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CANADA GEESE FEEDING ON FARMLAND IN NORTH CANTERBURY HIGH COUNTRY

by

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CONTENTS

CANADA GEESE FEEDING ON FARMLAND IN NORTH CANTERBURY HIGH COUNTRY

by

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ABSTRACT

Canada geese roosting on Lake Grasmere fed far more consistently and extensively on farmland at night than do geese generally in North America and Europe, presumably because of an absence of large ground predators such as foxes. They were less restricted in their choice of foods at night than during the day because of greatly reduced levels of disturbance in paddocks near farm buildings and roads. The relevance of the Grasmere study to the on-going problem of reducing costs associated with geese on South island high country farmland is discussed. Attention is drawn to extra difficulties of management likely to be encountered in New Zealand compared to North America and Europe.

1 INTRODUCTION

The Giant Canada goose (*Branta canadensis moffiti*) is the only truly wild goose species in New Zealand. The population originated from fewer than 40 birds which survived introduction from North America in 1905 and 1920 (Imber 1985). The majority occur in the eastern half of the South Island where they concentrate on various coastal and high country lakes from mid-summer onwards before dispersing in the spring to breeding grounds located mainly in the isolated headwater valleys of rivers flowing east from the Southern Alps (Imber 1985).

A marked increase in the development of crops and sown pastures in many South Island high country valleys over recent decades has encouraged an increased proportion of the population to overwinter on high country lakes and tarns. This trend, coupled with an expanding overall population has, in turn, led to increased claims of economic damage in the high country and strong pressure for intensive culls of geese.

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This paper describes the feeding ecology of Canada geese on farmland near Lake Grasmere (see Figure 1), a roosting site in high country North Canterbury, from 1984-1986. The costs incurred by the farmer as a result of the feeding described were previously estimated by Harris, Potts and Costello (1986) using methods employed in a preliminary study of the economics of Canada goose feeding in the South Island high country by Leathers and Costello (1986).

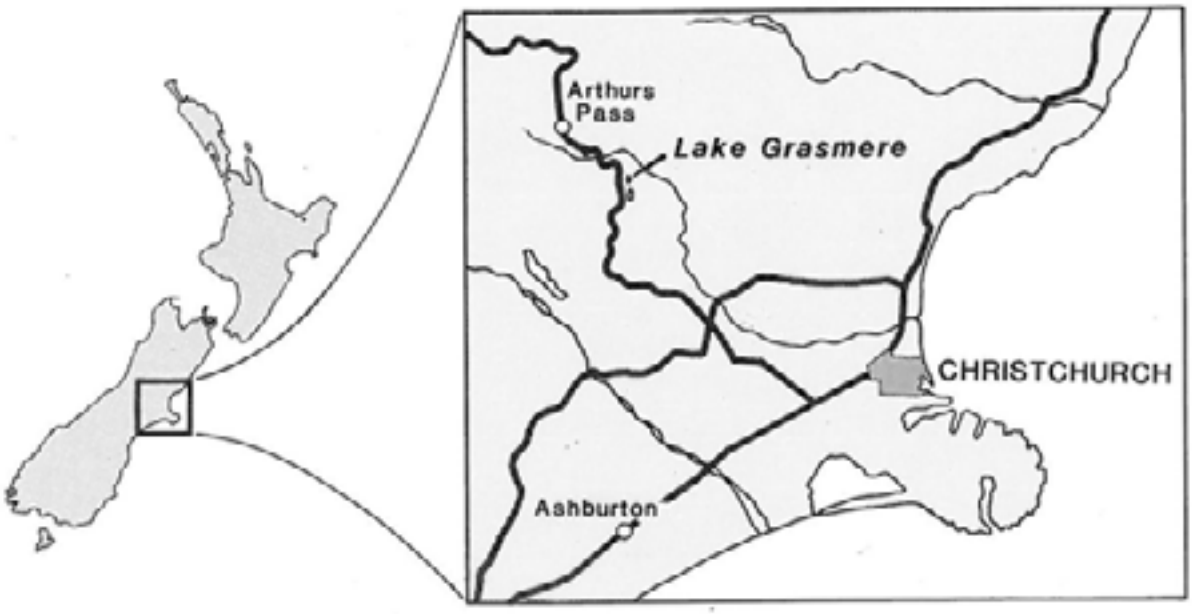

Fig. 1 Location of study area, South Island, New Zealand.

The relevance of the Grasmere studies and the earlier study by Leathers and Costello (1986) to the on-going problem of reducing costs associated with geese on high country farmland is discussed. Attention is drawn to extra difficulties of management likely to be encountered in New Zealand compared to Europe and North America.

2 STUDY AREA

Grasmere Station is a sheep farm covering several thousand hectares of mainly hilly terrain in high country North Canterbury. About half of the native tussock grassland which dominates the landscape below the snowline has been improved for grazing by aerial oversowing and topdressing. Small areas of flat cultivated land near Lakes Grasmere and Pearson in the Cass Basin are used to produce high quality pasture and fodder crops. The study area included Lake Grasmere and adjoining farmland (Figure 2).

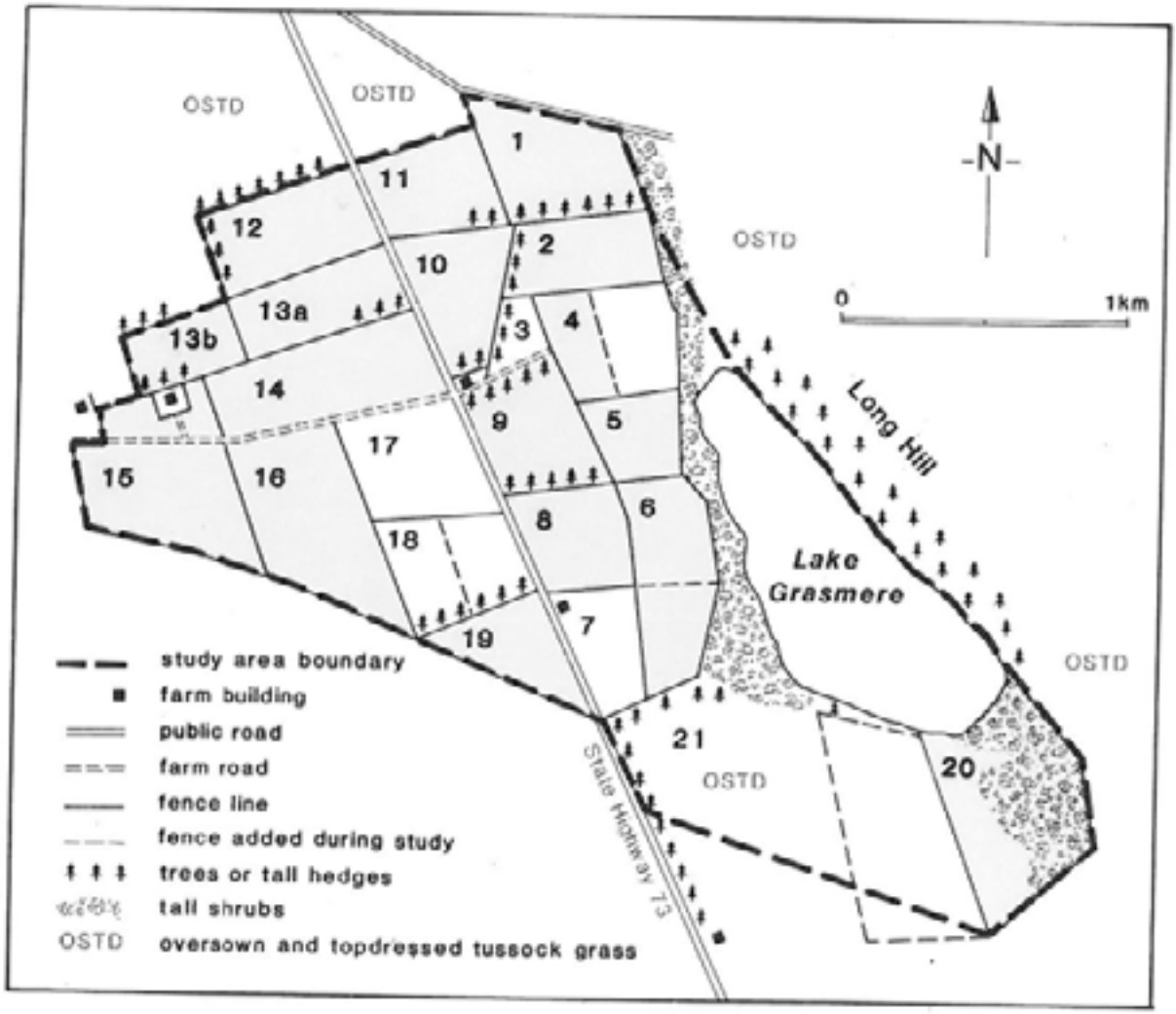

Fig. 2 Study area. Shaded paddocks contained sown pasture which was more than a year old when the study began.

The climate in the Cass Basin is characterised by hot summers and cool winters moderated by north-westerly winds. Severe frosts are common in the late autumn and winter. Snow may fall on a few occasions, but seldom persists (Greenland 1977).

Lake Grasmere, 583 metres above sea level, covers 63 hectares. It is fenced off from stock around its western margin and, in keeping with its refuge status, shooting and boating is prohibited. It has a maximum depth of about 12 metres depending on water levels which may fluctuate a metre of more throughout the year. The lake is fed by underwater springs as well as surface and subsurface drainage from catchment areas to the south and south-west.

Consistent with earlier studies (Ramsay 1976, Stark 1981) the lake contained an abundance of submerged macrophytes. The perennial adventive pondweed *Elodea canadensis* was the most common species, forming dense stands down to about 8 metres, most notably on the western margin where a continuous bed covered about a third of the lake floor.

The cultivated paddocks (Figure 2) were flat or nearly so, ranging in size from 4 to 36 hectares, each being separated by wire fences, supplemented in some cases by hedgerows or tall trees. Throughout the study period most paddocks were continuously under pasture comprising combinations of various perennial grasses and clovers (mainly ryegrass, cocksfoot and red and white clovers). Annual grasses, turnips and grain crops (oats and barley, usually undersown with clover) were grown periodically on a limited scale.

The pattern of stock and pasture management practised on Grasmere Station conformed to a general description given for South Island high country runholdings by Leathers and Costello (1986).

3 METHODS

3.1 Availability of Vegetation Types

An updated record was kept of ploughing, sowing, plant types, growth stages and harvesting in the paddocks. The distribution of aquatic vegetation in the lake was mapped at monthly or two monthly intervals by viewing from Long Hill next to the lake on its eastern side.

Vegetation or paddock types were classified as follows: oversown and topdressed tussock grassland (OSTD) (oversown mainly with red and/or white clover), new pasture (<1 year old, grass or grass/clover), established pasture (>1 year old, grass/clover), growing grain (oats or barley, sometimes undersown with clover), grain stubble, turnips (sometimes with rape), bare soil (usually ploughed), sown soil, submerged aquatic vegetation, lake margin vegetation (various grasses, clovers, weeds and semi-aquatic plants such as *Juncus, Scirpus* and *Carex* species).

The area availability of each type in each month was calculated on the basis of coverage, except in the case of aquatic vegetation where accessibility was a factor. Estimates of aquatic vegetation availability were determined from the feeding distribution of geese, the limits of accessibility being identified by `upend' feeding as opposed to the more usual surface feeding undertaken closer to the shore. When particularly high water levels forced the geese to depend on vegetation brought to the surface by the 40-70 black swans (*Cygnus atratus*) regularly present on the lake, estimates of availability were based on the feeding distribution of the swans.

3.2 Numbers and Distribution of Geese

The distribution and abundance of geese within the study area was recorded at hourly intervals from just after dawn to near dusk, 3-6 days per month for two years (April 1984 - March 1986). Feeding and non-feeding birds were distinguished. Each count took less than 40 minutes, so the effects of movements by geese was small. Although some disturbance was caused by normal farming operations and occasional recreational fishing, care was taken to avoid disturbance while counting. Counts were made from an elevated hide secluded in the line of trees leading to paddock 4 and from the highest point in the study area on the main road near paddock 21.

No counts were made at night, although regular notes were kept of flight and settlement patterns seen at dawn and dusk.

3.3 Numbers and Distribution of Stock

Stock (sheep and some cattle) were counted in all paddocks once on all survey days.

4 RESULTS

4.1 Availability of Vegetation Types

Table 1 shows the relative percentage proportions of vegetation types available in the study area in all months. Established and OSTD pasture, aquatic and margin vegetation were the only types available in all months.
In all months the proportion of established pasture exceeded the combined proportions of all other available vegetation types (62-67 percent). The geese had direct access to an approximately constant area of aquatic vegetation in all months except in November and December 1984 when water levels were unusually high. Then they were restricted to about half the usual area, relying almost exclusively on broken and uprooted material brought to the surface by black swans.

4.2 Usage

4.2.1 Seasonal Trends in Daytime Feeding. To show the broad pattern of goose population change and the relative extent to which daytime feeding was recorded as occurring in the lake and on adjoining farmland, records obtained from the 20-46 hourly dawn to dusk surveys done each month were averaged according to non-feeding, lake feeding and farmland feeding categories. The lake feeding category included feeding on submerged as well as margin vegetation, although feeding on the latter was relatively insignificant, accounting for no more than 0.5% of overall feeding recorded in any month. The results are summarised in Figure 3.

Table 1 Percentage areas of vegetation types available to geese in the study area (+ less than 0.5%).

	1984									1985													1986		
Vegetation	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Established pasture	67	67	67	67	63	63	63	65	65	63	63	63	63	63	63	63	62	62	62	62	62	62	62	62
New pasture																			9	9	9	9	9	9
Growing oats							3	3	3	3														
Growing barley																			1	1	1	1	1	1
Oat stubble											3	3	3	3	3	3	3							
Barley stubble	2	2	2																					
Turnips	4	4	3	1				6	6	7	7	7	7	+	+						7	7	7	7
Bare soil				5	10	7	+	1	1					6	6	13	14	17					1	1
Sown soil						3	6											1	10	7				
OSTD	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	9	9	9	9	9	9	9	9	9
Lake margin vegetation	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Aquatic vegetation	5	5	5	5	5	5	5	2	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

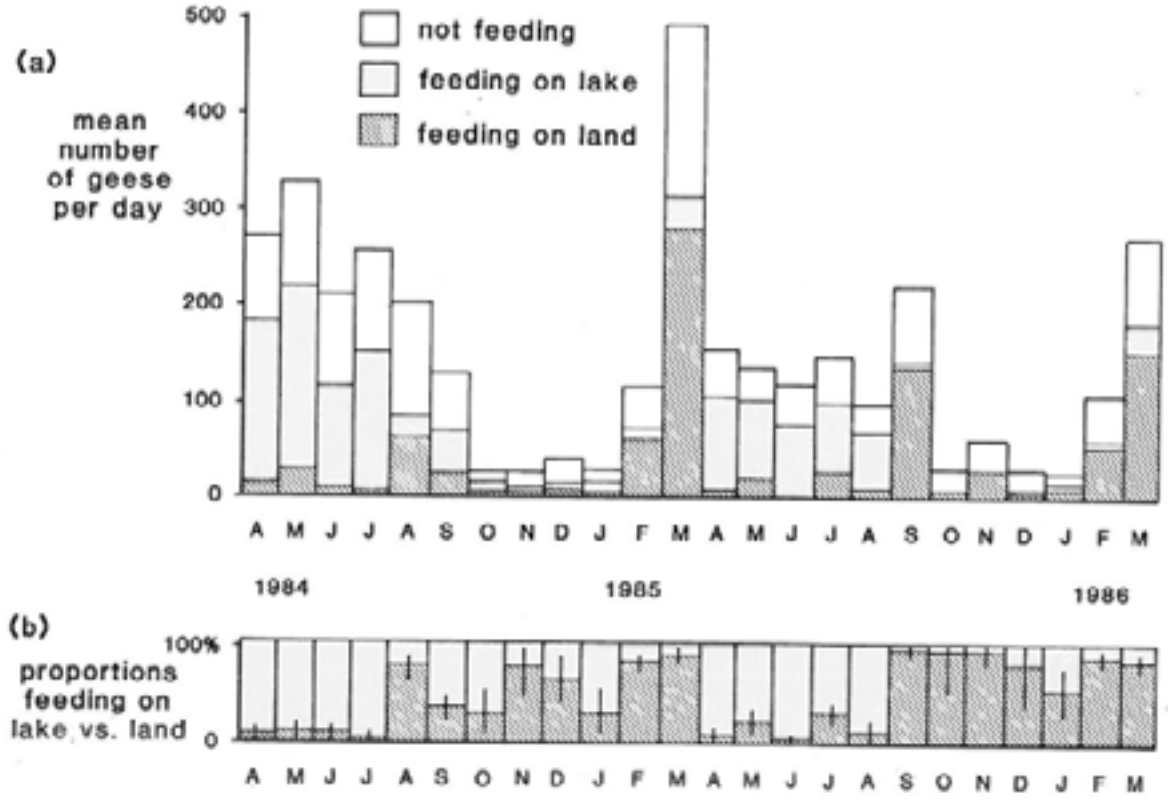

Fig. 3 Seasonal pattern of population change in the study area, and relative extent of daytime feeding recorded in the lake and on farmland. Vertical bars in lower part of figure indicate 95% confidence limits.

Figure 3(a) indicates that goose numbers were lowest in the late spring to mid-summer periods when breeding and brood rearing occurred in the hills and river flats outside of the vicinity. Numbers peaked in the autumn. The population mean shown for March 1986 was obtained from counts obtained before the middle of the month. Numbers increased to about 600 toward the end before dropping to around 250 in late April (Ross Novis, pers. comm.). (Band recovery data indicate that Lake Ellesmere, coastal North Canterbury, is probably the major destination of geese stating temporarily on Lake Grasmere in the autumn after breeding (see Imber 1971, Potts 1985).)

Although Figure 3(b) shows overlapping confidence intervals between some winter and non-winter months, the overall pattern suggests that farmland tended to be favoured less in the winter than at other times.

4.2.2 Use of Particular Vegetation Types.

4.2.2.1 Relative Daytime Use. Table 2 shows percentage daytime use of vegetation types in particular months. The analysis indicates that the seasonal daytime trend of lake vs. farmland feeding shown in Figure 3 was essentially in reflection of aquatic vs. established pasture usage. Ninety-five percent of all daytime feeding occurred on these types – 55% on aquatic vegetation, 40% on established pasture.

The extent to which the types were used in the daytime in proportion to relative availability in the study area is shown in Table 3. For each type in each month an index of usage was obtained by dividing percentage usage (from Table 2) by percentage area availability (from Table 1). Indices >1 and <1 indicate the degrees to which the types were used in higher and lower proportion to availability respectively. Aquatic vegetation (usually available in 5% of the area) was used in particularly high proportion to availability, especially and most consistently during the winter months. Established pasture (occupying from 62-67% of the area) was used in close proportion to availability throughout the spring to autumn periods, and in low proportion throughout the winters. Although crops were sometimes available in proportions approaching or exceeding that of aquatic vegetation, they were generally untouched in the daytime. New pasture and oat stubbles were the only crop types used in excess proportion to availability at any stage (in one month each).

4.2.2.2 Day *versus* Night Use. Figure 4 shows the percentages of overall daytime feeding recorded at particular sites. Table 4 indicates where daytime feeding occurred in particular months. Although no quantitative data were obtained at night, strong pointers to where the birds fed at this time were obtained from the notes made of flights and settlements at dawn and dusk.

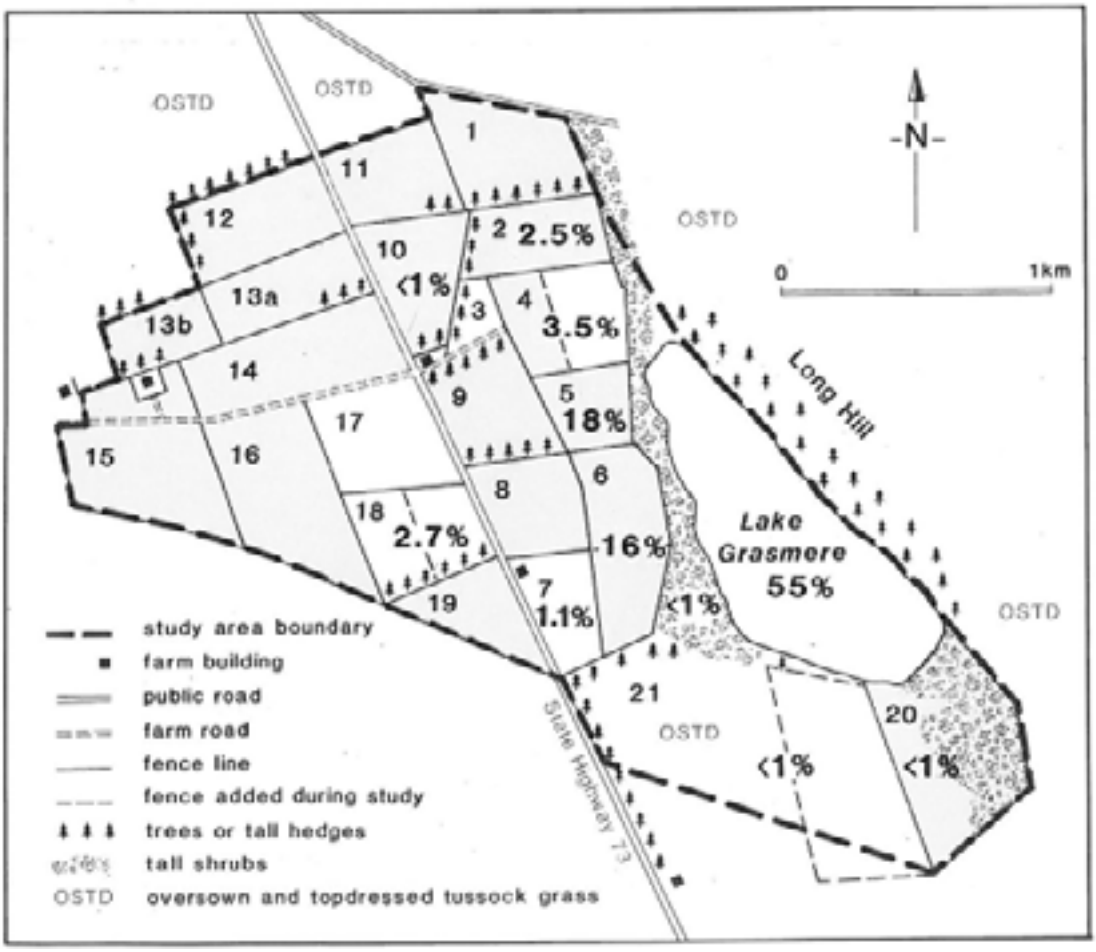

Fig. 4 Percentage proportion of feeding undertaken in different locations in the daytime. Shaded paddocks contained established pasture.

Table 2 Percentage daytime usage of vegetation types in different months (+ = less than 1%; 0 = available but not used). N = number of feeding records.

	1984							1985														1986		
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
N	5909	7049	2216	3934	2750	2633	693	393	581	712	1718	1253	4634	5286	3910	2941	3001	4332	519	363	485	668	1836	8197
Established pasture	8	9	11	3	78	35	28	73	64	64	82	73	6	19	1	35	12	96	98	98	82	54	62	86
New pasture																			0	0	0	0	28	0
Growing oats							0	0	0	0														
Growing barley																			0	0	0	0	0	0
Oat stubble											0	9	2	0	0	0	0							
Barley stubble	+	0	0																					
Turnips	+	0	0	0				5	0	0	0	0	0	0	0						0	0	0	0
Bare soil				0	0	0	0	0	0					0	0	0	0	0					0	0
Sown soil						0	0											0	0	0				
OSTD	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake margin vegetation	+	+	+	+	0	+	0	+	0	+	+	0	0	+	+	0	+	+	+	0	0	+	+	0
Aquatic vegetation	91	87	89	96	22	64	72	22	36	36	18	18	92	81	99	65	88	4	2	2	18	45	9	14

Table 3 Daytime use of vegetation types in proportion to availability. Indices >1 indicate the type was used in higher proportion to availability, <1 that it was used in lower proportion. + = < 0.1.

	1984									1985												1986		
	A	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**
Estab-lished pasture	0.1	0.1	0.1	+	1.2	0.6	0.4	1.1	1.0	1.0	1.3	1.2	+	0.3	+	0.6	0.2	1.5	1.6	1.6	1.3	0.9	1.0	1.4
New pasture																			0	0	0	0	3.1	0
Growing oats							0	0	0	0														
Growing barley																			0	0	0	0	0	0
Oat stubble											0	3	0.6	0	0	0	0							
Barley stubble	+	0	0																					
Turnips	+	0	0	0				0.8	0	0	0	0	0	0	0						0	0	0	0
Bare soil				0	0	0	0	0	0					0	0	0	0	0					0	0
Sown soil						0	0											0	0	0				
OSTD	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake margin vegetation	+	+	+	+	0	+	0	+	0	+	+	0	0	+	+	0	+	+	+	0	0	+	+	0
Aquatic vegetation	18.2	17.4	17.8	19.2	4.4	12.8	14.4	11.0	12.0	7.2	3.6	3.6	18.4	16.2	19.8	13.0	17.6	0.8	0.4	0.4	3.6	9.0	1.8	2.8

Table 4 Locations of feeding in study area April 1984-March 1986.

	1984								1985													1986		
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
Lake	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Lake margin	+	+	+	+		+		+		+	+			+	+		+	+	+			+	+	
Paddock (by number)	5 6 7 18	5 6 21	4 5	5 6	5	5 6 10	5 6	6 7	6 20	6 20	2 5	2 4 5 6 18	2 18	4 5 6	5 20	5 6	5 6	5 6 20	6	6	6 20	2 6 7	5 6	5 6 20

ESTABLISHED PASTURE.

Only certain paddocks near the lake and away from public roads received significant daytime use (Figure 4). Ninety percent of all daytime feeding recorded on land was on the permanent pastures shown, 75% on paddocks 5 and 6, representing only 7% of the farmland within the study area. One or other or both paddocks were used in every month except one (Table 4) and they were the only places apart from the lake where geese were ever continuously present (feeding and/or resting) throughout the day.

Although all of the established pastures next to the lake were free of high disturbance associated with farm buildings and public roads, they varied somewhat in terms of disturbance as well as openness. Paddocks 5 and 6 were subject to fairly infrequent disturbance and were free of tall shrub cover. Paddock 4, although free of tall cover, was subject to relatively greater disturbance since it was located at the end of a well used farm track (see Figure 2). Activity on the track invariably caused any birds on paddock 4 to fly to the lake. Even when the track was unused for long periods, geese were still less inclined to use paddock 4 than they were paddocks 5 and 6. Although paddock 20 at the south end of the lake was undoubtedly the least disturbance of the established pastures used, it was the only one in the study area with significant tall cover. About 70% of its area was occupied by unevenly distributed patches of sedge and matagouri (*Discaria toumatou*) plants approaching or exceeding one metre tall. Geese avoided all except one relatively open part extending along the western fenceline (5-10% of the paddock). However, rarely were more than a few birds seen there.

It should be noted that although the record of geese on particular pastures in particular months shown in Table 4 undoubtedly closely reflected the true overall importance of paddocks 5 and 6 and the consistency with which they were used in the daytime compared to other pastures, some explanation pertaining to the effects of rotational grazing and grass height at time of recording is required. For example, when in particular months geese were recorded as feeding only in paddock 5 or 6, it did not always mean that the other paddock was avoided in the month overall. In the period from February to October (in both years) large numbers of fresh or near fresh droppings were always seen in both paddocks. The recorded presence of geese solely on one or other paddock in particular months in this period was clearly mainly a direct effect of rotational stock grazing and the coincidental presence of stock in only one of the paddocks when all counts were done. The paddock with sheep tended to be avoided, particularly if numbers were high. On the occasions when both paddocks were empty or contained few sheep an element of chance appeared to be involved in comparative usage since the geese tended by nature to feed in a group in only one paddock at a time. The only times when paddock 5 was obviously avoided in favour of paddock 6 were in the periods from November to January leading to haymaking. Unlike paddock 5, paddock 6 was a one of the very few established pasture paddocks which was not managed for hay production (paddock 20 was the only other one on the lake side of the main road). At time of mowing paddock 5 contained an even spread of growth reaching to about 60 cm, whereas growth in paddock 6 seldom exceeded 10 cm. The shorter vegetation in paddock 6 was clearly preferred by the geese.

Overall, particular established pastures were used in the daytime primarily on the basis of closeness to the lake, although this factor was strongly linked to the requirements of openness and freedom or relative freedom from disturbance.

The apparent reduced tendency for geese to feed on established pasture in favour of aquatic vegetation during the winter indicated in daytime data in Tables 2 and 3 coincided closely with severe frosting. Clover died back almost completely in the winter (beginning in April) and grass quality and growth was reduced to a point where stock became increasingly dependent on supplementary feed. No comparable discolouration or marked reduction in the standing crop of aquatic vegetation was evident in the winter. When particularly warm spells of winter weather stimulated temporary pasture growth, which was characteristically shown in patches in the paddocks, the geese clearly favoured the green patches. General spring greening of pasture occurred earlier in 1984 than in 1985, corresponding with an earlier sharp upswing in recorded daytime usage (August compared to September).

The indications were strong that established pasture was the staple component of the land based diet at night as well as during the day throughout most of the study period. Dawn and dusk concentrations on one of the inner established pastures – particularly paddocks 5 or 6 – was the norm, following on from day settlement and feeding in those places. Certainly it was more usual to see geese on paddocks to the west in the early morning and toward evening than at any other stage of the day, but it was still a relatively inconsequential phenomenon except where one or two non-established pasture types were concerned (see later). The one recorded instance of geese on established pasture beyond the inner pastures (eight birds on paddock 10 next to the main road in September 1984) was obtained in a first count of the day, suggesting night settlement. Apart from the observed return of the birds from paddock 10 to the lake soon after they were recorded, no flights to or from the lake and any other established pasture to the west and north of the inner established pastures (paddocks 2-20) were ever recorded in the surveys.

LAKE MARGIN VEGETATION.
Although this general type was consistently available and more immediately accessible from the lake than any other land vegetation type, it was used by very few birds in the daytime in any month (Table 2). There were no indications from dawn and dusk sightings that night feeding was ever appreciably higher than during the day.

OSTD.
Although oversown and topdressed tussock grass was consistently available in open, relatively undisturbed conditions next to the lake – in paddock 21 at it south end – only in one month (May 1984) was daytime feeding recorded (see Table 2). In no month was there a suggestion from dawn and dusk observations that night use was significantly higher than during the day.

OATS.
Oats were sown on the western side of the main road – in paddock 18 – in the spring of 1984. There was no indication from surveys or site inspections of seed or plant usage,

but stubble grain, before it began to sprout in the early winter, was used extensively at night. In late February and in March and April mass flights to the paddock in the late afternoon or at dusk were a consistent feature as were returns at dawn or soon after. The general emphasis on feeding at night was consistent with the location of the food type in a paddock associated with high daytime traffic disturbance.

BARLEY.

Barley was sown in paddock 18 next to the main road in the spring of 1983 (before to the beginning of the study) and in paddock 4 next to the lake in the spring of 1985. As with oats there was no indication of feeding on seeds or plants, although heavy use was clearly made of pre-sprouting stubbles when they became available in both places in the autumn. In paddock 18 usage was mainly at night. As with oat stubbles available in the same roadside location in the following April, large-scale late afternoon or dusk settlements were the norm, with the birds returning to the lake soon after dawn. On one of the five survey days in April birds continued to feed during the first day count before returning to the lake soon after. Although the barley in paddock 4 next to the lake had not been harvested at the completion of surveys in March 1986, once this was done in late March, the farmer reported immediate heavy and continuous daytime concentration on the stubbles (previously the birds had focused on neighbouring intensive pasture paddocks 5 and 6). No comments were made with respect to dawn and dusk usage.

TURNIPS.

Turnips, which became available in early summer, sometimes lasting until mid-winter, were grown in an open, undisturbed paddock next to the lake (21), in three paddocks next to the main road (7, 17, 18) and in one elsewhere (3). Three crops were grown in paddock 3, two in paddock 7, and one each in paddocks 17, 18 and 21. No dawn or dusk settlement was ever noted on any of the crops, although quite heavy spasmodic daytime impacts were registered in single months (April, November 1984) on succeeding crops in paddock 7. Although regular site inspections made for droppings indicated marginally notable usage in paddock 7 in October 1984 (in the month preceding the sighted settlements), evidence for usage in the other paddocks was minimal or absent. Some lightly scattered near-fresh droppings were occasionally seen in paddock 21 next to the lake. None of note were seen in paddocks 17 and 18 or in the highly enclosed paddock 3.

NEW PASTURE.

New pasture became available in the spring of 1985 in three locations next to the main road – in paddocks 7, 17 and 18. As with turnips grown in these places, only in paddock 7 were birds recorded. Again, as with turnips grown in paddock 7, records were obtained in only one of the several months when the crop was available (February 1986). Daytime impacts were very heavy on two of the four days surveyed (in first and second day counts) and extensive night feeding was indicated by the earlier presence of the birds at dawn. Disturbance created by early morning traffic on the days concerned undoubtedly caused the birds to shift toward the lake. In terms of overall daytime usage in February, new pasture was used in quite high proportion to availability (see Table 4). Regular site inspections indicated some use of new pasture in paddock 7 in January and March, but no notable usage was ever indicated on paddocks 17 and 18.

AQUATIC VEGETATION.
Although in the daytime throughout the study period aquatic vegetation tended to be used in far higher proportion to area availability than any other vegetation type (see Table 3), as with other types, the factor of relative availability was undoubtedly much less relevant to usage than ease of access and availability in conditions of safety. Aquatic vegetation was located in perhaps the least disturbed area. Birds disturbed on the land always returned to the safety of the lake roost.

5 DISCUSSION

The following general trends relating to overall feeding activity at Grasmere were apparent. First, the way in which farmland resources were exploited tended to differ between day and night. In the daytime feeding was clearly influenced by a strong behavioural tendency to use open areas which were free from disturbance, preferably as close as possible to the lake. Although the study indicated that lakeside established pasture paddocks were the prime focus of farmland feeding both during the day and at night, the geese were far more inclined at night to venture further afield, not so much to obtain pasture over and above that which was readily available closer in, although this did occur to a limited extent, but more to obtain certain other feed types which were occasionally available but which they were actively discouraged from using in the daytime because they were grown in areas of high daytime disturbance. Certainly the levels of farm activity and traffic on the relatively isolated country highway tended to be far higher in the daytime than at night and this had a marked influence on where the birds could safely feed at this time. On the relatively few occasions during the day when birds were noted on paddocks next to the main road it was usually in first and last counts in conjunction with observed dawn and dusk settlement. At no time in the daytime proper did they settle for extended periods. They were always very alert and easily shifted by passing traffic.

Feeding on farmland at night was probably on average at least as extensive as during the day in most months. In no month was there a pattern of wholesale departure from the farmland to the lake at around dusk and a return at around dawn as has generally been reported for geese in North America and Europe (see, for example, Reed *et al*. 1977, Owen 1980). Indeed, more of a reverse trend was strongly indicated, particularly outside of winter when according to daytime trends the proportion of feeding carried out on land as opposed to aquatic vegetation tended to be highest (see Figure 3). Mass flights away from the lake were most commonly seen in the late afternoon or at dusk.

The tendency for geese at Grasmere to feed more extensively and consistently on farmland at night than do geese in Europe and North America is probably related to a general absence in New Zealand of large ground predators such as foxes. In Europe and North America where such predators are common, geese tend to feed on land only on moonlit nights or on nights following days when they have been prevented from feeding by hunting or other disturbance (Owen 1980). Owen stated that it is the risk of predation which inhibits night feeding by geese on land in Europe and North America rather than any inability to feed effectively in the dark. He noted that barnacle geese on

the fox-free island of Schermonnikoog in the Netherlands fly on to reclaimed pasture to feed in almost total darkness.

FOOD PREFERENCES.
Although the recorded pattern of day feeding gave some indication of food preference - particularly when choices were available close to the lake – this aspect was mainly clarified by night usage when feeding was less inhibited by road and farm disturbance.

Apart from the fact that established pasture was consistently available in open, relatively undisturbed conditions to the lake, the regular emphasis on this type in the day as well as night undoubtedly reflected its general quality as a food source (see later) and the fact that other attractive food options were only intermittently available and generally located in areas of high daytime disturbance next to the main road.

The consistency with which established pasture was used in lower proportion to aquatic vegetation in the winter (indicated in daytime data in Tables 2 and 3) was probably primarily a consequence of frost damage. This conclusion was most readily supported by the sudden up-swing in recorded usage once pastures greened in the spring and the preference shown for green patches in the winter, although it may be debated as to whether frost damage was sufficiently severe in April to fully account for the dramatic decline in usage recorded in this month in both years. This may have been related to the concurrent availability of highly preferred grain stubbles. Perhaps the geese were sufficiently deterred from using minimally frost damaged pasture in the daytime because stubble grain was still highly available and collectable in roadside conditions at night. In the latter part of winter sexual activity (focused on the water) may have had some bearing on low pasture usage.

Oversown and topdressed pasture and lake margin vegetation – the only other vegetation types apart from established pasture which were consistently available in undisturbed conditions next to the lake – were clearly far less attractive. Both types would undoubtedly have tended to be more fibrous and of lower protein quality than the regularly fertilised, high yield sown pastures (studies indicate that geese prefer low fibre, high protein vegetation – Owen 1980). Also, being relatively taller, the less expansive margin vegetation was probably less attractive as a base for unobscured mass settlement. (The well documented tendency of geese to prefer expansive areas offering good all-round views (see Owen 1980) was additionally suggested by the low use made of the shrub covered pasture paddock 10 compared to the more open lakeside pasture paddocks.)

The only other vegetation types which were sometimes available in relatively undisturbed, open conditions next to the lake were barley (paddock 4) and turnips (paddock 21). Growing barley was clearly avoided in this location and when it was available in the roadside paddock 18, although in the autumn its stubble form was highly favoured in both places. No feeding was observed on turnips next to the lake. Turnips were also avoided in the highly enclosed paddock 3, although spasmodic daytime impacts were indicated in paddock 7 next to the main road, possibly because it was next to the extensively used lakeside pasture paddock 6. Although turnips have, on

occasion, been reported to have been heavily foraged by Canada geese in the South Island high country (Leathers and Costello 1986), the relatively light overall impact detected at Grasmere may have been related to the availability of alternative quality food supplies. A study by Newton and Campbell (1973) showed that whilst Icelandic greylag geese (*Ansea ansea*), in common with many other geese, eat turnips, they only tend to do so when other foods are scarce, as during periods of snow cover.

As with growing barley there was no indication that any use was made of growing oats, although like barley, its stubble was evidently used extensively at night when it was available in paddock 18. Numerous studies involving a variety of goose species have shown a high general preference for grain stubbles in the autumn/early winter period. The food is easily gathered and is particularly high in energy which is a critical requirement for the build-up of fat reserves for autumn migration and survival in the winter (Owen 1980).

Apart from one month when new pasture in paddock 7 was used before established pasture in neighbouring paddocks next to the main road, there was no suggestion that it was highly preferred. Although many field and experimental studies have indicated that, given an equal choice, geese tend to prefer new over older pasture because of its generally higher protein and digestibility (see e.g. Owen 1980), it was likely that the protein and digestibility of the regularly fertilised established pasture next to the lake was sufficiently high for birds not to be heavily and consistently attracted to new pasture in less safe locations.

Apart from the fact that submerged aquatic vegetation was consistently widely available at the roost in conditions of safety, its heavy use was probably also related to its food value, which could have been as high or even higher than most other agricultural plants on offer. Bearing in mind that numerous studies have established that high protein and low fibre content are two of the most important characteristics of plants preferred by geese, it is also noteworthy that when published analyses of the protein and fibre values of submerged aquatic and agricultural plants are compared, the aquatic plants rate highly. For example, Jagush (1979) analysed the protein and fibre content of young and mature pasture (grass/clover), young and mature lucerne, and pasture and lucerne hays. Comparing Jagush's figures with comparable data supplied for a variety of aquatic plants by Gortner (1934) and Lin *et al.* (1975), it is apparent that only the young forms of pasture and lucerne had higher protein levels than the majority of the aquatic plants tested. The particularly low fibre levels recorded in the young pasture and lucerne were matched or even lower in many aquatic plants. It should be noted that the aquatic plant analyses referred to were reported without reference to growing conditions. The plants in Lake Grasmere were grown in eutrophic conditions promoted by considerable fertiliser run-off, so it is probable that they were of particularly high protein quality. In other words, they may have responded to chemical enrichment in the same way that land plants do. This conclusion is supported by analyses of aquatic plants obtained from several Rotorua lakes by Fish and Wills (1966). Analysing *Elodea canadensis* (coincidentally the predominant weed in Lake Grasmere) they found that samples taken from Lake Rotorua were higher in nitrogen (indicating protein), phosphorus and potassium than were plants taken from other less enriched lakes in the area.

6 MANAGEMENT IMPLICATIONS

As a basis for discussing some of the implications of the present study for crop and pasture protection in the South Island high country and New Zealand in general, ways in which the Europeans and North Americans have approached the problem of protecting farmland from geese are summarised as follows:

Different legislative approaches. In Denmark, for example, the hunting rights belong to the farmer and in that respect are incorporated in the use of the farm. They can hire out the hunting rights and in this way get some compensation for any damage caused by game species. It is their own responsibility to protect crops and pastures and they have no right to financial compensation from the state or other agencies. Because of this system in Denmark, the tolerance of farmers to damage caused by game birds is higher than their tolerance to damage by protected species. In other countries compensation is regularly paid to farmers for wildlife. The assessment of damage is a major problem with this system, particularly where crops and pastures are also used by stock. In Holland the amounts paid out for goose damage are now so high that the state is looking at other solutions to the problem.

Population control. This method has been employed with some success in North America and Europe, although geese move around a lot and culling does not necessarily lead to any permanent reduction in either geese or damage in particular areas. Good areas continue to attract geese.

Scaring devices and repellents – for review see Fog (1982).

Farming for game birds/reserves. In the Netherlands, for example, state agencies as well as private societies have bought or leased areas for birds. Coupled with intensive scaring on neighbouring farmland, this method of approach has proved successful in certain areas. Owen (1977) has commented on the problems inherent in the establishment of reserves to reduce conflicts with agriculture.

Changes in farming practice. Many studies of the ways in which geese use farmland have led to suggestions as to how farmers can manage their land to minimise damage. A frequent suggestion is to reduce paddock size and promote the planting of trees and hedges on the assumption that geese tend to avoid enclosed areas. This suggestion is, of course, often incompatible with modern agriculture. The problem according to Newton and Campbell (1973) is not so much one of repelling geese from a farm as a whole, but of protecting fields for short periods. A major conclusion drawn from their own studies and those of other researchers was that the size and location of a field was the main factor affecting how much geese fed there. Damage can be reduced when vulnerable crops are grown where geese do not like to feed – near roads, buildings and other areas of disturbance. On any modern farm the extent to which crops can be situated so as to avoid geese is restricted, but the use of knowledge of favoured feeding areas can do much to reduce damage. Newton and Campbell (1973) noted that 'More can be achieved with the help of scaring devices, several of which have been found highly effective for the few weeks that are necessary (DAFS booklet). Such devices have kept

geese off some greatly favoured areas, but of course are most effective on marginal ones. It is also important to repel birds as soon as they start on a field, for the more they have fed there, the more reluctant they become to desert it.'

Although some of the above general approaches have been employed with some success in New Zealand in terms of future consideration a number of important points should be borne in mind. First, if the high incidence of night feeding on farmland indicated at Grasmere is typical of New Zealand in general – and this is a strong possibility given the general absence of large ground predators such as foxes – then some added difficulty would be expected here. For example, farmers in North America and Europe could generally expect to achieve a very high success rate by planting vulnerable crops near busy roads. Even if volumes of traffic were drastically reduced at night, the risk of predation in conditions of darkness would more than likely be sufficient on its own to discourage feeding at this time. In New Zealand the planting of vulnerable crops in similar circumstances could probably achieve only partial success without employing supplementary scaring tactics at night. That is, without supplementary scaring tactics at night, success could presumably be guaranteed in the day time, but at night, because of an absence of ground predators, feeding may be carried out.

There is no short answer to the way in which New Zealand managers should set about dealing with geese on farmland other than to say that more can be done using methods apart from population control. Culling in particular areas can certainly temporarily reduce numbers in those areas – and this may be deemed worthwhile – but there is no evidence that the concerted culling which has been applied throughout the South Island since the late 1970's has had the desired effect of reducing the population as a whole. On the contrary, numbers appear to have increased somewhat since that time. Perhaps culling is producing a compensatory reaction in the population, whereby productivity and survival of young per breeding pair increases in response (removal of breeding birds may reduce competition for space and resources at breeding sites). It is not known at what level the population would stabilise if all killing ceased. The critical limiting factors are not understood at this stage, although breeding space may well be involved. It should also be noted that sustained culling in one area may contribute to a displacement effect in others (Potts 1984). In general terms under current legislation, farmers and game managers should be encouraged to develop an awareness of the way in which geese operate on farmland of concern, taking into account the possibility of significant feeding at night and different patterns of usage which are likely to occur then. Observations at around dawn and dusk are most important, as are checks for droppings. Having acquired such background information they will then be in a good position to think constructively about techniques of management.

South Island high country farmers have some advantage over farmers in other areas of New Zealand in that they now have access to relevant studies of the economics of Canada goose feeding (refer to a broadbrush study of the economics of Canada goose feeding in the South Island high country by Leathers and Costello (1986) and a more focused study dealing with Grasmere by Harris *et al.* (1986) (based on feeding data presented here). These indicate when, and in relation to which crop and pasture types, protection is likely to be warranted from a cost standpoint. One strong conclusion to be

drawn from these studies is the desirability of providing stubble grain in the autumn when goose numbers tend to be highest. When this source of food was used in the autumn it was shown to greatly reduce impacts on so-called autumn-saved sown pasture which was typically carried over the winter and into the following spring when food supply was limiting in terms of stocking capacity. (Because considerable night feeding on farmland is probably a general feature in the high country, the stubble should ideally be sited in areas where birds can readily take advantage of it both during the day and at night.) The studies also indicate that turnips should be protected as far as possible since even very light impacts on this crop can be extremely expensive. Some additional comments on the nature of the two economic studies and their proper interpretation with respect of management application is given under a separate heading below.

In terms of predicting which food types are likely to be used by geese in the high country, the food selection results obtained at Grasmere should be interpreted with caution. As similar goose studies undertaken overseas have shown, choices can be somewhat unpredictable, depending of combinations of foods on offer and other factors.

Economic studies by Leathers and Costello (1986) and Harris *et al.* (1986). In approaching the problem of estimating annual costs incurred by particular South Island high country farmers as a result of goose feeding, Leathers and Costello (1986) recognised that the form of analysis required was more complex than simply extrapolating from estimates of volumes eaten without reference to timing. They proceeded on the basis that monthly estimates of consumption must be interpreted in a dynamic way, taking into account changes and limitations in stock feeding supply and many other stock and farm related factors. In order to integrate and interpret all of the information necessary to achieve estimates of stock displacement due to geese they applied a method of analysis based on a stock feed budgeting model previously developed to assess stock carrying capacity in the particular conditions applying in the South Island high country. In brief, 21 high country farmers were carefully interviewed about monthly goose numbers on their properties and the types of feed used. Additional information was collected on the areas of all stock foods available and seasonal production. The seasonal demands made by the stock carried were also estimated. Using the computer-based feed budget model the stock feed demand and farm feed supply schedules were reconciled to produce the potential carrying capacity of the farms concerned. To establish how many extra stock could be carried in the absence of geese, the model was re-run adding the monthly estimates of dry matter weights of different foods consumed by the geese. Costs associated with stock displacement due to geese were then determined on the basis of gross margin data.

A subsequent study at Grasmere by Harris, Potts and Costello (1986) applied the feed budget modelling method of analysis developed by Leathers and Costello (1986) to consumption estimates based on 24 hour extrapolations from daytime feeding data presented in the present paper.

Quite apart from the actual figures generated in the above studies which may be taken to give some indication of the magnitude of costs incurred by the farmers at current goose levels, the main value of the studies concerned lay in the rationale applied to the

interpretation of the results generated. This rationale was based on a specialist understanding of the feed budget model itself and the nature and purposes of high country farm management to which it was applied. By articulating general relationships between seasonal stock feed supply and demand they were able to provide a coherent framework for making reasonably informed judgements about when and on what food types goose impacts are likely to be most serious from an economic standpoint. With regard to the fact that both studies were based on very approximate goose consumption data, it is important to note that the purpose of running the modelling exercise in both cases was to look for trends. Even if entirely accurate goose consumption figures had been obtained, feed budgeting analyses could not be taken to be definitive. Goose numbers and the types of foods available would be expected to change somewhat from year to year, as would other farm and stock related variables. The studies highlighted the sensitivity of the model to slight changes in particular variables.

In summary, although goose managers should be cautious about extrapolating directly from results obtained in the studies referred to, they can now at least make some reasonably informed judgements about when and on what food types goose impacts on farmland in the South Island high country are likely to be most critical in economic terms.

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