Changes in tussock grasslands, South Island high country, 1973-93

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PART 2: CHANGES IN THE TUSSOCK GRASSLANDS OF THE CENTRAL WAIMAKARIRI RIVER BASIN, 1980-93

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Trends in tussock grasslands, South Island high country: eastern Waitaki steeplands, 1973-93

Abstract

In 1993, plant species frequency counts, and stereo-photographic pairs of vertical photographs (each covering about 1.8 m2 of ground) and oblique landscape photographs, were repeated along two transects in tussock grasslands in the Waitaki basin. The transects were established and surveyed in 1973-74 as part of a wider network representative of the dry, eastern steeplands of the Waitaki basin. There was little overall difference in the overall proportion of living vegetative cover in 1973 and 1993. There was less litter and more local areas of bare soil in 1993. The lower altitude, montane to subalpine, short tussock grasslands on sunny slopes had a different appearance in 1993 compared with 1973-74. Short tussock species (hard, blue, and silver tussock) declined in numbers, frequency, and cover. The vegetation had become characterised low lower-growing herbaceous species. The number of recorded species was 39 in 1974 but only 30 in 1993. There was a large increase in mouse-ear hawkweed *(Hieracium pilosella).* Hawkweed increased from being sparse and patchy in 1974 to contributing between 5% and 50% of ground cover in 1993. It had established on both bare ground and on previously vegetated areas. Retention of the dominant tall tussocks *(Chionochloa rigida)* helped to preserve the visual appearance of the higher altitude, subalpine and alpine tall tussock grasslands. The minor short tussock species, Matthew's and blue tussocks, declined. The total number of recorded species in the tall tussock grasslands was 22 in both years. There was good agreement about vegetative cover change based on frequency data and on cover estimates derived from the ground-based vertical photographs. Photographic records are an effective medium for assessing vegetation change where the aim is to assess the general cover or the visually dominant species. Historic plots such as those visited in this study form a valuable baseline for assessing recent vegetation change.

1. Introduction

Monitoring vegetation is a vital part of ecosystem management to provide benchmarks for assessing change and to measure attainment of management objectives. In 1973-74, the Ministry of Works and Development established a

network of 222 permanently-marked plots in the extensively grazed montane to alpine tussock grasslands in the steeplands east of the Waitaki basin, South Canterbury (Appendix 1). The objective was to describe the species composition and ground cover and to establish baseline sites for monitoring future trends, especially those associated with grazing. Few sites have been resurveyed.

In 1993 the Department of Conservation commissioned Landcare Research to resurvey six of the original plots to provide information about the changes in the conservation status of the tussock grasslands, including the extent of tussock cover and the impacts of hieracium *(Hieracium* spp.*)*. The 1973-74 survey provided a baseline which predated the peak rabbit populations in the late 1980s and the major spread of Hieracium which appears to have occurred after the mid 1970s (Connor 1992). Associated objectives were to comment on the future potential of the these plots for monitoring vegetation change and associated conservation values in the upper Waitaki steeplands, and the effectiveness of the photographic plot monitoring method.

2. Objective

To determine temporal changes in species composition in ground cover in representative tussock grassland areas by resurveying six permanent plots (established in 1973) in the dry steeplands east of the Waitaki basin, and to comment on the future potential of these plots for monitoring vegetation change and associated conservation values, and the effectiveness of the photographic plot monitoring method.

3. Site description

The study area is approximately 35 km SE of Twizel. It lies in the Grampians Ecological District which encompasses much of the dry hill and mountain ranges to the south-east of the Waitaki basin (Fig. 1). The landscape comprises dissected hills and mountains with steep slopes, based on Torlesse sandstones and siltstones. The area receives from 400 to 750 mm annual rainfall with severe summer drought conditions, especially at lower altitudes and on northerly aspects. Fescue, silver and blue tussocks which previously characterised the montane, short tussock grasslands (below about 950 m), have low abundance and there is much bare ground and low herbfield comprising species such as sheep's sorrel, haresfoot trefoil and annual grasses. Shrubby species include matagouri, *Olearia* spp. and sweet brier. The soils are Omarama steepland, shallow, stony recent soils. These grasslands are represented in this study by three plots: Rosses 4/1, 4/2, 4/3 (Table 1, Fig. 2).

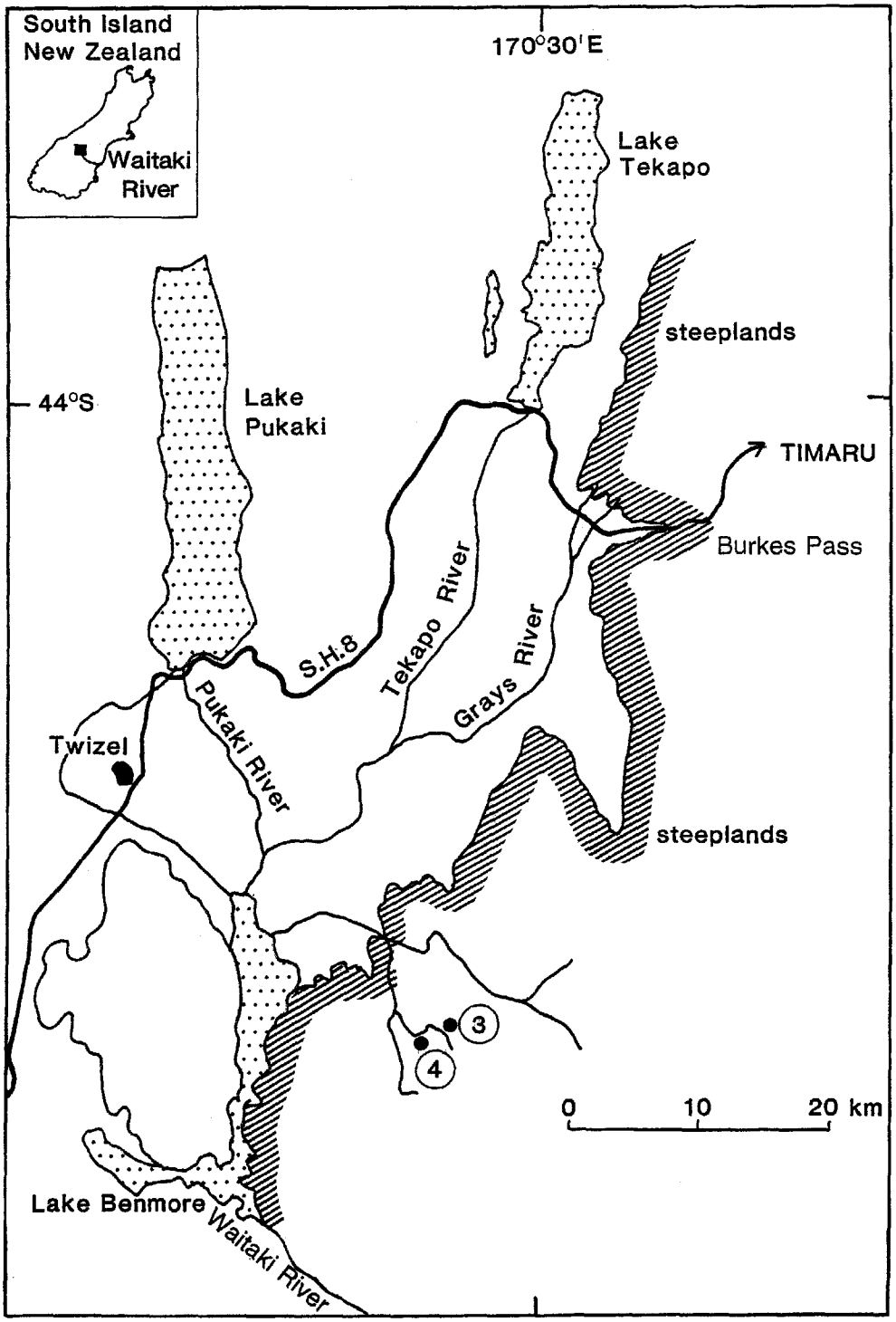

FIGURE 1. THE LOCATION OF THE SURVEYED SHORT TUSSOCK (4) AND TALL TUSSOCK GRASSLAND (3) IN THE STEEPLANDS SOUTH EAST OF THE WAITAKI BASIN, SOUTH CANTERBURY. HATCHES INDICATE THE FRINGE OF THE STEEPLAND LANDSCAPE,

TABLE 1. SUMMARY OF FEATURES OF THE SIX GRASSLAND PLOTS.

PLOT NAME	GRID REFERENCE	ALTITUDE(m)	ASPECT	SLOPE (°)	VEGETATION
Rosses 3/1	NZMS1: 5109/036457	1110	Sw	28	Tall tussock grassland (*C. rigida*)
Rosses 3/2	NZMS1: 5109/038458	1210	Sw	35	Tall tussock grassland (*C. rigida*)
Rosses 3/3	NZMS1: S 109/040459	1310	SW	28	Tall tussock grassland (*C. rigida*)
Rosses 4/1	NZMS1: 5109/026449	860	N	25	Sparse Hieracium herbfield and short tussock grassland
Rosses 4/2	NZMS1: 5109/023445	960	NE	27	Short tussock grassland and Hieracium
Rosses 4/3	NZMS1: 5109/022444	1060	NE	28	Sparse short tussock grassland

Above 950 m, the subalpine and alpine tall tussock grasslands have a prominent canopy of narrow-leaved and slim snow tussocks, although many former areas of tall tussock have changed to short tussock and exotic invaders, especially hieracium. There are also extensive areas with much inter-tussock bare soil, as well as of natural areas of unvegetated alpine screes. The soils are Benmore steepland, brown soils. These grasslands are represented in this study by three plots: Rosses 3/1, 3/2, 3/3 (Table 1).

The area is extensively grazed by sheep (see discussion).

4. Methods

Two hundred and twenty two plots located on 80 randomly-sited transects were positioned and surveyed in summer 1973-74, as being broadly representative of montane to alpine tussock grasslands in the steeplands to the east of the Waitaki basin (Appendix 1). The permanently-marked 20 x 20 m plots were located at approximately 100 m vertical intervals along the transects which extended upslope from valley floor to ridge crest. Six plots on two transects in the catchment of Ross Stream east of Lake Benmore were resurveyed in March

FIGURE 2. THE LOCATION OF SHORT TUSSOCK GRASSLAND PLOTS ON A WARM, SUNNY ASPECT HILL SLOPE IN THE CATCHMENT OF ROSS STREAM.

FIGURE 3. PHOTOGRAPHING GROUND COVER AT A PHOTOCENTRE IN THE SHORT TUSSOCK GRASSLAND AT PLOT 411

1993 (Fig. 1). They were chosen because they were located within a belt transect selected for soils and land use research undertaken by Landcare Research. The following information was collected in both sampling years using methods specified in Allen et al. 1983 (updated in Wiser and Rose, 1997):

- frequencies of plant species,
- ground cover type (living vegetation, litter, bare ground),
- stereoscopic vertical 35 mm colour transparency photographs of about 1.8 m 2 of ground area at eight photocentres, for estimating cover contributed by ground cover classes, species groups and tussock counts. (Fig. 3),
- landscape photographs.

Plot photographs were analysed as follows: One image from each photocentre for each year was projected side by side. Using standard % cover cards, each ground cover category (total living vegetation, litter, bare soil, rock/gravel, and species groups (short tussock, tall tussock, hieracium, sheep's sorrel, scabweed, catsear)) was allocated to a % cover class (not seen, <5%, 5-25%, 25-50%, 50-75%, 75-100%). For each 1993 image, each ground cover category was also visually judged to contribute more, less, or the same % cover as that in 1973. The number of individual tall and short tussock plants was counted. The different timing of the two surveys (late November in 1973 and early March in 1993), related to delayed access to the original plot data, has introduced the uncertainty of seasonal effects in the results for some species.

5. Results

5.1 SHORT TUSSOCK GRASSLANDS

5.1.1 Ground cover

In 1973 and 1993, the grassland plots typically comprised from 5 to 75% living vegetation, with abundant bare soil, gravels and rock (Table 2; Appendix 2: Plates 1, 2, 5-10). The overall extent of vegetative cover remained relatively stable through to 1993, although there were local areas where it increased and decreased (Tables 2, 3). Visual assessment of photographs show the decline in litter and associated increase in bare ground is strongly related to the decay of scabweed cushions.

5.1.2 Species composition

Hard, blue and silver `short' tussocks declined in number of individuals (by about 38%), % cover (from a typical cover of 5-25% to <5%) and frequency (Tables 4, 5, 6; Appendix 2: Plates 1, 2, 5, 6, 7, 9).

Cover of scabweed cushions declined, from being observed on 19 out of the 24 photocentres in 1973 at cover values up to 25% to only 6 in 1993 (all at <5% cover) (Table 5, Appendix 2: Plates 5, 8, 9, 10). Frequency data confirmed the trend (Table 6). Sheep's sorrel, although usually contributing <5% cover, had a high frequency in 1973, but decreased through to 1993. Catsear (grouped in the

TABLE 2. CHANGES IN % COVER CLASSES FOR GROUND COVER CATEGORIES FROM 1973 TO 1993, BASED ON EYE ESTIMATES FOR PHOTOCENTRES (N= 24 FOR SHORT AND N=22 FOR TALL TUSSOCK).

	NUMBER OF PHOTOCENTRES									
COVER	LIVING			LITTER			SOIL			ROCK/GRAVEL	
CLASS	VEGETATION										
year	1973	1993		1973	1993		1973	1993		1973	1993
Short tussock grassland (plots 2/1, 4/2, 4/3)											
nil	0	0		0	0		0	0		0	0
0	0	0		17	22		4	4		11	9
5-25	6	6		6	2		15	12		9	11
25-50	12	10		0	0		5	8		1	2
50-75	5	7		1	0		0	0		3	2
75-100	1	1		0	0		0	0		0	0
Tall tussock grassland (Plots 3/1, 3/2, 3/3)											
nil	2	2		1	1		11	10		2	2
<5	1	1		7	12		2	4		7	7
5-25	4	3		11	7		7	5		6	6
25-50	9	7		2	1		1	2		3	3
50-75	3	6		1	1		0	0		1	1
75-100	3	3		0	0		1	1		3	3

TABLE 3 TRENDS IN GROUND COVER FROM 1973 TO 1993, BASED ON VISUAL COMPARISON OF PHOTOCENTRES. COUNTS INCLUDE CHANGES FROM ONE COVER CLASS TO ANOTHER AND CHANGES WITHIN ONE COVER CLASS (N=24 FOR SHORT, N=22 FOR TALL TUSSOCK).

	NUMBER OF PHOTOCENTRES SHOWING CHANGE		
COVER CATEGORY	INCREASE	DECREASE	NO CHANGE
Short tussock grassland			
Living vegetation	6	6	12
Litter	0	9	15
Soil	10	2	12
Rock/gravel	3	2	19
Tall tussock grassland			
Living vegetation	6	1	15
Litter	0	7	15
Soil	3	1	18
Rock/gravel	1	1	20

photocentre data with minor amounts of native dandelion and *Crepis capillaris*, which could not be distinguished) was identified on every photocentre in 1973 at cover values of up to 5-25%. In 1993 it was identified on only 20% of the photocentres, with cover never exceeding 5%. Species frequency data confirms this decline (Table 6).

Other species which have decreased since 1973 included the grasses *Notodantbonia* sp., *Bromus mollis, B. tectorum*, blue wheat grass and herbs native dandelion, *Myosotis* sp, *Wahlenbergia albomarginata, Luzula rufa, Geranium sessiliflorum* (Table 6). Total recorded species numbers declined from 39 to 30.

A hieracium - mouse-ear hawkweed - showed the greatest increase. From being only sparsely present in 1973 it had increased to a more regular cover in the range of 5-50% by 1993 (Appendix 2: Plates 5-10). Its failure to establish a more complete cover was probably due to drought stress. Another hieracium - king devil - remained stable at very low cover levels. Sweet vernal, and to a lesser degree, white clover, also increased on the most well-vegetated plot.

5.2 TALL TUSSOCK GRASSLANDS

5.2.1 Ground cover

Setting aside the four photocentres which comprise unvegetated, stable, coarse rockfield, the tall tussock grassland plots typically comprised from 25-100% vegetative cover with variable amounts of litter and bare ground (Table 2, Appendix 2: Plates 11-15). A decline in litter and local increases in vegetative cover, especially at sites already well-vegetated in 1973, are the main trends (Tables 2, 3).

5.2.2 Species composition

Numbers, cover and frequency of narrow-leaved snow tussock (the tall tussock) remained stable over time. The short Matthew's and blue tussocks declined in number (by about 18%), % cover and frequency (Tables 4, 5, 6, Appendix 2: Plate 13).

In 1973, mouse-ear hawkweed and king devil were recorded at very low levels in the photocentres, but at higher levels in the species frequency data, probably because the individual or small rosettes which characterised the species at that time were too small to be resolved in the images, or were hidden by taller vegetation, especially tussocks. Both sets of data show the increase in both species to 1993, with their cover ranging up to 5-25% (Tables 5, 6).

Sheep's sorrel was widespread in 1973 but declined in cover and frequency through to 1993 (Tables 5, 6). Variable frequency data for minor indigenous species including *Wablenbergia albomarginata, Celmisia gracilenta, Luzula rufa* and *Carex* spp. show no significant or consistent trends. The total number of species recorded remained stable at 22.

TABLE 4. TRENDS IN THE NUMBER OF TUSSOCK PLANTS, BASED ON TUSSOCK COUNTS IN PHOTOCENTRES.

TUSSOCK TYPE	PLOT NUMBER	MEAN NO. TUSSOCKS PER PHOTOCENTRE		SIGNIFICANCE
		1973	1993	
Short tussocks (blue, Matthews's tussocks)	3/1	1.73	1.25	NS
	3/2	3.25	2.63	'
	3/3	5.33	4.5	NS
(Blue, silver, hard tussocks, Poa spp.)	4/1	4.63	1.63	**
	4/2	7.63	6.5	**
	4/3	11.0	6.75	
Tall tussocks (narrow-leaved snow tussock)	3/1	0.75	0.88	NS
	3/2	0.75	0.88	NS
	3/3	1.33	1.33	NS

(Significance using students T test; NS not significant, * P < 0.1, ** P < 0.05 ***P < 0.01)

6. Conclusions

Vegetation changes identified in this study are consistent with those previously documented for the area (e.g., Connor (1992); Treskonova (1989)). This survey provides information on vegetation cover for the mid 1970s period, considered by Connor to be critical to the understanding of the recent decline in the tussock grasslands.

6.1 TRENDS IN HIERACIUM

Mouse-ear hawkweed increased on 87% of the short tussock plot photocentres from 1973 to 1993. Most of the observed spread was into bare ground, with about one quarter of the spread into pre-existing grass and herb vegetation. Where it established into pre-existing vegetation, species such as fescue tussock, `catsear' and other small herbs were displaced. Sheep's sorrel was displaced by its spread into bare ground. The relative importance of establishment of new hieracium plants from seed and from vegetative spread, and their initial establishment into bare ground or amongst other vegetation, in determining the overall pattern of distribution, is unclear.

In 1973, mouse-ear hawkweed tended to occur as individual rosettes or small mats <15 cm in diameter, often in open, bare ground. On two of the three short tussock grassland plots, the sparse, open nature of the vegetation provided little opportunity for taller canopy plants to obscure hieracium plants in the photographs and, at least for these dry faces, it appears that mouse-ear hawkweed established as readily in bare soil as in pre-existing vegetation.

TABLE 5. CHANGES IN SPECIES COVER, 1973 TO 1993, BASED ON VISUAL ESTIMATES IN PHOTOCENTRES.

		NUMBER OF PHOTOCENTRES IN EACH COVER CLASS, BY YEAR													
GRASSLAND TYPE	% COVER CLASS	SHORT TUSSOCK		TALL TUSSOCK		MOUSE-EAR HAWKWEED		KING DEVIL		SHEEP'S SORREL		SCABWEED		CATSEAR	
		1973	1993	1973	1993	1973	1993	1973	1993	1973	1993	1973	1993	1973	1993
Short tussock grassland	not seen		2			11		22	22	8	16	8	18		19
	<5	7	14			13	1	2	2	15	8	13	6	19	5
	5-25	12	7				15			1		3		5	
	25-50	5	1												
	50-75														
	75-100														
Tall tussock grassland	not seen	5	6	7	6	22	17	21	12	17	19				
	<5	9	11	5	6		3	1	6	5	3				
	5-25	7	5	4	3		1		4						
	25-50	1		1	2										
	50-75			3	3		1								
	75-100			2	2										

TABLE 6 MEAN % FREQUENCY FOR THE MAJOR SPECIES IN THREE SHORT TUSSOCK AND TALL TUSSOCK GRASSLAND. SPECIES WITH % FREQUENCY AT LEAST 10% IN ONE PLOT ARE LISTED. TOTAL NUMBER OF PLANT SPECIES RECORDED IN ALL PLOTS IS NOTED.

SPECIES	% FREQUENCY			
	SHORT TUSSOCK GRASSLANDS		TALL TUSSOCK GRASSLANDS	
	1973	1993	1973	1993
Grasses				
Poa colensoi (blue tussock)	18	10	24	15.3
Notodanthonia sp.	18.6	1		
Poa spp.	12.0	0.6		
Poa cita (silver tussock)	8	3.3		
Chionochloa rigida (narrow-leaved snow tussock)			36	36
Festuca matthewsii (Matthew's tussock)			21.3	16
Dichelachne crinita	8.6	1.3		
Bromus mollis	18.6	0		
Bromus tectorum (downy brome)	8	0		
Elymus rectisetus (blue wheat grass)	4	0		
Anthoxanthum odoratum (sweet vernal)	0	6		
Festuca novae-zelandiae (hard tussock)	23.3	18		
Herbs				
Rumex acetosella (sheep's sorrel)	39.3	17.3	29.3	17.3
Raoulia sp. (scabweed)	10.7	6		
Hypochoeris radicata (catsear)	18	4		
Wahlenbergia albomarginata	22	8.7	7.3	10
Taraxacum magellanicum (native dandelion)	4	3.3		
Luzula rufa	12	1.3	6.6	8
Hieracium pilosella (mouse-ear hawkweed)	10	78	2.6	58
Hieracium praealtum (king devil)	5.3	4	15.3	35.3
Celmisia gracilenta			6.6	4.6
Raoulia subsericea			5.3	3.3
Aciphylla aurea (golden spaniard)			6	7.3
Mysotis sp.	6	0		
Carex spp.			9.3	4.6
Geranium sessiliflorum	6	3.3		
Trifolium repens (white clover)	1.3	4.6		
Shrubs				
Meublenbeckia complexa	4	1.3		
Total number of plants species recorded	39	30	22	22

In tall tussock grassland, there was a similar trend for both king devil and mouse-ear hawkweed to establish into bare soil or gravels, which were often overlain by a blanket of detached tussock tillers. However, the extent to which hieracium had established within existing tussock vegetation could not be determined.

These trends in hieracium distribution agree with Connor's (1992) view that although hieracium species had been widespread but rarely dense since the early 1960s, the major increase occurred sometime after 1976.

6.2 LANDSCAPE CHANGE

Landscape photographs taken in 1973 and 1993 provide a wider perspective to the small plot-based results. Medium-scale photographs encompassing the plots confirm the widespread decline in short tussock species and partially resolve the increase in hieracium (Appendix 2: Plates 1, 2). They also confirm the persistence of the snow tussocks (Appendix 2: Plate 4). Smaller scale, middle-distance photographs provide an even wider landscape perspective. They show that even near the short tussock-tall tussock gradation, nearly all individual snow tussock plants have persisted since 1973, even though field observation suggests that the inter-tussock spaces have been invaded by hieracium (Appendix 2: Plate 3). Middle-distance photographs are less able to resolve interactions between short tussock grassland and hieracium (Appendix 2: Plate 3).

Some landscape photographs provide an indication of the areas of greatest vegetation and hence landscape change. Field observations show that in 1993, extensive areas of the lower to mid-altitude short tussock grasslands, especially on shady aspects and/or with deep soils, support dominant hieracium wards with inter-mat bare ground. Colour changes on the photographs (e.g., lower slopes, Appendix 2, Plate 3) indicate vegetation change, but we have no records of the condition in 1973. The success of hieracium on these sites, compared to its formation of partial cover on plots 4/1, 4/2, and 4/3 appears to relate to their higher soil moisture levels. It is likely that vegetation patterns in these landscape components could be described by resurvey of additional plots selected from the network (Appendix 1).

6.3 I MPLICATIONS FOR CONSERVATION

Results reinforce other findings (e.g., Connor 1992, Treskonova 1991) that conservation values have declined in many tussock grasslands over the last 20 years. Impacts have been greatest in the short tussock grasslands. The decline in indigenous species of grasses and other herbs, the considerable increase in hieracium, and the associated decline in biomass and the visual effects of the loss of tussocks are features of that decline. Increased bare ground, often used as an indicator of land condition, does not appear to have been an essential feature of the decline.

The more enduring qualities of snow tussocks and the apparent persistence of inter-tussock species in some of the higher-altitude tall tussock grasslands have supported their conservation values up to 1993.

6.4 GRAZING MANAGEMENT

Neither the short tussock or tall tussock grassland areas have been burned (in living memory), nor has fertiliser or seed been applied. Scattered white clover noted in 1973 and 1993 on the short tussock transect would have been introduced by sheep.

The short tussock grassland is highly rabbit prone and has carried large numbers of rabbits through living memory. The present control strategy is shooting by helicopter. The runholder estimates kills of from 1000 to 1500 rabbits in an area of some 300 ha of sunny faces, which he expects to repeat at three to four years intervals. Previously, control was by poisoning at similar intervals. The tall tussock grassland has cool temperatures and hence is less prone to rabbits and has probably never held significant numbers of them.

Both grasslands are grazed by merino sheep, which range seasonally over 650 to 740 ha. blocks. The short tussock grassland transect lies in `winter country', grazed by wethers through winter (May to November). The estimated annual stocking rate is 0.35 sheep/ha. Stocking rates have been relatively stable over the last two decades, but with a shift from ewes to wethers some years ago.

The tall tussock grassland transect lies within `summer country', grazed by wethers in autumn (March-April), at an estimated, long-term, relatively stable annual rate of 0.35 sheep/ha. A subdivision fence within the block would have slightly increased the stocking load around the transect over the last 10 years.

6.5 SURVEY METHODS

A benefit from this work has been the opportunity to evaluate photographic plots for monitoring trends in the grasslands.

Although each vegetation survey method yields its own a set of `truths', the quantities expressed in any set of results are method-specific. For monitoring purposes, consistency of application over time may be more important than the initial selection of `best' method. In this study, two dissimilar methods, visual comparison between photographs and species frequency data, identified similar trends, even though they expressed them in different quantities.

Large-scale, vertical photographs provide an objective, but qualitative, record of ground cover and vegetation conditions. In the `patchy' tussock grasslands which are typical of the semi-natural grasslands in the Canterbury high country, large-scale photographs can be used to resolve many of the major species or species groups. A particular advantage of photographs is the ability to monitor changes in individual plants, patches of vegetation or areas of ground. The method is likely to be less robust in the `tighter' mixed swards typical of much of the high country in Otago, and in agriculturally improved areas. Species frequency may be a more sensitive method for detecting trends in minor species.

The different months of each survey (November in 1973 and March in 1993), related to delayed access to the original plot data, has introduced the uncertainty of seasonal effects in results for some species. This problem underlines the enduring commitment that is required for long-term monitoring programmes.

7. Conclusions

- The decline in abundance of indigenous species and the increase in the hieracium mouse-ear hawkweed since 1973 has reduced the naturalness (expressed as visual appearance as well as species composition) of the short tussock grasslands in the study area.
- The relative persistence of species abundance and cover has largely maintained the naturalness of the tall tussock grasslands since 1973, although the invasion of the hieraciums king devil and mouse-ear hawkweed indicates progressive change.
- The network of grassland plots established in 1973-74 provides a valuable baseline for assessing grassland trends and may be particularly relevant to DOC for monitoring trends in areas recommended for protection.
- Large-scale vertical photographic plots are an effective, qualitative yet objective vegetation survey method where the aim of monitoring is to determine general trends in ground cover or dominant species. The method is particularly relevant to visual, landscape-scale management objectives. Species frequency may be a more sensitive method for detecting trends in minor species.

8. Recommendation

- That the Department of Conservation notes the existence of a large number of permanent vegetation plots in the steeplands east and south of the Waitaki basin, South Canterbury, that could be used in comparison studies to monitor the effectiveness of the Department's tussock grasslands conservation management objectives and policies.

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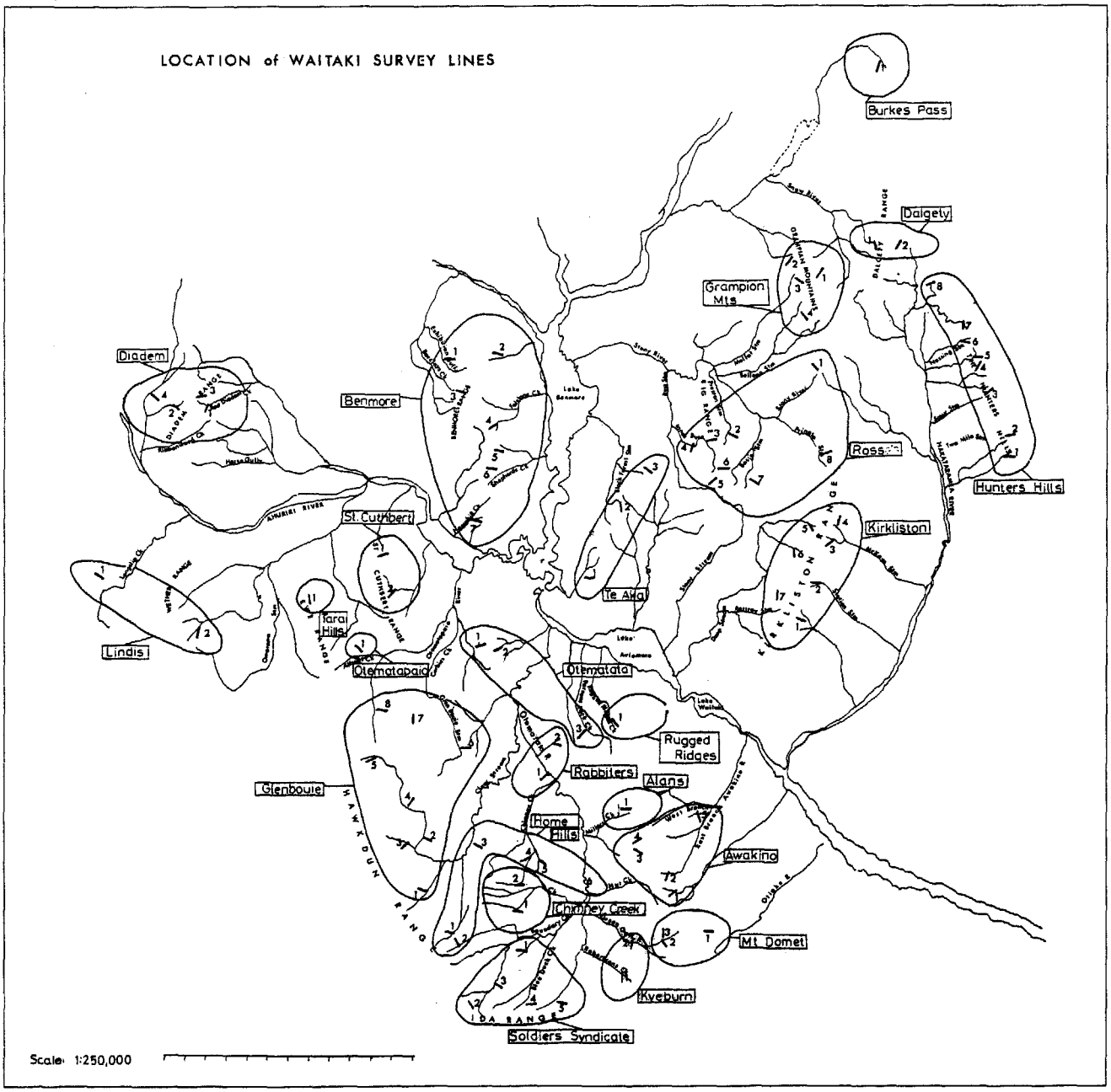
11. Appendices

11.1 THE DISTRIBUTION OF THE 222 PERMANENTLY MARKED GRASSLAND PLOTS SURVEYED BY MINISTRY OF WORKS AND DEVELOPMENT IN 1973-74.

Plots surveyed in this contract are labelled Ross 3 and 4, located in upper right centre.



11.2 PHOTOGRAPHIC RECORDS OF VEGETATION CHANGE

Summary of illustrations

Landscape scale

Plates 1, 2: Short tussock grassland
Plate 3: Short tussock/tall tussock gradation
Plate 4: Tall tussock grassland

Plot scale

Plates 5 - 10 Short tussock grassland photocentres
Plates 11 - 15 Tall tussock grassland photocentres

PLATE 1. SHORT TUSSOCK GRASSLAND, WITH PLOT 4/1 IN FOREGROUND; UPPER 1973, LOWER, 1993. VISUALLY DISTINCTIVE CHANGES INCLUDE A DECLINE IN SHORT TUSSOCK AND AN INCREASE IN MOUSE-EAR HAWKWEED. SCRUB HAS LOCALLY INCREASED IN THE MIDDLE DISTANCE. THE AMOUNT OF BARE GROUND HAS REMAINED RELATIVELY CONSTANT.

PLATE 2. SHORT TUSSOCK GRASSLAND, WITH PLOT 4/2, UPPER 1973, LOWER, 1993. TUSSOCK AND OTHER GRASSES HAVE DECLINED AND MOUSE-EAR HAWKWEED INCREASED. THE EXTENT OF BARE GROUND INCREASED SLIGHTLY.

PLATE 3. THE MID ALTITUDE ZONE BETWEEN THE SHORT TUSSOCK (FOREGROUND) AND TALL TUSSOCK PLOTS (BACKGROUND); UPPER 1973, LOWER 1993. MAJOR CHANGE FEATURES ARE THE DOMINANCE OF HIERACIUM SPECIES ON LOWER SLOPE AREAS WITH DEEPER SOILS (NOT REPRESENTED BY THE SURVEYED PLOTS) AND THE LOCAL INCREASE IN SCRUB. THE PERSISTENCE OF MOST TALL TUSSOCK PLANTS IS A FEATURE.

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