Vegetation: Scott height frequency transects

Version 1.0

This specification was prepared by Alan Rose in 2012.

Contents

Inventory and monitoring toolbox: vegetation

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Department of Conservation
Te Papa Atawhai

Synopsis

The Scott height frequency (SHF) method was designed to assess and monitor the composition and vertical structure of non-forest habitats under 2 m in height, e.g. tussock grassland, herbfield, cushionfield, shrubland and sometimes wetlands. SHF transects were developed in the 1960s (Scott 1965), and were occasionally used as a permanent monitoring tool up to the 1980s (Bulloch 1973). The use of permanent SHF transects became more widespread after the mid-1980s, when the Department of Lands and Survey (later DTZ) established about 50 transects on pastoral leasehold properties (C. Mason, DTZ, pers. comm. 2007). University and the Department of Scientific and Industrial Research (now Landcare Research) scientists established similar numbers of transects in sites identified under the Protected Natural Areas Programme (Dickinson et al. 1992; Grove et al. 2002). SHF transects produce statistically testable data and have been used to assess vegetation change inside and outside animal-proof exclosures (Rogers 1991; Grove et al. 2002) to monitor changes in stature and species composition associated with management practices such as grazing and burning (Bulloch 1973; Dickinson et al. 1992; Wardle & Fahey 2002; Mark & Dickinson 2003), and to monitor the impacts of animal pests (Rogers 1991; Lee et al. 2003). Data from the approximately 100–200 existing permanent SHF transects are now archived and catalogued in the National Vegetation Survey (NVS) databank at Landcare Research, Lincoln, Canterbury.

Examples of questions that SHF transects can address include:

- How do the composition, ground cover, and structure of grasslands compare before and after pest management?
- Are there any changes in species frequency, ground cover, or biomass index over time?
- How are palatable species changing and are they responding to pest control?
- Are weed species increasing or decreasing in response to animal management?
- What grassland types are present and what are their patterns of distribution in relation to environmental factors?
- How do sites with different pest population histories differ?
- How do site and management history affect vegetation composition, ground cover, biomass, and structure?

SHF uses permanently marked transects, along which species frequencies are recorded from their presence in evenly spaced subplots. A strength of this method is that it also measures vertical structure, which can then be combined with frequency to produce an indirect biomass estimate for each species (Scott 1965). SHF has also been adapted to suit other habitat types such as coastal shrubs and lowland podocarp forest (e.g. Spurr & Warburton 1991). The SHF method is detailed in Wiser & Rose (1997).[1]

Species are sampled every 50 cm using a 2 m vertical rod marked at 5 cm intervals along a 50 m transect. Many early SHF transects were not permanently marked, but it is now standard practice to

[1] Accessible at http://nvs.landcareresearch.co.nz/

do so. Attached to the rod are two or three horizontal metal rings or pairs of pins to define either a column or an open cube (see figures 8, 9 in Wiser & Rose 1997). One hundred sample points per 50 m transect are thought to be adequate to sample tussock and shrubland communities (Scott 1965; Dickinson et al. 1992). However, studies at Molesworth Station in 2007 have indicated that substantially fewer than 100 sample points may be required (S. Husheer, unpub.), but in the meantime the standard transect should be used.

It is important to keep the size and shape of the sampling volume consistent within surveys and between remeasurements. Generally the number of 5 cm height intervals is dictated by the height of the vegetation, e.g. for vegetation 1 m tall, 20 × 100 cm^3 volumes are standard practice, but earlier transects have varied in length, subplot size, and height intervals. For every SHF transect it is now standard practice to complete a bounded 50 × 5 m RECCE plot description defined by the area 2.5 m either side of the transect. Many earlier SHF transects did not have associated RECCE plots but it is now standard practice to do so (Hurst & Allen 2007a,b).

Wraight plots are an alternative method to monitor non-woody vegetation and both Wraight plots and SHF are described in Wiser & Rose (1997). Some of the factors that differentiate the two methods are as follows:

- SHF transects are suitable for vegetation > 1 m tall. Wraight plots are more appropriate for vegetation < 2 m tall.
- SHF transects use species height-distribution as a surrogate for biomass while Wraight plots use cover and tussock stature measurements.
- SHF transects are generally more sensitive to within-transect changes at a given site and historically have been used more for intensive monitoring at a few sites considered 'representative'. Wraight transects have been used more for broad-scale monitoring where extensive sampling, large numbers of plots, and stratified-random plot location are important.
- Neither method is appropriate for plant population studies, e.g. recruitment, mortality.

Assumptions

- In a randomly dispersed population, the frequency of occurrence for a particular sample size is related to cover abundance (Scott 1965).
- One hundred sample points with a 14% difference in frequency is significant at the 95% confidence level (Scott 1965). This does depend on the frequencies being compared.
- One hundred sample points is assumed to record most species present (Dickinson et al. 1992). However, a study in 2007 has suggested substantially fewer sample points may be required (S. Husheer, unpub.).
- It is assumed that the temporal changes recorded are representative of a much wider study area.
- Temporal or spatial changes in plant frequency predominantly reflect changes in abundance rather than changes in spatial distribution.

Advantages

- A proven method that has been used to set up permanent plots in non-forest habitats, particularly in the last 20 years. SHF transects have been established throughout New Zealand, mainly in mid- and high-altitude grasslands. Many have been measured more than once.
- A repeatable and relatively simple method to carry out.
- Effective in assessing changes in vegetation height structure which other methods may not capture.
- Useful for intensive monitoring of specific sites and also used for monitoring broader-scale changes.
- Able to be used where individual plants are unable to be distinguished (counted as individuals) and vegetation is under 2 m tall.

Disadvantages

Recording the presence of species within height intervals is partly subjective and can be difficult in windy conditions, in dense vegetation, on uneven and steep ground, and when several species are intermingled.

- Viewing the vertical rod from the side to read height intervals can be impractical in dense shrubland.
- SHF transects may not necessarily detect the presence of rare or threatened plants. However, the associated RECCE plots will include species not captured by the transect data.
- Individual sampling volumes probably will not be relocated exactly, because of uneven vegetation and ground surfaces, windiness, and inconsistent tape tension.

Suitability for inventory

SHF transects have been used for initial inventory of selected sites (Bulloch 1973; Dickinson et al. 1992; Grove et al. 2002), but are not primarily designed for rapid or broad-scale inventory.

Suitability for monitoring

SHF transects are suitable for monitoring non-forest habitats because they collect data on the vertical structure of the vegetation community of interest and can be applied when individual plants cannot be distinguished. Rare and uncommon species that may not occur on the transect will probably will be listed on the associated RECCE plot. SHF transects are intensive and collect a lot of data from one unit area but also capture the variation in vegetation at a site. Data from SHF transects has been used to compare sites with spatial or temporal differences in mammalian herbivore populations and to monitor changes in composition, abundance, vertical structure, ground cover and species richness (Bulloch 1973; Rogers 1991; Dickinson et al. 1992; Grove et al. 2002; Lee et al. 2003; Mark & Dickinson 2003).

Skills

- A moderate to high level of botanical expertise.
- A good level of navigational and general outdoor skills.
- Data summaries and analyses require a moderate level of skill with computer spreadsheets and statistical analysis packages.
- A background in plant ecology is essential for the interpretation of data.

Resources

- Two experienced people can generally establish and measure an SHF transect in 2 hours and with an associated RECCE plot in 3 hours. Times also depend on species diversity and the structural complexity of the vegetation.
- Standard field equipment includes: maps, datasheets, clipboard, compass, pens, pencils, 50 m tape measure, 2 m height frequency rod marked at 5 cm intervals, 100 cm^3 'cubes', 3 × stakes to mark either end and centre point of transect line, hammer, GPS, compass, altimeter, binoculars, cruise tape, plant identification books, collection bags and labels (see Wiser & Rose 1997, p. 48). A photo of the transect is optional but encouraged, and would require a wipe board, non-permanent marker and digital camera.
- Take a copy of the most up-to-date plant species codes from Landcare Research with you into the field.[2]
- For previously measured plots, have a copy of the manual and it is good to have photocopies of original datasheets and they are available free of charge. Users must request data using a NVS data request form or by emailing nvs@landcareresearch.co.nz. Complicated data requests may incur fees. Please allow up to 4 weeks for requests to be processed.[3]
- Electronic copies of SHF datasheets are not available from NVS. Observers will need to create their own copies following the example datasheets in Wiser & Rose (1997) and the minimum attributes to record. However, there are initiatives by Landcare Research to make these datasheets available in the near future as part of the update of the NVS databank.
- There are a number of ways in which the NVS website can be used to identify and locate particular vegetation surveys or search for data: broad-scale maps can be viewed to see listings of survey names within each DOC conservancy; a search can be conducted for a particular survey name, person, or known geographical area; or interactive maps can be viewed that show NVS plot locations and species distributions.[4]
- Adequate budget needs to be set aside to ensure unknown species are collected and identified and correct species names and codes are updated on the plot sheets before data entry.

[2] Refer to 'NVS plant names and maps' at http://nvs.landcareresearch.co.nz/
[3] Refer to 'Requesting data' at http://nvs.landcareresearch.co.nz/
[4] Refer to 'Interactive plot location maps' at http://nvs.landcareresearch.co.nz/

Minimum attributes

These attributes are critical for the implementation of the method. Other attributes may be optional depending on your objective. For more information refer to 'Full details of technique and best practice'. The minimum attributes to record for point height intercept measurements are detailed in Wiser & Rose (1997).

DOC staff must complete a 'Standard inventory and monitoring project plan' (docdm-146272).

Record details of the site:

- Survey
- Line
- Plot
- Date
- Observer
- Recorder

At every 0.5 m sample point record:

- The species observed in 5 cm height intervals (using the standard six letter species code) and the dominant ground cover (scree, vegetation, litter, bare ground, erosion pavement, broken rock or rock).
- Maximum tiller length where tussock species are the dominant ground cover.

Use the non-woody RECCE plot datasheet available online from Landcare Research.[5] Refer to the method description of RECCE plots for more information on minimum attributes.

Photos of transects are not mandatory but are recommended. They enable the quick relocation of a transect, and a pictorial record of changes to a site can be helpful when interpreting SHF data.

Other optional parameters that may enhance data interpretation include:

- Environmental factors (e.g. soil fertility, soil profile descriptions, potential solar radiation)
- Disturbance history (e.g. grazing, burning, roading, skiing)
- The cover of selected species (e.g. weeds like *Hieracium* spp.)
- Specific plant attributes (e.g. tussock flowering intensity, tussock nutrient status)
- Animal use indices (e.g. faecal pellet counts)

Data storage

- It is standard to deposit all original datasheets in NVS.
- For correct standards and procedures for archiving and retrieval of SHF data, consult the DOC standard operating procedure (SOP) 'National Vegetation Survey (NVS) databank data entry,

[5] See 'Manuals, sheets and tools' at http://nvs.landcareresearch.co.nz/

archiving and retrieval standard operating procedure' (docdm-39000). The SOP describes the protocols for submitting and retrieving SHF and RECCE plot data from NVS.

- RECCE plot data can now be entered using NVS Lite, an interface where plot data can be entered by staff into fields and electronically submitted to Landcare Research. NVS Lite is available from Landcare Research.[6] DOC staff must request for NVS Lite to be loaded onto their computer from DOC's network administrator. Otherwise, you must budget for data entry costs by Landcare Research. There are firm plans by Landcare Research to develop NVS Lite to accept SHF transect data.
- Never take original datasheets into the field. Store copies of datasheets in a safe location.
- Complete a metadata sheet when submitting data to NVS. Refer to 'Depositing data' at http://nvs.landcareresearch.co.nz/ for copies of metadata forms, though submitters are encouraged to use the more complete 'NVS metadata sheet' (docdm-53429).
- For more discussion on data collection, common problems and storage protocols, refer to the discussion documents Wiser et al. (1999), Newell & Baldwin (2000), Hurst et al. (2006), or contact the NVS databank administrator direct.

Analysis, interpretation and reporting

The approach to data analysis depends on the objectives of the monitoring programme. Always seek statistical advice from a biometrician or suitably experienced person prior to undertaking any analysis. The time and resources that are needed to undertake analysis of SHF and RECCE data are substantial but they are routinely underestimated. The skills required to collect the data vary considerably from the skills needed to analyse it. Mixed model analysis is relatively specialised and it is recommended that advice be sought from suitability experienced individuals before embarking on analysis. Training courses and guidance on repeated measured analysis using mixed models has been a recent focus of DOC, and it is anticipated they will be advanced through ongoing development work.

Before any analyses are undertaken, it is critical that data errors are identified and corrected. Various data checking and validation programs are run when data are archived into the NVS databank, whether data are submitted using NVS Lite or through other avenues (see 'Data storage'). Should any errors be identified, or corrections made to SHF or RECCE plot data supplied by NVS, it is important to lodge any corrections back with the NVS databank to ensure that the most up-to-date copy of the data is archived. Contact the NVS databank administrator for advice on lodging data corrections with NVS.

Summarising species data

Several types of abundance data can be obtained for each species, including: presence/absence; frequency (proportion of sample points occupied regardless of height tier); height-frequency (proportion of sample points occupied in each height tier); and biomass index (total frequency in all

[6] Refer to 'Depositing data' at http://nvs.landcareresearch.co.nz/

height tiers). Species richness can be calculated overall and for relevant groups of species (e.g. palatable native herbs, exotic weeds, shrubs).

Height-frequencies are summarised by totalling the number of times each species occurs in each height tier and converting that to a percentage of the total number of points sampled on the transect (Scott 1965; see Wiser & Rose 1997, p. 30, p. 50). This data can be represented as histograms, commonly called ‘kite’ diagrams, which depict the frequency of a species along the *x*-axis and the height classes in which they occur on the *y*-axis. Note that kite diagrams do not show the shape of plants, but demonstrate the structure of the plant community (see examples in Scott 1965; Dickinson et al. 1992; Wiser & Rose 1997; Mark & Dickinson 2003). Kite diagrams can be drawn using the graphics function of MS Excel. There have been some attempts to develop more sophisticated software to draw kite diagrams, but any basic statistical software package should be able to depict summary data into kite diagrams.

Calculate a biomass index by summing the frequency of each species in all height tiers. This is also sometimes referred to as a ‘summed height-frequency value’ or ‘importance value’. Williams (1975) describes an alternative data summary technique to avoid overestimating biomass when several species are present per sampling interval.

Analysing change on transects

To date, most studies have analysed within-transect changes. These effectively use individual sample points as replicates. Simple Chi-squared analyses and contingency tables are used to evaluate temporal trends in the height-frequency of key species and time × treatment interactions (e.g. Dickinson et al. 1992; Grove et al. 2002; Mark & Dickinson 2003). Temporal changes in the number of species are analysed using paired *t*-tests or non-parametric tests such as the Wilcoxon signed ranks test. These within-transect tests are approximate because they assume that consecutive sample points, separated by just 50 cm, are independent (Scott 1965). Independence can be increased by pooling groups of sample points (e.g. pooling the first five points starting from one end of the transect). The independence of these pooled values can be tested by correlating each with adjacent pooled groups. If there is no correlation, they are independent. The resulting means, presence/absences, or frequencies of species can then be used as replicates within the transect (C. Frampton, pers. comm.).

If there is adequate sample size, independent transects can be used as replicates. This allows the use of more sophisticated and informative statistics, such as repeated measures ANOVA and mixed model ANOVA, to assess temporal changes in mean frequency, height, ground cover, biomass index, species richness, and other parameters, as well as time × treatment interactions (Lee et al. 2003; see ‘Case study A’).

The use of transition matrices has been suggested to assess temporal change within transects (Dickinson et al. 1992), but this would assume that individual points are exactly relocated when remeasured, which is unlikely.

Classification and ordination

SHF species abundance data, including presence/absence, frequency, and summed biomass index can be used for classification and ordination. Classification groups compositionally similar transects into communities (e.g. Dickinson et al. 1992) and also groups species with similar distributions. Ordination extracts the main gradients of compositional change in the data and places the transects and species along these axes. Ordination and classification are frequently used together to interpret vegetation patterns in relation to environment or management (e.g. altitude, soil fertility, grazing history) or to follow changes in composition over time.

A large range of specialised software is available for implementing the many different classification and ordination techniques, e.g. PC-ORD, CANOCO, DECORANA, TWINSPAN, and specialised packages in R. Analysts should consult the large literature on these topics and relevant websites.[7]

SHF data can be classified and ordinated using the NVS software package PC-TRANSECT (Hall 1996), but the package is now rather dated. Data are entered in a standard ASCII text file format and run under MS-DOS. Data must be obtained in the appropriate format from the NVS databank. Transects are classified using either agglomerative clustering techniques or two-way indicator species analysis (TWINSPAN). Ordination is performed using detrended correspondence analysis (DECORANA). Data summary programs can be used to analyse changes in species abundance, and comparisons can then be made among species (e.g. in response to changing management). PC-TRANSECT is available for DOC staff on request from DOC's network administrator and manuals can be obtained free-of-charge from Landcare Research. Landcare Research plans to develop an updated set of analysis tools as part of the ongoing upgrade of the NVS databank and NVS Lite to include SHF data. It is anticipated that data summaries will graphically display summary results, including the ability to graph relationships between variables calculated by the summaries (e.g. species frequencies).

Regression techniques can be used in common statistical packages to evaluate the relationship between species abundance (e.g. frequency, biomass index) and covariates such as pest abundance indices (e.g. faecal pellet counts) and environmental factors (e.g. potential solar radiation, altitude; Bellingham & Allan 2002; Husheer 2005).

RECCE plot data analysis

Refer to the 'Analysis, interpretation and reporting' section of 'Vegetation: RECCE plots' (docdm-359575) for more information on analysing and interpreting RECCE plot data.

Case study A

Case study A: vegetation change (1989–2000) and use by deer of *Chionochloa pallens* subsp*. cadens* grassland in the Murchison and Stuart Mountains, Fiordland

[7] e.g. http://ordination.okstate.edu/index.html

Synopsis

This study follows changes in selected plant species preferred by deer and takahē over 10 years in three regions of Fiordland. It illustrates the power of ample replication and analysis of variance to detect often variable vegetation trends on SHF transects, to determine whether they are statistically different between areas, and to summarise overall trends. It also illustrates the usefulness of gathering additional data, in this case faecal pellet counts, takahē feeding sign and plant density data, to elucidate temporal trends and management effects.

Objectives

- Determine deer use of the alpine grasslands, particularly in plant communities and areas important for takahē conservation.
- Determine trends in deer use of *Chionochloa pallens* grassland over 10 years.
- Assess deer impacts on habitats important for takahē and provide management recommendations.

Sampling design and methods

- In 1989, permanent SHF transects and adjacent rectangular plots were established in three study regions (Chester, Takahē Valley, Glaisnock). All samples were in low-alpine *Chionochloa pallens* grassland, which is highly-preferred deer and takahē habitat.
- In each region there were 12 standard 50 m SHF transects. Adjacent to each transect there were two contiguous 50 × 2 m plots (24 plots per region).
- The transects were used to record the height-frequencies of *C. pallens,* large dicotyledonous herbs, woody species and selected other plant species, and the tiller height of *C. pallens.*
- The plots were used to record deer faecal pellets, the number of selected large herbs and the proportion browsed, and takahē droppings and feeding sign.

Results

- Changes in three transect variables were analysed for each of the main species: transect line frequency (the number of points at which a species occurs irrespective of height intervals); height of maximum frequency (the height above ground at which maximum frequency is found); and total height frequency. The mean tiller height of *C. pallens* was also analysed.
- The numbers of individual large herbs, takahē tiller piles and droppings, and deer droppings were analysed.
- Analysis of variance was used to assess differences between sample regions, basins (sub-regions), transects, plots, and years. For significant ANOVAs, Duncan's New Multiple Range Test was used to detect significant differences between means.
- Browsing damage was too infrequent to be analysed statistically.
- Takahē feeding sign increased in Chester and Glaisnock but decreased in Takahē Valley. Deer browsing damage remained at low levels in Chester, but increased in Takahē Valley and Glaisnock.

- The density of large herbs such as *Anisotome haastii* increased markedly, with larger increases in Chester and Glaisnock than in Takahē Valley.
- The large herbs *A. haastii* and *Dolichoglottis lyallii* increased in line frequency. For *C. pallens*, the height of maximum frequency increased, but the total height frequency consistently decreased by 30–45% compared with 1989. There were no significant differences in these temporal trends between regions.
- Temporal trends on the transects were clearer when species were combined into five major guilds based on growth form (Table 1). For dicotyledonous herbs, overall line frequency increased but total height frequency decreased. Shrubs showed a similar pattern for line frequency but increased most markedly in Glaisnock. Total height frequency of monocotyledonous herbs decreased markedly in Chester and Glaisnock. Grasses decreased in total height frequency in all regions. Ferns declined in line and height frequency in Glaisnock.

Table 1. Abundance of different guilds in *Chionochloa pallens* grassland in 1989, 1994 and 2000, Murchison Mountains, Fiordland National Park.

Guilds	**Regions**				
	Chester	**Takahē Valley**	**Glaisnock**	**Year**	**Region–Year Interaction**
Dicot herbs					
Line Freq (%)					
1989	33.9	21.6	13.5	**	NS
1994	34.9	21.7	14.5		
2000	41.6	24.3	17.9		
Total Height Freq					
1989	163	66	77	**	NS
1994	123	67	59		
2000	105	58	45		
Shrubs					
Line Freq (%)					
1989	14.7	38.5	3.4	***	*
1994	18.1	39.5	7.8		
2000	24.0	42.2	11.7		
Total Height Freq					
1989	81	167	31	NS	**
1994	89	163	56		
2000	79	140	53		
Monocot herbs					
Line Freq (%)					
1989	12.3	0.6	23.4	NS	**
1994	8.0	0.7	21.4		
2000	12.9	0.7	14.3		
Total Height Freq					
1989	49	2	121	***	**
1994	23	2	89		
2000	26.6	2	34		
Grasses					
Line Freq (%)					
1989	83.6	68.6	86.4	NS	NS

1994	85.2	73.5	82.2		
2000	81.5	73.8	85.5		
Total Height Freq					
1989	657	563	860	***	NS
1994	588	511	641		
2000	429	424	487		
Ferns					
Line Freq (%)					
1989	0	0	13.7	NS	*
1994	0.2	0.1	14.7		
2000	0.2	0.1	7.2		
Total Height Freq					
1989	0	0	63	*	*
1994	1	1	59		
2000	1	0	18		

- The vegetation changes need to be interpreted in the context of vegetation recovery from past intensive herbivory, natural successional dynamics of *C. pallens* grassland, and possible changes induced by climate change.
- The cause of the large decline in total height frequency of *C. pallens* between 1994 and 2000 was unclear, but was not related to deer browsing damage. Suggested causes included depletion after heavy flowering in four out of five summers and competition from expanding herb populations.
- Most vegetation parameters indicate steady improvement and recovery of the grassland under current deer densities.

Limitations and points to consider

- The vegetation changes need to be interpreted in the context of vegetation recovery from past intensive herbivory, natural successional dynamics of *C. pallens* grassland, and possible changes induced by climate change.
- The cause of the large decline in total height frequency of *C. pallens* between 1994 and 2000 was unclear, but was not related to deer browsing damage. Suggested causes included depletion after heavy flowering in four out of five summers and competition from expanding herb populations.
- Most vegetation parameters indicate steady improvement and recovery of the grassland under current deer densities.

References for case study A

Lee, W.G.; Wilson, J.B.; Maxwell, J.; Rance, B.D.; Walker, S.; Allen, C. 2003 (unpub.): Vegetation change (1989–2000) and use by deer of *Chionochloa pallens* subsp. *cadens* grassland in the Murchison and Stuart Mountains, Fiordland. Landcare Research Contract Report (LC0203/132). Manaaki Whenua – Landcare Research, Lincoln.

Case study B

Case study B: vegetation monitoring of recently protected tussock grasslands in the southern South Island, New Zealand

Synopsis

This study uses SHF transects to compare vegetation change on ungrazed and grazed sites in a range of communities. Vegetation changes were examined at 17 sites in four protected natural areas, including 10 sites with paired grazed and ungrazed transects. The communities included tall and short-tussock grassland, wetland, and high-alpine communities. The sites were established soon after formal protection in 1987–1991. The study was of short duration (5 or 6 years), but it does highlight the usefulness of sampling schemes that incorporate grazed controls when attempting to interpret the effects of removing grazing.

Objectives

- To assess initial changes in composition, structure, and species richness 5–6 years after the cessation of grazing.
- To compare vegetation change in grazed and ungrazed grasslands.

Sampling design and methods

- Standard SHF transects were established between 1987 and 1991 and remeasured 5 or 6 years later.
- Eight sites consisted of paired exclosure and control transects, two sites were in equivalent ungrazed and grazed grasslands; and seven sites were ungrazed.
- For the grazed/ungrazed comparisons, one transect was established per treatment.

Results

- For individual species, changes in biomass index over 5–6 years were assessed using Chi-square tests. In the paired sites the significance of grazing treatment was analysed using 2 × 2 contingency tables.
- Trends in total exotic biomass index for each site were analysed for individual species.
- Changes in the total number of vascular species at each site were compared using paired *t*-tests.
- All trends were variable, partly reflecting the short study period.
- At several sites, removal of grazing initiated the onset of increases in dominant tussock species. Where tussock canopy cover and height increased, there was a declining trend in the number and biomass of native and exotic inter-tussock species.
- There was no significant increase in exotic pasture species after removal of grazing.

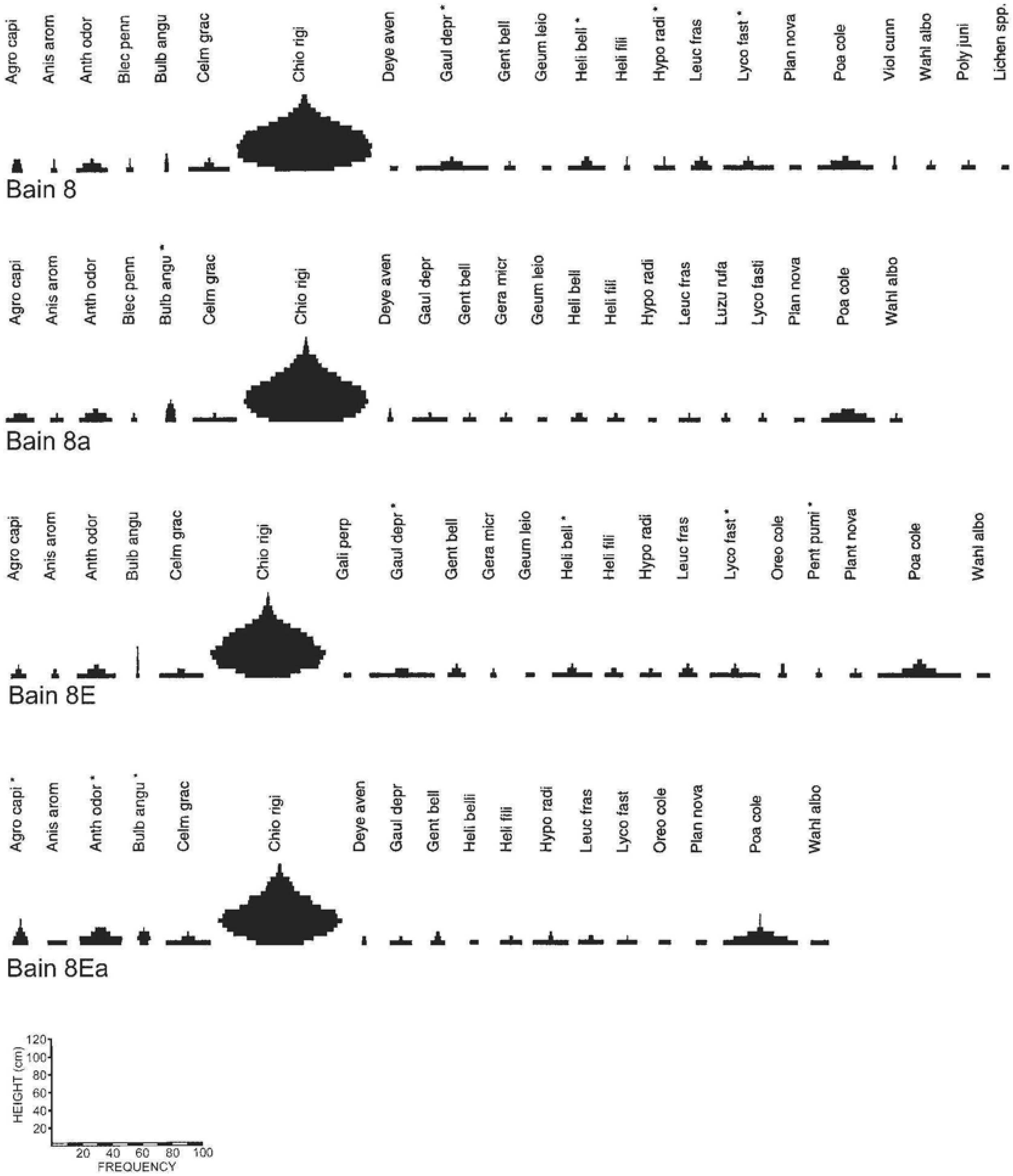

Figure 1. Diagrammatic representation of height-frequency values for the more important species (source: Appendix 2, Grove et al. 2002).

Limitations and points to consider

- Despite the short study period, there were general indications that removal of grazing would prompt recovery of the dominant tussocks in these communities.

- With ongoing tussock recovery it is likely that species diversity will decline.
- Exotic species were not likely to become more dominant after removal of grazing.
- The case-by-case treatment of sites using simple statistics, and a lack of consistent trends, resulted in a highly descriptive approach. Synthesis and interpretation would have been clearer using more informative, more powerful techniques such as analysis of variance and ordination.

References for case study B

Grove, P.B.; Mark, A.F; Dickinson, K.J.M. 2002: Vegetation monitoring of recently protected tussock grasslands in the southern South Island, New Zealand. *Journal of the Royal Society of New Zealand 32*: 379–414.

Case study C

Case study C: temporal responses over 30 years to removal of grazing from a mid-altitude snow tussock grassland reserve, Lammerlaw Ecological Region, New Zealand

Synopsis

In this study SHF transects were used to monitor five representative sites at the 145 ha Black Rock Scenic Reserve, Otago. The aim was to assess 30-year trends in the snow tussock (*Chionochloa rigida*) grasslands, which were fenced-off to exclude stock in 1971. Comparable grazed vegetation was not available as a control. Four sites were established in 1972 and remeasured in 1988 and 2002, and one site was established in 1991 and remeasured in 2002.

Objectives

- To assess 30 years of recovery of mid-altitude snow-tussock grassland after the removal of grazing.
- To investigate whether woody vegetation is succeeding snow tussock.

Sampling design and methods

- In 1972, four representative and permanently marked 1 ha sites were selected (Bulloch 1973). At each site, five parallel 100 m transects were established at 20 m intervals. These transects were re-sampled in 1988 and 2002 using the same method.
- In these early SHF transects, plant species were recorded in 5 cm height tiers at 2 m intervals along each transect, giving 50 sample points per transect and 250 per site. To reduce sampling disturbance to the vegetation, the sampling volume was modified to an open-ended cube defined by pins (Bulloch 1973) rather than a cylinder defined by rings (Scott 1965).
- Two further transects were added in 1988 and 1991 to monitor changes in the shrub *Dacrophyllum longifolium* and the weed *Hieracium pilosella*. The two additional transects used the now standard method of 100 sample points along 50 m transects.

Results

- Significant changes in the biomass index of species between sample years were tested using Chi-squared tests.
- Snow tussocks increased in dominance and the ground cover of mosses, lichens and several low growing shrub species increased after grazing ceased. There were only minor increases in most shrub species except for *D. longifolium*.
- Vascular species richness declined overall, reflecting canopy recovery. Relatively minor species with low biomass indices were principally responsible for gains and losses in species richness.

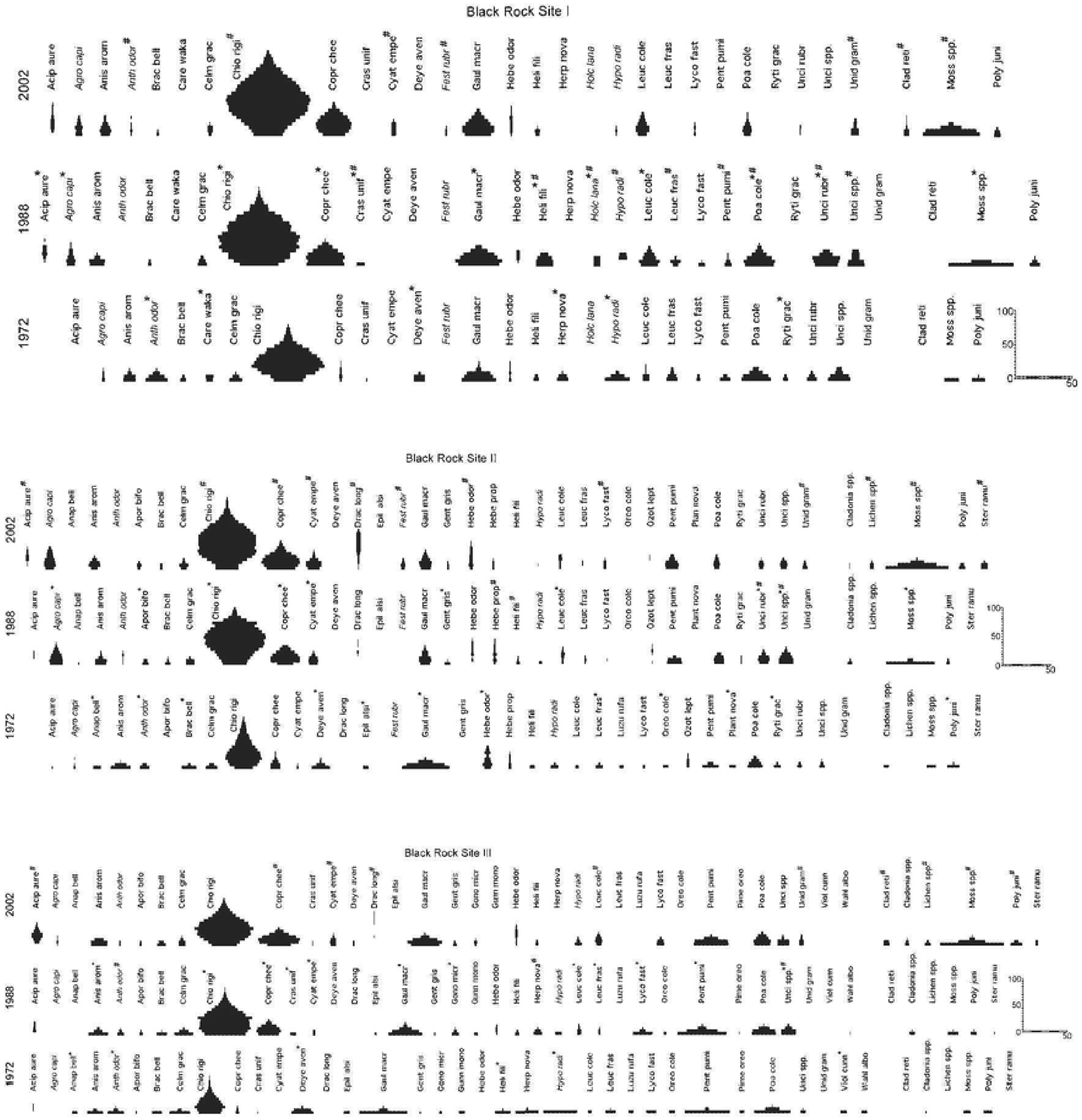

Figure 2. Diagrammatic representation ('kite diagrams') of height-frequency values for the more important species at sites I–III over a 30-year period (1972, 1988, 2002) at Black Rock Scenic Reserve (modified from fig. 2, Mark & Dickinson 2003, p. 659).

Limitations and points to consider

- After 30 years of successional change, the ungrazed grassland community is now dominated by snow tussock with an herbaceous ground cover, rather than by woody species as had been predicted.
- Removal of grazing will lead to a decline in species richness in these communities.

- The vegetation changes suggest a succession towards a mosaic of non-woody and woody vegetation that reflects variation in soils, microclimate, topography and disturbance.
- The study would have been enhanced by monitoring an equivalent grazed area, but this was not possible because of land development. This would have helped to confirm whether the results are a direct response to removal of grazing, and highlighted any ongoing adverse effects of grazing.
- Where there were three sample dates, the statistical analyses only compared consecutive sample dates and did not compare the initial and final values. Potentially this can lead to erroneous conclusions.

References for case study C

Mark, A.F; Dickinson, K.J.M. 2003: Temporal responses over 30 years to removal of grazing from a mid-altitude snow tussock grassland reserve, Lammerlaw Ecological Region, New Zealand. *New Zealand Journal of Botany 41*: 665–668.

Full details of technique and best practice

Full details of the SHF method are described in ‘Two permanent plot methods for monitoring changes in grasslands: a field manual’ (Wiser & Rose 1997).[8] For RECCE plot descriptions, consult the expanded and field versions of the protocol (Hurst & Allen, 2007a,b) or refer to ‘Vegetation: RECCE plots’ (docdm-359575).

To establish an SHF transect:

- Lay out a tape 50.2 metres in length. Keep the tape taut and permanently mark both ends with stakes.
- Species are sampled using a 2 m vertical rod marked at 5 cm intervals. Attached to the rod are two or three horizontal metal rings or pairs of pins to define either a column or an open cube (see figures 8, 9 in Wiser & Rose 1997). The rings or pins are designed so that each 5 cm height interval defines a consistent volume of 100 cm^3 and species are recorded according to which 5 cm height intervals they occur in. The optimum size of the SHF sampling volume depends on plant size and abundance. For example, when the ratio of quadrat size to plant size is small, the relationship between frequency and cover is close. When quadrat size equals or exceeds plant size, the relationship between frequency and cover becomes weaker (Scott 1965).
- At 0.5 m intervals along the transect (beginning at 0.5 m), hold the rod vertically (not at right angles to the ground) and record the plant species present in each 5 cm height tier. Record a species as ‘present’ if any vegetative part falls within the cube (flowering parts are excluded). Observers may need to crouch down to view the rod from the side to correctly assess the height tiers.

[8] Refer to ‘Manuals, sheets and tools’ at http://nvs.landcareresearch.co.nz/

- Record the dominant ground cover at ground level as either live vegetation, litter, bare ground, broken rock, rock, scree, erosion pavement, or (in rare cases) water. Taller species might need to be pushed gently aside once they have been recorded to assess smaller species, closer to the ground. If a tussock species forms the dominant ground cover, then the observer measures the maximum tiller length by pulling it up the vertical rod.
- It is standard to record a bounded 50 × 5 m RECCE plot method defined by an area 2.5 m either side of the transect. Note that RECCE height tiers used for grasslands are different from those specified for forests (Hurst & Allen 2007a,b).

References and further reading

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Appendix A

The following Department of Conservation documents are referred to in this method:

docdm-39000	National Vegetation Survey (NVS) databank data entry, archiving and retrieval standard operating procedure
docdm-53429	NVS metadata sheet
docdm-359575	Vegetation: RECCE plots
docdm-146272	Standard inventory and monitoring project plan