay	2	6
6a	12	Grz/Hay	1	2
7	13	Grz	1	
20	31	Grz	1	
21	36	Crop		35
43	100	Grz	2	

[1]Estimated percentage of total S.U. days (100.SU.days of block/Total SU.days of run) supplied by block/paddock.

[2]Estimated percentage of net total crop/hay supply contributed by paddock, status quo.

Grz - grazing.

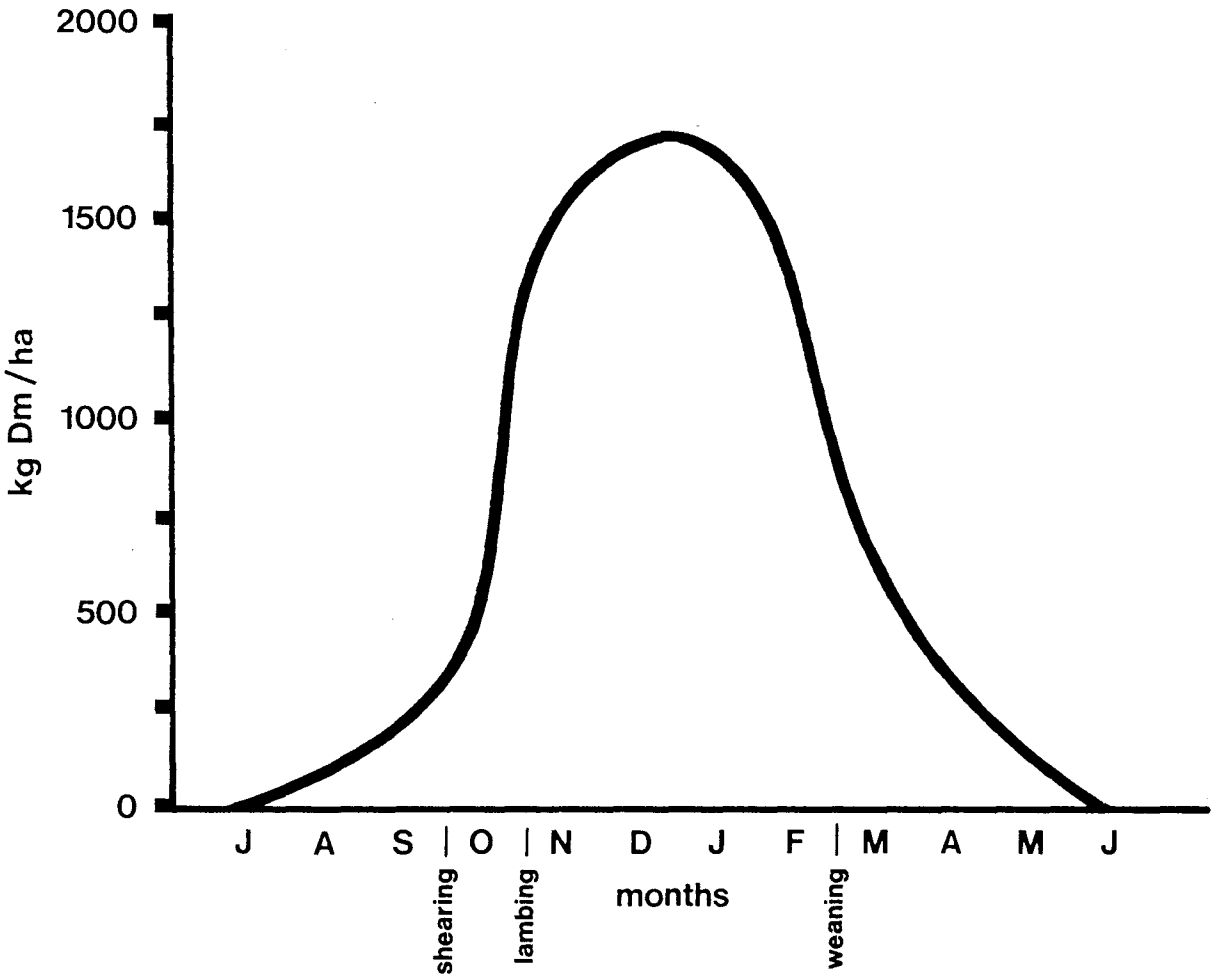

Figure 4. Monthly profile or herbage production at Grasmere Station.

2. Feed budgeting and the effects of goose food consumption on livestock carrying capacity

The grazing importance of each of the blocks and paddocks that were subject to goose damage was estimated from the grazing management charts and converting livestock numbers to standard stock units. As can be seen in Table 3 the paddocks affected by geese individually contributed no more than about two percent to total in-situ 'grazing' requirements of the livestock. However from a cropping/hay production viewpoint the per paddock importance was much higher, averaging about 11 percent. Clearly, at Grasmere, geese can potentially have a greater effect on cropping and hay production than on pasture production as such.

Pasture data (Appendix 2) and an estimated profile of pasture growth (Figure 4) were used as the basis for deriving monthly production, quality and utilisation characteristics of the pastures in each of the paddocks and blocks. The assumptions made at this point in the analysis were of paramount importance in producing realistic results. Summarised model output of these estimates for pasture production are presented in Table 4. The sheep numbers output by the model are according to the energy requirements of a 'basic' sheep flock derived directly from the flock information of Appendix 3 i.e. numbers per class in the same ratio.

Figure 5 summarises the results of running the feed budget model using the calculated monthly goose consumption estimates. The sensitivity of the model to a projected halving of consumption (0.35 - 0.17 kg) and a projected increase by half again (0.35 - 0.52) is also shown. When goose consumption is zero the carrying capacity of the Grasmere sub-leasehold is 10,195 sheep (includes compensation for hay sold off station). If the food calculated to be consumed by geese (assuming 0.35 kg/bird/day) is added to the total food resource of the farm, sheep carrying capacity would, according to the model, increase to 10,290. That is, the carrying capacity of the farm would have been higher by 95 sheep in the absence of geese. The other figures (0.17 and 0.52) give the effect of halving the existing goose population or increasing it by half again. The four points on the graph combine to give a curvilinear appearance. The carrying capacity level generated for 0.52 kg DM/day is somewhat lower than would have been

Figure 5. The effect of altering goose intakes on sheep carrying capacity.

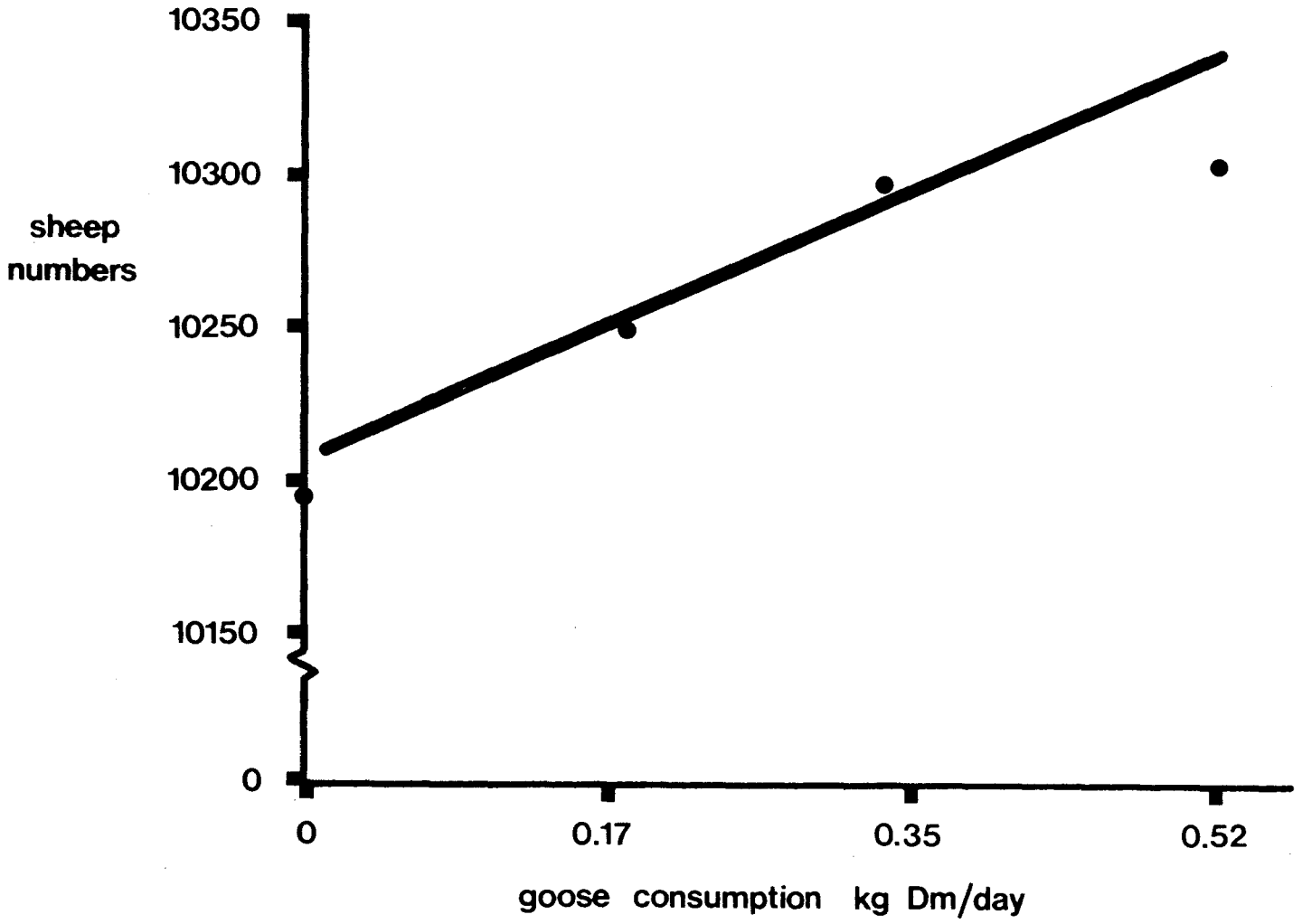

Figure 5 is testing the sensitivity of Grasmere Station to increases or decreases in goose numbers. When the goose consumption is zero we have the status quo where the carrying capacity is 10195 sheep (includes the hay sold off station and the existing goose population). If the food that the goose consume was converted into sheep then the sheep carrying capacity would increase. At the 0.35 kg DM/day (normal goose consumption) the increase is that which would occur if the existing goose population was removed. The other figures (0.17 and 0.52 Kg DM/day) give the effect of halving the existing goose population or incresing it by half as many geese again. The calculated line is to be used as the curvilinear appearance of the points may be caused by the characteristics of the model when dealing with such small percentage changes.

expected in the light of the 0.17 and 0.35 results. It may represent a distortion caused by the characteristics of the model when dealing with relatively small percentage changes. A linear regression (indicated by the straight line) was calculated to give what may be a more appropriate indication of the goose consumption/stock carrying capacity relationship.

Significance of different feeds consumed by the geese

Less than 0.5 percent of the overall food consumed by geese was turnips (seedlings were recorded as being taken on one occasion in November), yet 87 percent (83) of the 95 displaced sheep could be attributed to the effect of goose grazing the seedlings and young plants of this crop. Looking at it another way, 92 percent of the food consumed by geese was pasture, yet this accounted for only 12 of the 95 sheep displaced.

As was previously noted, the consumption of waste grain did not contribute to stock displacement.

Costs borne by the farmers

A range of greasy wool prices shown in Table 5 was used to indicate the sensitivity of gross margins to fluctuations in wool prices.

Table 5. Income increases by extra sheep and different gross margins/sheep depending on nett greasy wool prices.

No. of extra sheep	$6/kg	$5/kg	$4/kg
1	24.00	19.37	14.73
95	2,280.00	1,840.15	1,399.35

Source of gross margins, I.G.C. Kerr, (August 1986).

DISCUSSION

The modelling analysis indicated that under the management regime applying at Grasmere, a further 95 sheep could have been grazed in the absence of geese

The goose 'problem' is not so much one of volume of DM consumed as one of timing. In the high country region of the South Island the effects of the long harsh winters are reduced by the availability of improved pasture. Thus pasture saved in the autumn by judicious management is carried into the winter as standing crop (allowing for the influence of frost damage). This feed has high nutritive value and is essential for the pregnant ewe. In spring, lambing is timed to coincide with the regrowth of this pasture. Potentially the presence of geese in both autumn and again in spring has the effect of lengthening the winters. As far as Grasmere is concerned, the modelling analysis indicated that only 12 stock units were displaced as a consequence of geese using pasture throughout the year. Therefore the stock displacing effect of geese feeding on the staple pasture resource in the critical period extending from autumn to spring was not particularly significant. The availability and usage of waste grain in the autumn (mainly March 1985 - see Table 1) no doubt served to reduce impact on important autumn-saved pasture. The main stock displacing influence of geese was in November when they exploited seedling turnips which were planted expressly for stock feed in the subsequent winter. The one recorded grazing in this case (representing less than one percent of all food consumed) was responsible for 83 (87 percent) of the 95 stock units foregone.

On Grasmere Station the presence of the geese was buffered by a conservative stocking policy. This policy was indicated by both the runholder and the model.

As a point of clarification it should be noted that a conservative stocking policy is not synonymous with understocking. The policy opted for at Grasmere Station is one of high per animal performance as opposed to high per hectare performance i.e. a 'fat' versus a 'skinny' sheep policy. With

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the wide seasonal and yearly differences in pasture growth in the high country the average high country farmer tends to stock for a level that puts him in the overstocked category only in bad seasons. Hence in good years the average high country run is conservatively stocked.

The number of sheep displaced by geese was quite small (one percent). The returns of increased carrying capacity however were quite high because any added sheep required no extra inputs of fertiliser, management skills and very little extra labour. The gross margins in Table 5 cannot be compared with the gross margins used by Leathers and Costello (1986), due to the downturn in the farming economy. A range of greasy wool prices was used to test the sensitivity of gross margins to fluctuations in wool prices. While the gross margins quoted only refer to the added sheep, the lower the price of wool over the whole flock the greater the benefit to the farmer of the added sheep.

At Grasmere the availability of aquatic weed within the roosting site was an important factor in the overall exploitation of terrestrial food resources. The seasonal pattern of aquatic verses terrestrial feeding indicated in Figure 3 will be discussed in detail in a subsequent paper (Potts, in prep.)

This paper has looked only at the economics of goose consumption. It did not include potential damage caused by fouling and treading, although it is felt that these aspects would not represent a significant cost factor at Grasmere Station.

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APPENDIX 1. Derivation of livestock carrying capacity: A simplified example for a hypothetical run.

I Herbage Supply

For each pasture type: estimations of area (ha), annual dry matter production (kgDM/ha), percent utilisation ("U%"), monthly profile of relative herbage growth, and monthly profile of herbage quality (mega joules metabolisable energy/kg dry matter) are input:

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
(a) Native grassland 3500ha 450kgDM/ha U% = 45												
Growth	0	0	2	5	10	25	25	15	12	10	0	0
Quality	-	-	8.5	8.5	9.0	9.5	9.5	9.2	9.3	9.0	-	-
(b) Oversown and top dressed grassland 500ha 3500kgDM/ha U% = 60												
Growth	0	0	2	10	20	25	20	15	15	5	0	0
Quality	-	-	9.0	9.5	10.5	10.5	10.0	9.5	9.5	9.5	-	-
(c) Lucerne Hay 150ha 6500kgDM/ha U% = 60												
Growth	0	0	0	0	0	60	40	0	0	0	0	0
Quality	-	-	-	-	-	11.0	10.5	-	-	-	-	-

These data are converted to a schedule of monthly supply of net metabolisable energy as in situ pasture and as conserved fodder:

Month	$MJME^1 \times 10^6$ Pasture	Fodder
July		
August		
September	0.274	
October	1.170	
November	2.578	
December	4.076	3.861
January	3.491	2.457
February	2.261	
March	2.081	
April	1.055	
May		
June		

[1]Megajoules of net metabolisable energy.

APPENDIX 1a. Livestock energy requirements.

Assuming that the type of livestock production required is for wool based on a wether flock and breeding own replacements (other examples, fat lamb, beef or goat production), a monthly schedule of metabolisable energy requirement for a "base" flock is composed taking into account desirable growth rates, culling rates, lambing percentages, lambing dates, weaning dates, prescribed liveweights, and environmental factors.

The "base" flock of 100 wethers, 30 replacements, 50 ewes and nine miscellaneous sheep would require the following amount of metabolisable energy per month:

Month	MJME[1] x 10 3
July	30.78
August	38.14
September	58.44
October	89.87
November	104.27
December	99.07
January	94.79
February	79.67
March	62.48
April	60.05
May	43.08
June	30.63

[1]Megajoules of net metabolisable energy.

APPENDIX 1b. Reconciliation.

The above monthly energy requirements are increased by an estimated multiplier and then reconciled with the net energy supply, taking into account such factors as strategic fodder/forage supplies and quality losses of standing herbage. The 30 June surplus/deficit is evaluated and an adjustment is made to the multiplier until the surplus/deficit is within a prescribed limit. The result is the following monthly schedule of energy supply and demand.

Month	Herbage supply	MJME[1] x 10 6 Livestock demand	Surplus/ deficit
July		0.850	-
August		1.053	-
September	0.274	1.614	-
October	1.170	2.481	-
November	2.578	2.879	-
December	7.937	2.735	+
January	5.948	2.617	+
February	2.261	2.200	+
March	2.081	1.725	+
April	1.055	1.658	-
May		1.190	-
June		0.846	-

[1]Megajoules of net metabolisable energy.

The optimum multiplier is then applied to the numbers of livestock per class of the "base" flock and the carrying capacity is calculated:

Wethers	2761
Replacements	828
Ewes	1380
Misc.	248

Therefore, the carrying capacity of the hypothetical run is:

Sheep	5217

APPENDIX 2.

Pasture/fodder resources of Grasmere for 1985/86 seasons (ex interview and M.A.F. survey).

Number	Area (ha)*	Description
(a) PADDOCKS		
2	16	Cocksfoot and white clover. Used for hay (4000 bales) then grazed by hoggets
3	4	Not grazed since Aug. 1985
4a	12	Sown about 5 years ago. Contains red, white, alsike clovers plus sheep's burnett cocksfoot and weeds (especially yarrow). Grazed and cut for hay (600 bales).
4b	16	Barley crop (35t). Now fallow.
5	12	Good pasture of cocksfoot, timothy and red clover. Cut for hay Jan 1986.
6a	12	Normally used as hay paddock. White clover, red clover, timothy and other adventive grasses
6b	13	" "
7	13	Good quality Tama ryegrass. Sown Nov. 1985. Repeatedly fed to hoggets (1700).
8	12	White clover, alsike clover, timothy with some couch and cocksfoot. Grazed spring and autumn. Hayed during summer.
9	17	Best hay paddock of lucerne and red clover.
10	13	Hay paddock of timothy and white clover with some goose grass and other adventive grasses.
14	16	Holding paddock. Poor quality pasture.
17	16	Sown in grass Feb/Mar 1985
18	14	" "
19	13	Good quality paddock but subject to wind erosion.
20	31	Swamp paddock used for rams. Generally poor quality with matagouri and Scirpus sp. and some patches of clover
21	36	Turnips, sown Nov. 1985
22		Shearing paddock.

(All paddocks receive 375kg Super phosphate/ha/year)

Number	Area (ha)	Description
(b) BLOCKS		
30	885	Sugar Loaf. Native tussock and matagouri with browntop and clover. Eastern river-flats and northern spur (=270ha) receive 66% of grazing.
31	160	Sarah. Good sunny native pasture with some adventive white clover
32	365	Ewe Block. Very good sunny and generally native block with browntop higher levels of clover.
33	104	Magog. Colder, shady block grazed by wethers.

		Can be snow trap
34	208	Cassidies. Shady block with silver tussock. Browntop and clover on lower portions. Scrubby. Grazed by wethers.
35	104	Reserve Hill. Good sunny block of good quality, used for grazing hoggets.
36	365	Longspur. Good quality sunny block.
37	18	Hay paddock (3500 bales, 1 cut) of white clover, red clover and timothy. Sown about 1982.
38	18	Good quality paddock. OSTD early 1985.
39	104	Fisherman's. Oversown with white clover, and top dressed. Good quality.
40	60	Top Ribbonwood. Good quality pasture. OSTD 1984.
41	70	Mid Ribbonwood. Good quality pasture. OSTD 1984.
42	70	Bottom Ribbonwood. Not OSTD. Moderately wet, therefore useful in drier years.
43	100	Permanent Puddles. Good quality pasture. OSTD.
44	100	Hill Ribbonwood. Good native pasture.
45	260	Pearson's. Good quality pasture. OSTD on lower 40% with clover.

Total = 3260ha

---

* Areas estimated from maps.

APPENDIX 3

Livestock numbers per class for Grasmere (ex interview).

(a) Sheep	
Ewe hoggets	850
2T ewes (dry)	850
4T ewes	800
Flock ewes	1500
Wether hoggets	850
2T wethers	850
4T wethers	800
Flock wethers	2000
Rams	100
Misc.	130
Total	8730
(b) Cattle	
Calves	9
1.5 year	9
Total	18

APPENDIX 4.

Grazing management chart for Grasmere showing livestock numbers, classes and grazing periods of 1985/86 (ex interview).

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
(a) PADDOCKS												
Paddock 2				Hay----------Hay								
			2E---2E 145									
			2W---2W 145									
											EH----EH 104	
											WH----WH 104	
Paddock 3												
	Not grazed											
Paddock 4a				Hay----------Hay								
			2E---2E 113									
			2W---2W 113									
	EEEE 750										EEEE 750	
	RRRR 30										RRRR 30	
Paddock 4b												
	Barley then fallow											
Paddock 5				Hay----------Hay								
			2E---2E 113									
			2W---2W 113									
	EEEE 750										EEEE 750	
	RRRR 30										RRRR 30	
Paddock 6a				Hay----------Hay								
			2E---2E 121									
			2W---2W 121									
											EH----EH 78	
											WH----WH 78	
Paddock 6b				Hay----------Hay								
			2E---2E 121									
			2W---2W 121									
											EH----EH 84	
											WH----WH 84	
Paddock 7												
	EH--------EH 257											
	WH--------WH 257											
				|Sown in Tama ryegrass								
Paddock 8				Hay----------Hay								
			2E---2E 113									
			2W---2W 113									
											EH----EH 78	
											WH----WH 78	

Paddock 9

Hay----------Hay

EH----EH 110
WH----WH 110

Paddock 10

Hay----------Hay

2E---2E 121
2W---2W 121

EH----EH 84
WH----WH 84

Paddock 14

2E----2E 850
2W----2W 850

MS----------MS 130

Paddock 17

EH--------EH 316
WH--------WH 316

EHEH 453
WHWH 453

EH----EH 104
WH----WH 104

Paddock 18

EH--------EH 277
WH--------WH 277

EHEH 397
WHWH 397

EH----EH 91
WH----WH 91

Paddock 19

MS----------MS 130 MS--------MS 130

XX 1000

Paddock 20

RR----------RR 100

Paddock 21

Turnips

Paddock 22

Shearing/holding paddock

(b) BLOCKS

Block 30

WW----------WW 1400 WW----------WW 1750

WW----------WW 1150

Block 31

EE---EE EE----------EE 300

Block 32

EE---EE EE----------EE 1200

Block 33

WW----------WW 250

Block 34

2W----------2W 850

Block 35

4E---4E 4E----------4E 177

Block 36

4E---4E 4E----------4E 623

Block 37

Hay paddock

Block 38

EH----EH 125
WH----WH 125
EH----EH 117
WH----WH 117

Block 39

EH----EH 725
WH----WH 725

Block 40

4E4E 192 4E4E 192
RRRR 8 RRRR 8
2E----------2E 170

Block 41

4E4E 224 4E4E 224
RRRR 9 RRRR 9
2E----------2E 198

Block 42

4E4E 224 4E4E 224
RRRR 9 RRRR 9
2E----------2E 198

Block 43

Holding paddock 2E----2E 850

Block 44

4E4E 160 4E4E 160
RRRR 7 RRRR 7
2E----------2E 283

Block 45

4W----------4W 800

Grazing outside run

WW----------WW 600 WW----------WW 600

Key:

EE-flock ewes EH-ewe hoggets 2E-2tooth ewes
4E-4tooth ewes WW-flock wethers WH-wether hoggets
2W-2tooth wths 4W-4tooth wths
RR-rams MS-miscellaneous
XX- mixed classes of sheep
Hay---Hay - period during which paddock was closed for hay

Note: Often specific movement of a flock, particularly in a rotational grazing system, could not be recalled therefore some blocks/paddocks were assigned estimated stock loads according to area, and in others grazing use was assumed for a particular period.

APPENDIX 5.

Monthly, total (thousands of stock units) and proportional (%) livestock loading for each pasture of Grasmere.

Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total	Prop(%)
Block 2													
0.00	0.00	6.09	2.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.87	3.87	16.06	1
Block 4a													
21.67	0.00	4.75	3.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.97	50.87	2
Block 5													
21.67	0.00	4.75	3.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.97	50.87	2
Block 6a													
0.00	0.00	5.08	3.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.90	2.90	14.61	1
Block 6b													
0.00	0.00	5.08	3.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12	3.02	14.96	1
Block 7													
9.56	9.56	9.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.68	1
Block 8													
0.00	0.00	4.75	3.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.90	2.90	14.03	1
Block 9													
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.09	4.09	8.18	0
Block 10													
0.00	0.00	5.08	3.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12	3.12	15.06	1
Block 14													
36.89	36.89	0.00	0.00	2.73	2.82	2.82	2.82	2.82	0.00	0.00	0.00	0.00	87.79	4
Block 17													
11.76	11.76	8.34	16.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.87	3.87	56.44	3
Block 18													
9.93	9.93	9.93	14.73	0.00	0.00	0.00	0.00						

```
  0.00
0.00    3.39    3.39   51.30    2
Block  19
    2.82    2.82   23.73    2.82    0.00    0.00    0.00    0.00
  0.00
2.73    2.73    2.73   40.38    2
Block  20
    0.00    2.48    2.48    2.48    2.48    2.48    2.48    2.48
  2.48
2.48    2.48    0.00   24.80    1
Block  30
   30.38   30.38   30.38   30.38   24.15   24.15   24.15   24.15
 37.98
37.98   37.98   37.98  370.02   17
Block  31
    0.00    8.37    5.94    8.37    8.10    8.10    8.10    8.10
  8.10
8.10    8.10    0.00   79.38    4
Block  32
    0.00   33.48   23.76   33.48   33.48   33.48   33.48   33.48
 33.48
33.48   33.48    0.00  325.08   15
Block  33
    0.00    0.00    0.00    0.00    5.25    5.25    5.25    5.25
  5.25
5.25    5.25    5.25   42.00    2
Block  34
    0.00    0.00    0.00    0.00   17.85   17.85   17.85   17.85
 17.85
17.85   17.85   17.85  142.80    6
Block  35
    0.00    4.94    3.50    4.94    4.94    4.94    4.94    4.94
  4.94
4.94    4.94    0.00   47.95    2
Block  36
    0.00   17.38   12.34   17.38   17.38   17.38   17.38   17.38
 17.38
17.38   17.38    0.00  168.77    8
Block  38
    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
  4.65
4.65    4.35    4.35   18.00    1
Block  39
    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00
 26.97
26.97    0.00    0.00   53.94    2
Block  40
    5.56    0.00    0.00    0.00    1.79    3.69    3.69    3.69
  3.69
3.69    0.00    5.38   31.16    1
Block  41
    6.47    0.00    0.00    0.00    2.08    4.30    4.30    4.30
  4.30
4.30    0.00    6.26   36.30    2
```

Block 42
6.47 0.00 0.00 0.00 2.08 4.30 4.30 4.30
4.30
4.30 0.00 6.26 36.30 2
Block 43
0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
0.00
0.00 18.46 18.46 36.92 2
Block 44
4.64 0.00 0.00 0.00 2.97 6.14 6.14 6.14
6.14
6.14 0.00 4.49 42.80 2
Block 45
17.36 17.36 17.36 17.36 17.36 17.36 17.36 17.36
17.36
17.36 17.36 17.36 208.32 9
External
13.02 13.02 13.02 13.02 13.02 13.02 0.00 6.30
13.02
13.02 13.02 13.02 136.50 6

Note: Table derived from grazing management charts