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Changes in the tussock grasslands of the central Waimakariri River basin, 1980-1993

Abstract

In 1993, the Canterbury Regional Council and Department of Conservation jointly commissioned Landcare Research to assess trends in ground cover and species composition in the tussock grasslands of the Waimakariri basin. This was achieved by resurveying the vegetation along seven, long-term vegetation transects which had been established in 1947. They were located in areas selected as broadly representative of steep pastoral lands in the area. Following the resurvey in 1993, ground cover and species composition records were entered in the long-term dataset. Analyses were rerun to determine vegetation and ground cover changes since the most recent surveys in 1980 and 1981. Overall, the cover of living vegetation had increased between 1980 and 1993 at a level equivalent to half a percent a year. Following the long-term decline of fescue tussock *(Festuca novae-zelandiae)* from 1947 to 1981, the species had increased in 1993. At least four species of hieracium have become established in the Waimakariri basin. Hieracium appears to have increased exponentially following establishment but has since stabilised at sub-dominant levels, at up to 34% of ground cover. No clear relationships were found between vegetation trends and levels of grazing. However, the increase in taller-statured indigenous species including broad-leaved snow tussock *(Chionochloa flavescens)* and dracophyllum scrub *(Dracophyllum* spp.*)* on one transect and the increase in manuka scrub *(Leptospermum scoparium)* on another, retired from grazing in 1974 and 1989 respectively, may be related to reduced grazing and burning. The slowness and inconsistency of vegetation and ground cover changes in this environment, shown in this long-term study, suggest that management to reinstate plant communities dominated by indigenous species through simple reduction in grazing pressure is likely to be a long-term process.

1. Introduction

Monitoring vegetation is a vital part of rangeland management to provide benchmarks for assessing change and for measuring attainment of management objectives. In response to concern in the 1940s about depletion of tussock grasslands and increased soil erosion in the eastern South Island high country,

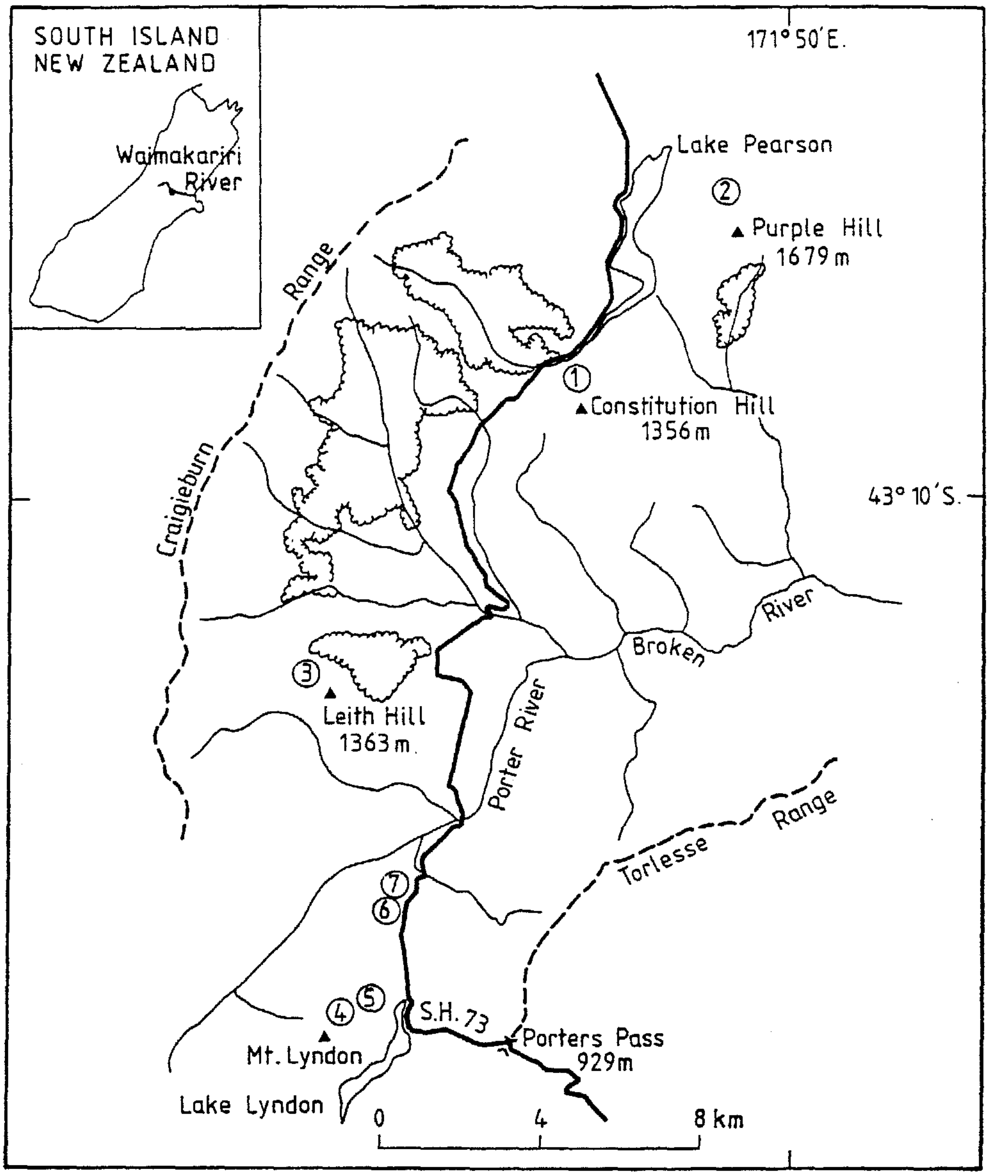

FIGURE 1. LOCATION OF THE GRASSLAND TRANSECTS IN THE CENTRAL WAIMAKARIRI RIVER BASIN. THE TRANSECTS ARE NUMBERED AS FOLLOWS: 1. CONSTITUTION HILL, 2. PURPLE HILL, 3. LEITH HILL, 4. LYNDON UPPER, 5. LYNDON LOWER, 6. CLOUDY KNOLL SOUTH, 7. CLOUDY KNOLL MIDDLE. AREAS OF FOREST ARE INDICATED BY SCALLOPED BOUNDARIES.

the North Canterbury Catchment Board established a series of permanently-marked transects in the extensively grazed montane and subalpine tussock grasslands in the central basin of the Waimakariri River. Assessments of ground cover and species composition were recorded regularly from transect establishment in 1947 until 1963. In 1980 and 1981, seven of the original transects which had not been substantively modified by pasture improvement or afforestation were resurveyed (Scott et al. 1988).

The principle results at that time were:

- There was no significant overall change in the total living ground cover from 1947 to 1981.
- However, within that period, there was an initial decrease from 1947 to 1953, and a slow increase thereafter.

- Fescue tussock *(Festuca novae-zelandiae)* decreased consistently over time, and on most transects. Other species showed more variable and local changes.
- Hieracium *(Hieracium* spp.) was recorded only rarely in the early years, but had become abundant on two transects by 1980.
- It was predicted that if recent climate and management conditions prevail, the cover of living vegetation will continue to fluctuate within the ranges recorded over the survey period.

This work provided a long-term and consistent set of data on vegetation change in the tussock grasslands. In 1993 the Canterbury Regional Council and Department of Conservation jointly commissioned Landcare Research to resurvey these transects. Although the management perspectives which have motivated the surveys since their inception in 1947 have changed over time, from concern about on and off-site effects of soil erosion, to concerns about the spread of weeds such as hieracium, and the need to determine sustainable levels of grazing to maintain production and conservation values, the transects continue to increase our understanding of longer-term trends in these grasslands. The transects were not established to monitor effects of specific management practices and although some of the transects have subsequently been retired from grazing, they are insufficient on their own for determining effects of grazing and non-grazing on vegetation and ground cover.

The condition of ground cover and species composition on the seven transects in 1993 is assessed and results are added to those from earlier years, previously reported in Scott *et al.* (1988).

2. Objectives

- To resurvey seven long-term tussock grassland transects in Waimakariri River basin, maintain the transect markers, and re-photograph historic transect landscapes.
- To input data into the long-term results database, and analyse and interpret results.
- To report results of the 1993 survey, thereby updating Scott *et al.* (1988).

3. Study area and transects

The seven transects in the central drainage basin of the Waimakariri River, Canterbury (Fig. 1) are on steep slopes on north-westerly to easterly aspects, in the mid-slope montane to subalpine zones. The annual rainfall of 1000-1400 mm is well distributed through the year.

The transects cover steepland tussock grasslands which are characteristic of the Torlesse (Cloudy knoll middle and south, Lyndon upper and lower), Cass (Constitution Hill, Purple Hill) and Craigieburn (Leith Hill) Ecological Districts (McEwen 1987). Short tussock grasslands dominated by fescue tussock *(Festuca novae-zelandiae)* and blue tussock *(Poa colensoi),* and grasslands derived from them, typically dominated by browntop *(Agrostis capillaris),* sweet vernal *(Anthoxanthum odoratum)* and hieracium occupy montane landforms below 950 m. The subalpine and alpine grasslands on the mid and upper slopes above 950 m support tall tussock grasslands characterised by broad-leaved snow tussock *(Chionochla flavescens)* and slim snow tussock (*C. macra).*

At least four species of the hieracium flatweeds, mouse-ear hawkweed (*H. pilosella),* king devil (*H. praealtum),* tussock hawkweed (*H. lepidulum)* and field hawkweed (*H. caespitosum)* now occur in the tussock grasslands of the central Waimakariri. Although they have not attained dominance over extensive areas, there is apprehension that they may continue to increase in abundance and geographical extent as has occurred in other high country areas.

These grasslands have been grazed by sheep under extensive rangeland conditions since settlement by Europeans in the late 1850s. Sheep numbers peaked in 1895 and progressively declined to about one half in 1917 and have since fluctuated at around that level. Since grazing levels on the transects were detailed in Scott *et al.* (1988) the Constitution Hill grazing block was retired from grazing in 1989. Grazing levels have remained relatively unchanged on the other transects.

4. Methods

The transects were positioned in 1947 to be broadly representative of montane to subalpine tussock grasslands in the Waimakariri basin. Each extended 200 or 300 m upslope and comprised 10 or 15 20 m segments whose ends were permanently pegged. Ground cover and species composition was assessed using a point sampler comprising 10 needles spaced at 50 mm intervals. During each field survey, annually from 1947 to 1963 and in 1980 and 1981, a line was run between adjacent pegs. Approximately 400 records were taken along each 20 m. Ground cover hit by each needle was recorded as either living vegetation, dead material (litter) or bare ground. In 1956, 1959, 1962 and 1980, plant species touched by needles 4, 7 and 10 were also recorded. The sampling procedure established in 1947 was rigorously followed each subsequent year, and field work was always undertaken in January and February to minimise variability.

Transects were remeasured, using the same methods, in February and one in early March 1993. Damaged or dislodged pegs were replaced and all pegs were secured for at least a further decade. Ground cover and species composition records were collected and the transect landscapes were rephotographed.

Ground cover and species composition records were aggregated into 1/4 of each 20 m segment (thereafter called a `sample') comprising approximately 100 ground cover points and 30 species composition records.

Analyses include graphical plotting and regression as well as time segment analysis (Scott 1993). The rates of change for ground cover type and species cover were determined for four overlapping time periods - 1947 to 1953, 1953 to 1962, 1962 to 1981, and 1980 to 1993. The rates of change were determined for each sample for each time period. These periods, and the method of determining rate of change, differ in detail from those in the earlier report and were changed to make better use of the intermittent sampling of later decades and the matching of cover and species composition measurements.

5. Results

5.1 GROUND COVER

On combined transects, the percentage living vegetation had continued to increase to 1993, equalling values recorded at the start of the study in 1947 (Fig. 2). The decrease in percentage bare ground was nearly balanced by gains in living vegetation, with minor changes in dead plant material. The 1993 measurements were proceeded by a drier and cooler than average spring, which, judging from previous analysis (Scott et al. 1988), may have resulted in slightly lower living ground cover.

The rates of change in ground cover components from 1980 to 1993 were very similar to those for the 1953-62 period, equivalent to an increase of half a percent per year in living vegetation (Table 1). There were some differences between transects (Fig. 3; Appendix). The greatest and most consistent trend was the increase of percentage living cover on Constitution Hill where the annual rate of increase has increased since 1953 and reached 1.39%/yr for 1980 to 1993. By contrast, the living cover on the Cloudy Knoll transects has reached a plateau. The decline in living vegetation on Cloudy Knoll middle is explained by a very localised debris avalanche which flowed down the line of the transect between 1981 and 1993 (Fig. 6).

TABLE 1. MEAN ANNUAL RATE OF CHANGE (%/YR) IN GROUND COVER FOR COMBINED DATA FROM ALL TRANSECTS FOR FOUR TIME PERIODS.

PERIOD	RATE OF CHANGE (%/YR) IN GROUND COVER		
	LIVING VEGETATION	DEAD MATERIAL	BARE GROUND
1947-53	-2.18	-0.10	2.25
1953-63	0.50	0.00	-0.49
1962-81	0.07	0.23	0.29
1980-93	0.51	-0.06	-0.45

5.2 SPECIES COMPOSITION

Percentage cover of the most abundant species, and their annual rates of change over the three sampling periods are given in Table 2. The groupings of species are based on the earlier analysis (Scott et al. 1988). The first group of high altitude species shows a weak trend of an initial decline giving way to a slight increase.

The rate of decline of fescue tussock appears to have reduced and it had increased by 1993 on Lyndon Lower, Cloudy Knoll south and Constitution Hill transects (Appendix). The rate of increase of browntop has tended to slow, though the trends differ between sites. It has been increasing on the higher rainfall Constitution Hill and Purple Hill transects but decreasing on Cloudy Knoll. The general decreasing rate of sweet vernal from 1953 to 1963 has changed to a generally increasing rate in the most recent period - particularly on the Cloudy Knoll south and Purple Hill transects. There are no general trends in the smaller grasses and herbs, other than for hieracium, discussed below.

The shrub species (the last group) differ in their responses. Manuka has been increasing, specifically on the high rainfall Constitution Hill transect (Appendix; Fig. 4). Matagouri has generally been decreasing across all transects.

Species diversity was estimated by determining how many of the twenty main species were present in each sample each year. The mean number increased overall from 4.5 to 5.2 from 1954 to 1993. Increases were greatest on Constitution Hill, Purple Hill, Leith Hill and Lyndon lower transects. The proportional reduction (k) in contribution to the cover of the four top species in each sample ($k = 0.67$) shows that since 1947, the living vegetative cover became more evenly spread between species.

5.3 HIERACIUM

The hieracium species were first distinguished in 1993, when king devil was consistently the more common species. It made up 4.9% of the mean 6.1% hieracium cover as compared to 0.6% for mouse-ear hawkweed, 0.1% for field hawkweed and 0.5% for tussock hawkweed. There were no major differences in proportions of the species between transects.

The relationship between increase in hieracium cover and the cover of hieracium, and its implications to long term trends were inferred by time segment analysis and are more fully described in another paper (Scott, 1993). The expansion phase of hieracium species was investigated in those samples from the combined transects in which hieracium contributed less than 15% to the ground cover. The generally linear relationship between the rate of increase of hieracium cover and the mean cover of hieracium implied an initial exponential rate of increase in hieracium once it has become established in the vegetation. The intrinsic growth rate determined from the regression gradient was in the range of 8 to 11% compound interest and was similar across transects (Table 3).

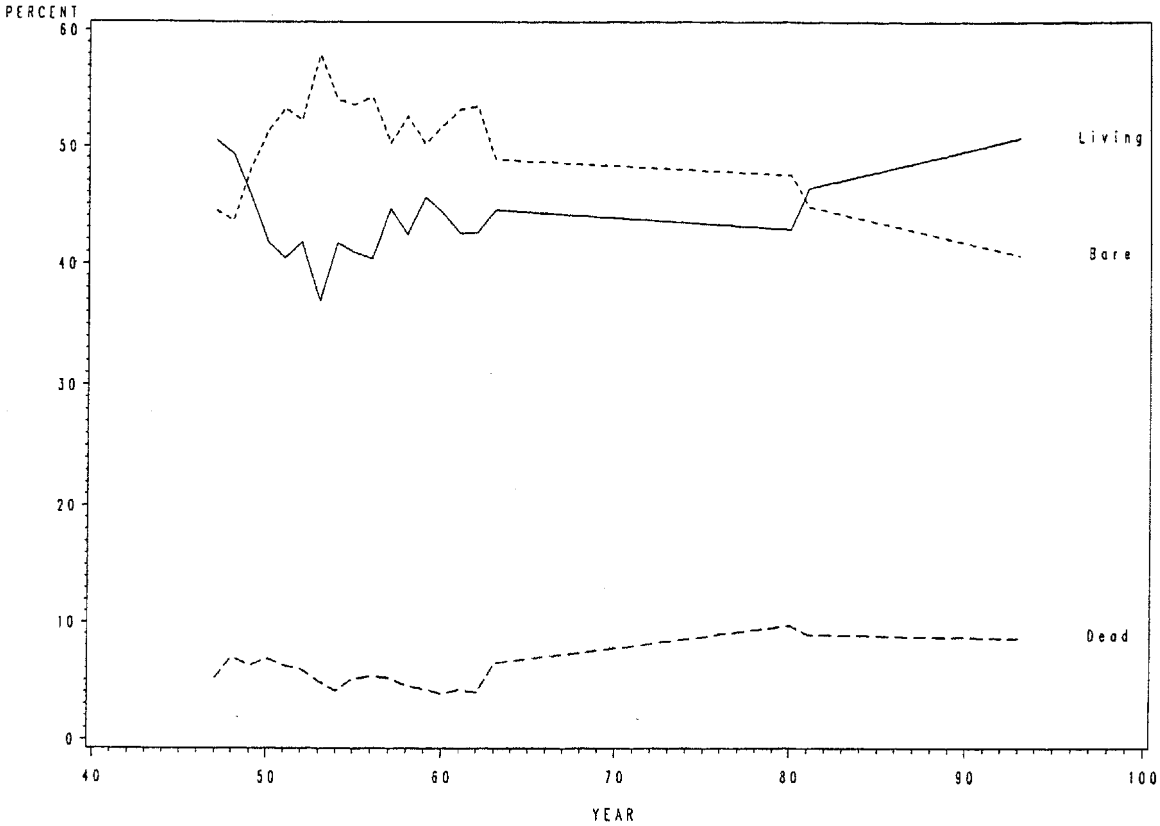

FIGURE 2. VARIATION IN GROUND COVER FROM 1947 TO 1993 FOR COMBINED TRANSECTS.

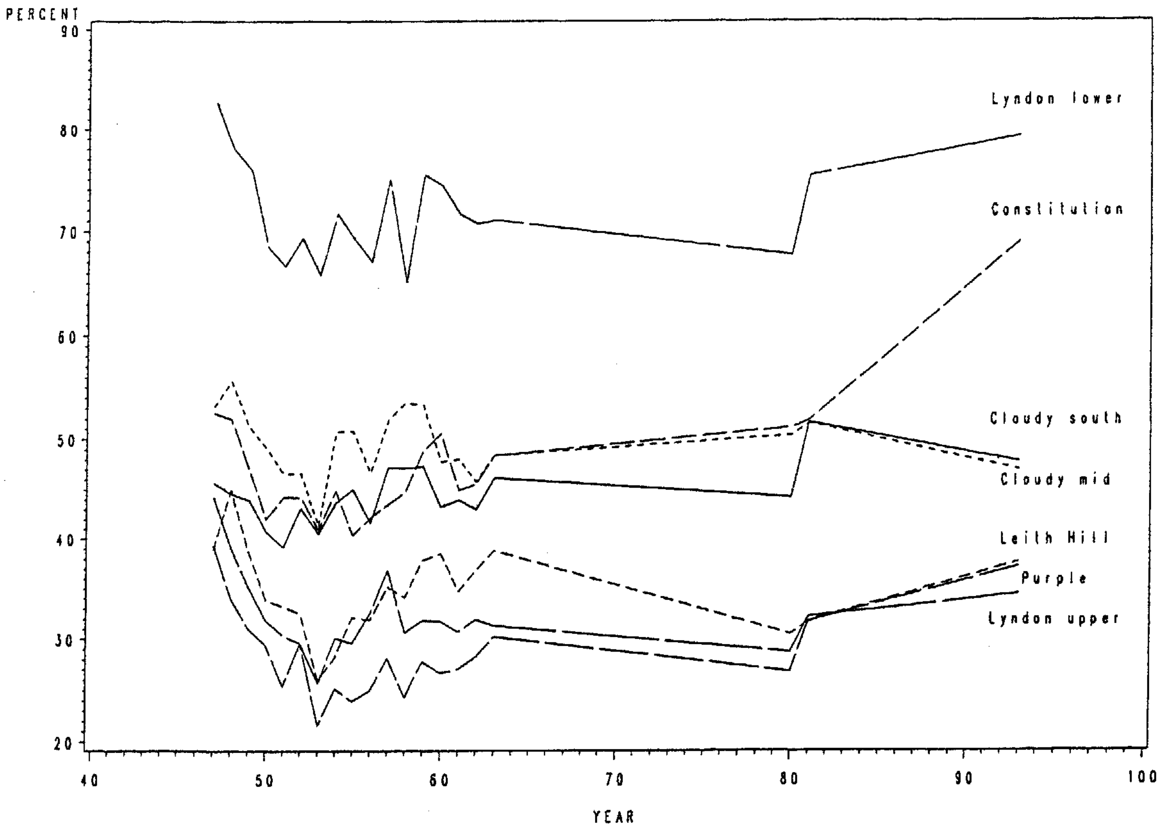

FIGURE 3. VARIATION IN LIVING VEGETATION COVER FOR INDIVIDUAL TRANSECTS FROM 1947 TO 1993.

TABLE 2. MEAN GROUND COVER OF THE MOST ABUNDANT PLANT SPECIES IN 1993 AND ANNUAL RATES OF CHANGE IN THREE PREVIOUS PERIODS. (DATA IS FROM COMBINED TRANSECTS ANDYEARS).

SPECIES	% COVER	RATE OF CHANGE (%/YR)		
	1993	1953-62	1962-81	1980-93
Chionochloa flavescens (broadleafed snow tussock)	3.1	-0.25	0.02	0.06
Chionochloa macra (slim snow tussock)	1.7	0.32	-0.01	0.0
Celmisia spectabilis (mountain daisy)	2.4	-0.03	-0.05	0.03
Dracophyllum spp. (turpentine scrub)	*1.0*	*-0.01*	*0.01*	*0.04*
Festuca novae-xelandiae (fescue tussock)	4.7	-0.23	-0.18	0.05
Elymus rectisectus (blue wheat grass)	0.3	0.13	-0.14	0.0
Acaena caesiiglauca (bidi-bidi)	0.9	-0.02	0.0	0.0
Aciphylla aurea (spear grass)	*0.1*	*0.0*	*0.0*	*0.01*
Agrostis capillaris (browntop)	5.5	0.22	0.0	0.08
Anthoxanthum odoratum (sweet vernal)	3.8	-0.07	0.04	0.08
Poa colensoi (blue tussock)	*1.7*	*-0.10*	*0.0*	-0.02
Hypocboeris radicata (catsear)	2.0	0.16	-0.02	*0.04*
Leucopogon fraseri	2.2	-0.01	0.03	0.03
Hieracium spp. (hieracium)	6.1	0.07	0.23	0.09
Raoulia subsericea	1.2	0.05	-0.01	·0.02
Discaria toumatau (matagouri)	1.3	-0.15	*-0.04*	-0.02
Leucopogon suaveolens	1.6	0.02	0.03	-0.09
Gaultheria spp. (snowberry)	2.6	*-0.04*	0.06	0.05
Leptospermum scoparium (manuka)	3.5	0.03	0.07	0.15
Cassinia vauvilliersii (cassinia)	0.6	0.04	0.02	0.0

TABLE 3. INCREASE IN COVER OF HIERACIUM SPECIES OVER TIME.

TRANSECT	% COVER					INTRINSIC GROWTH RATE (%)
	'56	'59	'62	'80	'93	
Constitution Hill	0.1	0.0	0.0	0.2	0.5	8
Purple Hill	0.0	0.0	0.0	0.0	0.0	
Leith Hill	0.0	0.0	0.3	0.3	6.1	10
Lyndon upper	0.0	0.0	0.0	0.0	0.1	11
Lyndon lower	0.0	0.1	0.0	0.9	7.5	9
Cloudy Knoll south	1.2	2.1	2.9	19.1	15.8	9
Cloudy Knoll middle	0.7	0.4	2.0	15.2	15.2	8

FIGURE 4. CONSTITUTION HILL. COMPARED TO 1981 (FIG. 9, SCOTT et al. 1988), THE FENCE TO RETIRE STOCK FROM THE UPPER SLOPES WAS COMPLETED IN 1989. MANUKA SCRUB IN THE RIGHT CENTRE HAS RECENTLY BEEN BURNED. MANUKA SCRUB HAS INCREASED LOWER LEFT OF THE FORESTED GULLY AND THERE HAS BEEN AN ADJACENT PATCH BURN AN AREA OF SHRUBBY VEGETATION, POSSIBLY BRACKEN FERN, HAS DEVELOPED TO THE RIGHT OF THE FORESTED GULLY. THERE HAS BEEN MINOR REACTIVATION OF THE DEBRIS AVALANCHE, LEFT CENTRE. THERE HAS BEEN NO SUBSTANTIVE CHANGE IN THE EXTENT OF BARE GROUND.

FIGURE 5. LYNDON HILL. COMPARED TO 1981 (FIG. 11, SCOTT et al. 1988), SCRUB, PROBABLY MATAGOURI (IN GULLIES) AND DRACOPHYLLUM (ON SHOULDERS), HAS INCREASED AT LOWER ELEVATIONS, MOST NOTABLY IN THE GULLY RIGHT OF CENTRE. TALL TUSSOCKS MAY HAVE INCREASED. THERE HAS BEEN A FURTHER DECREASE IN LOCALISED PATCHES OF BARE GROUND ON LOWER SLOPES, BUT NO SUBSTANTIVE CHANGE IN BARE GROUND IS APPARENT ON UPPER SLOPES.

FIGURE 6. CLOUDY KNOLL. COMPARED TO 1981 (FIG. 12, SCOTT et al. 1988) THERE HAS BEEN SLIGHT LOCAL INCREASES IN SCRUB, MAINLY MATAGOURI (e.g., HEAD OF THE NEW DEBRIS AVALANCHE LEFT OF CENTRE). NO MAJOR CHANGE TO THE EXTENT OF BARE GROUND IS EVIDENT. THE MINOR DEBRIS AVALANCHES HAVE BEEN REACTIVATED AND THE DEBRIS AVALANCHE LEFT OF CENTRE IS NEW.

However the inclusion of the samples exceeding 15% cover of hieracium showed a sigmoid or logistic type growth curve indicating that in this environment, hieracium might stabilise in the range of 34% cover, as has occurred on the Cloudy Knoll transects (Table 2).

The association between hieracium and other species was determined by principle component analysis. Changes in grouped hieracium species and browntop showed strong and similar trends, and they possibly replaced other species.

6. Discussion and conclusions

The results for 1993 confirm earlier findings (Scott *et al.* 1988) that changes in ground cover are small and variable over time. Careful and frequent monitoring is required to resolve longer term trends within the shorter-term year-to-year and sampling variation. Indeed, fluctuating ground cover values from 1947 to 1963 highlight the difficulties in assessing changes over the last decade from the single 1993 measurement, and a series of annual recordings would provide a more reliable measure of trends. However, although annual resurveys would provide a better estimate of trends, we believe that such intensive efforts should be reserved for studies addressing more specific management-related issues such as effects of different grazing regimes.

The transects were not originally established to determine the effects of specific management regimes and no consistent relationships between levels of grazing and vegetation change were confirmed from this data. The overall increases in vegetation cover on grazed transects Purple Hill and Leith Hill, and on ungrazed transects Lyndon upper and lower and Constitution Hill, suggest small, favourable trends which are independent of grazing. However, the increases in taller statured native species including broad-leaved snow tussock and *Dracophyllum* scrub on Lyndon Lower transect which was retired from grazing in 1974 are probably related to cessation of grazing, and possibly burning. The sharp increase in living vegetation on Constitution Hill is related to growth in manuka scrub in the absence of grazing and burning (Fig. 4).

The slowness and inconsistency of vegetation and ground cover changes in this environment, demonstrated by this long-term study, indicates that management to reinstate plant communities dominated by indigenous species through simple reduction in grazing pressure is likely to be a long-term process with uncertain outcomes. However, results from Lyndon Lower and Constitution Hill, retired in 1974 and 1989 respectively, appear to show a favourable response as noted above. The presence of seed-source parent plants as well as site conditions may influence the direction and rate of this process, as indicated by the different responses of vegetation inside exclosure plots established in 1974 in the nearby Porters Pass and Cloudy Knoll areas (personal observation of the author).

The 1993 results offer some new perspectives on hieracium. King devil was the main species, unlike the situation throughout drier parts of the high country including Waitaki basin and inland Marlborough where mouse-ear hawkweed is predominant. Data suggests that the potential intrinsic growth rate of hieracium cover is exponential at low levels. The indication that there may be an upper limit to hieracium cover in this environment was unexpected but is consistent with trends in mouse-ear hawkweed found by Cuff (1992) in the Orari catchment. However, this result is based on a very small sample and should not form the basis of any management strategy at this stage.

We were unable to explore the view that the current predominance of king devil suggests that further decline in the vegetation, including invasion by mouse-ear hawkweed, may result from additional stress from heavy grazing or environmental factors (Treskonova, 1991).

Observations suggest that, unlike the situations in drier tussock grassland areas, hieracium is not able to establish on the eroded subsoils and stone pavements which dominate the bare ground in the Waimakariri basin. Hieracium establishes in the relatively well vegetated areas where its dominance may be suppressed by other species. However, we note that mats of mouse-ear hawkweed have established on shallow, dry fan soils near some transects and that tussock hawkweed has begun to colonise montane scree on Cloudy Knoll adjacent to the transects.

Results from vegetation surveys are a product of the methods employed. In this study, use of a point sampling frame originally designed for sampling short grasslands has limitations for sampling large-statured tall tussock and shrubby vegetation. The rule of recording the single species with its crown closet to the needle tended to select against large, emergent species (e.g., tall tussock, manuka, matagouri, *Dracophyllum* spp.) in favour of low-statured subcanopy species. Consequently, the extent of these larger species, in terms of canopy cover, may have been under-estimated. Field observations suggest, for example, that the data under-estimates increases in *Dracophyllum* and broad-leaved snow tussock on Lyndon Lower transect and manuka up to its altitude limit on Constitution Hill.

7. Recommendations

- That the transects be maintained as a long-term record of vegetation change in humid, upper montane to subalpine tussock grasslands by being resurveyed at intervals of at least every 10 years.
- Although annual resurveys would provide a better estimate of trends, we believe that intensive efforts should be reserved for studies addressing more specific management-related issues such as effects of different grazing regimes.

8. Acknowledgements

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10. Appendix

The 1993 cover (%) and rates of change (%/yr) in previous periods for cover components and principal species on each of the transects.

TRANSECT	% COVER		RATE OF CHANGE (%/YR)	
GROUND COVER	1993	1953-62	1962-81	1980-93
Constitution Hill				
Ground cover				
living vegetation	69.0	0.70	0.25	1.39
bare ground	26.9	-0.77	-0.40	-1.12
Principal species				
Leptospermum scoparium	17.0	0.17	0.25	0.67
Anthoxantbum odoratum	7.4	-0.07	0.05	0.26
Poa colensoi	5.3	-0.15	0.17	-0.07
Festuca novae-zelandiae	4.8	-0.02	-0.28	0.15
Agrostis capillaris	4.5	0.02	0.02	0.31
Hypochoeris radicata	4.3	0.14	0.0	0.17
Purple Hill				
Ground cover				
living vegetation	37.2	0.62	0.01	0.65
bare ground	57.5	-0.67	-0.14	-0.62
Principal species				
Festuca novae-zelandiae	12.7	0.19	-0.09	0.11
Anthoxantbum odoratum	7.0	0.0	-0.15	0.33
Acaena caesiiglauca	3.6	0.05	0.06	0.0
Celmisia spectabilis	3.0	-0.05	0.0	0.15
Raoulia subsericea	2.3	0.02	0.03	0.03
Agrostis capillaris	2.0	0.01	0.03	0.12
Leith Hill				
Ground cover				
living vegetation	37.7	1.11	-0.37	0.53
bare ground	53.0	-1.08	-0.14	-0.13
Principal species				
Chionochloa macra	6.5	0.0	0.06	-0.11
Hieracium spp.	6.1	0.04	0.01	0.44
Chionochloa flavescens	5.7	0.0	0.03	-0.04
Gaultheria spp.	5.5	0.0	0.09	0.29
Hypochoeris radicata	3.8	0.15	0.06	0.09
Festuca novae-zelandiae	3.0	-0.40	-0.35	0.01
Lyndon Upper				
Ground cover				
living vegetation	34.5	0.29	-0.06	0.34
bare ground	52.9	-0.11	-0.35	-0.30
Principal species				
Celmisia spectabilis	8.6	0.0	0.08	0.1G
Chionochloa flavescens	7.5	-0.13	-0.20	0.15
Chionochloa macra	7.3	0.0	-0.11	0.05
Dracophyllum spp.	3.5	0.02	0.04	0.14
Gaultheria spp.	1.3	0.0	0.02	0.05

TRANSECT	% COVER		RATE OF CHANGE (%/YR)	
GROUND COVER	1993	1953-62	1962-81	1980-93
Lyndon Lower				
Ground cover				
living vegetation	79.2	0.41	0.05	0.64
bare ground	7.4	-0.51	-0.39	-0.43
Principal species				
Chionochloa flavescens	11.8	-0.11	0.06	0.49
Hieracium spp.	7.5	0.0	0.05	0.51
Festuca novae-zelandiae	5.6	-0.14	-0.01	0.05
Gaultheria spp.	5.0	-0.23	0.11	0.03
Dracophyllum spp.	3.7	-0.01	0.06	0.11
Hypochoeris radicata	3.2	0.57	-0.04	-0.05
Cloudy Knoll South				
Ground cover				
living vegetation	47.8	0.24	0.20	0.03
bare ground	44.8	-0.11	-0.35	-0.08
Principal species				
Hieracium spp.	15.8	0.29	0.90	-0.26
Agrostis capillaris	13.1	1.15	-0.05	-0.09
Anthoxanthum odoratum	5.3	-0.58	0.01	0.17
Discaria toumatou	2.2	-0.14	-0.05	0.0
Festuca novae-zelandiae	1.7	-0.71	-0.20	0.06
Leucopogon sauveolens	1.4	0.0	0.0	0.0
Cloudy Knoll Middle				
Ground cover				
living vegetation	47.0	0.1	0.22	-0.31
bare ground	41.7	-0.10	-0.29	-0.08
Principal species				
Hieracium spp.	15.2	0.21	0.74	0.0
Agrostis capillaris	14.9	0.49	-0.04	0.04
Discaria toumatou	1.8	-0.25	-0.02	-0.04
Leucopogon sauveolens	1.7	0.0	0.0	0.0
Gaultheria spp.	1.6	0.01	0.04	0.05