THE GRAZING BEHAVIOUR OF SHEEP *(OVIS ARIES)* ON A HIGH-COUNTRY SUMMER RANGE IN CANTERBURY, NEW ZEALAND

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SUMMARY: The distribution of sheep was monitored for three years on part of an unimproved high-country summer range composed of several land units with different phases of degraded tall tussock and short tussock grassland. Sheep distribution was found to be non-random and to vary seasonally. Available dry matter and water content of inter-tussock vegetation were monitored on well vegetated land units for one season. The sheep tended to move from the study area as the available inter-tussock herbage matured and declined in water content and quantity, up to mid-January. Those sheep remaining on the study area and additional sheep liberated onto the range in late February tended to show an increased preference for a damper area and an adjacent land unit. Factors apparently influencing this behaviour are discussed. The proportion of daylight hours the sheep spent grazing was consistently high but with an apparent decline in autumn.

INTRODUCTION

This study on patterns of grazing and the relationships between sheep *(Ovis aries)* behaviour and forage supply on unimproved range was initiated to establish a benchmark for a subsequent study assessing the influence on sheep distribution of partial oversowing and topdressing of the range.

There is little New Zealand-based scientific information on these important management topics. Shepherds and runholders have formed their

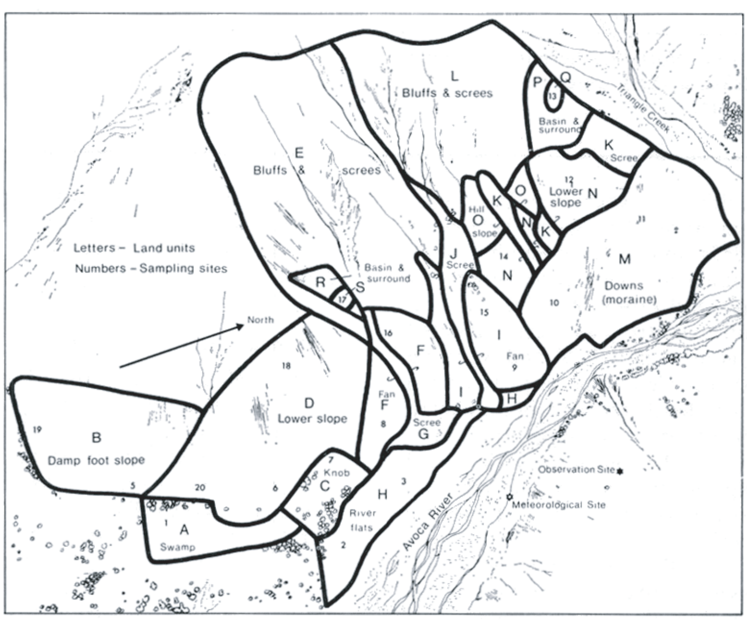

FIGURE 1. *Plan of study area showing boundaries of land units, sampling sites, observation site and meteorological site.*

TABLE 1. *Description of land units: physical characteristics.*

Land Unit		Approx. slope (degrees)	Area (ha)	Soil Sets[1]	Altitude[2] (metres a.s.l.)	Aspect[3]	% Total Area
A	Swamp	2	16.7	Tasman	720		3
B	Damp convex foot slope	20	46.9	Tekoa Hill	740-960	E	8
C	Knob	20	11.9	Cass Hill	720		2
D	Southern lower hill slope	25	66.8	Cass, Tasman and Tekoa Hill	740-1140	E/NE	11
E	Southern rocky bluffs and upper screes	>35	139.9	Spenser steepland, Alpine steepland. Tekoa steepland	920-1800	NE	24
F	Southern fan	20	22.9	Cass, Tasman	720-940	NE	4
G	Southern lower scree	20	9.2	Not known	720-940	NE	2
H	River flats	2	22.7	Tasman stony	720	NE	4
I	Central fan	20	25.2	Cass	740-960	NE	4
J	Central lower scree	20	18.6	Not known	720-1320	NE	3
K	Northern lower scree	35	15.2	Not known	860-1200	NE	3
L	Northern rocky bluffs and upper screes	>35	77.6	Spenser steepland, Alpine steepland, Tekoa steepland	1100-1540	NE	13
M	Northern downs		65.8	Cass	740-860		11
N	Northern lower hill slopes	35	22.9	Tekoa steepland	860-1100	NE	4
0	Northern "Totara" hill slope	35	10.7	Tekoa steepland	960-1200	NE	2
P	Northern basin surround	25	11.3	Tekoa steepland, Spenser steepland	1020-1320	NE	2
Q	Northern basin	25	1.2	Tekoa steepland Spenser steepland	1060-1240	NE	<1
R	Southern basin surround	35	3.8	Tekoa steepland	940-1280	NINE	<1
S	Southern basin	30	1.1	Tekoa steepland	1140	NINE	<1

[1] Information derived from North Canterbury Catchment Board Land Inventory following general survey of soils of South Island, New Zealand (Soil Bureau, 1969).
[2] Estimated to nearest 20 m.
[3] Compass points.

opinions from a wealth of experience but apart from such early observations on sheep behaviour as those of Butler (1863) and Guthrie-Smith (1969), little has been documented. The distribution of grazing or of herbage utilization by livestock on intensively grazed hill country has been reported by Hercus (1961), Kilgour *et al.* (1975) and Suckling (1975). Hughes (1975) recorded some aspects of the distribution of sheep on developed and undeveloped tussock grasslands. Scott (pers. comm., 1978) has been recently studying the effect of localised fertilizers and sowing on the grazing distribution of sheep on flat tussock grassland in the Mackenzie Basin in South Canterbury.

The present study had the following immediate objectives: (I) to assess changes in forage supply and water content during the grazing season on different land units of the study area; (2) to record the grazing distribution of sheep on the study area and to relate this to forage supply; (3) to record diurnal patterns of activity of the sheep and note any changes with time; (4) to monitor the diet of sheep.

DESCRIPTION AND ANALYSIS OF THE STUDY AREA

The 590 ha study area (Fig. 1) constituted part of the 6 200 ha summer range of Glenthorne sheep run in north-western central Canterbury. It comprised the north-eastern slope of The Spurs mountain, morainic downs at its north end, river flats along the Avoca River and a swampy tract at its south end near the base of Mt Fitzwilliam. The area, ranging in altitude from 730 m to 2000 m above sea level, allowed a wide range of terrain types to be observed from a single point across the Avoca River.

The summer climate of the study area is inferred from a single season's observations (Harris, 1978) to be similar to but slightly more humid than that recorded at Lake Coleridge. Precipitation at Glenthorne homestead five kilo metres from the study area averages 1500 mm per annum with a slight spring maximum and summer minimum (N.Z. Met. Service, 1973).

The summer range is regularly used for pastoral purposes. Approximately 3900 mixed-class Halfbred sheep (principally wethers) are released on to it in early October and a further 1900 ewes are added after weaning in mid- to late February. All sheep are mustered off the range early in April. Sheep are able to enter and leave the study area at will because it is not separated from the remainder of the summer range by fences or impassable natural barriers.

Terrain analysis of the study area was carried out after the manner of Christian (1957), using the land inventory data of the North Canterbury Catchment Board, supplemented by field survey of landforms and vegetation. Nineteen land units were recognised, each with a single landform, relatively constant association of soils and assemblage of plant species. Boundaries of these land units are shown in Figure 1, their physical characters being recorded in Table 1.

Nearly half of the study area is very poorly vegetated rocky bluffs, screes and shingle fans. Vegetation remnants associated with higher screes are of *Chionochloa-Celmisia-Poa* communities. Mid-slope screes have marginal remnants of *Chionochloa flavescens* and *Podocarpus nivalis*. The phytosociologic analysis of the vegetated land units (Table 2) was made from 400 m^2 releves chosen as representative of each vegetated land unit. Apart from the seral communities of unstable units (K, G, n, all the mid-slope land units (R, P, O, Q, S) have assemblages of species not greatly different from the snow-tussock-derived Phase *fnz* A of Connor's (1965) analysis of the Middle Rakaia Valley some 20 km further to the south-east. Releves from Q and S, being moist and more fertile, have abundant *Poa caespitosa*. The species' assemblages of lower slope land units (B, N, D) resemble in several respects those of Connor's Phase *fnz* B, but lack such strong evidence of derivation from any snow tussock grassland. Land units on depositional landforms at lower altitude (F, I, M) resemble Connor's Phase *fnz* C which he assumed had replaced a red tussock grassland. Remnants of beech indicate that these fans and moraines may here have been at least in part forested in recent times. A red tussock grassland persists on land unit A, not unlike Phase *cru* B of Connor.

Land unit C has herbaceous elements closely resembling those of other depositional landforms (M, I, F) and has abundant *Nothofagus* remnants such as also characterise the margins of the swampy land unit A and the lower slopes of Mt Fitzwilliam to the south of the study area. The river flats (unit H) are characterised by abundance of the gray moss *Rhaeomitrium lanuginosum* and the absence of many species present in other lower altitude land units. It is inferred that they have not been covered by either beech forest or tall tussock grassland.

There is historical evidence of forest destruction for the purpose of extending pasturage in the Harper-Avoca catchment during European times. The present botanical evidence indicates that most of the present short-tussock grasslands of the study area are not dissimilar to those derived from a suite of talI tussock communities characterised for the region (Connor, 1965), although some of them probably have their origin more recently in beech forest or riverbed fescue tussock grassland.

METHODS OF STUDY

Herbage measurement and analysis

Nineteen 20 m x 20 m plots, the locations of which are illustrated in Figure 1, were used for sampling available inter-tussock herbage on six occasions between mid-November and early April during the 1976/77 season. Seven larger land units were each represented by two or three plots. Four smaller land units each contained one plot. Eight land units which were lacking in homogeneity of herbaceous vegetation were not represented. In each sample plot, representative samples were chosen by determining mean reading with a herbage capacitance meter from 25 systematically spaced subplots and then harvesting the inter-tussock herbage on two 0.2 m^2 areas for which capacitance equalled the mean value of the 25 subplots. Only inter-tussock herbage was sampled because inclusion of tussocks which are but little eaten by sheep (Harris, 1978) would have grossly inflated apparent levels of ADM (available dry matter) and masked changes in dietarily important inter-tussock species. Harvested samples were weighed fresh, oven dried at 80 °C for 24 hours and weighed dry.

On three occasions, digestibility was determined *in vitro* by the method described by Clark (1978), for samples of available inter-tussock herbage from 12 of the 19 plots as well as several samples of selected species.

Sheep behaviour

All observations of sheep were made using

TABLE 2. *Description of land units: Plant species abundance/dominance and ground cover information in representative relevés within each land unit.* (*Key and note at end of table.*)

Species	H	A	C	M	I	F	B	N	D	R	P	O	Q	S	K	G	J	Occurrence
							Land Unit											
Festuca novae-zelandiae	2.2	3.2	3.2	3.2	2.2	3.2	2.2	3.2	3.2	2.2	2.2	1.2	3.2	2.2	2.2	+	+	17
Anthoxanthum odoratum	2.1	1.1	2.1	2.1	3.1	2.1	1.1	2.1	2.1	1.1	1.1	1.3	2.1	1.1	+	+	+	17
Hieracium pilosella	+	1.3	1.3	2.3	1.3	3.4	1.3	2.3	1.3	1.2	1.3	1.3	+	r	r	r	r	17
Crepis capillaris	+	r	r	+	1.1	+	r	+	+	r	r	+	r	r	r	r	r	17
Rumex acetosella	+	r	r	+	+	+	r	+	r	r	+	r	+	r	r	r	r	17
Agrostis tenuis	2.3	2.3	2.1	3.3	2.2	2.1	2.1	2.3	2.1	r		1.3	r	+	r	+	+	16
Acaena caesiiglauca		+	r	r	+	r	+	1.3	+	r	+	r	+	r	+		+	15
Agropyron scabrum			r	(r)	1.1	+	r	+	+	+	+	+	1.1	+	r	+	+	15
Hypochaeris radicata		r	+	+	1.1	+	r	+	+	+	+	+	r	+	r		r	15
Trifolium repens		1.1	+	+	(r)	r	r	+	+	r	r		+	+	+	r	+	15
Wahlenbergia albomarginata	r		r	1.1	1.1	+	r	1.1	r	+	r	r		r	r	r	r	15
Geranium sessiliflorum		r	+	+	+	+		r		+	+	r	+	+	r	+	+	14
Holcus lanatus		+		+	r	r	+	1.1	+	r	+		1.1	+	r	(r)	(r)	14
Poa caespitosa		3.2	r	r	2.2	+	1.2	3.2	1.2				3.2	3.2	+	+	+	13
Cyathodes fraseri	1.1		1.1	1.1	1.3	(r)	1.1	+	+	+	1.1	1.1	+				r	13
Raoulia subsericea			+	1.3	+	+	+	+	+	+	r	+		r	r	r		13
Hydrocotyle novae-zelandiae	r	+	+	+	+		+	+	+	r	r		r	r	+			13
Moss		1.3	1.3	(r)	(r)	r	2.3		+	+		r	+	r		r	r	13
Cerastium vulgaris	r	1.1				+	+	r	+		r	r	r	+	r	r	r	13
Polytrichum juniperinum	1.1	+	r	1.1	1.1	1.1	1.1		+	r	r		r		r			12
Viola cunninghamii	+		+	+	+	+	r	+	+		r			+	r	r		12
Epilobium sp.	(r)				+	+		+		r	+	r	r	+	+	r	+	12
Carex sp.	+	r		+	+	+	+	r	+		r	(r)	r	r				12
Notodanthonia sp.	1.1	1.1	1.1	+	(r)		1.1	r	1.1		+		r		r			11
Muehlenbeckia axillaris	1.3	r			+	r		+				r	r	1.3	+	+	2.4	11
Gnaphalium sp.	+	r	+	1.1				+		r	r	+	r	+	r			11
Blechnum penna marina					+		+	+		+	r	r	r	r	r	+	+	11
Arenaria serpylliflolia			+	r	1.1	r	+	r	+			r	r		r		r	11
Dichelachne crinita				(r)	(r)	+		1.1		r	r	+	r	+	r	(r)		11
Helichrysum filicaule	r		+	+	(r)		+	(r)	+		r	r	r		r			11
Schizeilema haastii	(r)		r	+		r	+	r	r	r	r				r		r	11
Leontodon taraxicoides		r		r		r	r	+		r	r	r	r	r	r			11
Hymenanthera alpina					r	(r)		r		+	+	r		1.1	r	r	r	10
Taraxacum officinale	r	r		+	+				+				r	r	r	r	r	10
Oreomyrrhis colensoi	+		r	+	r	r	r	r	+					r				9
Poa colensoi	2.2			2.2				+		2.2	2.2	1.2	2.2	r				8
Trifolium dubium	+	r	r			r	r	r								r	+	8
Discaria toumatou	r				r						1.1	2.1	1.1		r	r		7
Celmisia spectabilis				r						+	r	1.2	r	r			(r)	7
Scleranthus uniflorus				+	r	+	r	r	r			r						7

Table 2. continued:

Acaena inermis							2.3	r					1.3	r		+	+	6
Acaena sp.		1.1	+				1.3	(r)			r			r				6
Pteridium aquilinum var *esculentum*						+	+	1.1				r		1.1	+			6
Pimelea oreophylla	+				+		+	+			+		r					6
Anisotome spp.	r	r					+		+		r		r					6
Cirsium sp.		+					+						r	r	r	r		6
Linum cartharticum			+		r	r	1.1		+									5
Poa traversii	r					(r)	+		r		r							5
Notodanthonia setifolia				r						+	r	r			r			5
Verbascum sp.										r			r		r	r	+	5
Luzula rufa			r					r	r		r		r					5
Coprosma petriei	1.3				+	r											r	4
Cyathodes colensoi										r	r	+	r					4
Angelica sp.			r		r				r		r							4
Polystichum vestitum										r				r		r	r	4
Rhacomitrium lanuginosum	3.4			+	1.3													3
Pimelea prostrata				2.3				+					+					3
Gnaphalium collinum						+	+		+									3
Ranunculus hirtus				+			r	r										3
Ranunculus lappaceus			r						+				r					3
Raoulia spp.	(r)				r		+											3
Aciphylla sp.										r	r	r						3
Corokia cotoneaster								r				r			r			3
Langenophora cuneata				r				r					r					3
Mysotis sp.	r							r				r						3
Senecio bellidiodes	r										r		r					3
Podocarpus nivalis										r		3.3						2
Juncus sp.							1.2					r						2
Chionochloa rubra		4.5																1
Ground cover (%)																		
Bare soil	5	0	1	10	15	5	10	10	1	5	1	5	1	0	10	1	1	
Rock and rubble	10	1	0	20	20	10	10	20	1	25	5	1	1	5	40	90	85	
Litter	10	1	5	10	10	5	1	10	1	5	1	5	1	5	5	1	1	
Vegetation	75	98	94	60	55	80	79	60	97	65	93	89	97	90	45	8	13	

Key:
- r = of erratic occurrence
- \+ = sparsely or very sparsely present, cover very small
- 1 = plentiful but of small cover value
- 2 = very numerous or covering at least 1/20 of the area
- 3 = any number of individuals covering ¼ to ½ of the area
- 4 = any number of individuals covering ½ to ¾ of the area
- .1 = growing one in a place, singly
- .2 = grouped or tufted
- .3 = in troops, small patches or cushions
- .4 = in small colonies, extensive patches or forming carpets
- .5 = in great crowds
- ( ) = occurred outside sampling area but within land unit

Note: (1) Except for *Podocarpus nivalis* (land units R and O), *Juncus* sp (land units B and O) and *Chionochloa rubra* (land unit A) only those species appearing in three or more relevés are listed.

(2) The two land units consisting of higher altitude rocky bluffs and screes (E and L) were not sampled. They are mainly of exposed rock with small patches of tall tussock associations.

16 x 50 binoculars, from a site across the valley from the study area and 150 m above the valley floor. Sheep distribution was recorded at hourly intervals during daylight for a twenty-four-hour period, beginning midday, between eight and ten times during each of the 1974/75, 1975/76 and 1976/77 seasons. A gridded photographic panorama of the study area was used for recording grazing distribution, sheep positions being identified on the panorama and the grid co-ordinates recorded. Average numbers recorded in each grid unit during each day and average numbers within land units were computed from the grid summaries.

Sheep activities were recorded during the 1976/77 season only. A group of between 30 and 50 sheep easily viewed from the observation point were selected and their activities recorded every ten minutes. The activities were grazing, walking (except when grazing), standing (except when grazing), and lying. Data for each of these activities were converted to percentages of total sheep observed at each observation.

Diet analysis

Diet of the sheep was analysed qualitatively using the faecal plant cuticle technique described by Stevens (1977). Fresh faecal samples were collected on five occasions during the grazing season. Results are presented in terms of percentage botanical composition from a set of no less than two hundred positive cuticle identifications per faecal sample.

Grazing pressure

Grazing pressure was calculated as the ratio of stock units to available herbage at a particular time (Kothmann, 1974). For the six dates at which herbage supply was measured for eleven land units, numbers of stock units on each of these land units were estimated by interpolation from the sheep

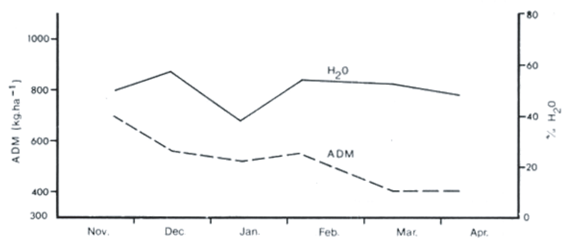

FIGURE 2. *Changes in available dry matter and herbage water content within the study area during the 1976/77 season.*

TABLE 3. *Levels of available dry matter (kg.ha^{-1}) and percentage water content of vegetation per land unit on six dates during the 1976/77 season.*

Land Unit	22 / 11 / 76 ADM	22 / 11 / 76 H_2O	14 / 12 / 76 ADM	14 / 12 / 76 H_2O	12 / 1 / 77 ADM	12 / 1 / 77 H_2O	5 / 2 / 77 ADM	5 / 2 / 77 H_2O	11 / 3 / 77 ADM	11 / 3 / 77 H_2O	7 / 4 / 77 ADM	7 / 4 / 77 H_2O	Average ADM	Average H_2O
A	380	73	370	69	410	62	190	64	210	67	60	63	270	66.3
B	540	51	535	63	600	44	495	56	440	58	305	52	486	54.0
C	450	58	430	62	350	45	480	59	250	61	170	49	355	55.7
D	820	55	665	62	450	41	600	57	420	52	350	51	551	53.0
F	315	57	1090	61	475	51	405	59	365	55	230	49	480	55.3
H	700	36	590	41	580	23	720	42	685	36	495	44	628	37.0
I	240	53	500	55	370	38	475	56	270	54	405	45	377	50.2
M	1025	41	360	48	565	25	540	49	335	47	660	42	581	42.0
N	930	38	570	54	700	30	855	48	540	55	395	49	665	45.7
Q	1200	58	1690	70	1530	55	1760	63	1200	60	1890	63	1545	61.5
S	1220	45	1750	56	2240	49	2060	64	2650	47	3200	45	2187	51.0

TABLE 4. *Digestibilities (per cent) of available dry matter samples from twelve selected sites on three sampling dates.*

Sampling site	Land unit	14/12/76	2/2/77	7/4/77
1	A	71.5	55.6	52.6
5	B	62.0	42.9	45.1
19	B	56.9	48.5	45.5
7	C	61.9	51.7	42.9
6	D	63.0	46.8	46.0
18	D	48.4	48.4	46.6
20	D	59.3	62.5	41.8
8	F	61.9	54.4	45.4
16	F	48.8	56.3	54.0
10	M	54.1	50.6	40.1
12	N	57.3	54.6	38.9
17	S	55.6	54.1	41.4
Average		58.4	52.2	45.0

densities recorded. One sheep was assumed to equal 0.8 stock units.

RESULTS

Availability and quality of herbage and composition of sheep diet

Between late November and early April of the 1976/77 season the calculated available herbage on the well vegetated portion of the study area declined fairly steadily from 700 kg.ha^{-1} ADM to 410 kg.ha^{-1} (Fig. 2). Moisture content remained at about 50 per cent except for a marked drop from mid-December to mid-January (Fig. 2). Individual land units showed some variations from these common trends (Table 3). The small basins at mid slope (Q, S) generally maintained or increased ADM as the season progressed. Water content of available herbage in the swamp site (A) remained consistently high throughout the season. Digestibility of available inter-tussock herbage generally declined from December to April (Table 4).

Overall, *Anthoxanthum odoratum* and *Trifolium* spp. each accounted for an average of 21 per cent of the cuticle fragments recovered in the faeces (Table 5), while other species each accounted for no more than 8 per cent on average (Harris, 1978). Diet composition remained similar over the five collection dates except for an approximate 20 per cent reduction in grass fragments after the first (mid-December) collection. More than a quarter of this reduction is accounted for by a corresponding increase in clover. The digestibility of *Trifolium* spp. remained high during the grazing season. *Anthoxanthum odoratum,* which was the most abundant inter-tussock grass in the study area as a whole, showed a marked decline in digestibility from mid-December to early February and an even more marked recovery by early April, in contrast to the continual decrease in digestibilty of the grasses as a whole (Table 5). Bulk samples of inter-

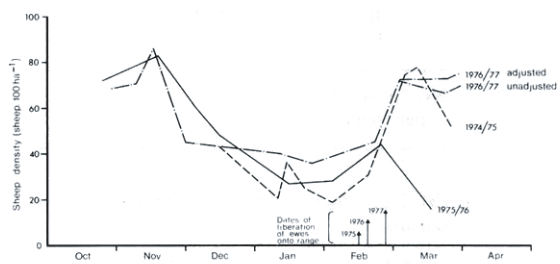

FIGURE 3. *Changes in sheep density on the study area during the 1974/75, 1975/76, and 1976/77 seasons. (Explanation of 1976/77 adjustment in text).*

TABLE 5. *Botanical composition of the diet (per cent of identified cuticle) and the percentage dry matter digestibility (in parentheses) of some dietary components.*

	13/12/76		12/1/77	1/2/77		9/3/77	5/4/77	
Grasses								
Anthoxanthum odoratum	21	(65)	19	21	(54)	21	23	(72)
Agrostis tenuis	12		11	7		6	6	
Notodanthonia sp.	9		6	9		4	6	
Sub-total grasses	76	(75)	57	58	(70)	47	58	(64)
Other herbs								
Trifolium spp.	14	(81)	23	21	(79)	25	21	(80)
Sub-total other herbs	22		42	35		44	35	
Unknown	2		1	7		9	7	

TABLE 6 (a). *Average sheep density (sheep.100 ha^{-1}) within each land unit for each of the* 1974/75, 1975/76 *and* 1976/77 *seasons. Ranks of sheep densities for each season are also shown.*

	(I) 1974/75		(II) 1975/76		(III) 1976/77	
Land Unit	Sheep Density	Rank	Sheep Density	Rank	Sheep Density	Rank
A	148	3	148	4	210	3
B	63	8	70	7	67	12
C	136	4	154	3	249	2
D	62	9	62	9.5	77	10
E	2	19	1	19	2	18.5
F	44	12	76	6	84	9
G	25	13	33	13	49	13
H	157	2	186	2	206	4
I	93	6	114	5	111	6
J	13	16	17	15	20	16
K	10	17	8	17	18	17
L	4	18	3	18	2	18.5
M	49	10	62	9.5	109	7.5
N	48	11	59	11.5	74	11
0	17	14	11	16	26	14
P	15	15	19	14	25	15
Q	167	1	293	1	333	1
R	102	5	59	11.5	118	5
S	81	7	68	8	109	7.5
No. observations per season	9		8		10	

(b). *The degree of concordance of ranks of sheep densities per land unit between paired seasons.*

Pairs of seasons	1 & II	II & III	I & III
Spearman's Rank Correlation Coefficient	0.92**	0.92**	0.96**

* * significant at 1 % level.

tussock herbage showed lower digestibility including as they did both senescent and dead material (Table 4).

Sheep distribution

Highest average sheep densities (264 to 169 sheep.l00ha^{-1}) for the 1974/75, 1975/76, 1976/77 seasons were recorded in the northern basin (Q), river flats (H), knob (C), and swamp (A). Lowest densities (2 to 12 sheep. 100 ha^{-1}) occurred in the higher altitude rocky bluffs and screes (E, L) and the northern lower screes (K) (Table 6a). Similarity of average sheep distribution between seasons is shown by a significant concordance (p = 0.01) between ranked sheep densities for pairs of seasons (Table 6b).

Changes in overall sheep density on the study area as each season progressed followed a similar V-shaped pattern up to March (Fig. 3). From their release on to the summer range in mid-October, sheep increased in density on the study area for approximately four weeks, then declined to a minimum in late January or early February. A general increase in sheep density followed. The date of liberation of ewes after weaning on to the summer range is shown for each year on Figure 3.

Decline in densities during March may be more apparent in Figure 3 than is real. Difficulty in observing sheep resting about midday led to an adjustment in 1976/77 season, for the sake of grazing pressure calculations, by omitting midday data for late March and early April.

Changes in sheep densities over time on individual land units differ somewhat between grazing seasons (Harris, 1978) and show some variations from the changes described for the study area as a whole.

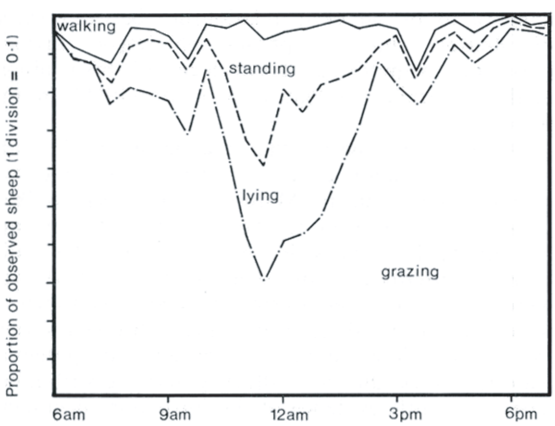

FIGURE 4. *Average daily activity pattern during the 1976/77 season.*

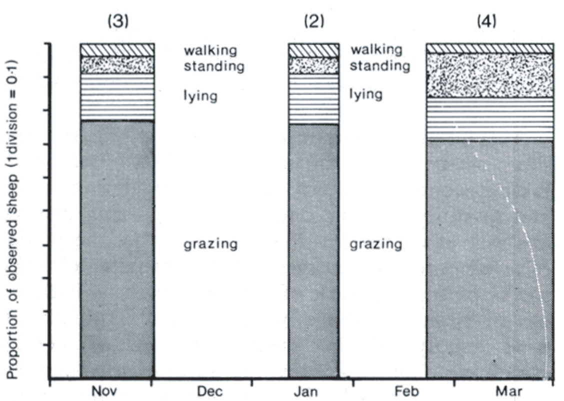

FIGURE 5. *Average proportions of time (7.40 a.m. to 7.00 p.m.) the sheep spent grazing, lying, standing and walking during three periods of the 1976/77 season. (Figures in parentheses show number of composite observation days in each period).*

TABLE 7. *Average index of grazing pressure for each land unit for the* 1976/77 *season.*

Land unit	Average Index of Grazing Pressure.	Range
A	11.0	1.1-42.7
B	1.3	0.3-2.9
C	7.1	1.9-18.8
D	1.1	0.4-2.1
F	1.9	0.3-3.7
H	2.1	0.8-3.2
I	2.1	1.0-3.0
M	1.6	0.8-2.2
N	1.0	0.2-1.9
Q	2.1	0.8-3.3
S	0.5	0.0-1.6

(n = 6)

$$\text{* Index of grazing pressure} = \frac{\text{Stock Units .ha}^{-1}}{\text{tonnes Available Dry Matter .ha}^{-1}}$$

Sheep activities

Averaged daily activity patterns (Fig. 4) revealed the percentage of sheep grazing decreased considerably between 10.00 a.m. and 2.00 p.m. effectively dividing the day into two major grazing periods. The percentage of sheep lying and standing increased during the midday period whereas the proportion walking remained consistently low. Over the 1976/77 season as a whole, sheep spent about 73 per cent of the day (7.40 a.m. to 7.00 p.m.) grazing, 14 per cent lying, 9 per cent standing and 4 per cent walking. The proportion of time spent grazing decreased slightly as the season advanced. Late in the season time spent standing increased at the expense of other activities (Fig. 5).

Grazing pressure

Calculated grazing pressures for the 1976/77 season (Table 7) show that the swamp (A) and knob (C) have highest mean values. From November 1976, grazing pressure for the study area as a whole (Fig. 6) tended to decrease slightly until mid-January and then increased to reach its highest level in early April. Changes in grazing pressure within individual land units varied considerably from that described by the whole study area (Fig. 6). Especially noteworthy are the six-fold and forty-fold increases in values for the knob (C) and swamp (A) respectively from mid-January to autumn.

DISCUSSION

The similarity among the three seasons observed of both the overall trends in sheep density and the mean sheep densities for individual land units indicates that sheep distribution over the study area was not random. Average sheep densities were generally highest in those well vegetated land units containing areas occasionally fed with flushes from higher ground (land units Q, A, C, S) or of most recent deposition (land unit H). Moderate densities were recorded on the low to medium altitude vegetated slopes and morainic downs (land units I, M, F, D, B, N) and low densities in the higher altitude vegetated land units P and 0 along with the poorly vegetated land units of screes and rocky outcrops (G, J, K, L, E).

The inclusion of data for ADM in grazing pressure analysis for the 1976/77 season revealed

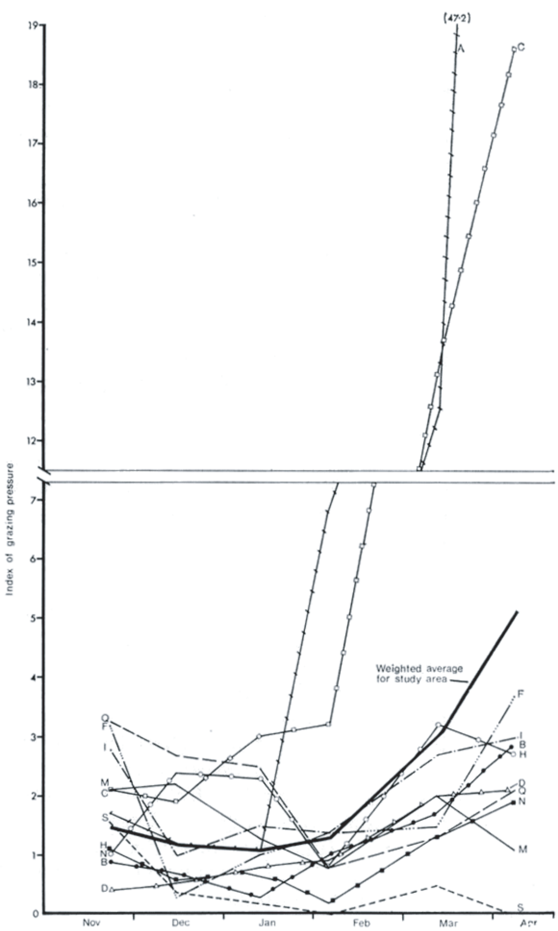

FIGURE 6. *Changes* in *grazing pressure with time per land unit, and* in *the study area as a whole (heavy line). during the 1976/77 season.*

that grazing pressure *on* all well-vegetated land units with the exception of A and C fluctuated from 0 to 3 stock units per tonne ADM. Despite high sheep densities, the high basins (Q, S) declined in grazing pressure to low or moderate levels. ADM was not measured on their surrounds (P, R) but estimates of ADM indicated that overall grazing pressures on such terrain remained within the 0 to 3 range. ADM was not measured within the area of higher altitude rocky bluffs and screes (E, L) but if the few sheep observed there were grazing the isolated plants and patches of herbage, such vegetation might well be subject to local high grazing pressures.

The non-random, dynamic distribution of the sheep cannot be attributed to any single factor. There appears to be no clear relationship between sheep distribution and the phases of fescue tussock grassland as perceived from local phytosociologic analyses parallel to that of Connor (1965) in the middle Rakaia.

Observations suggest that the presence of shade had only a minor effect *on* overall grazing distribution except during March, when sheep walked considerable distances to the trees near the swamp and knob. It is possible, however, that the daily grazing patterns of some sheep were such that they were near the trees during midday. Although a watch was kept, sheep were never observed watering, so it is inferred that the presence of potential watering sites did not affect grazing distribution. There was little evidence of the formation of grazing bands and associated home ranges which tend to affect grazing patterns.

Movement of sheep between the study area and the rest of the summer range was found to be inversely related to calculated changes in soil moisture (Harris, 1978) for the 1974/75 season. A clear relationship was not, however, supported for the next two seasons.

A synthesis is proposed to explain the dynamic sheep distribution during the 1976/77 season by taking account of sheep activities, vegetation quality and quantity, dietary data and the grazing pressure analysis available for that season. The sheep were released onto the summer range approximately eight weeks before the peak of spring growth as indicated by maximum herbage water content. Initially the food supply of the sheep consisted of herbage remaining from the previous autumn together with early spring growth. For the following four weeks as spring herbage growth rates increased, sheep moved on to the study area. Subsequently different species, especially grasses and in particular the dietarily important *Anthoxanthum odoratum,* progressively flowered. This phase, from spring to mid-summer, is characterised by a reduction in digestibility and water content of the herbage. Levels of available dry matter diminished and some of the sheep moved from the study area. Diminishing supplies of higher quality feed on the sunny study area during mid-summer would be matched with more attractive feed regimes on the shady parts of the summer range where lower soil and air temperatures delay the spring peak of herbage production and slow the decline in summer herbage quality.

After mid-summer, renewed vegetative growth following maturation of seed heads may occur in the early flowering *Anthoxanthum odoratum* if favoured by adequate soil moisture. Evidence of this phase is a slight increase in ADM, increased water content of available herbage and overall increased digestibility of a number of species. *Anthoxanthum odoratum* is again notable. The liberation of additional sheep on to the range in February confuses interpretation of sheep movement during this autumn period. Although data are inconclusive, sheep movement on to the study area after mid-January may have been initiated before additional sheep were released on to the range (late February), indicating that once again sheep responded to changes in herbage condition.

The outstanding feature of the mid-summer to autumn phase is that while overall available dry matter was reduced by the increased sheep population, most of the resultant increase in grazing pressure was concentrated in two land units, the swamp (A) and knob (C). Specific reasons for this increased relative preference are unclear. A pronounced midday sheltering behaviour beneath the trees of the swamp and knob contributed to this phenomenon, but only during late March. The possibility exists of grazing induction of more attractive sward conditions on such areas, after the manner discussed by Nicholson (1974) and Hunter (1962). Higher utilization of herbage in the swamp, as indicated by lower levels of available dry matter, is likely to have reduced the amount of standing dead material relative to most other land units, thus increasing its attractiveness, especially after mid-summer. In addition, the swamp has the highest abundance of clovers, a major diet component less affected by senescence than other main dietary species. Water content and digestibility of available dry matter samples from the swamp were consistently amongst the highest for the study area, but give little indication of increased attractiveness from approximately mid-January. Overall, cuticle fragments recovered in the faeces indicated that qualitatively the diet remained similar despite considerable changes in grazing pressure and differences in the phenology of the dietary species. *Anthoxanthum odoratum* and *Trifolium* spp. were consistently the most abundant species, together accounting for, on average, 42 per cent of cuticle fragments.

The proportion of time spent grazing between 7.40 a.m. and 7.00 p.m. remained high during the grazing season but showed a slight decrease during late February and March. This decrease became pronounced after the March equinox, when midday sheltering was observed to occur despite the potential of higher grazing pressure to increase grazing time. Grubb and Jewell (1974), observing feral sheep *(Ovis aries),* suggested that changes in photoperiod may affect grazing times and noted that between late summer and mid-winter grazing activity became more restricted to times other than the middle of the day. Their sheep spent more time lying during the period about the autumn equinox than during the period about the spring equinox.

Results of this study show that domestic sheep 0:1 range may show seasonal changes in grazing distribution similar to those described for feral sheep by Grubb and Jewell (1974), and for wild sheep *(Ovis canadensis)* by Geist (1971) and support the suggestions of many overseas studies (e.g. Hunter, 1954; Hughes *et al.,* 1975; Griffiths, 1962; and Milner and Gwynne, 1974) that better quality herbage has a powerful influence on grazing distribution. The ability of sheep to exploit site variability in herbage growth patterns on range warrants further study.

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