

Field protocol for Tier 1 Vegetation Monitoring - Tahr Browse Impacts



Version 4.0 Season 2019.2020



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Version history

Version 1.0

Version used in the 2016/2017 season.

Department of Conservation. 2016: *Field protocols for DOC Tier 1 - Vegetation Monitoring - Tahr Browse Impacts, Version 1.0*. Department of Conservation, Wellington.

Version 2.0

Version used in the 2017/2018 season (first training course).

Department of Conservation. 2017: *Field protocols for DOC Tier 1 - Vegetation Monitoring - Tahr Browse Impacts, Version 2.0*. Department of Conservation, Wellington.

Version 2.1

Version used in the 2017/2018 season (second training course).

Department of Conservation. 2017: *Field protocols for DOC Tier 1 - Vegetation Monitoring - Tahr Browse Impacts, Version 2.1*. Department of Conservation, Wellington.

Version 3.0

Version used in the 2018/2019 season (first training course).

Department of Conservation. 2018: *Field protocols for DOC Tier 1 - Vegetation Monitoring - Tahr Browse Impacts, Version 3.0*. Department of Conservation, Wellington.

Version 4.0

Version used in the 2019/2020 season.

Department of Conservation. 2018: *Field protocols for DOC Tier 1 - Vegetation Monitoring - Tahr Browse Impacts, Version 3.0*. Department of Conservation, Wellington.

Changes since the previous version

See Appendix 9 for a summary of the main changes to the manual since Version 3.0

1. Background

Introduced herbivores are known to impact on snow tussock grassland, shrubland and herbfields in subalpine and alpine zones, but the degree of these impacts and the consequences are little understood.

The impacts of Himalayan tahr (*Hemitragus jemlabicus*) are of interest, as severe impacts have been observed throughout their range, but tahr are also of intense interest to hunters.

This document outlines additional monitoring to be completed on the Tier 1 alpine and subalpine sample plots and describes methods to collect additional data on plant species sensitive to tahr impacts and known to form a component of their diet.

The Himalayan Tahr Control Plan and the Tahr Management Policy (Department of Conservation 1993) established a national tahr population limit at no more than 10,000 individuals and maximum tahr density thresholds for management units. Permanent vegetation plots were established to monitor the impacts of tahr on sensitive subalpine vegetation and to help guide tahr management. A recent report and paper summarise the trends found in this monitoring and associated pellet counts from the 1990's onwards (Cruz et al. 2014, 2017). They show that tahr negatively impact snow tussocks and that overall the condition of snow tussocks has declined over time, suggesting that current management of tahr is insufficient.

However, the conclusions drawn from this original study are of limited use for management, mainly because the vegetation plots were subjectively located, limiting the ability for inference to other sites, and data on tahr densities in the study areas were not consistently collected. The monitoring data can be interpreted only for the subjectively chosen areas - areas with high snow tussock biomass and assumed high tahr use - and observed trends in vegetation condition cannot be related to catchment-wide tahr densities. This means reporting on vegetation condition at the catchment or tahr management unit level is impossible, and an understanding of the relationship between tahr densities and vegetation condition, and potentially acceptable levels of tahr densities is still lacking. The Department of Conservation (DOC) needs to be able to make broader statements about the impact of tahr on vegetation communities across the landscape and requires a better understanding of population and distribution trends in the overall tahr herd.

The continued roll out of DOC's Tier 1 terrestrial monitoring programme offered an opportunity to capitalise on the systematic (unbiased) sample design of Tier 1 by adding measures to monitor tahr abundance and potential impacts on vegetation.

This document describes the measures added to the standard Tier 1 protocol, aimed at monitoring potential impacts of tahr on vegetation. The new measures will be tested against the standard Tier 1 methods to determine whether the latter are already sufficient to report on tahr impacts, or whether the additional measurements (Tier 1 tahr method, described below) are necessary.

2. Objective

To monitor browse impacts of tahr on alpine and subalpine vegetation communities.

This method is adapted from earlier tahr vegetation monitoring methods and DOC's Tier 1 20x20 vegetation plot methodology (Department of Conservation 2018, Gruner et al. 2012).

Earlier versions of the Tier1 vegetation monitoring tahr browse impact protocol improved how some particular plant growth forms were measured. This latest version (4.0) of the protocol has the same measurement standards as version 3.0 (2018/2019).

A review of the potential to integrate the Tier 1 tahr plots with existing historic tahr plots in the tahr management and exclusion zones was undertaken by Landcare Research (Bellingham 2018). Subsequent advice from Landcare Research recommended measurement methods remain stable and consistent until all the vegetation plots are measured once. The first round of measurement will be completed by the end of season 2020/2021.

3. Species selection

As tahr populations change, browse pressure on sensitive plant species will change in response. The following groups of tussock, fleshy, herbaceous and woody species have been selected for additional monitoring on standard Tier 1 20x20 vegetation plots. These include species that have been monitored in the past where data is required for ongoing comparison, plus additional species that are sensitive to tahr browse and most likely to show changes in abundance and/or height structure in response.

3.1. Snow tussock species

- Species to monitor are: *Chionochloa flavescens*, *Chionochloa pallens* and *Chionochloa rigida*. Include subspecies if they are present in the plot and can be distinguished.
- Snow tussocks comprise about 30% of tahr diet and are only a minor component of the diet of chamois and possums¹ (Parkes & Thomson 1995).
- It is known that snow tussocks have high biomass and are reduced in size by tahr, and changes in the condition of snow tussock species because of tahr have previously been measured (Rose & Allen 1990; Cruz et al. 2014, 20176).
- These three species grow as distinct snow tussocks and individuals can be identified.

¹ Hares also eat snow tussocks (Wong & Hickling 1999) and may confound the assessment of tahr browse impacts. However, by combining the Tier 1 Tahr method data (sensitive species and measures of tahr abundance) with the standard Tier 1 data (vegetation in 20x20 and pellet lines), this issue can be reduced allowing detection of large changes caused by tahr.

3.2. Fleshy and herbaceous species

- Species monitored are: *Ranunculus lyallii*, all *Celmisia* species, *Aciphylla aurea*, *Aciphylla colensoi*, *Aciphylla crenulata*, *Aciphylla divisa*, *Aciphylla borrida*, *Aciphylla montana* and *Aciphylla scott-thomsonii*.
- These species are palatable, thus their size or abundance may change because of the pressure from ungulate browse.
- Individuals can be distinguished (and counted) and size measured.
- *Aciphylla* species are common in the diet of tahr, but uncommon in the diet of chamois and possums.

3.3. Woody shrubs

- All woody shrubs species. Are monitored.
- Many woody shrubs are palatable and a known part of the diet of tahr.
- They have high biomass and are reduced in size by tahr.
- Species are easily identified.
- The growth form of many species is easy to monitor and measure.

3.4. Other rare species

- Other palatable, rare or range restricted species are not monitored (e.g. *Ranunculus godleyanus*).
- While known to be a component of the diet of tahr, rare species such *R. godleyanus* are often restricted in distribution and/or present in low abundance, which makes them unlikely to provide useful data.

4. Plot layout and order of methods

The tahr browse impact monitoring methods described below are additional methods completed at each existing Tier 1 20x20 vegetation plot within the tahr management units and exclusion zones as defined in the Tahr Control Plan (Department of Conservation 1993) (Figure 1). Lay out the 20x20m plot (Figure 2) and complete the Tier 1 methods following the field protocols for DOC Tier 1 Inventory & Monitoring and LUCAS plots including any required additional methods or collections (e.g. vascular, non-vascular collections (Department of Conservation 2019)). Complete the additional methods and measurements for tahr browse impacts as described below.

It is strongly recommended that the additional tahr browse impact monitoring is completed on the same day(s) as the Tier 1 20x20 monitoring and by the same team. If this is not possible, care must be taken to ensure the returning monitoring team has the required botanical skills to confidently identify the selected species. Species must be carefully matched with the Recce Vegetation Description from the current Tier 1 20x20 monitoring and updates and collections may be required if a returning team disagrees with species identification or finds additional species. Take the current Tier 1 20x20 monitoring data to the tahr plot for species naming and collected species comparisons. Collected species on the current Tier 1 20x20 monitoring RECCE will be marked as collected in the tahr browse impact monitoring data.

If the vegetation team is planning to complete the tahr pellet counts ([DOC-2970914](#)), these should ideally be done before any Tier 1 or additional tahr browse impact methods to avoid trampling and impacting data quality.

The tahr browse impact method can be completed concurrently or after the standard Tier 1 20x20 vegetation monitoring has been completed. The most efficient approach is probably to measure and record all data one subplot at a time, but teams may change this approach depending on the terrain and number of team members present.

Record the time taken to complete tahr browse impact measurements on the Tahr Metadata Record Sheet (Appendix 1. Tahr Metadata record sheet). Teams may need to estimate the time because of the complexity of some vegetation plot measurements.

The following sections describe the tahr browse impact methods in detail and a summary table is provided in Appendix 2.

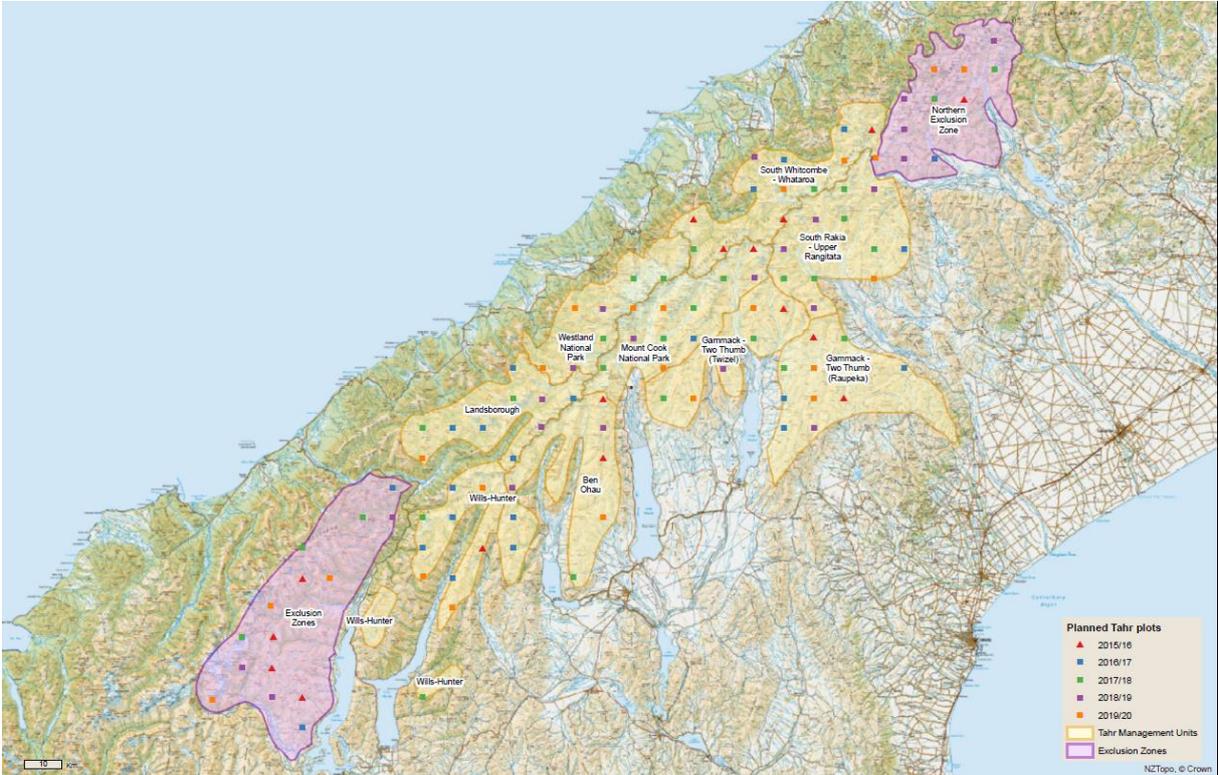


Figure 1. Tier 1 20x20 plots within the tahr management units and exclusion zones as defined in the Tahr Control Plan.

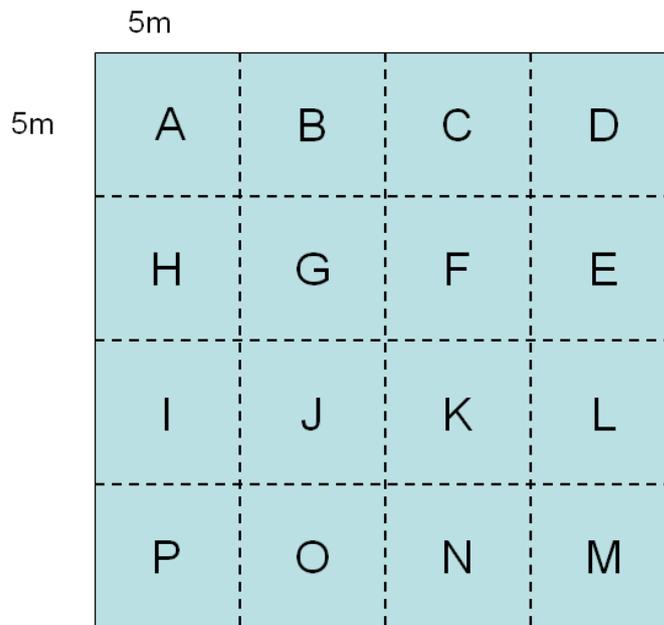


Figure 2. Tier 1 20x20 Vegetation Plot Layout with 16 subplots A-P.

5. Snow Tussock species - Percentage cover estimate for entire 20x20m plot

5.1. Combined percentage cover estimate

After the plot is established, use the Percent Cover Scale (Appendix 3) to estimate the total combined percentage cover for *C. flavescens*, *C. pallens* and *C. rigida* (including all subspecies) within the entire 20x20m plot to the nearest 5% or to the nearest 1% if below 5%. This estimate should include the live plant material and any dieback (dead tillers). Do not separate the three species (or subspecies) or record cover by height tier.

Record the overall cover estimate into the Snow Tussock Percentage Cover field of the Tier 1 Tahr Random Subplots Record Sheet (Appendix 5). If no Snow Tussock species are present record zero (0) or “None”.

6. Snow Tussock species – Individuals: entire plot measurement or sub-sampling?

6.1. Explanation

The abundance of snow tussock is highly variable throughout the tahr management area. Some plots may have a very high abundance of snow tussock while others have very low abundance, or snow tussocks may be absent altogether. Additionally, snow tussocks may be highly clumped or more evenly dispersed within a plot.

To obtain an accurate measure of the abundance of snow tussock it is **preferable** to measure all individuals in the 20x20 plot (i.e. entire plot measured). However, on some plots where snow tussock is very dense, it may not be possible to measure and record every individual plant in all 16 subplots within the time and resources available.

Field teams may reduce overall effort by measuring all individuals in six subplots that have been pre-selected, whilst still obtaining an acceptable estimate of abundance for the entire plot. This is referred to as sub-sampling. Sub-sampling is not applicable to herbs and woody species.

Use the Snow Tussock Percentage Cover (Section 5.1) and the flow chart in Figure 3 to determine where to measure snow tussock individuals.

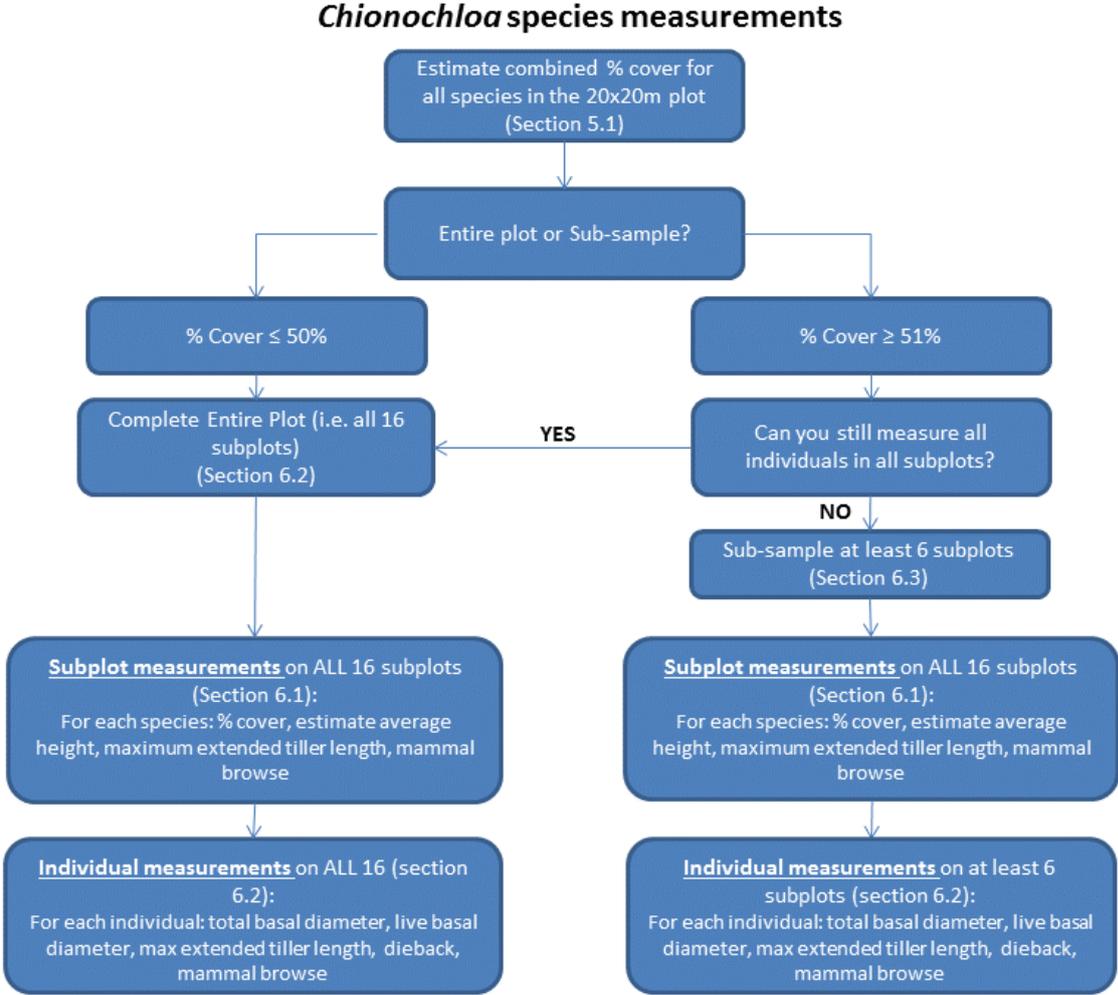


Figure 3. Process for determining snow tussock monitoring requirements for individual tussocks (DOC-2717803).

6.2. Entire plot measurement for snow tussock

If the total combined percentage cover estimate for *C. flavescens*, *C. pallens* and *C. rigida* (or subspecies) for the 20x20m plot (Section 5.1) is ≤ 50 %, complete the individual snow tussock measurements on the entire plot i.e. on ALL 16 subplots (Section 7.1 and Section 7.2).

If the entire plot is measured, record “Yes” in the ‘Measured’ column for all 16 subplots (even if there are no snow tussocks present on a subplot) on the Random Subplots Record Sheet (Appendix 5).

6.3. Sub-sampling for snow tussock

If the total combined percentage cover estimate for *C. flavescens*, *C. pallens* and *C. rigida* (or subspecies) for the 20x20m plot (Section 5.1) is $\geq 51\%$, determine whether you;

- Can complete the individual snow tussock measurements on the entire plot (i.e. on ALL 16 subplots) in the time allocated to complete the plot.
- If not, sub-sample and complete individual snow tussock methods on a minimum of six subplots in random sequential order (Section 7.1 and Section 7.2).

Subplots have been randomly pre-selected and are spatially balanced across the plot (see Appendix 5). Each plot has a Random Subplots Record Sheet that will need to be printed, taken into the field and completion status recorded. This record sheet provides the unique order of subplots to be established if sub-sampling is required.

- Do NOT re-select or re-randomise the order of the subplots. Carry out measures for subplots in the order provided on the Random Subplots Record sheet.
- If you are confident you can complete all required six subplots, then you may measure them in any order you prefer, provided ALL the minimum number of selected subplots are completed.
- If a pre-selected subplot is unsafe to measure, do not measure it and move to the next subplot on the list. Ensure you continue until the minimum number of six subplots is measured. Record “AB” in the measurement status and the reason why the subplot was abandoned in the notes section of the Random Subplots Record Sheet (Appendix 5).
- Once the minimum number of six subplots has been completed and time permits, continue to measure additional subplots in the order prescribed on the data sheet. The more subplots measured, the better the estimates of vegetation condition will be.
- Record measurement status of ALL 16 subplots on the Random Subplots Record Sheet (Appendix 5); Yes (measured), AB (required but abandoned) and dash (not required).

7. Snow Tussock species – Subplot and individual measurements

Measure the selected *Chionochloa* species; *C. flavescens*, *C. pallens* and *C. rigida* (or subspecies) as described below.

7.1. Subplot measurements for snow tussocks

Measure the three snow tussock species (or subspecies) and use the NVS 6 letter codes CHifla, CHIpal and CHIrig (or subspecies codes).

Record data into the Subplot Measurements - Snow Tussock, *Aciphylla* and Fleshy Herb record sheet (Appendix 4). If no target species are present in a subplot, record “None” in the Species column.

Complete subplot measurements on all subplots even if the plot is sub-sampled for measurement of individual tussocks. Do not revise subplot measurement data after estimating the combined percentage cover, other subplot measures or the individual snow tussock measurements. This would compromise comparisons between these methods later.

In each subplot measure and record;

Percent cover:

Use the Percent Cover Scale (Appendix 3) to estimate the percentage cover for each snow tussock species. Measure cover to the nearest 5% or to the nearest 1% if below 5%. This estimate should include the entire tussock including any dieback (dead tillers).

Average *estimated* natural height:

Estimate the average natural height of each of the selected snow tussock species (or subspecies) within each subplot to the nearest 5 cm (1 cm if average height < 5 cm). Natural height is defined as the maximum height of the live plant as it naturally stands (Figure 6 and Figure 5), rather than measuring the pulled up or extended height. It may be necessary to measure the height to the top of the tallest live tillers on some of the plants to help estimate the average. Only include live tillers but include any dead tiller tips. Flowering culms are excluded from the estimates.

On sloping ground, complete these estimates from the side of the snow tussock (not from above or below) and measure on the vertical axis not perpendicular to the slope (Figure 4).

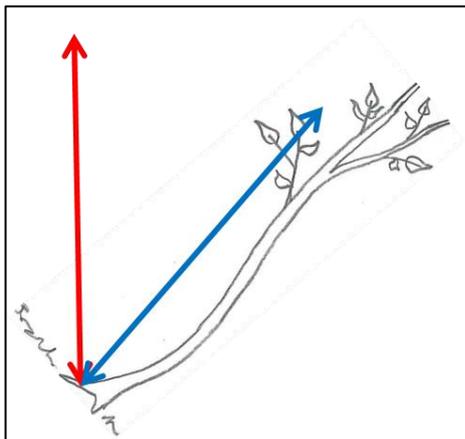


Figure 4. Height is measured on the vertical axis (red arrow), not perpendicular to the slope (blue arrow).

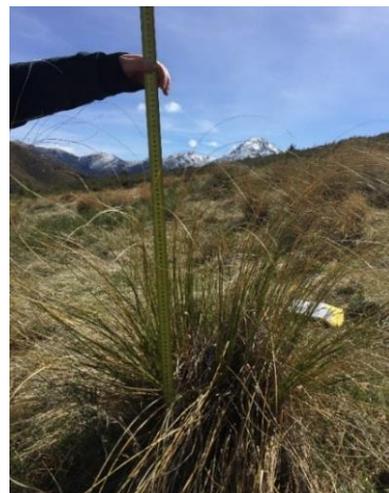


Figure 5. Measuring natural standing height.

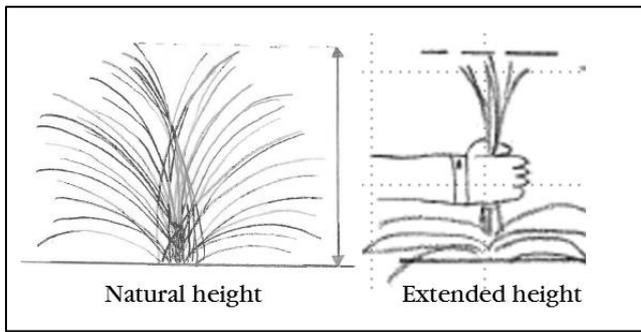


Figure 6. (left). Measurement of natural height as opposed to pulled up (extended) height

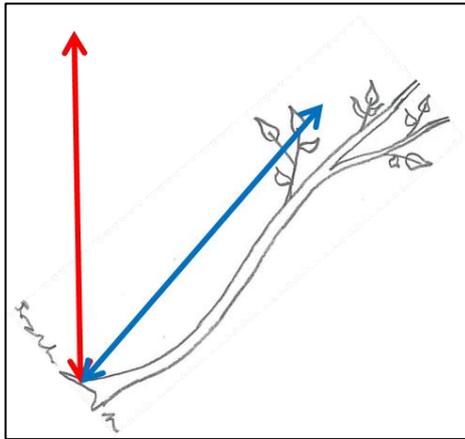


Figure 4. Height is measured on the vertical axis (red arrow), not perpendicular to the slope (blue arrow).

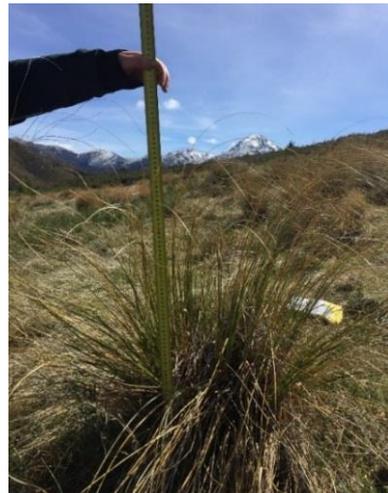


Figure 5. Measuring natural standing height.

Maximum extended live tiller length:

For each of the three snow tussock species (or subspecies), find the tallest individual in a subplot and measure the maximum extended tiller length to the nearest centimetre. Exclude flowering culms.

Use a builder’s tape and measure from the ground surface. Pull up a handful of tillers to their maximum height (Figure 7). Only measure live tillers but include any dead tiller tips.

On sloping ground, measure the vertical height from the side of the snow tussock (not from above or below).

Height is measured on the vertical axis (Figure 4) not perpendicular to the slope.



Figure 7. Measuring maximum extended live tiller length.

7.2. Individual snow tussock measurement.

Within the entire 20x20m plot or selected subplots, measure and record all individual juvenile, mature and senescent snow tussocks. Seedlings are excluded. Size-age classes are defined in Table 1.

Table 1. Snow tussock age-class and individual definitions

Size-age class	Basal diameter limits	Additional criteria
Seedling	≤ 1 cm	Do not measure seedlings as their abundance is likely to vary mostly because of factors unrelated to tahr, e.g. microhabitat and seed availability.
Juvenile	> 1 to 5 cm	
Mature snow tussock:	> 5 cm	And up to 50% crown death.
Senescent snow tussock	> 5 cm	And more than 50% crown death.

Individual snow tussocks are defined as having greater than 1 cm space between the tillers at the base of one individual to the base of the neighbouring snow tussock (Figure 8). There should be no dead tiller/tiller bases linking them (Figure 9).

An individual snow tussock is counted and measured if more than 50% of the basal area is inside the plot. Where an individual snow tussock is spread across more than one subplot, measure and record this in the subplot with the largest proportion of basal area.

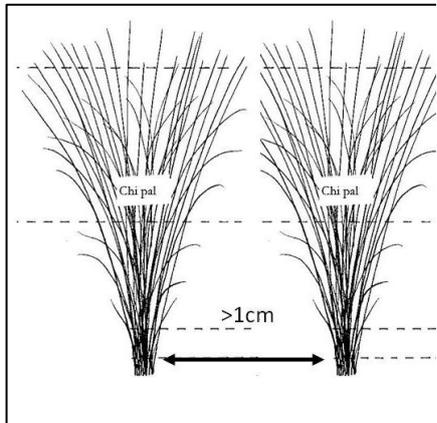


Figure 8. Determine snow tussocks as separate individuals when there is > 1 cm between the tillers at the base.



Figure 9. A snow tussock individual where live tillers are in two separate bunches but connected by dead, but botanically clearly recognisable tiller bases.

Within each subplot, measure and record size and height of all *C. flavescens*, *C. pallens* and *C. rigida* (or subspecies) individuals.

Record all data for snow tussock on the Individual Measurements - Snow Tussock record sheet (Appendix 6). If no snow tussock species are present in a subplot record “None” in the Species column. If the plot is sub-sampled, record “NA” in the Species column for those subplots not required to be measured.

Measured snow tussocks can be temporarily marked with brightly coloured pegs, or tapes can be used to further subdivide the area to keep track of which individuals have been completed.

In each subplot or selected subplot if sub-sampling, for each individual, measure and record;

Subplot:

Label as A - P.

Species:

Measure the selected snow tussock species (or subspecies) and use the NVS 6 letter codes CHifla, CHIpal and CHIrig (or subspecies CHIfsb, CHIfsf, CHIfsh, CHIpsc, CHIpsp, CHIrSa, CHIrSr and CHIspa).

Total basal diameter:

Measure the total basal diameter to the nearest centimetre using a builder’s tape. Total basal diameter includes both live and dead tillers/tiller bases (Figure 10, Figure 11, and Figure 13).

Place the tape at the base of the snow tussock close to the ground and measure along the slope of the ground (NOT along the horizontal). Two orthogonal measurements are taken, the first measurement at the widest part of the snow tussock base and the second one perpendicular to the first. Measure the snow tussock as it stands and do not pull the tillers apart. Do not include flowering culms.

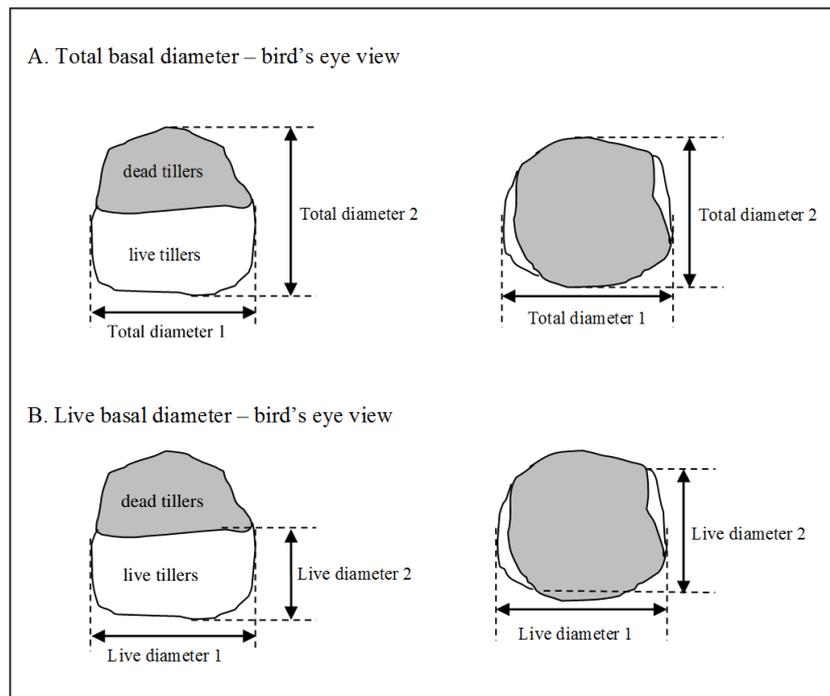


Figure 10. Measurement of total basal diameter (A) and live basal diameter (B) of snow tussocks (bird's eye view).

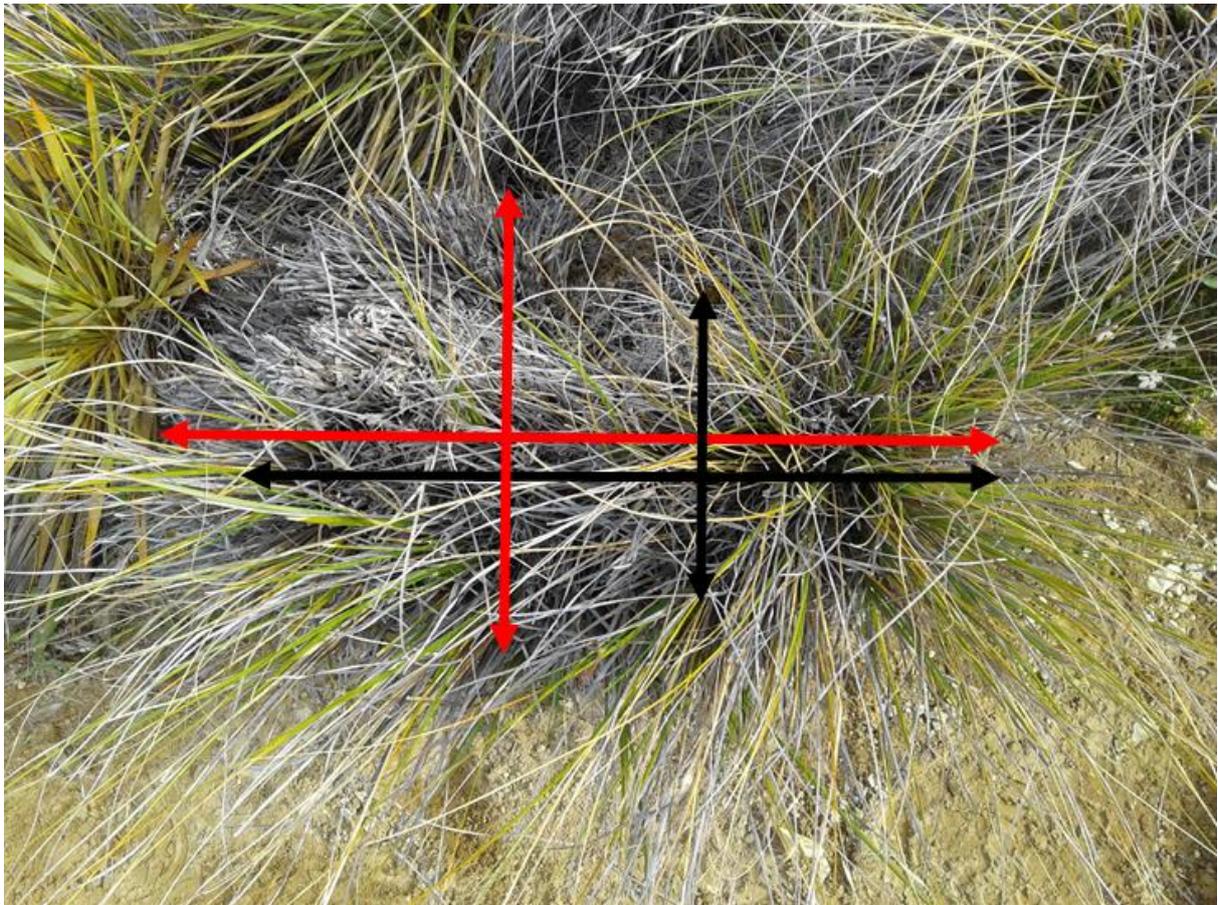


Figure 11. Example where total basal diameter (red) differ from live basal diameter (black) due to inclusion of live and dead tillers/tiller bases.

Stop measuring where the tussock becomes “botanically indistinct”. This is where the structure of tillers and sheaths begins to decay and break down (Figure 14, Figure 15 and Figure 16)



Figure 12. Measurement of total basal diameter of snow tussocks (side view).



Figure 13. Measure across the base, include live and dead tillers until the tussock becomes “botanically indistinct”.



Figure 14. (Above). This photo demonstrates measuring the first of two orthogonal measurements. Measure across the base. Include the dead tillers until the point where the tussock becomes “botanically indistinct” at approximately 20 cm (tip of the **red arrow**).



Figure 15. This is the second orthogonal measure taken at right angles to the one shown in Figure 14. Measure across the base, include live and dead tillers until the tussock becomes “botanically indistinct” (shown in a **red arrow**, at approximately 22 cm here).



Figure 16. and Inset. **Red arrow** showing where the sheaths and tillers become “botanically indistinct”.

Live basal diameter:

Measure the live basal diameter to the nearest centimetre using a builder’s tape. Live basal diameter includes only live tillers. On snow tussocks where the area of dieback (dead tillers) is in the centre, total and live basal diameter are the same. Place the tape at the base of the snow tussock close to the ground. Take two orthogonal measurements; the first measurement at the widest part of the live snow tussock base and the second perpendicular to this (Figure 17 and Figure 18).

The widest part of the live snow tussock base may differ from the widest part of the total basal diameter. In some cases, the live measurement may need to be completed on a different axis.

Measure the individual snow tussock as it stands and do not pull the tillers apart. Do not include flowering culms.



Figure 17. Live basal diameter is measured along the ground between live tillers (shown by the **red arrow**). Dead tillers to the left are not included.



Figure 18. The same tussock from a different view. Live basal diameter measurement is measured along the ground, to the side of the tussock, capturing the maximum distance between the bases of live tillers (shown by the **red arrow**). In this example, it includes the area of dead tillers in the centre (shown by the **black arrow**).

Maximum extended live tiller length:

For each snow tussock, measure the maximum extended tiller length to the nearest centimetre. Exclude flowering culms.

Use a builder's tape and measure from the ground surface. Pull up a handful of tillers to their maximum height (Figure 7). Only measure live tillers but include any dead tiller tips.

On sloping ground, measure the vertical height from the side of the snow tussock (not from above or below).

Height is measured on the vertical axis (Figure 4) not perpendicular to the slope.

For large tussocks with long bases that extend downhill, find the maximum tiller length by measuring the vertical height at several locations along the length of the tussock keeping the tape measure on the ground and to the side of the tussock (Figure 32f).

Dieback:

A tiller can consist of both live leaves with sheaths and dead leaves with sheaths (Figure 19a and Figure 19c). When a snow tussock leaf dies it may break off leaving only the sheath behind (Figure 19b) or remain attached to the plant. When the entire tiller is dead this is classified as dieback.

Use the Percent Cover Scale (Appendix 3) to estimate the percentage of dead tiller area in the total basal area of each individual snow tussock (Figure 19a, Figure 19b and Figure 19c). Measure dieback to the nearest 10% or to the nearest 5% if less than 10%. Only include fully dead tillers (Figure 20). Do not include dead sheaths or dead leaves that are part of live tillers in the estimate of dead tiller area, as these are a natural feature of snow tussock tiller growth. Exclude areas of dead tussock that are no longer botanically recognisable.



Figure 19. Chionochloa tiller features; a. Tillers with live and dead leaves, b. Tillers where leaves have died and broken off leaving the sheaths behind, c. Close up of an individual tiller with live leaves and dead sheaths.



Figure 20. Photo of a tiller with both alive leaves (green) and dead (brown) leaves.



Figure 21. Bird's eye view looking down on top of a tussock. The red outline depicts the total basal area within which to assess.

Mammal browse:

Assess each individual plant for mammalian browse (Section 10).

8. Fleshy and herbaceous species – Subplot and individual measurements

Measure herb species *Ranunculus lyallii*, **each** *Celmisia* species and selected *Aciphylla* species (*A. aurea*, *A. colensoi*, *A. crenulata*, *A. divisa*, *A. horrida*, *A. montana* and *A. scott-thomsonii*) as described below. These species are not sub-sampled.

8.1. Subplot measurements for fleshy and herbaceous species

Measure the selected herb species (or subspecies) and use the NVS 6 letter codes (e.g. RANlya, CELsem, ACIaur).

Record data into the Subplot Measurements - Snow Tussock, *Aciphylla* and Fleshy Herb record sheet (Appendix 4). If no target species are present in a subplot record “None” in the Species column.

Complete subplot measurements on all subplots. Do not revise subplot measurement data after completing measures on other subplots. This would compromise comparisons between these methods later.

In each subplot, measure and record;

Percent cover:

Use the Percent Cover Scale (Appendix 3) to estimate the percentage cover for *R. lyallii* **each** *Celmisia* species and *A. aurea*, *A. colensoi*, *A. crenulata*, *A. divisa*, *A. horrida*, *A. montana* and *A. scott-thomsonii*. Measure cover for each species (or subspecies) to the nearest 5% or to the nearest 1% if below 5%.

Average estimated natural height:

Estimate the average height of each species within each subplot to the nearest 5 cm (1 cm if average height < 5 cm). Natural height is defined as the maximum vertical height of the plant as it naturally stands, rather than measuring the pulled up or extended height (Figure 4 and Figure 7). Measure the height to the tallest live leaves on some of the plants to help estimate the average. Flower heads and their stems are excluded.

On sloping ground, measure from the side of the plants (not from above or below). Height is measured on the vertical axis (Figure 4) not perpendicular to the slope.

Maximum natural height:

For each species find the tallest individual in a subplot and measure the maximum natural height to the nearest centimetre. Measure the natural height of the tallest live leaves excluding flower heads and their stems. Natural height is defined as the maximum vertical height of the plant as it naturally stands, rather than measuring the pulled up or extended height (Figure 4 and Figure 7).

On sloping ground, measure from the side of the plants (not from above or below).

Height is measured on the vertical axis (Figure 4) not perpendicular to the slope.

Mammal browse:

Assess each species for the percentage of live leaves browsed by mammals (see Section 10 for instructions on how to assess browse).

8.2. Individual fleshy and herbaceous species measurements

Within each subplot, measure and record the size and height of all individuals of *R. lyallii*, *Celmisia semicordata*, *A. aurea*, *A. colensoi*, *A. crenulata*, *A. divisa*, *A. horrida*, *A. montana* and *A. scott-thomsonii*.

Fleshy and herbaceous species are not sub-sampled.

An individual is counted and measured if more than 50% of the crown area is inside the plot. Where an individual is spread across more than one subplot, measure and record this in the subplot with the largest proportion of the crown area.

Record all individual fleshy and herbaceous species data into the Individual Measurement - *Aciphylla* and Fleshy Herb record sheet (Appendix 7). If no target species are present in a subplot record "None" in the Species column.

Measured plants can be temporarily marked with brightly coloured pegs, or tapes can be used to further subdivide the subplot to keep track of which individuals have been completed.

In each subplot, for each individual, measure and record;

Subplot:

Label as A - P.

Species:

Measure the selected fleshy herb species and use the NVS 6 letter codes (e.g. RANlya, CELsem, ACIaur).

Crown diameter:

Crown diameter captures the spread of foliage of the live plant. Use a builder's tape to take two orthogonal measurements across the top of a plant, the first measurement at the widest part of the plant and the second one perpendicular to this (Figure 22 and Figure 23). Measure the crown diameter to the nearest centimetre.

Only live diameters are recorded. Therefore, measure only live foliage but include leaves with partial dieback. Exclude flower heads and their stems.

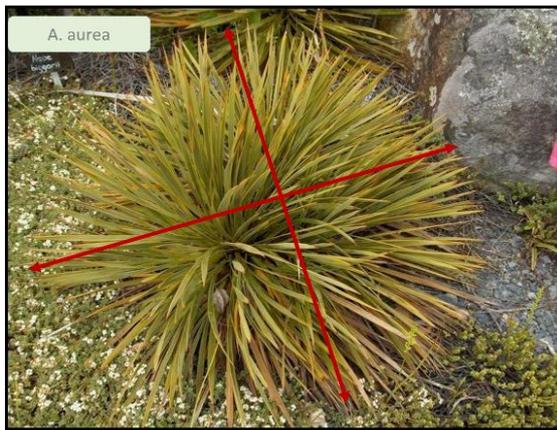


Figure 22. Measurement of crown diameter of *Aciphylla* species. Only live diameters are recorded (bird's eye view).



Figure 23. Measurement of crown diameter of *Celmisia semicordata*. Only live diameters are recorded (bird's eye view).

Tahr can heavily browse *R. lyallii* leaving only green stem tips. Do not include these in your measurement but include browsed leaves if some leaf blade area is left on the stalk. *R. lyallii* plants can have a trailing form and leaves can be spread widely apart along the stem. To capture the spread of foliage on these plants, visualise moving the leaves of the plant together to estimate the two widths. Alternatively, if leaves are of similar size, measure some of the leaves to get an average of their widths and multiply this by the number of leaves on the plant. Record "est" (estimated) beside the Crown Diameter Widths in the Individual Measurements - *Aciphylla* and Fleshy Herbs record sheet (Appendix 7). Also record this in the notes section of the Tahr Metadata Record Sheet (Appendix 1) and in the Browse section of the Tier 1 Recce Site Description Record Sheet.

R. lyallii may spread or clump and you may not be able to clearly define individual plants for measurement purposes. Figure 24 is an example of how to measure the widths of a clump. If individuals cannot be defined, then measure as a 'clump' and record 'clump' beside the Crown Diameter Widths in the notes of the Individual Measurement - *Aciphylla* and Fleshy Herb record sheet (Appendix 7).



Figure 24. Demonstrating measurement of a *R. lyallii* clump. Take two orthogonal measurements across the top of the clump; the first measurement at the widest part and the second perpendicular to this. Write 'clump' and 'est' in the notes section beside Crown Diam.

If individual plants of *C. semicordata* and *Aciphylla* are particularly dense and it is not possible to take two measurements for the crown diameter (e.g. an individual is partially buried, or leaves overlap), measure one width of the exposed side and record the value in the Width 1 column. Record the same measurement in the Width 2 column and record "est" (estimated) in the notes of the Crown Diameter Width section of the Individual Measurement - *Aciphylla* and Fleshy Herb record sheet (Appendix 7).

Do not apply "clumping" assessments to *C. semicordata* or *Aciphylla* species.

Natural height:

Natural height is defined as the maximum vertical height of the plant as it naturally stands, rather than measuring the pulled up or extended height (Figure 4 and Figure 7). Using a builder's tape measure the maximum natural height to the nearest centimetre. Measure the vertical height from the ground to the tallest live leaves on the plant. Flower heads and their stems are excluded (Figure 25 and Figure 26).

On sloping ground, measure from the side of the individual (not from above or below). Height is measured on the vertical axis (Figure 27a - d), not perpendicular to the slope.

R. lyallii plants may trail down the slope making the maximum natural height harder to measure. In these cases, measure the maximum height to the nearest centimetre of the individuals/clumps. You may need to take multiple height measurements across the individuals/clumps to determine the point of maximum natural height (Figure 27b).

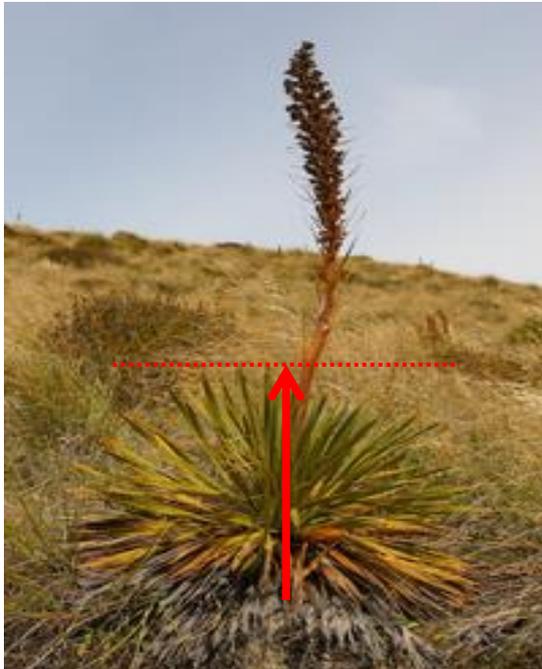


Figure 25. Measure natural height for *Aciphylla* species to tallest live leaves and exclude flower heads and their stems (side view).

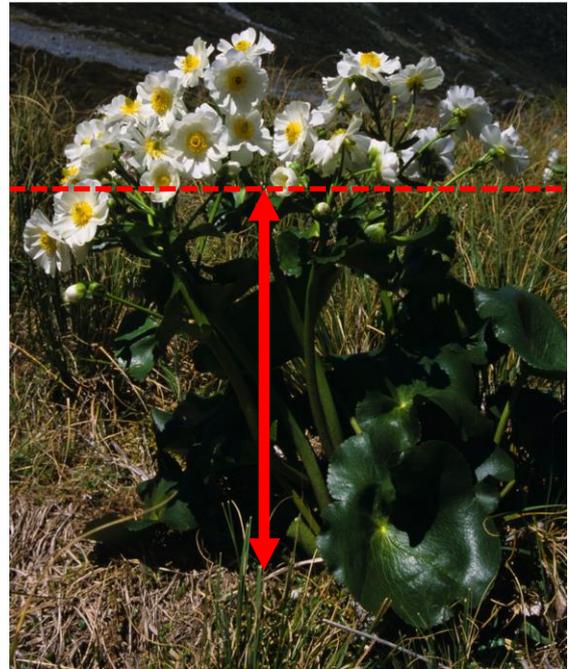


Figure 26. Measure natural height for *R. lyallii*. Measure to the tallest live leaves and exclude flower heads and their stems (side view).

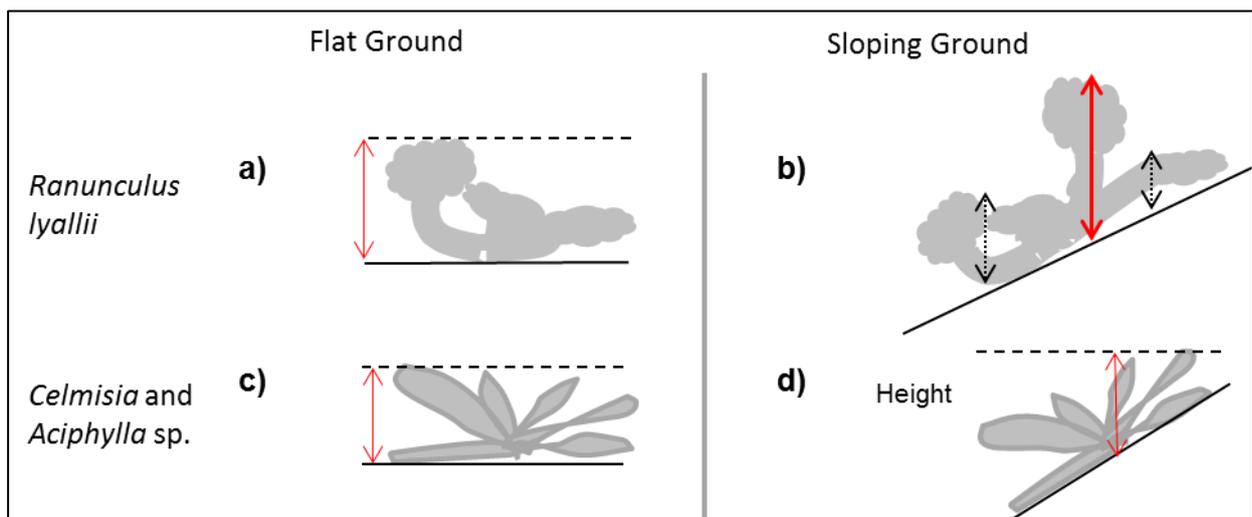


Figure 27. Measurement of natural height for herb species. Measure the tallest live leaves and exclude flower heads and their stems (side view for flat ground and sloping ground).

Mammal browse:

Assess each individual plant for mammalian browse (see Section 10 for instructions on how to assess browse).

9. Woody shrubs – Individual measurements

Measure all woody shrubs as described below. Subplot measurements are not required for woody shrubs. Woody shrubs are not sub-sampled.

9.1. Woody shrubs - definition

Woody shrubs are small to medium-sized woody plants <5 m tall, and at least 0.1 m (10 cm) in height. They will often have an architecture unsuited to stem diameter measurements due to multi-branching and short stature.

However, some plots occur in subalpine altitudes where individual shrubs (e.g. *Dracophyllum*) may be tagged and measured like stems or counted as saplings as part of the Tier 1 vegetation 20 x 20 m method. For the tahr impact monitoring, these are included in the woody shrub measurements.

Shrubs are grouped into three forms; individual shrubs, shrub-clumps and continuous shrub. Each need to be measured differently (Figure 28).

- Individual shrubs (I) are discrete clearly defined single species shrubs where **each individual is distinguishable**. There is no visible above ground connection with neighbouring individuals and each individual can be measured separately.
- Shrub-clumps (SC) are a group of two or more discrete shrubs whose growth form is unsuited to individual measurement due to overlapping and being heavily intertwined. **Individuals are distinguishable but cannot be accurately measured**. The shrub's volume is more accurately measured as a single clump. A shrub-clump has no visible above ground connection with neighbouring individuals or shrub-clumps. Shrub-clumps may consist of more than one species.
- Continuous shrubs (CN) are where shrubs merge so closely or have a growth form (sprawling or mat forming species) that **individuals are not distinguishable**. The volume is more accurately measured as a single continuous mass. Continuous shrubs may consist of more than one species.

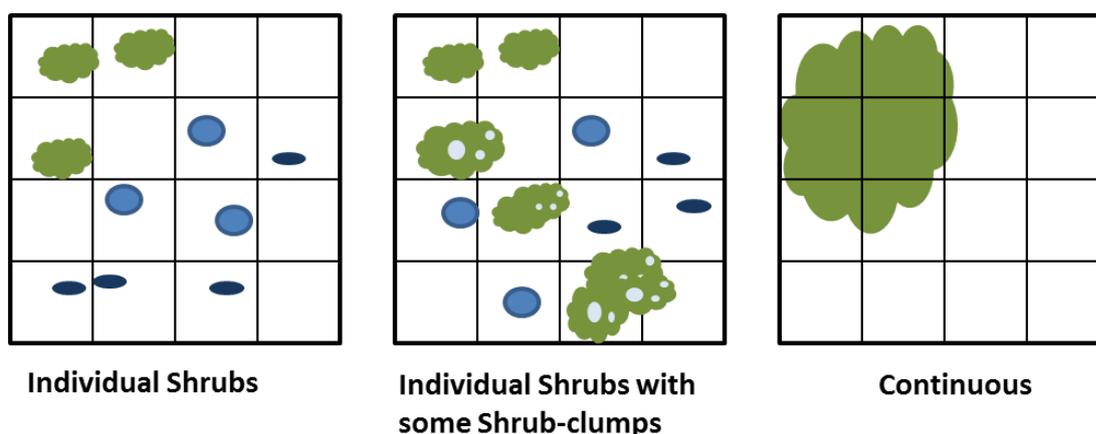


Figure 28. Shrub forms defined as individual shrubs, shrub-clumps and continuous shrubs.

An individual shrub or shrub-clump is counted and measured if more than 50% of the crown area is inside the bounded plot area (Figure 29). If so, then the whole shrub/shrub clump is measured including the parts that are outside the plot (Figure 29). Where an individual shrub or shrub-clump is spread across more than one subplot, measure and

record this in the subplot containing the largest proportion of the crown area and record this in the notes.

Continuous shrubs are defined as being within the plot if any part of the crown area occurs within the plot boundaries (Figure 29). Continuous shrub measurements **do not** include parts of the crown that are outside the plot (Figure 29). Where a continuous shrub is spread across more than one subplot, measure and record this in the subplot containing the largest proportion of the continuous shrub's crown area and record this in the notes.

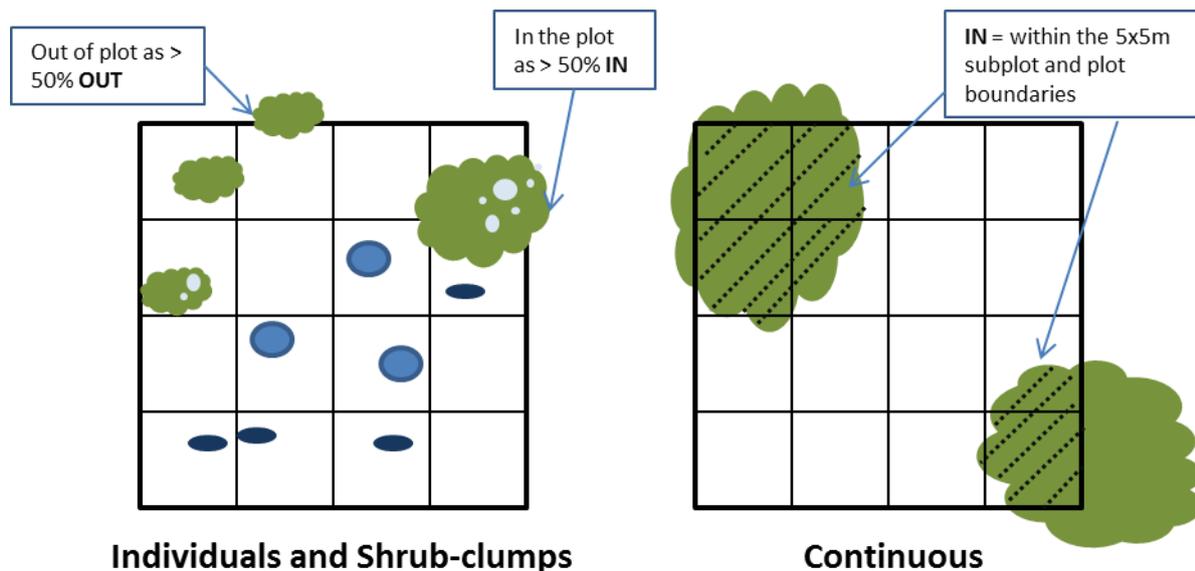


Figure 29. Rules for determining if an individual shrub, shrub-clump and continuous shrub are included in the Woody Shrub measurements.

All measurements of woody shrubs include both live and dead material. The shrub methodology treats each live shrub, shrub-clump or continuous shrub as a mass of branches (both live and dead) with foliage. The purpose of the measurements is to measure the approximate volume of this mass.

Entirely dead shrubs are not measured.

Measured shrubs can be temporarily marked with brightly coloured pegs, or tapes can be used to further subdivide the plot to keep track of which individuals have been completed.

9.2. Individual, clumped and continuous shrub measurements

Record data for woody shrub species on the Individual Measurement - Woody Shrubs record sheet (Appendix 8). If no woody shrubs are present in a subplot record “None” in the Species column.

Measured shrubs can be temporarily marked with brightly coloured pegs or tapes can be used to further subdivide the area to keep track of which individuals have been completed.

In each subplot, for each shrub, measure and record;

Subplot:

Label as A - P.

Species:

Record the shrub species and use the NVS 6 letter codes.

Shrub Type:

Record if the shrub is an individual shrub (I), a shrub-clump (SC) or a continuous shrub (CN).

Crown diameter:

Crown diameter captures the spread of foliage of the shrub (including dead foliage but excluding entirely dead shrubs) and is different to the basal diameter recorded for individual snow tussocks (Section 7.1).

Measure the crown diameter in metres to the nearest 5 cm of each individual shrub, shrub-clump or continuous shrub.

Individual shrubs

Measure the crown diameter of individual shrubs by taking two orthogonal widths.

Using a builder's tape, measure two orthogonal widths in the horizontal plane, the first measurement at the widest part of the plant and the second perpendicular to this. Use a plumb line (or similar method) at each side of the shrub to ensure you are holding the tape level and in the correct position relative to the shrub for accurate measurement of shrub dimensions (Figure 30). On sloping ground, some species have a sweeping form. For these, the whole shrub is included in the crown diameter measures and measurements are taken from the base of the stem to the end of the sweeping shrub (Figure 31).

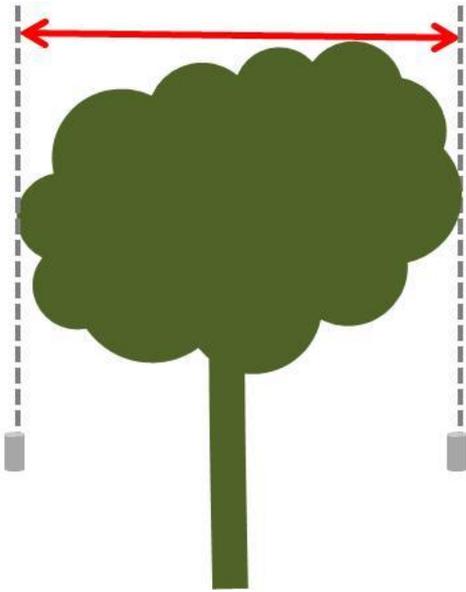


Figure 30. Measurement of crown diameter of individual woody shrubs using a plumb line (side view).

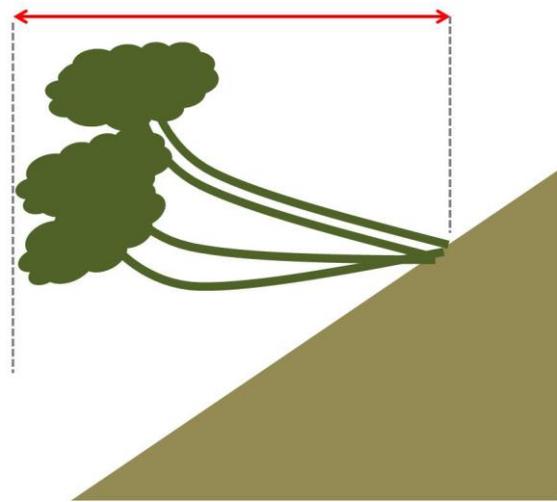


Figure 31. How to measure the crown diameter of sweeping shrubs.

Shrub-clumps (SC) and Continuous shrub (CN)

Include shrub-clumps or continuous shrubs in the measurements if at any point along the clump their maximum natural height is ≥ 10 cm. Continuous shrub measurements do not include parts that are outside the plot.

Measure the crown diameter by taking two orthogonal widths of the clump.

Using a builder's tape, measure two orthogonal widths in the horizontal plane, the first measurement at the widest part of the clump and the second perpendicular to this. Use a plumb line (or similar method) to ensure you are holding the tape level and in the correct position relative to the edge of the shrub-clump/continuous shrub for accurate measurement of its dimensions (Figure 30).

List all species in order of their contribution to the total shrub-clump or continuous shrub volume. Record the dominant species first, separate the species codes using one row per species and record the two orthogonal widths, height and browse in row 1 of the shrub-clump or continuous shrub. Denote the shrub-clump or continuous shrub with brackets and record "SC" or "CN" in the correct column on the Individual Measurement - Woody Shrubs record sheet (Appendix 8).

Natural height:

Natural height is defined as the maximum vertical height of the plant as it naturally stands, rather than measuring the pulled up or extended height. Height is measured on the vertical axis (Figure 4) not perpendicular to the slope. Height is measured from the lowest point of the shrub (Figure 32b).

Measure the maximum natural height in metres (m) to the nearest 5 cm of each individual shrub, shrub-clump or continuous shrub > 20 cm. For shrubs between 10 -20 cm, measure to the nearest 1 cm.

Individual shrubs

Include shrubs if their maximum natural height is ≥ 10 cm.

- Using a builder's tape, measure the maximum natural height of each individual shrub. This is the vertical distance between the projected horizontal line of the highest point and the projected horizontal line of the lowest point (Figure 32a).
- On sloping ground, some shrubs species have irregular forms and in these cases the height needs to account for the whole shrub. Here, this means that the height measurement may start below the rooting height if the shrub has grown partially downhill (Figure 32b).

Shrub-clumps

Include shrub-clumps if at any point along the clump the maximum natural height is ≥ 10 cm.

- Using a builder's tape, measure the maximum natural height of each shrub-clump. This is the vertical distance between the projected horizontal line of the highest point, and the projected horizontal line of the lowest point (Figure 32c).
- On sloping ground, some shrub-clumps have irregular forms and in these cases the height needs to account for the whole shrub. Here, this means that the height measurement may start below the rooting height if the shrub has grown partially downhill (Figure 32d).

Continuous shrub

Include continuous shrub if at any point along the continuous shrub the maximum natural height is ≥ 10 cm.

- Using a builder's tape, measure the maximum natural height of each continuous shrub. This measure differs from individual shrub and shrub-clumps. The maximum natural height is measured along the vertical axis from the ground to the tallest point of the continuous shrub rather than the projected horizontal line of the highest point. To determine this, you may need to take multiple height measurements across the continuous shrub area (Figure 32e).
- On sloping ground, some mat-forming species (e.g. *Podocarpus nivalis*) may form a continuous shrub and individuals cannot be distinguished. Measure their natural height in the same way (Figure 32e and Figure 32f).

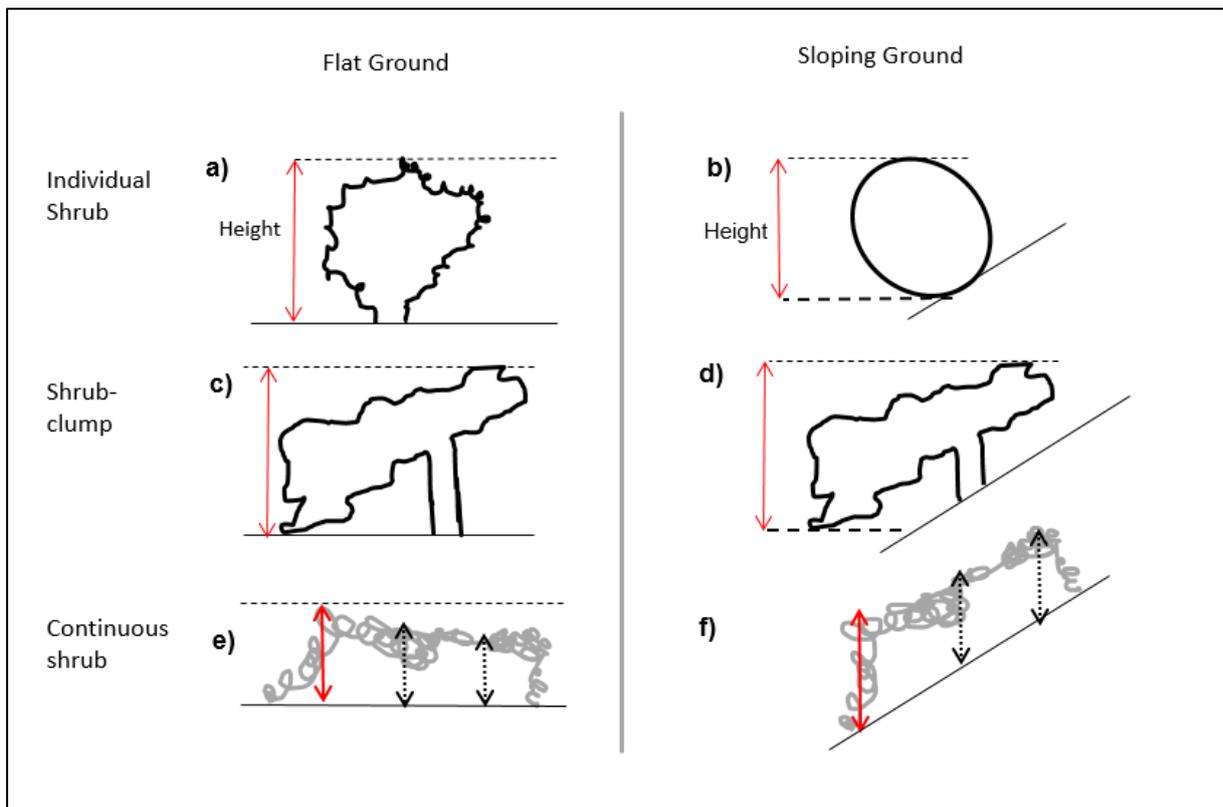


Figure 32. How to measure the maximum natural height of individual shrubs, shrub-clumps and continuous shrubs on flat ground and sloping ground. Height is measured along the vertical axis (red arrows). Figures (a) and (b) show how to measure the maximum natural height of individual shrubs. Figures (c) and (d) show how to measure the maximum natural height of a shrub-clump. Figures (e) and (f) demonstrate that multiple measurements may be needed to determine the maximum natural height of continuous shrubs. Note that for (e) and (f) maximum natural height is measured along the vertical axis from the ground to tallest point of the continuous shrub - not the projected horizontal line of the highest point.

Mammal browse:

Assess each individual shrub for mammalian browse (see Section 10.for instructions on how to assess browse).

10. Mammal browse:

Use the Percent Cover Scale (Appendix 3) to estimate the percentage of live tillers browsed by mammals for each of the three snow tussock species (or subspecies) within each subplot.

Score mammalian browse in one of six browse classes:

- 0 = no browse.
- 1 = almost none with < 1% of leaves browsed.
- 2 = very low with up to 5% of leaves browsed.
- 3 = low with 6 - 33% of leaves browsed.
- 4 = medium with 34 - 66% of leaves browsed.
- 5 = high with > 66% of leaves browsed

DO NOT include insect browse, flower heads, culms or dead tillers. Only score when confident it is mammal browse.

It is not thought to be mammal browse when only the very tips of tillers are nipped off *Chionochloa* sp. Hares tend to cut across the leaf blade in an angle while tahr will usually shear the leaf straight across. Figure 33, Figure 34, Figure 35 and Figure 36 are examples of browse patterns on herb and shrub species.



Figure 33. Herbivore browse on *Ranunculus* sp. Note the leaf ribs are totally removed on one side. There are remains of what looks like leaf veins (with no actual leaf vein) probably from teeth marks. Photo credit Mike Perry.



Figure 34. Mammal browse on *Celmisia* sp, most likely from tahr browse on one side of the plant. Insects tend to spread browse over the entire plant. Also, there appears uniform timing of browse due to consistent browse edge colouring which suggests mammal browse.



Figure 35. Heavy browse on *Dracophyllum* sp most likely herbivore browse. The bite angle at the stem is not 45° (which is more common from hare browse). If the nipped end is a single nip, then it is more likely to be mammalian browse over insect browse.



Figure 36. Most likely tahr browse on stem tips and trampling of *Phormium* sp. Photo credit Mike Perry.

11. Data recording - Best Practise

Follow the protocols and best practices for data recording as per the Tier 1 Monitoring programme. A few of these are highlighted below;

- Record the date in full e.g. “30 January 2016”.
- Record the name of the recorder and observer consistently on all data sheets for the whole season (e.g. “Mike Perry”). Do not use abbreviations e.g. “MP”.
- Fill in all fields and cells. Do not leave any cells blank, record a dash (-) or “NONE”.
- Record subplots in order of A to P on the data sheets.
- Write clearly and in pencil.
- Do not record data or notes in the margins of the plot sheets. Use the notes field.

12. Acknowledgements

We acknowledge the team who developed the original field protocol; Tahr browse monitoring method Knightbridge et al. 2012 (DOCDM-280062). Meredith McKay and Kate McNutt with contributions from Ingrid Gruner, Ian Westbrooke, Paul Van Dam-Bates, Sam Rowland and Kathrin Affeld developed this current protocol. Review and feedback on earlier drafts were provided by the DOC Biodiversity Monitoring Team.

13. References

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- Ministry for the Environment (2015) Land Use Carbon Analysis System Natural Forest Data Collection Manual Version 2.4.

TAHR METADATA RECORD SHEET

Check List for Tahr data sheets: in-field QA of data & samples collected

<input type="checkbox"/> Tahr General	<input type="checkbox"/> Unique plot identifier on all plot sheets <input type="checkbox"/> All collection completed passed to the Tier 1 20x20 Recce botanist. <input type="checkbox"/> All species recorded in Tahr methods are on the Tier 1 20x20 Recce
<input type="checkbox"/> Tahr Metadata	<input type="checkbox"/> Team information completed <input type="checkbox"/> Time allocation completed <input type="checkbox"/> Number of subplots sampled recorded <input type="checkbox"/> All collections made during Tahr methods recorded in Tahr Method Collections
<input type="checkbox"/> Tahr Random Subplots Record Sheet	<input type="checkbox"/> Snow Tussock Percentage Cover recorded <input type="checkbox"/> All subplots either Yes (measured), AB (abandoned) or dash (not required) <input type="checkbox"/> If subsampled, subplots measured in Individual Measurements match those recorded on the Random Subplots Record Sheet
<input type="checkbox"/> Tahr Subplot Measurements	<input type="checkbox"/> All four selected groups checked and measured in all subplots; <ul style="list-style-type: none"> <input type="checkbox"/> Snow Tussock <input type="checkbox"/> <i>Aciphylla</i> <input type="checkbox"/> Fleshy Herb <input type="checkbox"/> Woody Shrub <input type="checkbox"/> All subplots measured and recorded (including where "None") <input type="checkbox"/> Collected © have same tag name as on Individual Measurements and Tier 1 20x20 Recce
<input type="checkbox"/> Tahr Individual Measurements	<input type="checkbox"/> Individual Measurements – Snow Tussocks record sheet completed <ul style="list-style-type: none"> <input type="checkbox"/> If sub-sampled, "NA" recorded in Species column for subplots not required <input type="checkbox"/> Individual Measurements – <i>Aciphylla</i> and Fleshy Herb record sheet completed <input type="checkbox"/> Individual Measurements – Woody Shrubs record sheet completed <input type="checkbox"/> If no target species are present "None" recorded in Species column <input type="checkbox"/> Collected © have same tag name as on Subplot Measurements and Tier 1 20x20 Recce
<input type="checkbox"/> Tahr Pellet Count Methods (if applicable)	<input type="checkbox"/> Pellet count start and end time recorded <input type="checkbox"/> All Plots and Transect records complete Tick, dash or NS

Additional Tahr plot photos (if taken)

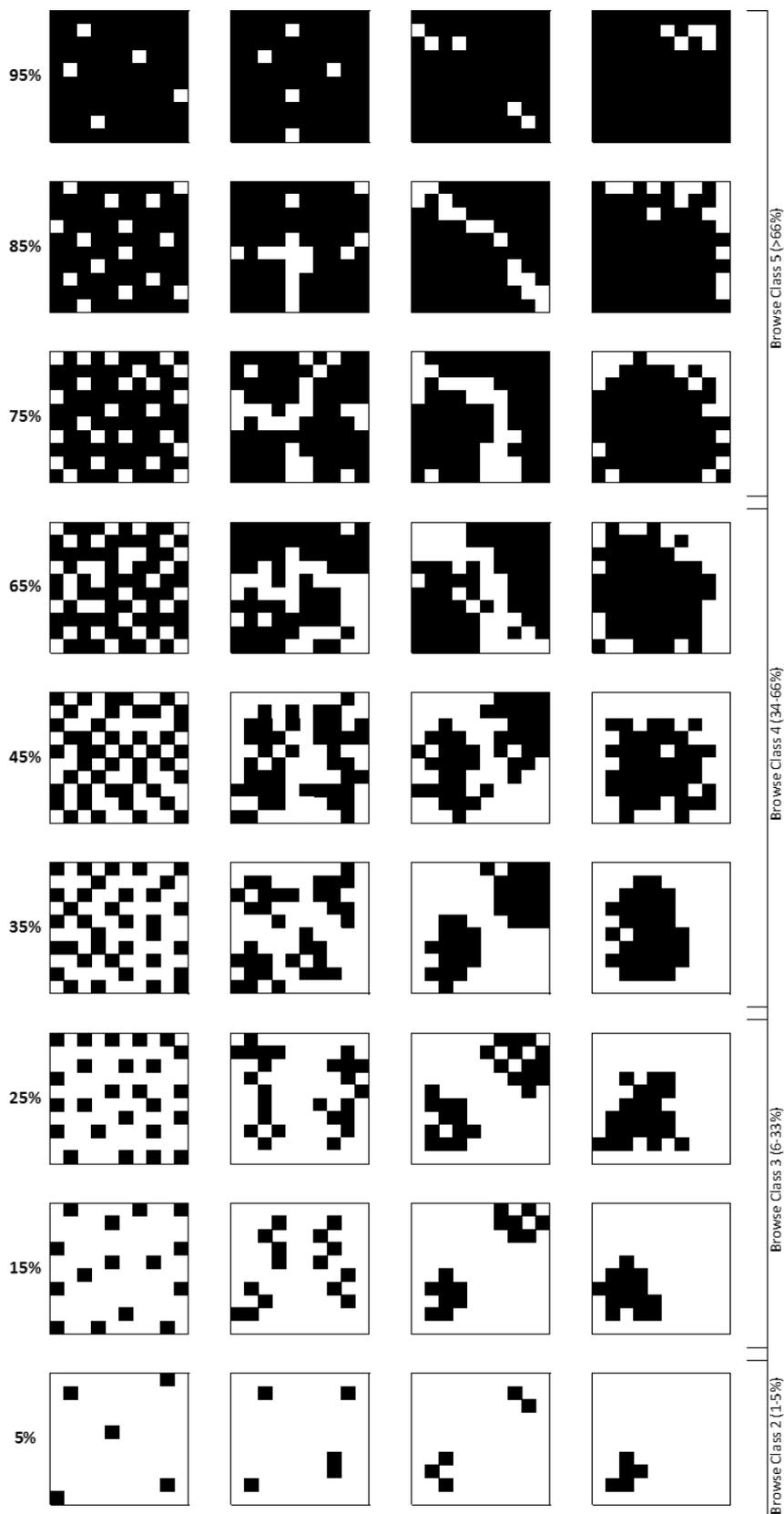
Photo seq	Image number	Description of photo and its purpose (e.g. methods questions photo)	Date	Time
1				
2				
3				
4				

Appendix 2. Methods and measurement units for each group

Selected	Species*	Codes	Subsample possible?	Subplot measurements required if the selected species present (Yes/No)	Tier 1 Tahr Record sheet	Individual measurements required if selected species present (Yes/No)	Tier 1 Tahr Record sheet
Chionochloa	<i>Chionochloa flavescens</i> <i>Chionochloa ballens</i> <i>Chionochloa rigida</i> (or subspecies)	CHIFLA CHIPAL CHIRIG	YES			YES - all individuals of each species* in all subplots or selected subplots if sub-sampled	Individual Measurements - Snow Tussocks
Aciphylla	<i>Aciphylla aurea</i> <i>Aciphylla colenso</i> <i>Aciphylla crenulata</i> <i>Aciphylla divisa</i> <i>Aciphylla horrida</i> <i>Aciphylla montana</i> <i>Aciphylla scott-thomsonii</i>	ACLAUR ACICOL ACICRE ACIDIV ACIHOR ACIMOT ACISCO	NO	YES - each species in each subplot	Subplot Measurements - Snow Tussock, Aciphylla and Fleshy Herb	YES - all individuals of each species* in all subplots	Individual Measurement - Aciphylla and Fleshy Herbs
Fleshy Herbs	All <i>Celmisia</i> spp. <i>Ranunculus lyallii</i>	Various RANLYA	NO			YES - all individuals of <i>Celmisia semicordata</i> and <i>Ranunculus lyallii</i>	Individual Measurements - Woody Shrubs
Woody shrubs	All species	NA	NO	NO	NA	YES - all individuals of each species* in all subplots	Individual Measurements - Woody Shrubs

	Subplot Measurements			Individual Measurements		
	Attribute	Units	Precision	Attribute	Units	Precision
Chionochloa	Percent Cover	%	≥ 5 to nearest 5% < 5 to nearest 1%	Total basal diameter Live basal diameter	cm	to the nearest cm
	Average Estimated Natural Height	cm	≥ 5 to the nearest 5cm < 5cm to the nearest 1cm	Dieback	%	≥ 10 to the nearest 10% <10 to the nearest 5%
	Maximum extended live tiller length	cm	to the nearest cm	Maximum extended live tiller length	cm	to the nearest cm
Aciphylla	Percent Cover	%	≥ 5 to nearest 5% < 5 to nearest 1%	Crown diameter	cm	to the nearest cm
	Average Estimated Natural Height	cm	≥ 5 to the nearest 5cm < 5cm to the nearest 1cm	Natural Height	cm	to the nearest cm
	Maximum natural height	cm	to the nearest cm			
Fleshy Herbs	Percent Cover	%	≥ 5 to nearest 5% < 5 to nearest 1%	Crown diameter	cm	to the nearest cm
	Average Estimated Natural Height	cm	≥ 5 to the nearest 5cm < 5cm to the nearest 1cm	Natural Height	cm	to the nearest cm
	Maximum natural height	cm	to the nearest cm			
Woody shrubs				Crown diameter	m	to the nearest 0.05m (5cm)
				Natural Height	M	>20cm to the nearest 0.05m (5cm) 10 -20cm to the nearest 0.01m (1cm)

Appendix 3. Percent Cover Scale



Note: there is no cover score for 0 - 5% in this tool. Cover scales approximate to Browse Classes are denoted with brackets

Appendix 4. Subplot Measurements - Snow Tussock, Aciphylla and Fleshy Herb record sheet

Subplot Measurements - Snow Tussock, Aciphylla and Fleshy Herbs

START TIME:	9.00	FINISH TIME:	10.45
Plot Identifier:	BC123	Measured by:	Kate McNutt, Kate Ladley
Date:	22 February 2016	Recorded by:	Mike Perry

Subplot Measurements Per Species

Sub-plot	Species	Percent Cover ¹ (to the nearest 5%)	Average Estimated Natural Height ² (to the nearest 5cm)	Maximum Natural Height ³ (cm)	Maximum Extended Live Tiller Length (cm) ⁴	Browse Class ⁵
A	CHfla	50	60	-	80	1
A	CHrig	55	60	-	71	2
A	CHpal@	15	70	-	88	1
A	ACiaur	15	40	58	-	2
A	ACidiv	20	25	30	-	2
A	RANlya	20	25	30	-	3
A	CElsem	10	20	25	-	0
B	CHrig	50	60	-	71	2
C	CHfla	50	60	-	71	2
C	CHrig	15	75	-	85	1
C	CHpal@	10	50	-	88	0
C	RANlya	5	20	47	-	1
D	None					
E	CHrig	50	55	-	70	1
E	RANlya	5	20	47	-	1
E	CElsem	10	20	30	-	1
E	ACidiv	15	40	58	-	0

- 1 Use Appendix 3: Percent Cover Scale to estimate % cover. Round to nearest 5% for 4% and over. Record actual % for 1-3%.
- 2 Average height of each species, live leaves, natural height. Flower heads and their stems excluded. Round to nearest 5 cm for 4 cm and over. Record actual cm for 1-3 cm.
- 3 Relevant to Herbs and *Aciphylla* only - Tallest live leaves, natural height, Flower heads and their stems excluded. Round to nearest 1 cm.
- 4 Relevant to Snow Tussocks only - Measured to the nearest cm, pulled up height to leaf tip, including any tiller tip dieback BUT excluding flowering culms). Round to nearest 1 cm.
- 5 Mammal browse. Browse classes: 0 (none), 1 (<1%), 2 (1-5%), 3 (6-33%), 4 (34-66%), 5 (>66%).

Appendix 5. Random Subplots record sheet

Random Subplots Record Sheet

START TIME:	8.30	FINISH TIME:	9.00
Plot Identifier:	BC123	Measured by:	Kate McNutt
Date:	22 February 2016	Recorded by:	Mike Perry

Snow Tussock Percentage Cover³ (To the nearest 5%):	65%
--	-----

Subplot Selection Tool

Subplot	Order ¹	Measured (Yes/No) ²	Notes (If any subplots abandoned record the reason why)
C	1	Yes	
J	2	Yes	
E	3	Yes	
A	4	Yes	
N	5	Yes	
F	6	Yes	
B	7	-	
L	8	-	
H	9	-	
O	10	-	
M	11	-	
P	12	-	
K	13	-	
D	14	-	
I	15	-	
G	16	-	

1. Subplots are randomly selected and can be measured in the prescribed random **order** or for efficiencies these may be completed as per the normal order of subplots (A-P) but **all** must be completed.

2. Record measurement status of all 16 subplots - Yes (measured), AB (required but abandoned) and dash (not required).

NOTE - If a pre-selected subplot is unsafe to measure, do not measure it and move to the next subplot on the list. Ensure you continue until the minimum numbers of subplots are measured for the plot.

3. If Snow Tussock Percentage Cover is ≤ 50% - **DO NOT SUBSAMPLE**. Measure all subplots

If Snow Tussock Percentage Cover ≥ 51% - Complete all if time permits. If not measure a minimum of 6 subplots

Appendix 6. Individual Measurement - Snow Tussock record sheet

Individual Measurements - Snow Tussocks

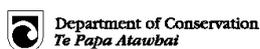
START TIME:	12.30	FINISH TIME:	17.00
Plot Identifier:	BC123	Measured by:	Kate McNutt, Kate Ladley
DAY/MONTH/YEAR:	22 February 2016	Recorded by:	Mike Perry

Tussock Measurements

Sub-plot	Species	Basal Diameter Width 1 (cm) ¹		Basal Diameter Width 2 (cm)		5			Notes
		TOTAL ¹	LIVE ²	TOTAL ¹	LIVE ²	Maximum Extended Live Tiller Length (cm) ³	Dieback % ⁴	Browse Class ⁵	
A	CHrig	24	24	20	20	71	0	1	
A	CHrig	44	40	45	40	55	10	1	
A	CHrig	80	40	80	40	60	50	1	
A	CHrig	22	22	33	33	60	0	0	
A	CHfla	90	71	80	80	80	10	1	
A	CHfla	28	28	21	20	55	20	1	
A	CHfla	16	15	16	16	60	0	1	
A	CHrig	70	40	80	62	65	30	2	
A	CHrig	45	33	33	31	58	20	0	
A	CHfla	24	24	20	18	65	0	0	
A	CHfla	14	13	12	12	58	0	0	
A	CHpal@	15	15	18	18	88	0	1	
A	CHpal@	20	15	25	18	70	10	1	
A	CHpal@	10	10	20	15	60	20	0	
B	None								
C	CHrig	70	40	80	62	65	30	2	
C	CHrig	45	33	33	31	58	20	0	

- TOTAL Basal Diameter measured to the nearest cm, include both live and dead tillers.
- LIVE Basal Diameter measured to the nearest cm, include live tillers only.
- Maximum Extended Live Tiller Length measured to nearest cm, pulled up height to leaf tip, include leaf tip dieback, exclude flowering culms.
- Dieback in % to the nearest 10%.
- Browse classes for % of leaves browsed by individual(s): 0 (none), 1 (<1%), 2 (1-5%), 3 (6-33%), 4 (34-66%), 5 (>66%).

Appendix 7. Individual Measurement - Aciphylla and Fleshy Herb record sheet



Page 1 of 4

Individual Measurement - Aciphylla and Fleshy Herbs

START TIME:	12.30	FINISH TIME:	17:00
Plot Identifier:	BC123	Measured by:	Kate McNutt, Kate Ladley
DAY/MONTH/YEAR:	22 February 2016	Recorded by:	Mike Perry

Aciphylla & Fleshy Herbs

Sub-plot	Species	Crown Diameter Width 1 (cm) ¹	Crown Diameter Width 2 (cm) ¹	Natural Height (cm) ²	Browse Class ³	Notes
A	ACIaur	35	35	50	1	
A	ACIdiv	35	27	22	2	
A	RANlya	45	73	35	2	
A	RANlya	42	53	40	1	
A	RANlya	90	66	22	2	
A	RANlya	30	53	25	2	
A	CELsem	18	18	25	0	
A	CELsem	23	18	20 ^{est}	0	
A	CELsem	16	21	15	0	
A	RANlya	30	53	42	3	
A	ACIdiv	23	22	25	1	
A	ACIdiv	35	27	35	1	
A	ACIdiv	16	18	21	2	
A	ACIaur	25	17	44	1	
A	ACIaur	21	19	45	2	
A	ACIaur	10	11	40	2	
B	None					
C	RANlya	30	53	47	1	
D	None					

1 Live Crown Diameter measured to the nearest cm.

2 Natural Height measured to the nearest cm. Flower heads and their stems are excluded.

3 Browse classes % of leaves browsed by individual(s): 0 (none), 1 (<1%), 2 (1-5%), 3 (6-33%), 4 (34-66%), 5 (>66%).

Appendix 8. Individual Measurement - Woody Shrubs record sheet

Individual Measurements - Woody Shrubs

START TIME:	11.30	FINISH TIME:	12.30
Plot Identifier:	BC123	Measured by:	Kate McNutt, Kate Ladley
DAY/MONTH/YEAR:	22 February 2016	Recorded by:	Mike Perry

Shrub measurements

Sub-plot	Species	I, SC OR CN ¹	Crown Diameter Width 1 (m) ²	Crown Diameter Width 2 (m) ²	Natural Height (m) ³	Browse Class ⁴	Notes
A	COPser	I	0.45	0.25	0.50	0	
A	COPser	I	0.40	0.30	0.40	0	
A	DRARos	I	0.55	0.35	0.30	1	
A	DRARos	I	0.70	0.80	0.90	0	
B	COPser	I	0.15	0.20	0.11	0	
B	DRARos	I	0.30	0.20	0.18	0	
B	DRARos	} SC	3.60	1.90	1.20	0	
B	DRARos						
B	DRARos						
C	None						
D	COPser	I	0.45	0.25	0.50	0	
D	COPser	I	0.40	0.30	0.40	0	
D	DRARos	I	0.55	0.35	0.30	1	
D	DRARos	I	0.70	0.80	0.90	0	
D	PODniv	CN	1.60	1.90	0.40	0	
D	DRARos	I	0.70	0.80	0.90	0	
D	DRARos	} CN	0.60	0.50	0.30	0	
D	COPche						
D	PHYalp	} CN	5.70	3.20	0.90	2	
D	VERsub						
D	PODniv						

1 Record I for Individual Shrub, SC for Shrub Clumps and CN for Continuous Shrub.

2 Crown Diameter measured to the nearest 0.05 m (5 cm).

3 Natural Height measured to the nearest 0.05m (5 cm) for shrubs > 20 cm and to the nearest 0.01 m (1 cm) for shrubs between 10-20 cm

4 Browse classes % of leaves browsed by individual(s): 0 (none), 1 (<1%), 2 (1-5%), 3 (6-33%), 4 (34-66%), 5 (>66%).

Appendix 9. Summary of major manual updates

Section	Page	Description of change	Reason
3.2	4	<p>Species Selection: Fleshy and herbaceous species</p> <p>Combined sections 3.2 and 3.3 into a single section labelled Fleshy and herbaceous herb species. This section now includes methods for <i>Aciphylla</i>, <i>Celmisia</i> and <i>Ranunculus lyallii</i> combined.</p>	Refinement
8.0 - 8.2	18-19	<p>Fleshy and herbaceous species: Subplot and individual measurements</p> <p>Method for <i>Aciphylla</i>, <i>Celmisia</i> and <i>Ranunculus lyallii</i> combined into one section and section title changed to “Fleshy and herbaceous species”.</p> <p>Additional description for <i>R. lyallii</i> measurements.</p>	Refinement
9.2		Combines text for measuring crown diameter of shrub clumps and continuous shrub measurements.	Refinement
10.0		Creation of a new section and subheading 10. Mammal Browse. New photos of browse have been added with descriptors of photos. Photos have been checked by a tahr browse expert who has provided descriptors for photos.	New section. Refinement