Manaaki Whenua
Landcare Research

The Recce method for describing New Zealand vegetation – expanded manual

Version 5

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Summary

Effective management of New Zealand's diverse vegetative cover requires methods for describing its composition, structure, and variation. The Reconnaissance (Recce) method is widely used for this purpose, and this manual updates and standardises the field procedures, which can be used in a diverse range of vegetation types.

Guidelines on representative and subjective sampling schemes are outlined for Recce descriptions, the use of which depends on the specific objectives of the survey. At each site, the plant species present are recorded in height tiers, along with associated cover estimates. Site characteristics (e.g. altitude, aspect, and slope) and additional characteristics of the vegetation (e.g. animal browse) are recorded, because these are often required to interpret vegetation patterns. Quality control procedures are also discussed.

Most of the Recce description data collected so far are stored in the National Vegetation Survey (NVS) Databank, administered by Manaaki Whenua – Landcare Research, Lincoln, and the procedures for data deposit and retrieval are outlined. Recce measurement protocols are also available in a shorter format as a field manual (Hurst et al. 2022b; see http://nvs.landcareresearch.co.nz/).

1 Introduction

1.1 Why do we need to understand vegetation patterns?

New Zealand's land surface of around 26.9 million ha has a diverse vegetative cover (Newsome 1987). Human settlement has altered much of the landscape, but large areas are still dominated by indigenous vegetation, ranging from herbfields to tussocklands, shrublands, wetlands, and forests. Planted and naturalised exotic species cover is also prominent.

Increasing awareness of the environmental implications of land management has highlighted the need for accurate information on New Zealand's vegetation pattern. This includes information on key vegetation characteristics such as vegetation structure and species composition, and how these vary with environment. The need to manage vegetation and protect biodiversity is enshrined in New Zealand legislation (e.g. Forests Act 1949, Conservation Act 1987, Resource Management Act 1991). New Zealand also has legally binding international reporting obligations as a signatory to the Convention on Biological Diversity, and as a participant in the Forest Resource Assessment of the Food and Agriculture Organisation (FAO) and the Montreal Process (Bellingham et al. 2000). Since 2015 New Zealand also has national monitoring obligations for atmosphere, air quality, land, freshwater and marine systems through the Environmental Reporting Act 2015.

As in most countries, early descriptions of New Zealand vegetation were largely subjective. At a national level the first standardised inventories of indigenous forest were undertaken by the former New Zealand Forest Service. The National Forest Inventory (initiated in 1923) and the National Forest Survey (1945–1955) both concentrated on the merchantable forests to assess potential timber yield (Anon. 1923; Masters et al. 1957). The North Island Forest Ecological Survey (Ecosurvey, started in 1956) extended this coverage to include non-merchantable forests and collected ecological information (McKelvey 1995). The National Forest Survey and Ecosurvey provided the foundation for the classification and mapping of New Zealand's indigenous forests (Nicholls 1976; McKelvey 1984).

It was then recognised that a detailed knowledge of vegetation patterns would provide an essential basis for understanding the impact of browsing animals (e.g. Wardle et al. 1971; Wardle 1974). This, along with a focus on the role of natural forest and grassland vegetation in protecting catchments from erosion, led to increased interest in the development and refinement of inventory and monitoring methods. The Reconnaissance (Recce) description method was initially designed for rapid, broad-scale inventory surveys of mountainland forests (Allen 1979, 1992; Allen & McLennan 1983). The method is similar to the Braun–Blanquet relevé methods that are widely used for phytosociological analysis internationally (see Mueller-Dombois & Ellenberg 1974). Similar methods also formed the basis for much of the data collected in the Protected Natural Areas Programme, which identifies areas of private land worthy of protection (Myers et al. 1987).

Although originally developed for extensive forest surveys, the Recce description technique is perhaps the most widely used method for collecting semi-quantitative vegetation data in New Zealand. It has been applied to a diverse range of vegetation communities, including coastal turfs, grasslands, wetlands, shrublands, indigenous and plantation forests, and agricultural systems such as vineyards (e.g. Leathwick 1987; Norton & Leathwick 1990; Dickinson & Mark 1994; Allen et al. 1995; Burns 1997; Rogers 1999; Wood et al. 2017). It is this versatility that is a key strength of the Recce method: it can be used in a diverse range of both natural and managed vegetation, differing in composition and structure.

This manual updates and standardises Recce descriptions for use as a rapid vegetation inventory method. Recce descriptions include information on floristic composition, recorded by vertical strata, with cover classes for each species as an abundance estimate. Because vegetation composition, structure or changes are often best interpreted in the context of environment, each Recce description also includes the collection of readily obtainable site data.

While most appropriately used for one-off vegetation inventory surveys, Recce descriptions can also be used to monitor compositional and structural changes in vegetation over time on permanently delineated areas. Note that Recce descriptions using similar protocols to those outlined here form an important component of both grassland and forest permanent-plot monitoring protocols (Wiser & Rose 1997; Hurst et al. 2022a).

1.2 Examples of uses of Recce descriptions

1.2.1 Understanding vegetation–environment relationships

The primary use of Recce description data has been to understand vegetation–environment relationships. Vascular plant composition, diversity, structure or spatial patterns of species turnover can be related to readily obtainable environmental characteristics. For example, an inventory of the species and communities present in Waipapa Ecological Area, and their relationship to environmental variables (such as elevation, aspect, and slope), was undertaken by Leathwick (1987) using 258 Recce descriptions.

Ancillary environmental data collected in addition to standard protocols, such as detailed data on soil fertility or pH, can also be used in such analyses (Dickinson & Mark 1994; Burns 1997). For instance, the relationships between alpine tussock grassland communities, soil parameters, and landform were studied by Rose et al. (1988) at Lake Wapiti, Fiordland, using 139 subjectively located Recce descriptions. Similarly, Lusk et al. (2020) explored the hypothesis that divaricate growth form is most valuable to plants on fertile soils that attract herbivores at sites where climatic constraints prevent plants quickly growing out of the browse zone. By measuring climate and soil fertility across topographic gradients they could show using data from 9,877 Recce descriptions that assemblages of divaricating woody species were more diverse and had greater cover at sites where climatic restrictions on growth coincide with relatively high nutrient availability.

Syntheses of Recce data from independent Recce surveys can also be undertaken and show enormous potential for increasing our understanding of broad-scale vegetation patterns in New Zealand. For example, an analysis of geographical variation in vegetation composition and species richness was undertaken using approximately 1,200 Recce descriptions located throughout South Island conifer-broadleaved hardwood forests. The combined data were used to compare community composition, and species turnover in relation to elevation, among nine localities (Reif & Allen 1988; Allen et al. 1991).

1.2.2 Describing or mapping vegetation for management purposes

Recce surveys can provide quantitative data to guide the selection of reserves. For example, the number and extent of the main vegetation communities in the Mackenzie Ecological Region were surveyed to provide a framework for recommending representative conservation areas under this programme (Espie et al. 1984). Recce surveys have also often been used to map or inventory the vegetation in conservation reserves, to inform conservation managers of the species and communities present, and help set priorities for reserve management (e.g. Wardle et al. 1971; Leathwick 1987). The species composition of Recce descriptions also permits classification into vegetation associations and alliances such as that undertaken for New Zealand forests and shrublands (Wiser et al. 2011) and non-forest vegetation types (Wiser et al. 2016).

1.2.3 Baseline data for designing a research or monitoring programme

Recce surveys can provide the semi-quantitative baseline data needed in the design of monitoring programmes. For example, a vegetation inventory with a Recce description can be used to determine whether the structure and composition of vegetation of proposed paired treatment and non-treatment sites are comparable before a larger investment is made in a research or monitoring programme. During the planning phase of DOC's project to assess the benefits of adaptive management of deer in New Zealand, Recce descriptions were used to identify two discrete areas with similar forest vegetation that could be used as treatment and non-treatment areas (Forsyth et al. 2013).

1.2.4 Understanding faunal and floral distribution patterns

Recce descriptions have been used extensively in 'dual' studies, such as those focused on understanding habitat use by fauna, including birds (e.g. Spurr & Warburton 1991; Steffens et al. 2005), insects (e.g. Hutcheson & Kimberley 1999; Harris & Burns 2000), and mammalian herbivores (e.g. King et al. 1996). Such studies can determine whether animals preferentially select certain habitats over others.

Other studies have used Recce descriptions to understand and classify the environmental and community relationships of rare or threatened flora (e.g. Rogers & Walker 2005). Recce data have been used to understand the environmental relationships and compositional distinctions of rare ecosystems and plant communities, using comprehensive sampling of every known example (e.g. Rogers 1999). Recce data can also be used to explore questions of how land cover change could trigger shifts in the factors controlling plant distributions (Nomura et al. 2019).

More recently, McCarthy et al. 2021 created species distribution models (SDMs) for all New Zealand's native Myrtaceae species based on presence–absence data from the NVS Databank. These models were examined against a spatial layer of mean daily myrtle rust

(*Austropuccinia psidii*) infection risk to quantify range non-overlap and identify potential refugia where conservation efforts could be prioritised (McCarthy et al. 2021).

1.2.5 Documenting impacts of introduced mammalian herbivores

Quantifying the impacts of introduced herbivores is a long-standing use of Recce descriptions. Approaches include comparing the vegetation of treatment and non-treatment areas; comparing the vegetation of mainland sites to that of offshore islands without introduced herbivores; and comparing the abundances of species known to be preferred or avoided by specific herbivores.

Browse indices of various types have also been used in such studies, including indices based on the presence and absence of species in height tiers as a measure of susceptibility (e.g. Wardle et al. 1971). Because of the difficulties in distinguishing natural vegetation patterns from those caused by introduced herbivores, care must be taken when interpreting the results of observational studies (Bellingham & Lee 2006; Forsyth et al. 2018). Any conclusions regarding the impacts of introduced herbivores on observed vegetation patterns are conditional on whether observed patterns result from unrelated site differences (e.g. differences in light, soil fertility, initial species composition, disturbance history or natural stand dynamics). Previous studies in New Zealand suggest complex causes of vegetation pattern and change, highlighting the importance of appropriate study designs so that the effects of specific factors can be adequately isolated (Bellingham & Lee 2006; Forsyth et al. 2018). When vegetation patterns are to be related to the distribution or abundance of introduced herbivores, it may be useful to collect additional data on animal distribution or abundance using standard methods (Baddeley 1985; Forsyth 2005; National Pest Control Agencies 2015).

1.3 Existing vegetation survey data based on Recce descriptions

Recce descriptions have been made across a wide range of New Zealand vegetation types and throughout the length and breadth of the country (Wiser et al. 2001; see Figure 1). As of 2022, 66,000 Recce descriptions are stored in the NVS Databank, administered by Manaaki Whenua – Landcare Research, Lincoln (Hayman et al. 2021, see section 8). These records form an invaluable data set for understanding the compositional and structural pattern of New Zealand's indigenous vegetation, as described above. Before planning any new inventory programme, all existing information collected from a study site should be identified and evaluated.

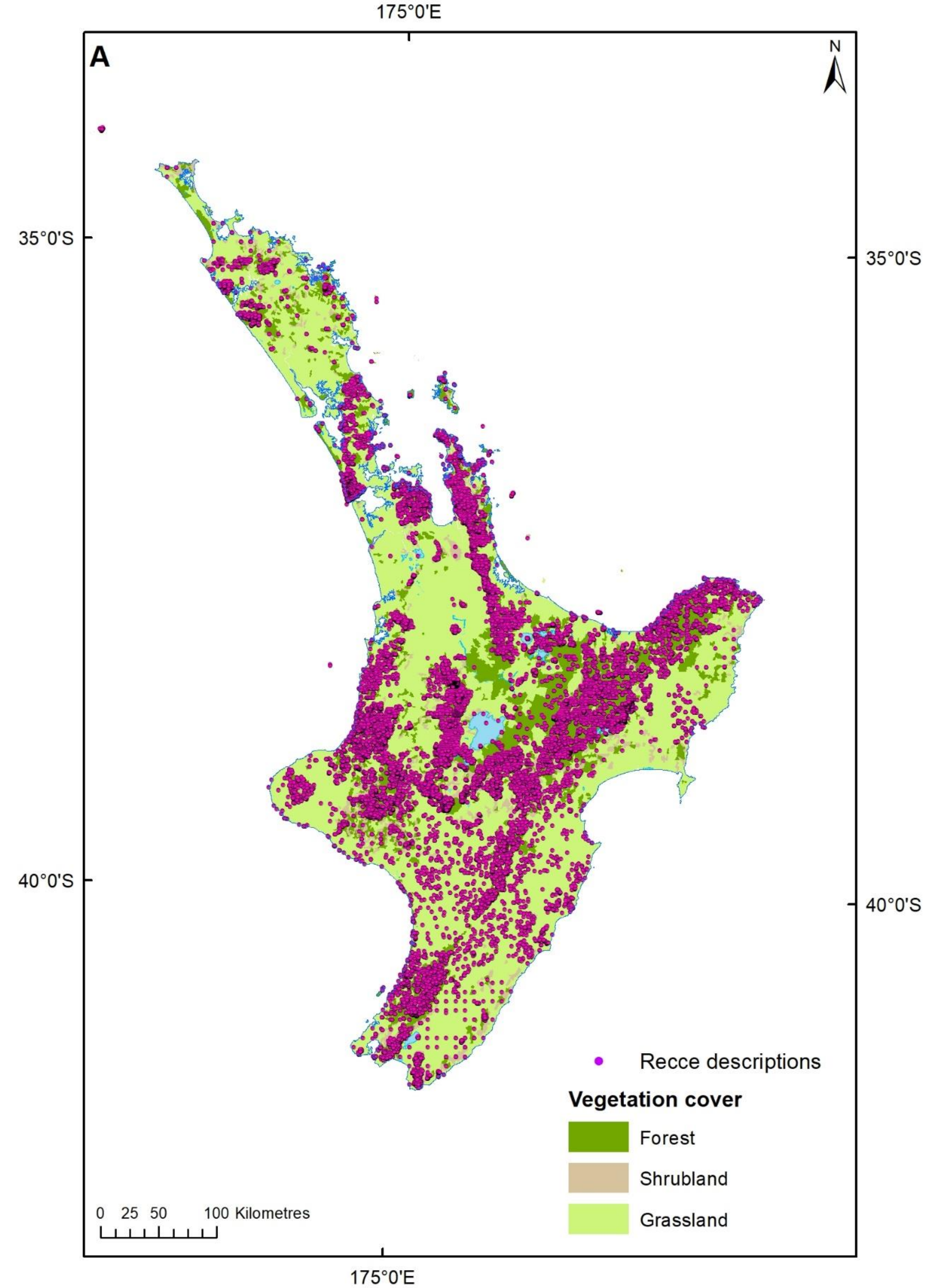

Figure 1. Locations of Recce descriptions archived in the NVS Databank for which location data are available: (a) North Island, (b) South Island and Stewart Island / Rakiura. As of March 2022 the NVS Databank held data from over 66,000 Recce descriptions. Recce locations were overlain onto maps with vegetation cover classified as forest, shrubland, and grassland by the Vegetative Cover map of New Zealand from Manaaki Whenua – Landcare Research. Crown copyright reserved.

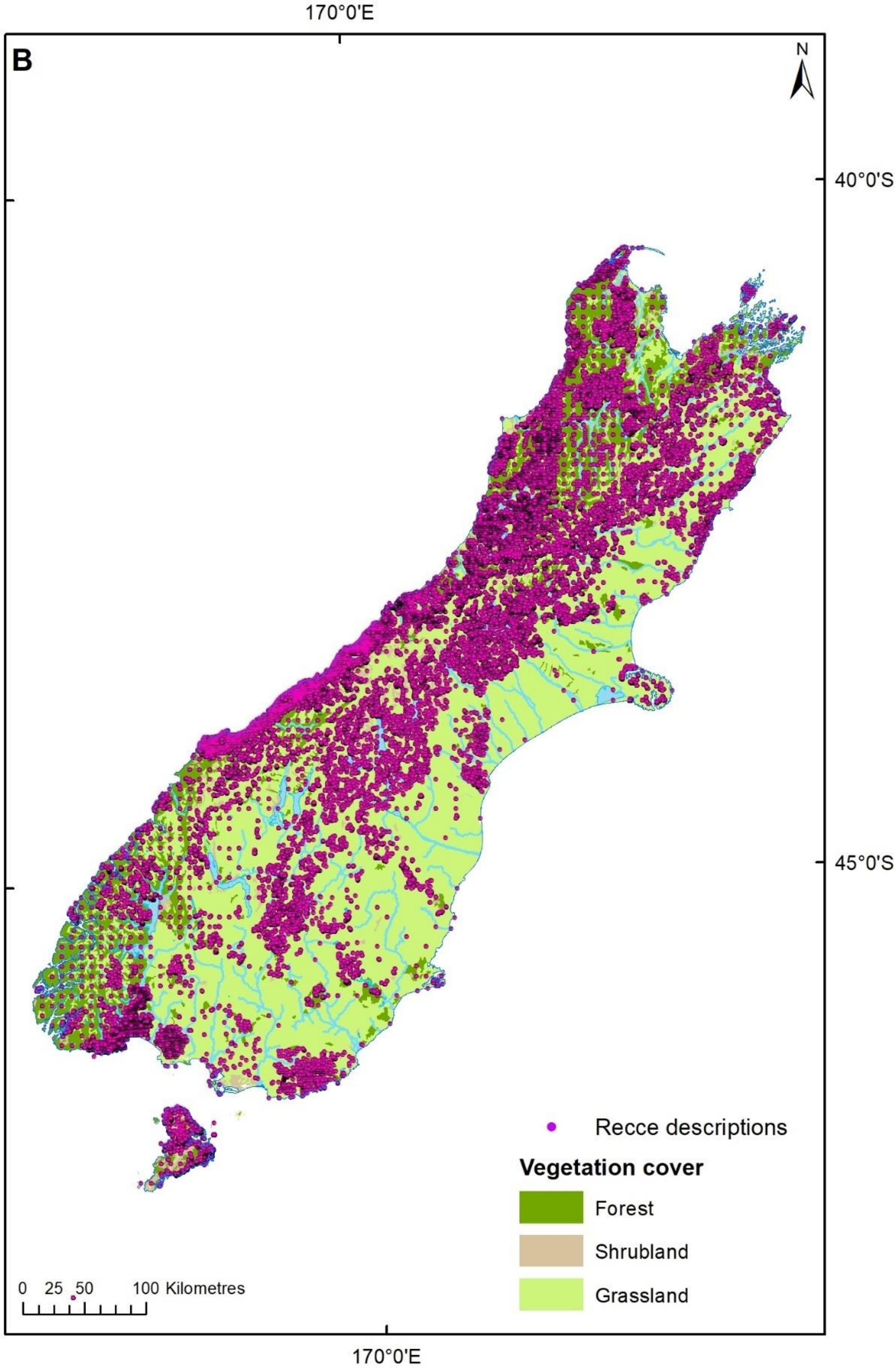

Figure 1. Continued from previous page.

1.4 What is the purpose and structure of this manual?

1.4.1 Purpose

The importance of standardised and widely accepted protocols for measuring vegetation is readily apparent. Standardisation ensures vegetation patterns detected over time and space really are occurring in nature and are not simply the result of measurements taken in slightly different ways. This means standardised monitoring programmes will be credible and more likely to withstand scrutiny. The publication of standard protocols also allows potential data users to interpret data more easily and gauge their suitability for any particular study.

This manual updates and expands on earlier Recce description manuals (Allen 1979, 1992; Allen & McLennan 1983) in order to standardise protocols and outline commonly agreed 'best practice' Recce description procedures. Specifically, this version of the manual is an update of version 4 (Hurst & Allen 2007). Historical versions of this manual will continue to be used both domestically and internationally. This revision has therefore been conservative and has attempted to retain as much continuity as possible with earlier versions while clarifying any sources of ambiguity

1.4.2 Structure

In section 2 we provide some basic principles of sampling and general guidelines on objective vs subjective sampling options. Funding for inventory and monitoring will always be limited, and sample sizes limited to what can be practically undertaken. The use of representative sampling is therefore strongly advocated, because vegetation surveys allow inferences to be made about a larger, unmeasured study area.

Some general guidelines on Recce size and shape are also provided (section 2.1). For any vegetation inventory programme several alternative designs are often available. Major decisions include whether to use fixed- or variable-area Recces, and whether to collect quantitative or qualitative species-importance information. In developing the guidelines here, an attempt has been made to balance the sometimes conflicting demands of one-off, rapid, semi-quantitative inventory methods (for which the Recce description method has traditionally been used) against the need for an inventory method that provides robust detail on a wide range of ecosystems. The result is a manual that is, by necessity, flexible in allowing the use of various Recce sizes or shapes, the choice of which will be specific to an individual survey.

Section 3 outlines some important components of pre-fieldwork planning to help ensure work is conducted efficiently and high-quality data are collected. Protocols for the location and establishment of Recce descriptions are provided in section 4, although the specific details will depend on the sampling methodology of the survey. Protocols for the measurement of Recce descriptions are then provided in section 5. This section includes rules for coding species names when recording data. On each Recce several different kinds of data are collected and recorded as part of standard protocols, as follows.

Recce identification information – this identifies the Recce and its location (e.g. GPS reference, location in relation to readily identifiable topographic features). If Recces are permanently marked to be remeasured, all information required for relocation is recorded here.

Site description and stand parameters – the site description includes easily obtainable topographic data (e.g. aspect, slope and altitude) and other characteristics of the site (e.g. characteristics of the ground surface and cover, and predominant vegetation structure). Such data are often required to interpret vegetation patterns. Additional biological information, such as notable features of the vegetation or the occurrence of disturbance or animal impacts, is also recorded.

Vegetation description – this involves a detailed description of the structure and composition of the vegetation, including records of the occurrence of species within height tiers and cover classes.

In this revised manual, comparability with data from historical Recce surveys is largely maintained by retaining original protocols, as outlined in Allen 1979, Allen 1992, Allen & McLennan 1983, and Hurst & Allen 2007. Collection of the standard data outlined in this manual will maximise future comparability of data and ensure inventory programmes meet the required standards of data quality, so that they will be credible and can withstand scrutiny. It is therefore recommended that any different protocols used should be as additions to the standard methodology. Brief treatments are given, with appropriate references, for some additions previously found useful.

Because high taxonomic standards are required for detecting biodiversity patterns through time and space, section 6 provides guidelines on the collection and recording of unknown plant specimens. Section 7 outlines further data quality assurance procedures for the fieldwork planning, data collection, and data management stages of a vegetation survey. In section 8, steps are outlined for archiving data in the NVS Databank. Archiving vegetation data in the NVS Databank is now a DOC standard operating procedure. A glossary is provided in Appendix 1. An equipment list is provided in appendix 2. Examples of completed Recce field sheets are provided in Appendix 3. Appendix 4 is a list of non-standard species codes. Appendix 5 is a canopy cover scale.

2 Sampling

Given unlimited resources, an entire population of interest could be quantified in any defined survey area. In such cases we would say that 100% of a population had been sampled. However, such an approach is seldom taken, since the resources required and the precision obtained are usually unwarranted. Instead, some form of sampling is used.

Sampling decisions are crucial and will determine both how the data can be used and the feasibility of undertaking the programme. Ultimately, the monitoring design must allow the objectives of the programme to be met. To ensure this, the following questions must be answered:

- What are the populations/communities of interest?
- What parameters or characteristics of the vegetation need to be reliably measured, and to what accuracy?

Inventory designs are often a trade-off between practical constraints, such as the resources available and the nature of the terrain to be surveyed, and the amount and accuracy of data required to meet the objectives of the project.

Some general guidelines are outlined in this section. Our aim is not to review the complete range of alternative designs for inventory surveys. Inventory sampling designs have received comprehensive treatment elsewhere, and investigators should consult relevant textbooks for further details (e.g. Mueller-Dombois & Ellenberg 1974; Jongman et al. 1987; Økland 1990; Elzinga et. Al. 1998; Newton 2007).

2.1 General guidelines and principles of sampling

Key inventory sampling design decisions concern:

- the *arrangement* and *number* of sample Recce descriptions – these decisions affect the statistical properties of the data (e.g. whether formal statistical tests will be valid), and the representation of dominant vs rare species and/or communities, and they will also have practical implications, such as influencing the number of Recce descriptions that can be established within a given time frame
- whether sample Recce descriptions should be *temporary* (i.e. for a one-off inventory only) or *permanently marked* (enabling remeasurement)
- the *size* and *shape* of each Recce description.

2.1.1 Arrangement of sample Recce descriptions

(a) Representative sampling and statistical inference

The objectives of a vegetation survey usually require generalisations to be made about a large group of interest (the population), based on measurements made for a small subset of the group (the sample). This is called *statistical inference*.

Some sort of representative sample should always be used when statistical inference is required. The process of statistical inference allows statistical estimates of vegetation parameters to be produced, along with an estimate of their reliability. Representative samples require that every site within a predefined study area have a known, non-zero probability of being included in the Recce description network. Statistical inferences can only be made for areas that have a chance of being included in the sample.

(b) Defining the area/population of interest

A fundamental step before determining Recce locations is to clearly define and document the boundaries of the areas/populations of interest (the sampling universe). Study areas vary in size and shape – from large, contiguous forest blocks to small and scattered remnants. Vegetation boundaries can often be defined by reference to aerial photographs, maps, and some initial field reconnaissance.

Sites considered unsafe to sample due to the nature of the terrain or access restraints (e.g. beyond the range of helicopter flight) can be excluded from the sampling universe before implementing a sampling scheme, but no statistical inference can then be made about these areas. Furthermore, clear rules about Recce location rejection must be developed before fieldwork and subsequently used to adjust (by proportion) the sampling universe (e.g. if 2 out of 100 Recces were rejected during fieldwork due to bluffs, it would mean 98% of the sampling universe was actually sampled).

(c) Stratification in heterogeneous areas

While representative sampling is ideal whenever it is important to know the relative abundance of species or communities, some redundancy may result for very common species or vegetation types, and rare species or vegetation types can be poorly represented, particularly when sampling intensity is low (Økland 1990). In areas that are heterogeneous, stratified sampling (e.g. by vegetation type or a nominated environmental gradient) is often suggested as a way to more efficiently achieve accurate estimates of vegetation parameters, or to more equally sample the range of different conditions present (Jongman et al. 1987).

For example, three sampling strata were identified in the Waipapa Ecological Area based on vegetation structure (Leathwick 1987). The strata were forest, scrub, and mire. Stratification allowed each of the three strata to be sampled at different intensities, to compensate for both the differences in strata extent and the heterogeneity of vegetation within strata. Each stratum was sampled using a systematic grid network of Recce descriptions, with grid spacing of 500 m for forest, 250 m for scrubland and 100 m for mire (Leathwick 1987).

Such stratification by current vegetation patterns can be used in one-off inventory surveys using Recce descriptions, but note that unequal sampling can make it more difficult to provide information on the relative abundance of different species or communities across all strata. Within a vegetation survey, whenever some parts of a study area are sampled more intensely than others using stratification, the specific details should be recorded in the metadata (see section 8.2.3) for the survey.

(d) Subjective sampling

Subjective sampling (also called selective or preferential sampling) should be avoided whenever statistical inference is required to some larger, non-sampled area. Subjective sampling is the least formal approach to locating Recce descriptions. In this type of sampling Recce descriptions are located in vegetation that is perceived to be typical, representative or undisturbed. When subjective sampling is undertaken by attempting to sample the range of species assemblages in a study area rather than by selecting sites considered to be in some way ‘typical’ of the species assemblages, the approach is termed *subjective sampling without preconceived bias* (Mueller-Dombois & Ellenberg 1974).

Subjective sampling has been widely used in descriptive ecology, partly because careful subjective selection of sampling sites often includes greater floristic variation than more formal schemes, and it can be used to efficiently sample along environmental gradients to understand vegetation patterns (see Austin 1985). While statistical summaries of data can be made whenever more than one Recce is established, it is inappropriate to extrapolate results to the study area as a whole because the data are not representative. When used in such a way, subjective sampling methodologies are easily discredited by critics, and may produce biased, unreliable information.

Although representative sampling designs are strongly advocated for most long-term monitoring projects, this does not mean that surveys using subjectively located Recce descriptions are completely invalidated. If a Recce survey using subjectively located sites already exists, the need for representative sampling must be balanced against the benefits of maintaining an existing long-term data set on vegetation change.

(e) Summary

Before implementing any particular sampling design, it is strongly recommended that the proposed design receive peer review from other ecologists and/or a statistician. Regardless of the approach taken to place Recce descriptions, in the metadata for a survey always record details of the sampling approach employed (see section 8.2.3) to ensure the long-term integrity of the survey. In other words, record the rationale for the sampling design used to ensure that in the future it will be clear how Recce locations were decided on.

2.1.2 How to obtain a representative sample of a study area

A representative sample of a study area can be obtained by locating Recces using either random or systematic sampling methodologies. For full guidelines on the benefits of alternative representative sampling methodologies, consult detailed texts on the subject (e.g. Økland 1990).

(a) Random Recce description placement

In random survey designs, Recce placement is typically determined using a random number generator in conjunction with a coordinate system overlaid onto a topographical map. The boundaries of the study area should first be clearly defined. An effective technique for generating randomly located Recces involves overlaying a grid onto a topographical map of the study area. Then *x* and *y* coordinates can be assigned to the grid cells, and a random number table (e.g. as generated from a spreadsheet) used to select grid cells randomly. A second pair of numbers in the range 0–9 can then be used to define the precise location of the Recce within each selected cell. This process is continued until the desired number of sample Recce descriptions have been located.

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(b) Stratified random Recce description placement

Although random Recce description placement is unbiased, it is less efficient than spatially balanced designs if spatial autocorrelation (where values for a variable are correlated at nearby locations) exists within a sampling area (van Dam-Bates et al. 2018). A master sample utilising balanced acceptance sampling (BAS) that in theory can be used to coordinate and scale monitoring designs can permit both sampling consistency and coordination between different agencies (van Dam-Bates et al. 2018). A master sample is essentially a set of points that can be subsampled for different monitoring activities. A BAS master sample can be generated quickly to sample a selected area using a shape file (van Dam-Bates et al. 2018). A master sample can also accommodate existing monitoring networks. For those who are familiar with programming in R, a maintained version of the code used to generate a master sample in New Zealand is available online (https://doi.org/10.5281/zenodo.1193953).

(c) Systematic Recce description placement

In systematic sampling methodologies (also called 'regular' or 'grid' sampling), Recces are placed systematically across the study area using a grid system. Systematic sampling methodologies are sometimes considered to provide better coverage of the study area than random sampling methodologies, so they may be particularly suitable for understanding spatial patterns and changes in vegetation over environmental gradients (Økland 1990).

First, the boundaries of the study area should be clearly defined, and the origin of the systematic grid assigned randomly. Because the size of the grid (distance between grid lines) will determine the number of sample Recces, the grid size used must be appropriate for the task. An appropriate grid size can be roughly calculated for a study area of known size and for a given sampling intensity. For example, in a study area 10,000 ha in size in which you want to establish 50 sample Recces, there would be one Recce every 200 ha (i.e. 2×10^6 m^2). Approximating such a sampling intensity would then require a grid spacing of c. 1,414 m (i.e. the square root of 2×10^6 m^2).

(d) Systematic Recce description placement along transects

Monitoring projects using Recces in New Zealand have typically employed randomly located transects, on which Recces are then placed systematically (one-dimensional grid sampling, in the sense of Økland 1990). Transect origins were typically located on a watercourse and finished at the treeline or a ridge-top, with Recces located at fixed intervals (often 100 or 200 m). One advantage of this sampling scheme is increased efficiency, especially in mountainous country, where a field party may more easily visit more than one Recce location in a day, compared with simple random or systematic sampling.

To assign Recce locations on transects, the boundaries of the study area should first be clearly defined. An effective technique for generating randomly located transects involves overlaying a grid onto a topographical map of the study area (e.g. the 1,000 m^2 map grid on a topographical map), assigning *x* and *y* coordinates to the grid cells, then using a random number table (e.g. as generated from a spreadsheet) to select grid cells randomly (the number selected depends on the sampling intensity required). Mark the centre of each selected grid cell and use either a random or a systematic approach to assign transect directions.

Alternatively, where transect origins are to be located on watercourses, identify the point on a watercourse nearest to the centre of each selected grid cell and make this point the transect origin. Flip a coin to randomly assign the transect to one or other side of the watercourse, and draw a line from the origin to the nearest main ridge or treeline (as dictated by the predetermined study area boundaries).

For each transect, the compass bearing used in the field is determined from the line drawn on the map, with correction for magnetic declination. The predetermined distances between the systematically located Recces along each transect are typically set at 200 m intervals (Allen 1992).

2.1.3 Vegetation inventory vs monitoring using Recce descriptions

In designing the Recce description method, the intention was to establish a rapid one-off vegetation inventory method. The method is *not* considered to be as suitable for determining change in vegetation structure and composition as some other methods that were designed specifically for this purpose (e.g. Wiser & Rose 1997; Hurst et al. 2022a). For this reason, Recce descriptions are often left unmarked, and there is usually no intention of remeasuring. This was the approach used in most Recce surveys carried out by the former New Zealand Forest Service (Allen 1979, 1992; Allen & McLennan 1983) and Recce description data collected using similar methods as part of the Protected Natural Areas Programme (Myers et al. 1987).

The following guidelines are provided for those wishing to use the Recce description method to monitor vegetation change, noting that this might be driven by different objectives from the original survey. There are two instances where this is appropriate: (1) using a repeat sample of the study area to contrast attributes of the vegetation at two points in time, and (2) using repeat measures of Recce descriptions to detect change. In a repeat sample, the Recce descriptions must be located representatively at both points in time but can follow either the variable-area or fixed-area approach (see Table 1). However, the most robust method for detecting change using Recce descriptions is the repeated measures approach, which, by necessity, requires that Recce descriptions be permanently marked fixed areas with boundaries that can be accurately relocated. For such surveys, whether descriptions are subjectively or representatively located will depend on the objectives of the monitoring.

Table 1. Summary of pros and cons of temporary vs permanent Recce descriptions

Recce description	Pros and cons
Temporary, unmarked	• Fast and efficient inventory • Widely used • Either variable- or fixed-area Recce descriptions may be used. Variable-area descriptions are faster to measure, as boundary tapes do not need to be laid out. • Each Recce description cannot be accurately relocated and remeasured because the site is not permanently marked. • Recces may be located either representatively or subjectively; if representatively, the option of future repeat sampling to monitor vegetation change is retained.
Permanently marked	• The most robust approach if using Recce descriptions to monitor vegetation change. • The survey is future-proofed as Recce descriptions can be remeasured to address new ecological issues or priorities. • Recce descriptions must be bounded to a fixed area that is permanently marked, so that the boundaries of the description area can be accurately re-established. • Compared with temporary unmarked Recce descriptions, greater time and resources are required to permanently mark each Recce. • May be representatively or subjectively located, depending on the objectives of the study (see section 2.1.1).

2.1.4 Size and shape of RECCE descriptions

The fundamental factor when selecting the size and shape of Recce descriptions is the provision of an adequate measure of the composition (i.e. species richness) and structure of the vegetation. The traditional approach to defining the Recce description area for inventory surveys is to use the minimal-area concept to dictate the size and shape of Recce descriptions.

One method for determining minimal Recce areas is to use a species–area curve to ensure the area described is large enough to adequately represent the composition of the community. The species–area curve is a graph of the cumulative number of species recorded within a defined area of a particular environment (Mueller-Dombois & Ellenberg 1974). Despite New Zealand’s long history of vegetation inventory, there has been little published research on optimal Recce description sizes in New Zealand vegetation. Although species–area curves can be useful for determining a generally appropriate Recce size for any given community, determining the appropriate minimal area is not always straightforward, such as where vegetation gradients are steep, since the species–area curve may never approach an asymptote.

The adequacy of the overall sampling methodology will depend not only on Recce description size but also on sampling intensity (e.g. how many descriptions are undertaken in any particular vegetation type). In practice, it is usually impractical to accurately calculate minimal-areas for every vegetation survey. Furthermore, because the relationship between vegetation pattern and environment is often complex, no one Recce description size will necessarily be 'correct' for any particular study.

(a) Variable-area approach

A practical compromise is to limit the area described by each Recce to a homogeneous area of vegetation, as determined in the field. Hereafter, this approach is termed the 'variable-area' approach, since the size of the area described will vary among Recce descriptions (although for each individual Recce, the area is fixed prior to undertaking any measurements).

Each Recce should be small enough to be relatively uniform in habitat and topography, yet large enough to contain most of the species that occur in the plant community (Mueller-Dombois & Ellenberg 1974). This requirement of homogeneity in both vegetation and landform applies because, in general, physiography and vegetation are inter-related, and a change in one is likely to be reflected in the other (e.g. Daubenmire 1968; Mueller-Dombois & Ellenberg 1974).

Notwithstanding these guidelines, the boundaries of the homogenous area described at each Recce location are open to a degree of observer subjectivity. Vegetation communities are never completely homogeneous, and within-stand differences in structure and composition are generally inevitable. Trials conducted to assess observer differences indicate that, in the majority of cases, field parties comprising several observers will delimit similar boundaries for Recce descriptions (L.E. Burrows, Landcare Research, pers. comm.). Where heterogeneity is a characteristic feature of a specific plant community (e.g. canopy gaps in forest), such heterogeneity should be sampled (Mueller-Dombois & Ellenberg 1974). It is recommended that variable-area Recce descriptions be located representatively (see section 2.1.2).

The appropriate size for each Recce description generally varies depending on the structure of the vegetation (e.g. the sizes, spacing, and layering of plants and species in a stand). As a general guide, the taller the vegetation, the larger the Recce description is likely to be. Areas of approximately 2 m^2, 20–50 m^2, 80–150 m^2, and 200–400 m^2 are usually considered suitable in turf, grassland, shrubland, and forest communities, respectively (e.g. Mueller-Dombois & Ellenberg 1974). Recce descriptions somewhat larger than a 'minimal' area are acceptable, and it is generally better to describe vegetation for an area that may be larger than strictly necessary than limit the description to an area too small to characterise the plant community.

(b) Fixed-area approach

For some types of studies (e.g. those focused on comparing patterns of species richness) it is important to record the dimensions of the area used for each Recce description. For such reasons, some vegetation inventory surveys require all Recce descriptions within a survey to be bounded to an equally sized fixed area to allow comparison of vegetation attributes without any confounding effect of sample area. Hereafter, this is termed the 'fixed-area' approach, as all Recces within the inventory survey are the same size. If fixed-area Recce descriptions are to be used, by convention such Recces are usually square quadrats.

When using this approach, Recces within a survey are often the same size (unless, for example, different sizes are used to sample very different vegetation strata within a study area, such as wetland and forest). An appropriate quadrat size should be chosen for the predominant vegetation in the study area. Note that because boundary tapes are laid out that clearly define the bounds of each quadrat, such an approach is likely to result in increased precision of species cover-class estimates, as percentage canopy cover can be more easily related to a fixed area of the quadrat (see also section 2.1.3 regarding permanently marked Recces).

2.1.5 Number of sample RECCE descriptions

In many management and ecological studies, the number of Recce descriptions established is dictated by resources, with limited consideration of statistical issues. Compromises in sampling intensity could render the data inadequate for their intended purpose, as too few will not allow conclusions to be drawn about the parameters of interest. Conversely, too many Recce descriptions will increase the expense of the programme and may mean redundant data are collected.

(a) How to decide on the sampling intensity

When deciding on the sampling intensity required, consider the following questions.

- *How heterogeneous is the vegetation within the study area?* If vegetation is highly variable in composition and structure, then a larger number of Recce descriptions is required within the study unit to accurately describe that variation and to estimate vegetation parameters to a given level of precision. Conversely, where vegetation is relatively homogeneous, it may be appropriate to use fewer Recce descriptions.
- *What vegetation parameters are of interest?* Because species and vegetation attributes differ in how they vary through space, different sampling intensities may be required to accurately estimate the abundance of different species, or to accurately determine different vegetation characteristics.
- *What is the desired accuracy of results?* The accuracy required in parameter estimates directly affects the number of Recce descriptions required.
- *How will Recce descriptions be located?* A greater number of representatively located Recces would be needed to sample the complete range of vegetation or sites present compared with unrepresentative, subjectively located Recces.

- *What resources are available?* The higher costs associated with undertaking surveys in increasingly large areas often means that lower sampling intensity is used. The average cost of establishing Recce descriptions varies considerably among areas, mostly reflecting the nature of the terrain and ease of access, as well as the complexity of vegetation.

(b) Doing initial calculations

Some preliminary familiarisation with the study area – a pilot study and/or power analysis using existing Recce data – is very useful to address these issues. Initial field familiarisation can help assess the spatial heterogeneity of vegetation within the study area and can also help define the boundaries of any areas of special interest (as specified in the study objectives). These may include, for example, areas where a particular species or community of particular interest is present.

Simple power analyses using Recce description data from existing studies in comparable forest types can also be used to approximate the number of samples required to estimate vegetation parameters to a given precision. Detailed procedures for conducting simple power analyses are available in statistical textbooks (e.g. Goulding & Lawrence 1992), and analytical packages are available for estimating statistical power from a variety of sampling designs, and for a wide range of data distributions (e.g. the SIMR package; Green & MacLeod 2016).

3 Pre-fieldwork planning for locating and measuring Recce descriptions

Pre-fieldwork planning ensures that fieldwork proceeds as efficiently and smoothly as possible, the data are of high quality and meet the intended purpose, and the work is completed within budgeted timeframes. As part of the overall management of the inventory or monitoring programme, realistic budgets and work plans must be developed, suitable staff selected to undertake the work, and all equipment and resources organised. Quality control procedures should also be considered during the planning phase of a survey (see section 7).

Pre-survey planning includes the following tasks.

3.1 Developing the sampling design

This includes making decisions on the number and arrangement of Recce descriptions needed to ensure adequacy of sampling to meet specific study objectives. This may necessitate a pilot study, statistical analysis, and/or a peer review of the proposed study design.

3.2 Scheduling and logistics

A scoping exercise may be necessary to determine the availability of field skills and the personnel required to measure/establish the Recce descriptions. Logistical planning may also be required to determine local service providers (e.g. helicopter transport) and to assess potential access issues (e.g. crossing private land).

3.3 Organising and purchasing equipment.

Equipment required for the completion of Recce descriptions is detailed in Appendix 2. Obtain all necessary equipment and check that it is in working order before undertaking fieldwork. Ensure spare equipment is on hand in case any is lost or broken.

3.4 Selecting staff

Where required, select a field team coordinator and support staff who have a background in project management, and preferably Recce description measurement. When selecting staff, consider the fieldwork, vegetation survey, and botanical experience of potential team members and ensure there is a good mix of complementary skills across the team. Accurate identification of plants in the field is a key skill that underpins all vegetation measures. Therefore, each team needs at least one member with a high level of plant taxonomy knowledge. Selecting appropriate staff will ensure the work runs as smoothly and efficiently as possible without compromising data quality.

3.5 Training staff

This should include instruction in all Recce measurement protocols to be followed, with a strong focus on correctly recording and checking data on field sheets. Staff training should also include familiarisation with the use of all field equipment, including GPS receivers, metal detectors, altimeters, and other measuring equipment. Training should be provided to ensure all field staff understand health and safety and risk management processes, as well as relevant biosecurity protocols. Additional training in team leadership and coordination should be provided for relevant personnel.

3.6 Pre-season

Before the field season begins, all field staff should be briefed on the logistical and operational processes for field trips.

3.7 Create a detailed field plan

Sufficient time and resources must be available to complete the work to a high standard. The time taken to establish and measure each Recce description varies considerably depending on the complexity of the vegetation, the difficulty of the terrain, and the experience of the field team, as well as whether any ancillary data are collected.

When drawing up a field plan, assign potential start and finish dates for each field trip, including extra contingency time for bad weather. If multiple field methods are being used simultaneously, teams should be provided with guidelines on how to prioritise field effort when time is constrained (e.g. due to poor weather). Include in field plans how teams will travel from place to place and all the associated expenses (e.g. helicopters).

Note that after each field trip a sufficient break should be scheduled in order to deal with collected plant specimens (i.e. arranging pressing and drying, see section 6), store field sheets, and restock consumable equipment (see Appendix 2).

3.8 Allocating time to follow up work after the fieldwork is complete

Sufficient time must be allocated to identify collected plant specimens and correct field sheets (section 6), and to arrange for data entry and for the general management and archiving of data (section 8).

3.9 Obtain lists of species likely to be encountered in the survey area

Gather as much information about the vegetation of the survey area as possible, such as the types of plants and communities you are likely to encounter, previous survey reports, species lists (e.g. from botanical societies or the New Zealand Plant Conservation Network; http://www.nzpcn.org.nz) and (where possible) regional floras. Inaturalist (inaturalist.nz) and the Global Biodiversity Information Facility (gbif.org) are also excellent resources that capture species distribution records. Species lists for surveys archived in the NVS Databank can be obtained via the website (http://nvs.landcareresearch.co.nz).

Compile short field guides and/or keys providing distinguishing features for any genus or species for which identification is likely to be problematic. Compile species lists alongside correct NVS six-letter species codes (see section 5.1). Updated *Flora of New Zealand* taxonomic treatments with excellent images and maps are available as fascicles in PDF format from http://www.nzflora.info/publications.html.

3.10 Obtain permission to cross land and collect specimens

Arrange permission from the landowner or administrator of the land that must be crossed to reach each Recce description location. Permits must also be obtained from landowners or administrators to collect material such as plant specimens.

3.11 Biosecurity

Include mechanisms in logistical planning processes that ensure the field teams are aware of the biosecurity risks in the areas they are intending to work in and are equipped to deal with those risks. Dealing with biosecurity risks could include developing protocols to abandon or relocate new Recce descriptions, as well as introducing stringent cleaning and quarantining protocols; the latter, in most cases, will have already been developed by DOC and the Ministry for Primary Industries. As of 2021, access to tracks and forests in several

New Zealand regions is restricted because of kauri dieback (caused by the oomycete pathogen *Phytophthora agathidicida*) and myrtle rust (caused by the fungus *Austropuccinia psidii*).

4 Recce description location

4.1 Overview

When implementing representative sampling designs, the precise Recce description location in the field must be determined in a truly objective (unbiased) way to ensure the data collected are a representative sample of the study area. This can often be facilitated through the use of GPS to locate Recce positions. However, note that GPS receivers cannot always be used to determine location, particularly in mountainous terrain or beneath tall or dense forest canopies. In this case alternative procedures to locate the Recce description must be followed, such as the use of a hip-chain and compass to locate the Recce description from a nearby landscape feature that is easily identified on a topographical map.

A predetermined Recce location may sometimes fall where it is unsafe or impractical to undertake a Recce description (e.g. bluffs, very steep terrain). Do not establish a Recce at the specified predetermined location where doing so would be likely to endanger the field party. For such Recces, use the Notes section of a Recce sheet to briefly describe the situation and vegetation, and archive this with the rest of the data from the survey. A Recce relocation protocol can be used if a site is unsafe. An example of a plot or Recce description relocation protocol currently used in New Zealand requires a field team to examine a hierarchical set of 30 alternative locations, derived from 10 random bearings at 200, 400, and 600 m intervals from the original point, and sampling the first safe location (DOC 2019).

4.2 Locating Recce descriptions at systematic or random sample points

Where Recce descriptions are to be established at points determined prior to fieldwork, enter the most recent grid reference into a GPS receiver before setting off. Check the coordinate system of the grid references before entering them. If they were collected in New Zealand Map Grid they will need to be converted to New Zealand Transverse Mercator.

When GPS reception can be obtained, use it to navigate to within c. 30 m of each Recce location. Set the direction function of the GPS receiver to magnetic, and use the GPS waypoint function to obtain a bearing and distance to the Recce. Follow the bearing and measure the distance using a hip-chain or tape. This procedure is recommended because the accuracy with which a GPS receiver can locate any specified point decreases as the point is reached (Burrows 2000).

When GPS reception cannot be obtained, follow a bearing and measured distance using a hip-chain (as above) to locate the Recce from a significant nearby landscape feature that can be accurately identified on a topographical map (e.g. stream confluence, high point, bush edge, ridge). Similarly, if there is no GPS reception at the Recce location, re-fix the position of an identifiable point (e.g. a prominent landscape feature). Where possible, re-fix each Recce position with the GPS receiver and record the coordinates on the Recce sheet (see section 5.2.1).

4.3 Locating Recce descriptions along transects

Where Recces are to be located along transects, navigate to the transect origin using a map, compass and GPS receiver (where possible, as outlined above). Record the transect bearing (magnetic) and GPS reference for the transect origin (where possible) on the Recce sheets of all Recces on the transect (see section 5). When travelling along each transect, ensure the compass bearing is accurately followed. Measure the pre-specified distance to each Recce with a hip-chain or tape (typically 200 m). Where possible, fix each Recce position with the GPS receiver and record the coordinates on the Recce sheet (see section 5).

4.4 Establishing permanent fixed-area Recce quadrats

4.4.1 Fixed-area quadrat orientation

If establishing *permanent fixed-area Recce descriptions* (see section 2.1.4), establish a square quadrat, labelling the corners 'A', 'B', 'C' and 'D' clockwise around the Recce (e.g. Wiser & Rose 1997). One system for determining the quadrat orientation is to mark corner D at the selected point, and then establish the D–C quadrat boundary along the predominant contour of the slope. While standing at the Recce corner, determine the bearing by using a sighting compass to sight on somebody standing 10–15 m away along the contour of the slope.

Take 90° off the compass bearing of the D–C boundary to determine the compass bearing of the D–A and C–B boundaries, and lay out two boundary tapes at right angles to the first. Join the open end along the A–B boundary, with a fourth boundary tape to form a square quadrat.

When a Recce quadrat is located on flat terrain (average slope is less than 5°, see section 5), establish it so that the C–D boundary lies in a north–south direction (i.e. corner C is north of corner D).

4.4.2 Fixed-area Recce quadrats on transects

When Recce quadrats are located on *transects,* establish the quadrat so that the D–A quadrat boundary lies along the transect in the direction of travel. Each quadrat should be established to the right of the transect (relative to the direction of travel). The D–C and A–B boundaries should be laid out perpendicular to the transect (i.e. add 90° to the compass bearing of the D–A boundary).

4.4.3 Laying out permanent fixed-area Recce quadrat boundary tapes

Use a sighting compass to lay out Recce quadrat boundary tapes to the correct magnetic bearings. The tapes should be pulled tight when laying out a Recce quadrat on even ground. When the Recce quadrat is in a gully or over a ridge, the tapes should generally follow the ground surface. Ignore small bumps or depressions. Where possible take the tape under windfalls, or, if that is not possible, pull the tape above them.

Lay boundary tapes out as straight as possible. When trees are located along Recce quadrat boundaries, include them in the quadrat when their trunk is predominantly (>50%) rooted within the quadrat. Try to minimise disturbance to the Recce quadrat area and immediate surroundings to reduce the possibility that changes measured over time will result from measurement activities.

4.5 Permanently marking fixed-area Recce quadrats

For any Recce descriptions that are to be remeasured, adequate permanent marking is absolutely essential to ensure Recce quadrat boundaries can be accurately re-established during future measurements. Do not rely solely on GPS references for relocation purposes, as GPS fixes can be imprecise. It is important to adequately mark the route to each permanently marked Recce position so that they can be relocated easily by future field parties.

Where possible, use a GPS receiver to locate the Recce position and to record the location of significant landscape features along the route to the Recce; for example, transect origins (where applicable), stream confluences, bluffs, high points, campsites, helicopter landing sites. All access route and Recce location markers should be robust enough to withstand disturbance from animals (e.g. stock) and natural elements. Suitable marking depends on the vegetation of the study area.

4.5.1 Forest vegetation

Mark each quadrat corner with a large strip of Permolat attached to an aluminium peg (e.g. 7 mm diameter, 45 cm long) placed in the ground. Ensure you scratch or stamp onto the Permolat strips the appropriate corner letter (i.e. ‘A’, ‘B’, ‘C’, ‘D’ clockwise around the Recce). Do not use permanent marker pens. The aluminium peg should be bent at the top to reduce the likelihood of the Permolat falling off.

At each corner peg, select the nearest live tree outside the Recce area on which to nail a strip of Permolat and provide corner location information. Label each Permolat strip with the measured distance along the ground, the magnetic bearing *from* the centre of the base of the tree *to* the corner peg, and the appropriate corner letter (e.g. ‘Corner A 1.6 m @ 205º’). Nails should protrude by at least 2 cm to allow for tree growth. Adequate Permolat marking near corners is invaluable when Recce descriptions are to be remeasured, as corner pegs can be lost over time.

4.5.2 Grassland or wetland vegetation

Quadrat corners may be marked using 50 × 50 mm wooden stakes, angled aluminium standards, or waratahs (Y-posts/steel standards), as appropriate. Such corner pegs should protrude from the ground by 0.8–1.0 m so that they are easily visible to assist relocation. Aluminium pegs are lighter to carry and may be suitable, particularly where the interval between quadrat establishment and remeasurement will be short. Brightly coloured, recycled-plastic waratahs are similarly easily transportable. Rock cairns and photographic records can assist with quadrat relocation. The coloured Permolat strips often used to mark study sites in forest vegetation are not recommended in South Island alpine zones because they attract kea.

A combination of the above approaches may need to be taken in vegetation composed of scattered grassland and shrubs.

5 Measuring Recce descriptions

Always thoroughly document Recce measurement protocols in the metadata for a survey (see section 8.2.3), and outline in detail any intentional variations to standard Recce description measurement protocols.

The equipment required to undertake Recce descriptions is detailed in Appendix 2. A Recce description can generally be undertaken most efficiently by two people. Each Recce is recorded on a double-sided Recce description sheet (see Appendix 3), which can be obtained from the NVS Databank website (http://nvs.landcareresearch.co.nz/). Two alternative field sheets are available with different sets of fixed-height tiers for the Recce vegetation description (see section 5.2.5). Print field sheets onto both plain and waterproof paper or card for use in the field.

Note that collecting data over extended periods in wet or cold weather is not advisable, as data quality generally suffers. When the ground is wet, measurement activities can also cause considerable damage to the vegetation in the Recce, especially on steep terrain. This concern is especially relevant where permanently marked, fixed-area Recce quadrats are used to monitor vegetation change.

5.1 Plant species nomenclature and coding system

5.1.1 Naming species

The recommended nomenclature authority for New Zealand is Ngā Tipu o Aotearoa – New Zealand Plants database (https://nzflora.landcareresearch.co.nz/). The database annually releases date-stamped species lists, which are available from https://datastore.landcareresearch.co.nz/organization/plant-names-database-reports . The use of a date-stamped species lists permits a work programme to achieve taxonomic consistency over a specified time period. The Biota of New Zealand portal (https://biotanz.landcareresearch.co.nz/) can be used to search nomenclatural details in the database (filter the record source to Names_Plants to improve search outcomes).

Plant species should be identified and recorded to a level of taxonomic resolution the field botanist can confidently recognise as a unique taxon. Where appropriate, record taxon identifications below species level (i.e. to subspecies or variety, if relevant). Although subspecies and varieties are sometimes raised to species level during data analysis, recording the most accurate identification possible can capture valuable distribution data for subspecies and varieties that are threatened, and also future proofs data against potential taxonomic changes (e.g. a subspecies becomes recognised as a distinct species).

5.1.2 Using the coding system

Plant species must be recorded using a standard species-coding system to guarantee that data can be interpreted in the long term. Key requirements of the species coding system are that:

- each taxon is recorded using a unique code that applies *only* to that taxon
- codes used for each taxon are *consistent* within and between surveys.

Before beginning fieldwork, all survey participants should be familiar with the species-coding system, be aware of potential non-intuitive species codes (Appendix 4), and know how to check that the species codes used are correct. Rules for constructing species codes are outlined below.

(a) Coding species

- Each plant species is represented using a unique six-letter NVS code on field sheets and in electronic form once the data are entered. The species code usually consists of the first three letters of the plant genus (upper case), followed by the first three letters of the species name (lower case). For example, *Pseudopanax crassifolius* is recorded as PSEcra on all field sheets. The current catalogue of species codes is maintained by the NVS Databank team and is directly linked to Ngā Tipu o Aotearoa – New Zealand Plants database (https://nvs.landcareresearch.co.nz/Resources/NVSNames).
- Where only the genus is able to be determined due to a lack of identifying features (e.g. *Parsonsia*), use the first six letters of the generic name (written in upper case on field sheets; e.g. PARSON).
- Some taxa have not been formally described (e.g. *Coprosma* sp. (d)) but are generally recognised as distinct and are listed on the Ngā Tipu o Aotearoa – New Zealand Plants database (http://nzflora.landcareresearch.co.nz/). For such species, the code should consist of the first three letters of the genus (upper case) followed by the letter used to identify the informal species (lower case) (e.g. COPd).

(b) Non-intuitive species codes

- The simple species-coding system outlined above provides a unique code for most taxa. However, following this coding system, some six-letter codes could denote more than one taxon. For example, the intuitive code for both *Pseudopanax* *colensoi* and *Pseudowintera colorata* is PSEcol. To ensure each taxon receives a unique code, non-intuitive codes are used for some species (e.g. the code for *Pseudopanax colensoi* is NEOcol).

- Be aware of any non-intuitive codes for species you are likely to encounter during the survey. A list of some common non-intuitive codes for vascular plants in the New Zealand flora is given in Appendix 4, but others may be devised as a result of ongoing taxonomic revisions.

- *Do not* use *ad hoc*, non-standard plant species codes, because at a future date these are likely to be misinterpreted by people unfamiliar with the data set. Where there is any possibility of ambiguity, or if you are in doubt about the correct six-letter species code, write out the plant name in full.

(c) Coding subspecies and varieties

- For subspecies and varieties, various methods have been used to construct unique species codes. The species code usually consists of the first three letters of the plant genus (upper case), followed by the first letter of the species name (lower case), followed by either an 's' or a 'v' (to denote subspecies or variety), followed by the first letter of the subspecies or variety name (lower case).
- For example, *Polystichum neozelandicum* subsp. *zerophyllum* is denoted as POLnsz on field sheets, while *Ascarina lucida* var. *lanceolata* is denoted as ASClvl. These conventions ensure the intended taxonomic concept is clear and unambiguous. In contrast, note that if a plant was identified in a wider sense (i.e. to species level), then, for the previous examples, *Polystichum neozelandicum* would be recorded as POLneo, and *Ascarina lucida* as ASCluc.
- Because of the potential for duplicate species codes, the codes used for some subspecies and varieties do not follow the standard system (e.g. *Olearia virgata* var. *lineata* is denoted as OLEvli). Always refer to the list of six-letter species codes to check that the species code recorded is correct.

(d) Coding hybrids

- For hybrids with a recognised hybrid name (e.g. *Coprosma cunninghamii = Coprosma propinqua* × *C. robusta*), the code consists of the first three letters of the genus (upper case), followed by an x (to denote the hybrid status of the plant) and the first two letters of the hybrid name (e.g. COPxcu for *Coprosma cunninghamii*).
- For hybrids without a recognised hybrid name (e.g. *Fuscospora cliffortioides* × *F. truncata*), the code should consist of the first three letters of the genus (upper case) followed by the first letter of each putative parent (lower case) separated by an × (e.g. FUScxt for the mountain x hard beech hybrid).

5.1.3 Checking that species codes used are correct

- Before starting fieldwork, obtain an up-to-date list of all species codes currently used in the NVS Databank from the NVS website (https://nvs.landcareresearch.co.nz/Resources/NVSNames), and use this list during and following data collection to check that each six-letter code used is correct.

- Also, before starting fieldwork, reconcile any lists of plant species that are expected to be encountered on the survey (e.g. regional flora lists or plant identification books, species lists compiled by botanical societies, species lists from nearby vegetation surveys) against the correct six-letter species codes. Species lists for surveys archived in the NVS Databank can be obtained via the website (http://nvs.landcareresearch.co.nz).
- Because of ongoing taxonomic revisions, at any point in time there may be recognised published species that have not yet been incorporated into the list of species codes used in the NVS Databank. Use the search functions on the New Zealand Plant Names Database (Ngā Tipu o Aotearoa – New Zealand Plants; http://nzflora.landcareresearch.co.nz/) to check that each species name is current or recognised.
- When a species name does not yet have an assigned six-letter species code, contact the NVS Databank manager (email nvs@landcareresearch.co.nz), who will arrange for the species to be added to the NVS Databank list and provide you with the new NVS code for the species. *Do not* assign *ad hoc* six-letter codes to any species without checking with the NVS Databank manager, as the code could conflict with a six-letter code already assigned to another vascular or non-vascular species.
- If a formally recognised species is not listed on the New Zealand Plant Names Database, use the feedback function on the New Zealand Plant Names Database website and/or contact the NVS Databank manager.

5.1.4 Documentation of plant species recorded in metadata

Despite the general rules outlined above, achieving consistency in the use of species codes within and among surveys has proven difficult. Ongoing taxonomic revisions mean that historical data normally include out-of-date species codes, and the uptake of taxonomic name changes can be slow. The following 'best-practice' guidelines are recommended to help ensure species codes are used consistently within a vegetation survey, and that the intended meaning of each species code used in a survey is documented.

- During the survey, maintain a list of the full taxonomic names of every species recorded, along with the six-letter codes used on field sheets. An easy way to create and maintain this list during fieldwork (e.g. at the field base) is to mark species off on the master list of species codes currently used in the NVS Databank as they are recorded in the survey.
- Document the basis of nomenclature followed for individual species or logical groups of species (e.g. ferns, grasses), preferably conveyed by reference to a standard authoritative work. In lieu of an authoritative reference for each species, plant identification texts can be referenced where they are used to identify all species within certain groups of plants (e.g. all fern species). Include information on the edition and year of publication.

5.2 Recce description measurement

Recce identification information and descriptive data on the site and vegetation (sections 5.2.1–5.2.4) are recorded on the front side of the sheet. An example of a completed Recce sheet is provided in Appendix 3a. Take the following steps when measuring and recording the Recce identification and site data.

- Define the boundaries of the area that will be described before undertaking any measurements. Where variable-area Recce descriptions are to be used, mentally take note of the features forming the boundaries of the area that will be described. If using fixed-area Recce quadrats, use tapes to define the Recce area (see sections 2.1 and 4.4).
- Limit data to constrained categories (where these are supplied). For example, do not record drainage as 'okay'; always record it as 'good', 'moderate', or 'poor'. Use the Notes section where justification or further detail is required.
- Confer with other field-party members if you are at all unsure of the value for a data field. This applies especially where subjective visual assessments are required (e.g. surface characteristics and ground cover).
- Ensure data are legible. Neatly record data to minimise any possibility they will be misread or unable to be interpreted.
- Do not leave any field on the data sheet blank. Where data are intentionally not recorded in a data field (e.g. the sub-catchment in which the Recce is located is unnamed), record a dash ('—') or 'none' to ensure the data are not interpreted as missing. Record 'not measured' where data were not measured for some reason.

5.2.1 Recce identification information and location

Recce identifier:	Record the unique identifier for the Recce (including the transect line number where appropriate). Ensure the unique identifier is recorded on both sides of the Recce sheet in case it is photocopied onto separate sheets.
Survey:	Record the name of the survey (e.g. Kokatahi).
Region:	Record the region (e.g. Westland).
Catchment:	Record the name of the catchment in which the Recce is located (e.g. Whitcombe River).
Sub-catchment:	If the Recce is located in a named river or creek running into the main catchment, record this as a sub-catchment (e.g. Vincent Creek).
Measured by:	Record the full name of the person(s) doing the Recce measurement (e.g. Larry Burrows).
Recorded by:	Record the full name of the person(s) recording the descriptive data (e.g. Susan Wiser).

Permanently marked: Circle Y (yes) or N (no) to indicate if the Recce is permanently marked.

Date: Record the day, month, and year in full (e.g. 3 March 2005).

Topographical map: Record the topographical map series, map sheet number, and name (e.g. Topo 50 BV18 – Kokatahi).

GPS reference: Record the make and model of the GPS receiver (e.g. Garmin 64S). Where possible, a GPS reference should be recorded using a GPS receiver; for consistency this should be taken at corner D when measuring the Recce as a fixed-area quadrat. This provides accurate location information (important for some data analyses, and facilitates future relocation, where applicable). Record the Easting and Northing in the space provided, preferably using seven-figure New Zealand Transverse Mercator coordinates; for example, (Easting) 1652112, (Northing) 5319823.

GPS fix: Circle whether a single position was measured or if the position was averaged (see GPS accuracy below). Circle if it was a 2D or a 3D fix: this is relevant for older model receivers only – a 2D fix requires only three satellites and cannot measure altitude (i.e. it assumes sea level). It is important to ensure the GPS receiver is set to the datum relevant to the topographical maps used. Early topographical maps (1972–2000) used the New Zealand Map Grid projection, defined in terms of the New Zealand Geodetic Datum 1949 (NZGD1949). Contemporary topographical maps (e.g. NZTopo50, 2001 onwards) produced by Land Information New Zealand use the New Zealand Transverse Mercator projection, based on the New Zealand Geodetic Datum 2000 (NZGD2000). Circle which geodetic datum was used to obtain the GPS reference (i.e. NZGD1949 or NZGD2000). Be aware that older GPS references (pre-2001) were probably taken using the New Zealand Map Grid projection (NZGD1949) and will differ substantially in position when plotted onto contemporary maps that use the New Zealand Transverse Mercator projection (NZGD2000) (see http://www.linz.govt.nz/).

Ensure the Recce location is correctly marked on a topographical map and, if applicable, on an aerial photograph (where available). Note that there will be times and places (e.g. mountainous terrain) where it is very difficult to obtain a GPS fix at a Recce location. In these instances, try to obtain a reading from the nearest high point or canopy gap where good reception can be found. Record this position in the approach notes and mark it on the location diagram. Measure the distance and direction to the Recce using compass and hip-chain or tape, and record this information in the approach notes. More detailed information on using GPS receivers can be found in Burrows 2000.

GPS accuracy: For Garmin GPS receiver units that are 60 series or older, average a waypoint, allowing 30 measurements. For Garmin 62 units or newer, use the multi-sampling averaging function. The unit will display 100% once the averaging process is complete; circle Y (yes) on the Recce sheet to confirm 100% averaging. To obtain the accuracy displayed in metres, immediately scroll through to the satellite page after averaging. For greater accuracy, average the waypoint twice, waiting for a minimum of 90 minutes between. Record the accuracy obtained (e.g. ±4 m).

GPS location: Circle CORNER D if this is where the GPS reference was taken (preferred), or record the GPS reference location.

Approach: For Recce descriptions that are not permanently marked, record brief information on the location of the Recce in relation to prominent features of the landscape or vegetation.

Where the Recce is permanently marked, record detailed instructions on how to get to the Recce location. Include information on the location of the Recce in relation to prominent features of the landscape or vegetation. Record any important GPS waypoints along the approach route. Where the Recce is located on a transect, record the compass bearing of the transect and the GPS or map reference for the transect origin. Also, record if you found the line start (where applicable), how this was marked and if you followed a Permolat line to the Recce description location, and record the colour of the Permolat.

Accurate and detailed approach notes are very important for the future relocation of Recce description locations. Do not assume that GPS references will be completely adequate for relocation purposes. The description should be sufficiently detailed to enable people who have not previously been to the Recce site to locate it without extensive searching. Do not copy previous approach notes, but ensure that any points of confusion or misleading notes from the previous measurement are clearly explained.

Location diagram: Where the Recce is permanently marked, sketch the route to the Recce, emphasising prominent landscape or vegetation features (e.g. ridges, gullies, streams, slips, bluffs, roads, large tree-fall gaps). Indicate all features for which GPS grid references are provided in the approach notes.

Location diagrams should always have an arrow indicating north (magnetic), and the direction of flow of any streams or rivers should be indicated.

Size of Recce: For ‘variable-area’ Recces (see section 2.1.4), record the approximate (±10%) size of the area described (e.g. 100 m2). If bounded to a fixed-area Recce quadrat, record the quadrat dimensions (e.g. 20 × 20 m).

Vegetation description and notes: Provide a short description of the vegetation on the Recce and any additional observations or impressions, such as evidence of erosion, disturbance, pest impacts or notable features of the topography. Information recorded here should provide a general impression of what the Recce looks like (see example in Appendix 3a).

5.2.2 Site description

Site data collected provide important information on abiotic factors that may influence vegetation structure and composition. As a minimum, a set of basic, readily obtainable measures is required, as outlined below.

Altitude: Determine the altitude using a barometric altimeter, or use the GPS coordinates to determine the Recce position on a topographical map (or the map loaded onto the GPS), and then use the map contour lines to determine the altitude. Record altitude to the nearest 10 m. If using a barometric altimeter, it should be calibrated from a known spot-height on the topographical map each morning before work starts, and more frequently in changeable weather.

Altitude should not be directly read from GPS receivers because the reading can be inaccurate. Some models of GPS receiver contain in-built barometric altimeters: check the specifications of the GPS receiver used.

Physiography: Circle the applicable option from: ridge (including spurs), face, gully, or terrace. When more than one category could apply, circle the predominant physiography and record any major change in physiography within a Recce in the Notes section.

Note that in addition to the standard methodology, more detailed landform classifications have sometimes been used in studies focused on relationships between vegetation composition and landform (e.g. Myers et al. 1987; Rose et al. 1988; Whitehouse et al. 1990). For example, Dalrymple et al. (1968) developed a general nine-unit land surface model that has been used with Recce descriptions (see Selby 1982 for details).

Aspect: Determine the physiography of the Recce before measuring the aspect. Use a compass to measure the predominant aspect at right angles to the general lie of the Recce, to the nearest 5º (magnetic). Aspect cannot be determined on flat or almost-flat sites (slope <5º) and should be recorded as 'X'. Do not use zero to record aspect on flat Recces, as this will be misinterpreted as a northerly aspect. Where there is a major change in aspect across the Recce, record the predominant aspect.

Slope: Use a clinometer (or equivalent instrument) to measure the average slope of the Recce along the predominant aspect, to the nearest degree. From the middle of the Recce, sight the clinometer on an object at eye level near the upslope and downslope boundaries of the Recce and average the two readings.

Parent material: Identify the predominant bedrock type or parent material. This can often be determined prior to fieldwork from geological survey maps. Copies of geological survey maps are available in libraries and can be obtained from GNS Science (http://www.gns.cri.nz/). Where available, the QMAP geological map series at 1:250,000 scale should be used, which supersedes the Geological Map of New Zealand 1:250,000 ('four miles to the inch') series.

Where the field party contains staff with expertise in identifying rock types, any disagreement with the broad map classifications can be noted in the field, particularly when there are extrusive/intrusive rocks. Circle the relevant option to record whether parent material was derived from the mapped classification or observed in the field. If you are unaware of the parent material while in the field, record 'Unknown'.

Drainage: Circle the applicable option from good (fast runoff and little accumulation of water after rain), moderate (slow runoff, water accumulation in hollows for several days following rain), or poor (water stands for extended periods).

This subjective, point-in-time drainage assessment will probably identify extremes in soil drainage only. Several other soil drainage scales have been used previously on Recce descriptions (e.g. Taylor & Pohlen 1962), but they do not overcome this limitation.

Mesoscale topographic index: Use a clinometer (or equivalent instrument) to measure the angle from the centre of the Recce to the horizon at eight equidistant (45º) magnetic compass bearings. Record whether each angle is above (+) or below (−) the horizontal. Move around the Recce description area if necessary. When the horizon angle is obscured (e.g. by low cloud or dense vegetation), estimate the horizon angle and make a note that the recorded value is an estimate (e.g. −8° (est)). An estimate of the horizon can be made by projecting ridges using your knowledge of the Recce description area based on your observations as you travel to and around the site (lowest visible light is not necessarily the horizon). If measuring or estimating the horizon is impossible, then record 'obscured'. When all eight values are averaged, the resulting value provides an indication of the relative protection (e.g. high values) or exposure (e.g. low values) of the site (McNab 1993). It is also possible to calculate a metric of Recce protection in the landscape using a Digital Elevation Model in a GIS.

Terrain shape index: Use a clinometer (or equivalent instrument) to measure the angle from the centre of the Recce to eye-level 20 m from the centre of the Recce at eight equidistant (45º) magnetic compass bearings. Record whether each angle is above (+) or below (−) the horizontal. The index is a quantitative description of surface shape and is used in forestry as an explanatory variable for metrics such as tree height (McNab 1989). It would be useful to have a second person and an extra 20 m tape for measuring terrain shape index. To save time, measure the terrain shape index while measuring the mesoscale topographic index.

Surface characteristics: Record the following for the Recce.

Percentage bedrock, percentage broken rock: estimate the percentage of the Recce ground surface comprising bedrock and broken rock (>2 mm) to the nearest 5%. Include all rock that is evident, even if covered by vegetation, moss, or a thin layer of litter.

Size of broken rock (>2 mm): record whether rocks greater than 30 cm (>30 cm) or less than 30 cm (<30 cm) form the predominant cover of broken rock by circling the relevant option. If there is no broken rock, cross out both options.

Mode of transport of broken rock: classify (if possible) whether broken rock was mostly deposited as a result of alluvial (river deposits), colluvial (erosion debris), moraine (glacial deposits), or volcanic activity.

Note that previous versions of the Recce description method (Allen 1979, 1992; Allen & McLennan 1983) also required the presence or absence of rock and bedrock to be recorded. In this manual the modes of transport (‘Description’ in previous manuals) include the range of deposition modes likely to be encountered.

5.2.3 Vegetation parameters

Note that the following vegetation parameters are estimated visually and so are relatively subjective. They are included because of their use in demonstrating marked differences between sites and provide a data user with a better impression of what the Recce looks like. These variables have been used in studies of vegetation dynamics (e.g. Harcombe et al. 1998; Wiser et al. 1998).

Ground cover: Estimate the percentage of the Recce area (to the nearest 5%), below 1.35 m, that is covered by the following.

Vascular vegetation: live, vascular vegetation, including foliage, tree trunks and exposed roots. Note that tree trunks and exposed roots normally comprise only a very small portion (usually <1%) of vegetative cover. As this estimate is of actual vegetation cover, any gaps in the vegetation are excluded from it.

Non-vascular vegetation: all non-vascular vegetation, including mosses, liverworts, hornworts, lichens (including crustose species) growing on soil, litter, coarse woody debris, and rock, and non-vascular plants growing as epiphytes on other living plants, stems and roots, and on dead-standing stems.

Litter: visible dead plant material that is detached from the live plant (including leaves, dead logs, and branches) that is in contact with the ground. This includes litter among low-growing vegetation.

Bare ground: exposed soil not covered by litter, vegetation, moss or rocks.

Rock: exposed rock, either broken rock or bedrock, not covered by vegetation, moss or litter.

The above five values must sum to at least 100%, but because of multiple layers of overlapping cover they will normally sum to more than 100%. As Recce description locations are seldom flat (e.g. there may be hollows or cliffs present), it is best to imagine flattening these features and estimating ground cover as a proportion of the entire flattened surface. Note that in some historical Recce data, percentage ground cover estimates may have only included the top intercept, so that the sum of cover in all classes was 100% (Allen 1979; Allen & McLennan 1983).

Average top height: Estimate the average top height of the dominant vegetation on the Recce, to the nearest metre. For low-statured communities (i.e. where average top height is <1 m), these are recorded to the nearest 0.1 m. The dominant vegetation is defined as all vegetation in the tallest tier (as recorded on the Recce vegetation description; see section 5.2.5) with an overall cover of >25% (i.e. overall cover class of ≥4). Where none of the tiers have cover >25%, average top height should be calculated across all height tiers.

Height estimates should be calibrated regularly, with heights measured using a tape (e.g. 8 m builder’s tape), height pole, hypsometer or equivalent instrument.

Note that in previous manuals (Allen 1979, 1992; Allen & McLennan 1983) this parameter was termed ‘mean top height’, a term that may be confused with more formal definitions used in forestry literature; and that in structurally complex vegetation, the vegetation to be included was at the discretion of the observer.

Canopy cover (%): Visually estimate the total canopy cover of the Recce area above 1.35 m, to the nearest 10%. Canopy cover is the vertical projection over the Recce area of all vascular and non-vascular live or dead material (leaves, trunks and branches) >1.35 m above the ground. This measure reflects how much light to the ground surface is blocked. Use the

Canopy Cover Scale (Appendix 5) to help arrive at this estimate. For Recce descriptions with a dense subcanopy, several estimates may need to be made from different positions around the Recce and then averaged.

Alternative, less subjective estimates of canopy cover can be obtained using a canopy densitometer. This instrument consists of a mirror that, when held horizontally below the canopy, reflects the view of the canopy. Cover can be assessed at evenly distributed points across the Recce area. Each point where the marked crosshairs at the centre of the mirror appears to be covered by canopy is counted, and the proportion of canopy-covered points out of all those sampled is converted to a percentage. Note that the accuracy of the overall canopy cover estimate obtained depends on the number of points assessed (see Stumpf 1993).

Basal area: In forest vegetation, stand basal area (m^2/ha) may be estimated where relevant to the survey objectives, and can be recorded in the Notes section. In relatively open forest, basal area can be determined using angle-gauge sampling. With angle-gauge sampling, a tree is included if the angle its diameter subtends at the Recce description centre is greater than the angle-gauge-specific critical angle. The contribution of each included tree is determined from a basal-area factor that is specific to the instrument being used (Allen 1992). For detailed instructions on conducting angle-gauge sampling, refer to Goulding & Lawrence 1992.

5.2.4 Additional biological information

Cultural: Record direct evidence of human interference using the categories provided (logged, burnt, tracked, cleared, mined, grazed [by domestic stock], none). Use the Notes section to justify your choice(s), where necessary, or to record indirect evidence of human activity.

Treatment: Has a treatment been applied to the Recce description area (e.g. 'fenced' or 'not fenced' for Recces that are part of a grazing exclosure trial). Record not applicable (NA) when Recces are not part of an experimental trial.

Fauna: Record the presence of any mammalian, bird, reptile, or invertebrate species that can be positively identified by sight or sound. Note that only birds may have been noted on historical Recce descriptions (Allen 1979, 1992; Allen & McLennan 1983).

Browse: Record conspicuous browsing damage in all height tiers to plant species on the Recce using the following categories.

Light (L): browse on one or two shoots only, on only a few of the plants of the species present.

Medium (M): browse on more than one or two shoots, but most plants of the species not browsed.

Heavy (H): browse on most accessible shoots on most plants of the species.

Record the animal responsible where this can be reliably determined (e.g. ungulate, goat, deer, tahr, chamois, possum, insect, rabbit, hare), or record 'unknown'. If necessary, use binoculars to closely observe canopy foliage. Possum-browsed leaves often have torn edges and jagged leaf stubs, while insect damage typically consists of holes and wavy, clean-edged browse or straight, finely milled edges (Payton et al. 1999). Refer to Payton et al. 1999 for examples of typical insect and possum browse on some common tree species.

General observations on animal impacts can also be recorded in the Notes section (e.g. bark stripping and the height of browsing).

There are more detailed, quantitative and repeatable methods to monitor animal impacts on vegetation and to monitor animal distribution and abundance (e.g. Baddeley 1985; Forsyth 2005; National Pest Control Agencies 2015). Such methods may be used in conjunction with Recce surveys, depending on the objectives of the monitoring programme.

5.2.5 Recce vegetation description

On the reverse side of the Recce field sheet, vegetation structure and composition are described in height tiers (strata) using cover classes (Appendix 3b).

Fixed-area Recce quadrats are bounded (i.e. include everything within the boundaries of the fixed area). All vegetation within the three-dimensional bounded area is included in the Recce vegetation description, including any foliage overhanging from plants rooted outside boundary tapes. For variable-area Recce descriptions, define the bounds of the homogeneous area that will be described before beginning the vegetation description.

Observe the following guidelines when completing the Recce vegetation description.

(a) General guidelines

- *Apply high taxonomic standards:* reporting changes in plant biodiversity over time and between areas requires consistent, accurate taxonomic standards. Follow the rules for assigning standard six-letter species codes when recording data (section 5.1) or record species' names in full. When a species is not known, collect a specimen for later identification at the field base or office (section 6).
- *Make a thorough attempt to record all live vascular species present on the Recce:* where identifiable, dead annual species or browned-off geophytes (i.e. terrestrial orchids) are to be included in height tiers. To capture these, record the species as present (cover score of 'P') against the relevant height tiers. Record a note 'dead' to

the left of the species code (Appendix 3b). Do not include dead plants of other perennials.

- *Non-vascular species* (i.e. mosses, liverworts and hornworts) can also be included on Recce vegetation descriptions as an addition to the standard method.

(b) Cover classes and height tiers

- *Use the standard fixed-height tiers* (Figures 2 and 3 and Table 2): fixed-height tiers provide standardised and repeatable data that are readily comparable between Recce descriptions within a survey and between surveys. Fixed-height tiers follow a contour that is perpendicular to the ground surface, and the tiers occupied by a plant are relative to its rooted position (Figure 4). For fixed-area Recce quadrats, boundaries are defined vertically with respect to the ground surface (Figure 4). For foliage overhanging the Recce area from plants rooted outside the Recce boundary tapes, estimate the height tier relative to the plant's rooted position.
- Before beginning the field survey, *determine the predominant structure of vegetation within the survey area and select the appropriate set of standard height tiers* based on the predominant vegetation (see Table 2). Note that the tiers used for study areas dominated by non-woody vegetation (Figure 2) can be combined into the tiers used for areas dominated by woody vegetation (Figure 3).
- *Use the standard cover-abundance scale* (Table 3) to assign a cover class to each species with live foliage in each tier (tiers 1–7): the standard cover-abundance scale is modified from the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974). Several other cover-abundance scales exist, of which those of Bailey & Poulton (e.g. Leathwick 1987) and Braun-Blanquet (e.g. Allen et al. 1991) have been used to collect Recce description data in New Zealand. The standard cover-abundance scale should be used (Table 3) because it is simple and comparable with most data previously collected from Recce descriptions in New Zealand.
- The use of a cover-abundance scale, rather than recording continuous percentage canopy cover estimates, allows rapid data collection and speeds up fieldwork considerably, is more repeatable, and affords greater ease of training. In contrast, recording continuous percentage-canopy-cover estimates gives a false sense of precision and different observers will rarely agree. The use of roughly logarithmic cover-abundance scales provides greater precision for species that are comparatively small and uncommon and also improves consistency; for example, it is easier to tell the difference between 1% and 2% than between 51% and 52%.
- The cover class assigned to each species in each tier represents the percentage of the Recce area covered by a vertical projection downwards of the outermost perimeter of the crown of each plant (Daubenmire 1968; Jennings et al. 1999). Small openings within the crown of each plant are included in cover-class estimates, and care should be taken not to bias the estimate because of high or low foliage density. Cover class estimates are less susceptible to seasonal variation in leaf phenology than indices that take foliage density into account.
- Plant species are deemed to be present in a height tier only when they have living foliage within that tier. For example, if a thin layer of *Rubus cissoides* only occurred c. 10 m above the ground, it would be recorded in tier 3 (5–12 m); and if a

Weinmannia racemosa had foliage in each of tiers 1 through 6, then it would be recorded in all these tiers.

- *Use the canopy cover scale* in Appendix 5 to help determine percentage canopy cover and assign cover classes.
- An exception to the living foliage rule that applies to fixed-area Recce quadrats is if a species is rooted in the bounded Recce area but all the foliage is outside the Recce area (leaning out). To capture this, record the species as present (cover score of 'P') for tier 6 only (regardless of the height of the foliage outside of the bounded Recce area). Record a note 'leaning out' to the left of the species code (Appendix 3b).
- Note that cover estimates represent the absolute rather than relative proportion of vegetation present in a stratum. For example, if mountain beech formed a monospecific canopy, with a cover of 40%, it would be recorded with a cover class of 4, not as 100% of the stratum (cover class of 6).
- *For parasitic plants with no foliar cover* (e.g. *Gastrodia* spp.): record the species as present, and record a cover score using the standard cover-abundance scale for the corresponding height tiers where plant parts occur (excluding reproductive material).
- *Fallen dead trees* (i.e. logs) are considered ground substrate as they are touching the ground surface, and any plants growing on these should be recorded in the appropriate tiers 1–6.
- *The epiphyte tier (tier 7)* includes any plant growing on another living or dead standing plant/branch that is suspended off the ground surface. Parasitic plants (e.g. mistletoes), where present, are also recorded in the epiphyte tier. Plants growing on live roots of other plants should also be listed as epiphytes if they are growing on the root itself, not in soil or litter that has accumulated around it.
- *Record lianas* in all tiers in which their foliage occurs.
- *Use the standard cover-abundance scale (Table 3) to assign an overall cover class to each tier (tiers 1–6)*: for each height tier the overall cover class is the total canopy cover of all species collectively in that tier (*not* the sum of the cover classes for each individual species). The overall canopy cover of each tier will therefore never exceed 100% (cover class of 6), but must always be equal to or greater than the highest of the cover classes recorded for any individual species in the tier. For each tier, record the overall cover class in the row labelled 'Overall cover' (see Appendix 3b).

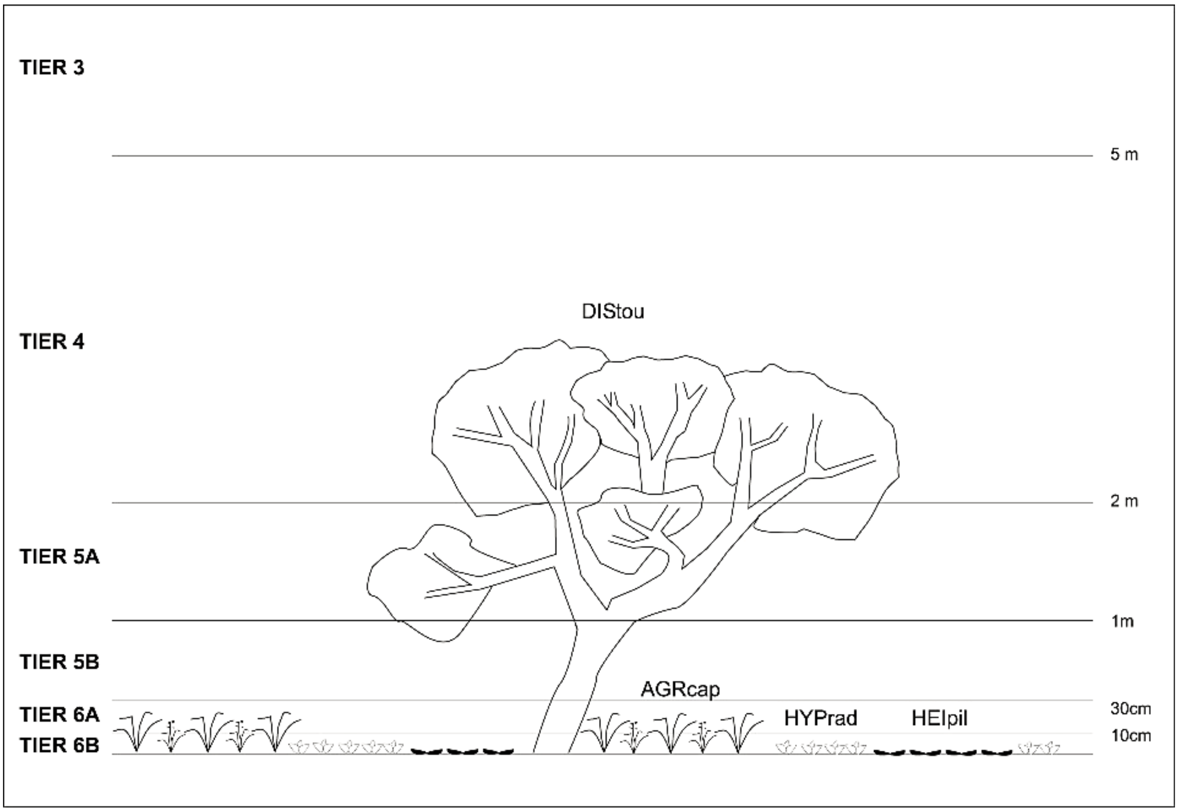

Figure 2. Height tiers used for Recce vegetation descriptions in study areas where vegetative cover is predominantly non-woody (see Table 2). In this simplified example, *Discaria toumatou* (DIStou) would be recorded in tiers 4 (i.e. 2–5 m), 5A (i.e. 1–2 m) and 5B (i.e. 0.3–1 m) as it has foliage in these tiers. *Agrostis capillaris* (AGRcap) would be recorded in tier 6A (i.e. 0.1–0.3 m) and tier 6B (i.e. <0.1 m), and both *Hypochaeris radicata* (HYPrad) and *Hieracium pilosella* (HIEpil) only in tier 6B (i.e. <0.1 m).

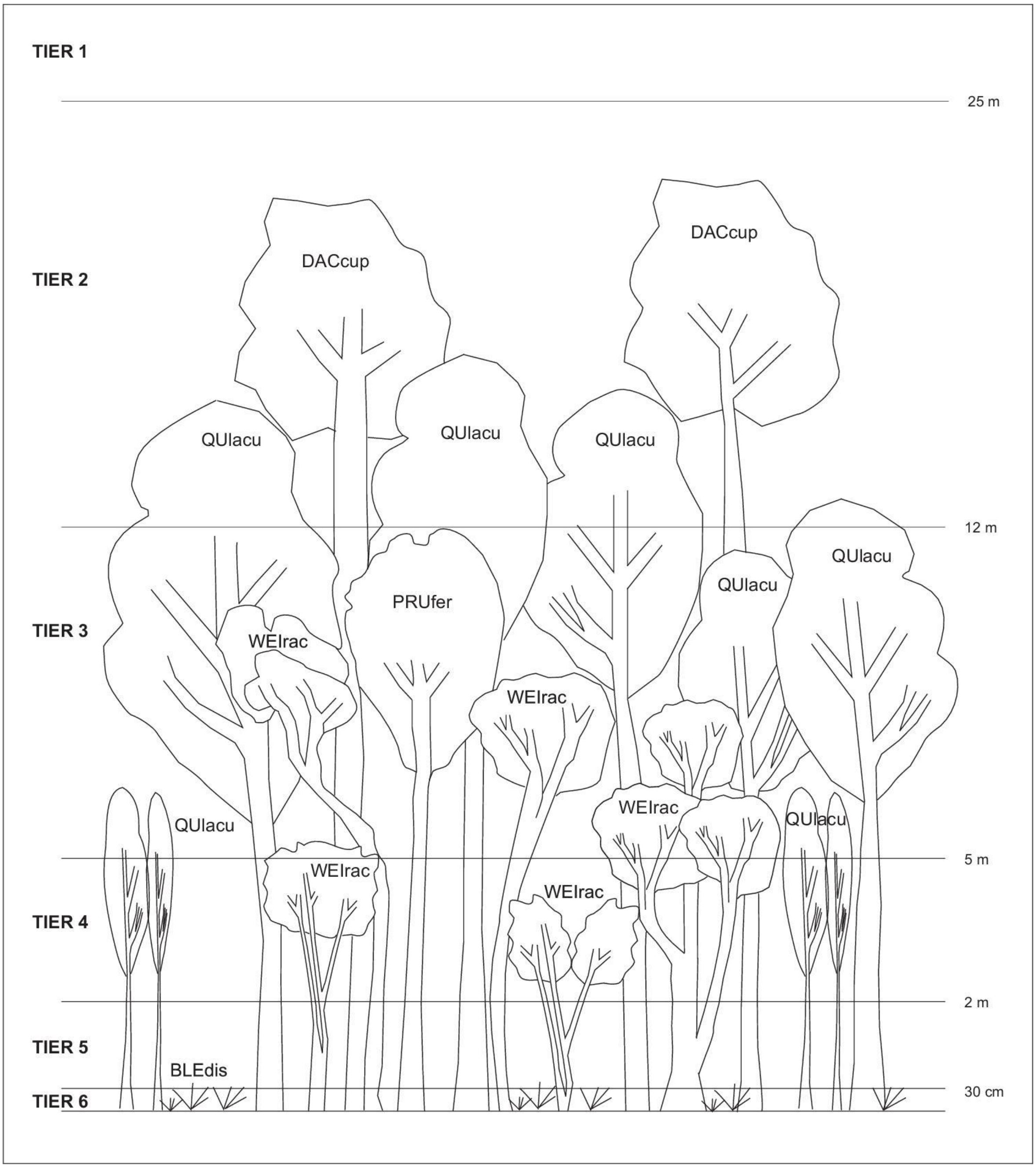

Figure 3. Height tiers used for Recce descriptions in study areas where vegetative cover is predominantly woody (see Table 2). A seventh 'tier' includes all epiphytes (not shown). In this example, *Quintinia acutifolia* (QUIacu) would be recorded in tiers 2 (12–25 m), 3 (5–12 m), and 4 (2–5 m) as it has cover in all of these tiers. By contrast, miro (*Prumnopitys ferruginea*, PRUfer) would be recorded only in tier 3 (5–12 m), and rimu (*Dacrydium cupressinum*, DACcup) only in tier 2 (12–25 m). Crown fern (*Blechnum discolor*, BLEdis) would be recorded in both tiers 5 (0.3–2 m) and 6 (<0.3 m).

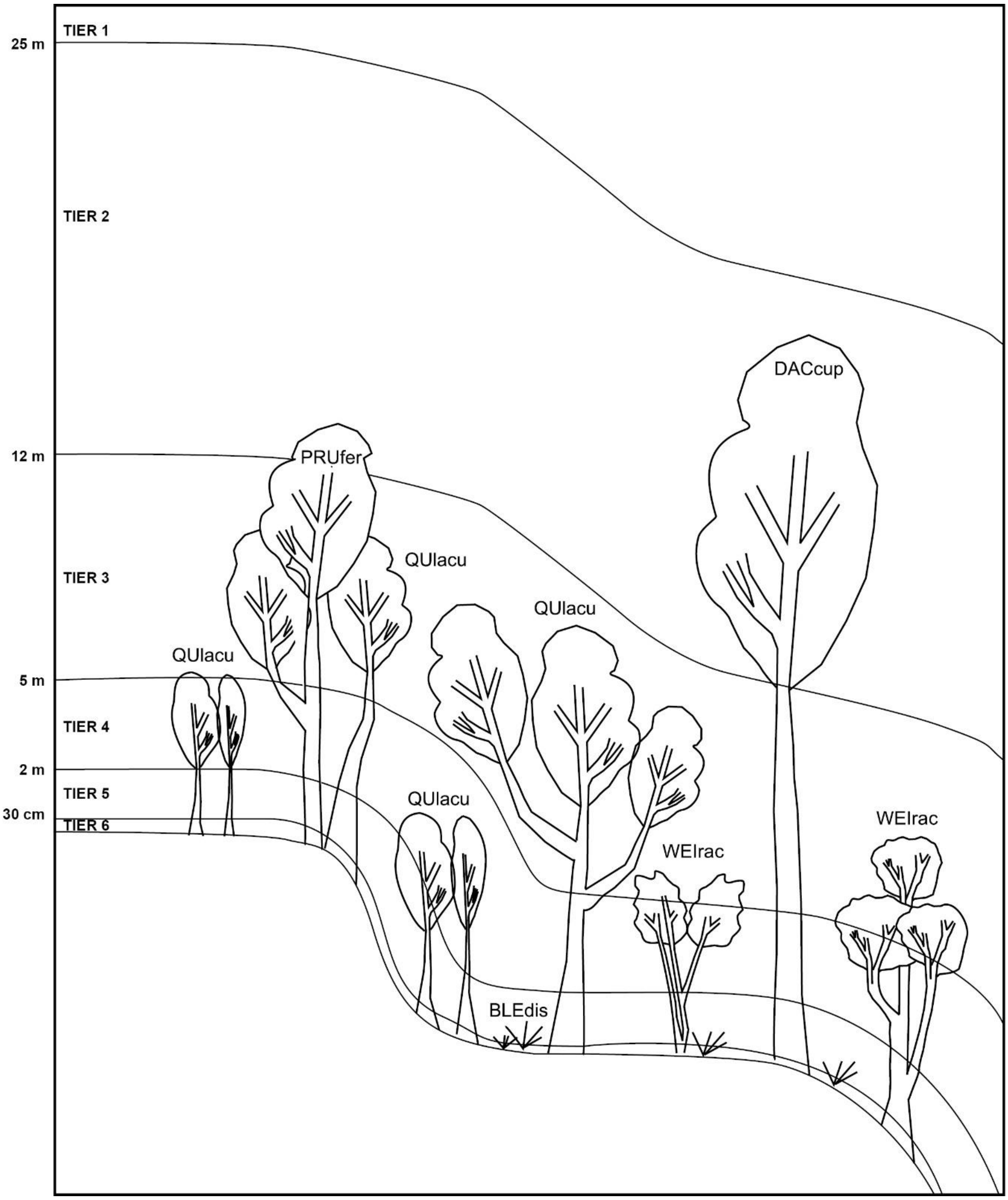

Figure 4. Fixed-height tiers follow a contour that is perpendicular to the ground surface, whereas for fixed-area Recce quadrats, Recce boundaries are defined vertically with respect to the ground surface.

Table 2. Standard height tiers used when vegetation within the study area is: (a) predominantly non-woody (e.g. grassland, some grassland–shrubland mosaics, and some wetlands); these tiers are consistent with those used in standard grassland monitoring methods (Wiser & Rose 1997); and (b) predominantly woody (e.g. forests and tall shrublands); note that these tiers are consistent with those used on standard (20 × 20 m) permanent forest plots (Hurst et al. 2022a).

Tier	(a) Standard tiers used when vegetation within study area is predominantly non-woody	(b) Standard tiers used when vegetation within study area is predominantly woody
1		>25 m
2		12–25 m
3	5–12 m	5–12 m
4	2–5 m	2–5 m
5		0.3–2 m
5A	1–2 m	
5B	0.3–1 m	
6		<0.3 m
6A	0.1–0.3 m	
6B	<0.1 m	
7	Epiphytes (at any height)	Epiphytes (at any height)

Notes: Within any one vegetation survey all Recce descriptions should be measured using the same set of height tiers. However, note that the standard height tiers in (a) can be supplemented as necessary with tiers 1 and 2 to deal with any isolated occurrences of plants taller than 12 m.

Table 3. Cover classes applied to the species present in each height tier on the Recce vegetation description. Cover classes are modified from the Braun-Blanquet cover-abundance scale (see Mueller-Dombois & Ellenberg 1974).

Cover class	Percentage canopy cover
1	<1
2	1–5
3	6–25
4	26–50
5	51–75
6	76–100

(c) Practical tips for completing the Recce vegetation description

- When recording data, each species occurring should be allocated one row on the field sheet, so that if the species occurs in more than one height tier it can be ticked on the same row (see Appendix 3b). Use a dash (i.e. '–') where a species does not occur in a shorter tier (see Appendix 3b), to allow the field sheet to be readily checked for completeness before finishing the Recce.

- Where the number of plant species present exceeds the number of rows on the Recce field sheet, use a second sheet, and ensure that both sheets contain the same header information (e.g. unique Recce identifier, date) and that they are cross-referenced (e.g. 'Page 1 of 2').
- Work in pairs, where possible, particularly if field staff are new to the method.
- If a species has been collected for identification, record a collected symbol (©) in the empty cell to the immediate left of the species name. If the species occurs in tier 1 or tier 7, and there is no empty cell to the immediate left, record the collected symbol (©) in the same cell as the species name, in the upper right corner of the cell (see Appendix 3b).
- Adopt systematic procedures when completing the Recce vegetation description to ensure that species present are not missed. Take the following steps.
    - Start by listing species present in the uppermost (tallest) height tier and work your way down through to the lowermost (shortest) tiers.
    - Once all obvious species are recorded, traverse the Recce description area, recording additional species in each tier as you see them. It is usually necessary to move around to gain better vantage points of the canopy, particularly in dense or complex vegetation.
    - For small or cryptic canopy foliage, gain a good vantage point and use binoculars if necessary to help ensure each species is correctly identified.
    - Small and rare species are important to record. Be aware that in the understorey tiers, uncommon and small species can be easily overlooked. At the conclusion of the Recce vegetation description, conduct a systematic search of the entire Recce description area to ensure that all species present have been recorded.
- Develop straightforward approaches to arrive at your estimates of cover for each species in each height tier.
    - In each tier, mentally move plants of each species to an edge of the area described, and then estimate what proportion of the area they cover. Use the canopy cover scale (see Appendix 5) to help arrive at accurate cover estimates.
    - When the cover of a species within a tier is very high, it may be easier to estimate the proportion of the Recce area *not* covered by the species.
    - For species with very few individuals present, estimate the proportion of the Recce area covered by each individual in each tier, add these together within each tier, and assign a cover class.
    - Visualise the canopy of each species squashed into a flat plane, and then estimate the proportion of the Recce area covered by the species (i.e. avoid biasing cover estimates because of high or low foliage density).
- Take care to ensure that species are assigned to the correct height tiers. Observers should calibrate height estimates frequently against heights measured, using a tape, height pole, hypsometer, or equivalent instrument.
- Observers should regularly compare their cover class estimates with one another. As a balance between the repeatability and accuracy required for cover estimations,

trained field staff should generally be able to estimate cover classes consistently and repeatedly to within one class of each other.

- Note that viewing the cover of trees obliquely rather than vertically can result in overestimation of cover. Move around as necessary when making cover estimates.

6 Collecting and recording unknown plants

Reporting changes in plant biodiversity over time or between areas requires consistent, accurate taxonomic standards. Whenever you are unsure of the identity of a plant species on a Recce description, collect it and have the identity of the plant properly checked at the field base or office. Adopt a systematic approach to collecting and storing specimens, recording specimens on field sheets and correcting field sheets once the specimen identifications are resolved.

Prior to fieldwork, field staff should become familiar with the range of species likely to be encountered within the survey region. This will help guide staff on the important identifying features that must be included when collecting specimens. Be aware of any provincially or nationally threatened species that may be encountered, and ensure that collecting activities do not contribute to the decline of populations at risk. Before making collections, ensure you have the necessary permission or permit from the landowner or administrator.

6.1 Collecting unknown plant specimens

- *A specimen should be collected whenever the identity of a species on a Recce is unknown or uncertain.* If Recce descriptions are to be remeasured to monitor vegetation change, collect specimens from outside the Recce area, where possible. Do not collect a specimen if doing so would eliminate the species from the Recce area and immediate surroundings.
- Aim to collect as much of the vegetative and floral parts as practical. The specimen should include (where appropriate and available) root, stem, leaves, flowers, fruits and seeds, and should provide an adequate example of the overall habit of the plant.
- Give each collected species a provisional 'tag name' that reflects a notable feature of the plant or a potential genus or species. Each tag name should be considered specific to the Recce description at which it was created. When you are confident of the genus, include this in your tag name. If you have some confidence about the species, use the six-letter NVS code for that species. If you are collecting multiple taxa within a genus, combining the genus code with a notable feature of the plant can help generate distinct tag names for all specimens collected at that Recce description location (e.g. ASTgrey).
- *Every* time a collected unknown species occurs on the field sheets, annotate the tag name record with the symbol '©' to indicate that a specimen was collected. When the tag name is assigned to more than one individual plant, ensure the plants really are the same species. Where there is any doubt whatsoever, collect an additional specimen and assign it another unique tag name.

- While *at the Recce description area*, label the plant specimen using a suitable label (e.g. a plant nursery label). Record the tag name (*exactly* as it appears on field sheets), survey name, Recce description name/number, collection date, and collector's name, as well as any notable features of the plant's habit, height or substrate. Attach the labels to the specimens and ensure they cannot be separated during transportation back to the field base.
- Use a portable plant press (e.g. hard-covered book with absorbent pages, or a smaller version of a standard plant press) or plastic bags to temporarily store collected specimens until arrival at the field base.

6.2 Storing unknown plant specimens

- At the field base, transfer each collected specimen into a plant press as soon as possible. A plant press can easily be constructed using plywood, sheets of corrugated cardboard (and/or corrugated aluminium sheet), and absorbent paper (e.g. newspaper), held together using belts or straps.
- While transferring specimens, systematically check that all collected specimens were recorded on the field sheets, and that the tag name recorded for the species was used consistently across all field sheets, *and was annotated with a '©' symbol every time it occurred.*
- Carefully place each specimen within a folded piece of plain newsprint, and separate specimens using sheets of cardboard and additional paper. Ensure the natural habit of each plant is retained and that features important for the specimen's identification are not obscured. Fold large specimens neatly so that they fit inside the plant press. Place seeds or other loose material in a labelled envelope.
- Change the paper in the plant press regularly to prevent specimens from going mouldy, particularly in damp climates or where specimens were wet when pressed. Specimens will dry most quickly when the plant press is stored in a well-ventilated, sunny location.

6.3 Identifying unknown plants and correcting field sheets

- Once dry, sort the specimens into logical groups, such as by genus or life form. Use identification books and taxonomic keys to identify specimens to species, subspecies or variety level. Don't assume the genus or species used as the tag name is correct. Seek help from a botanist or herbarium to identify specimens and/or to validate each identification.
- Record clearly the new, correct identity on the nursery label attached to each specimen, and cross out the tag name (ensuring it remains legible). Check that all species names used are current and correct (see section 5.1.1).
- Create a spreadsheet or list of unknown plants. For each collected specimen, list the unique Recce identifier, tag name initially recorded on field sheets, resolved identity, and name of the person who resolved the identity. The spreadsheet or list of unknown plants ensures the connection between the tag name and the resolved identity of each specimen is clearly documented, so that if dubious species occurrences are later

queried, specimens can be rechecked and field sheets amended where necessary. Print this list and file it with the field sheets.

- Use the list of unknown plants and take a systematic approach to ensure tag names on all field sheets are corrected (where necessary). Do not rub out the '©' symbol, but put a line through it to indicate that the identity of the specimen was resolved.
- Keep all specimens until any report or publication using the data has been completed. Consider lodging specimens of each species in a regional herbarium, especially species that are taxonomically difficult, rare, or outside their documented geographical range. Links to the major public herbaria in Australasia can be accessed at https://avh.chah.org.au/. Herbarium curators can provide detailed information on the data required when lodging specimens.

7 Quality control procedures for Recce inventory surveys

Quality control procedures are an essential part of any monitoring programme. Quality control should consist of internal systems of routine technical activities and procedures to ensure data consistency, comparability, and completeness, and so that inventory and monitoring programmes are efficient and will ultimately satisfy the requirements of data users. In this case, the aim of the recommended quality control procedures outlined below is to ensure that reliable data on forest composition and structure are collected from Recce descriptions.

7.1 Routine quality control procedures

Routine procedures should be followed before and during a Recce survey to help ensure high-quality data are collected. Before starting fieldwork, check that:

- field staff have sufficient training, supervision and/or skills to undertake the work to a high standard
- field staff are informed of measurement protocols for the survey – field teams should be provided with written documentation on any intentional, planned deviations from standard Recce measurement protocols
- all equipment (see Appendix 2) is available and in good working order, and field staff are familiar with its use
- work plans for the survey are sufficient to enable high-quality data to be collected, and will not force field staff to leave out certain measurements or undertake them to a low standard
- if the survey is a remeasurement of permanently marked Recce description sites, copies of Recce sheets from the previous measurement and lists of problems previously identified in data-checking exercises are taken and resolved, where possible.

Before completing fieldwork on each Recce, field staff should:

- methodically check that all data are correct, complete and legible

- recheck that unknown plant species have been collected, labelled and correctly recorded on field sheets (section 6).

For the duration of each field trip and on return to the field base or office, ensure the following tasks are completed.

- Securely store data: during fieldwork, suitable data storage consists of envelopes or bags and box files in which to file the field sheets in a logical order. On return to the main base, ensure safe interim storage of field sheets until the complete set of data from the survey is ready to be properly archived. You should scan or make a back-up photocopy of field sheets.
- Ensure collected plant specimens are properly pressed and dried (see section 6.2).
- Ensure all gear is in working order and that sufficient supplies of consumable items are available (see Appendix 2).

At the end of the fieldwork for a survey, ensure that:

- the identities of unknown plant specimens are resolved and checked, and field sheets are corrected (see section 6.3)
- computerisation of data is arranged
- data are securely archived (see section 8).

8 Data management and storage using the NVS Databank

Agencies that collect vegetation data are increasingly aware of the need for systematic data storage to ensure data are easily accessible and safeguarded against loss. Storage of Recce description data is facilitated by the NVS Databank, which is recognised as New Zealand's primary repository for data on the structure and composition of indigenous vegetation.

The NVS Databank's primary function is as a national archive, where data can be deposited with confidence that it will be safeguarded. The NVS Databank is both a physical archive, holding hard-copy records of vegetation data in secure, climate-controlled, insect- and fire-proof storage facilities, and a digital databank, storing electronic copies of data.

Many of the vegetation survey data previously collected in New Zealand are stored in the NVS Databank, including vegetation surveys carried out by the former New Zealand Forest Service, by the Protected Natural Areas surveys, and, more recently, by DOC, Manaaki Whenua – Landcare Research, regional councils, and universities.

8.1 Benefits of the NVS Databank for data providers and users

There are many benefits of a national repository for vegetation inventory and monitoring data. The NVS Databank enhances data availability for data users while protecting the interests of data providers. It has become invaluable as policy makers and researchers increasingly seek to address questions at multiple scales, requiring more data than one team or agency could collect (Wiser et al. 2001).

Following are some of the direct benefits to data providers and users.

- Data collected using standard methods are systematically archived in both hard-copy and electronic formats.
- Archived data are kept up to date with available technology (e.g. data originally deposited in older, highly coded file formats have now been migrated to a relational database). Ongoing updates ensure that data can continue to be deposited and retrieved in formats that meet the needs of data providers and facilitate ease of data use.
- Systematic error-checking and correction exercises undertaken by NVS staff have improved the quality of data archived in the NVS Databank, benefiting both data providers and users.
- Metadata associated with each vegetation survey ensure that relevant information about the data are archived, safeguarding information for the future and allowing data users to assess whether data are appropriate for any particular purpose.
- Online search facilities provide data users with quick summaries of what data sets are archived, their geographical location, and what taxa were recorded. Links with other databases (e.g. the New Zealand Plant Names Database: Ngā Tipu o Aotearoa – New Zealand Plants; http://nzflora.landcareresearch.co.nz/), and the Ecological Traits of New Zealand Flora (http://ecotraits.landcareresearch.co.nz/) allow potential data users to access information on the taxa recorded.

8.2 Depositing data into the NVS Databank

Before depositing data into the NVS Databank, organise hard copies of field sheets, electronic data (where available), and any other relevant documentation about the survey (i.e. metadata; see below). For further information on depositing data into the NVS Databank, refer to the NVS website (http://nvs.landcareresearch.co.nz/) and/or contact the NVS Databank manager (nvs@landcareresearch.co.nz).

8.2.1 Hard copies of data sheets

Archive all original data sheets (preferable) or make high-quality photocopies. Photocopies of data sheets should ideally be done on acid-free paper at 95% the original size and one shade darker than usual, to ensure all data are legible and complete. Check the quality of all photocopies before archiving them in the NVS Databank. Maps and aerial photographs showing Recce description locations should also be archived in the NVS Databank. If hard copies of maps are not available, scan maps and archive the electronic files in the NVS Databank.

8.2.2 Data in electronic form

Copies of electronic data should be supplied to the NVS Databank manager when these are available. Alternatively, data can be entered in the NVS Databank by staff who specialise in entering vegetation data. There are benefits to arranging for data to be entered straight into the NVS Databank; for example, automated checks are conducted at the point of data entry and throughout the process, ensuring data are of high quality, errors are minimised, and potential errors or problems are highlighted. NVS Express is a freely available, purpose-built Windows tool for entering and summarising vegetation data compatible with the NVS Databank and can be downloaded from the NVS website (https://nvs.landcareresearch.co.nz/Data/dataentry). Requirements and costs associated with data entry can be discussed with the NVS Databank manager (nvs@landcareresearch.co.nz).

8.2.3 Metadata

Metadata are data *about* the data. Metadata provide information essential for the long-term use of the data set, as well as information required for remeasurement. Metadata can be submitted via the NVS website (https://nvs.landcareresearch.co.nz/Data/Contribute). Metadata must be submitted for all data sets that are deposited into the NVS Databank, and should include (where applicable):

- instructions regarding access to data – the interests of data providers are protected through written agreements that determine access rights to specific data sets within the NVS Databank (refer to the NVS website for further information on access levels)
- what data were collected and the objectives of the survey
- the sampling methodology used to determine Recce description placement, including study area boundaries
- the measurement protocols that were followed – any deviations from standard Recce measurement protocols should be documented in detail
- the full names of all people involved in data collection
- the sources of nomenclature usage followed for a survey, either for each group of taxa or (where necessary) for each individual taxon – this information will help ensure nomenclature used remains unambiguous over time (see section 5.1)
- any problems found during data entry or checking that cannot be resolved, or problems to address at the next Recce measurement
- any notes regarding data quality (e.g. problems identified during data collection, data checking or data entry).

If the vegetation survey involved remeasuring existing permanently marked Recce descriptions, errors and problems may have been found in the original data. Errors in historical data should be corrected, where possible, and any changes made to archived data must be documented (see Newell & Baldwin 2000; Hurst et al. 2006; http://nvs.landcareresearch.co.nz/).

8.3 Retrieval of data from the NVS Databank

Hard copies of data, electronic data and documented metadata can be readily retrieved from the NVS Databank (http://nvs.landcareresearch.co.nz/). In the NVS Databank, data from Recce descriptions are curated as components of particular surveys or projects. The NVS website provides online access to detailed information (i.e. metadata) about surveys.

There are a number of ways the NVS website can be used to locate particular vegetation surveys or to search for data, such as:

- conducting a search for a particular survey name, person, known geographical area or species
- viewing interactive maps that show NVS Recce description locations and species distributions.

If a data set cannot be satisfactorily located, or where a more general type of request is required, then a 'search data request' can be sent using the form provided on the website, and the NVS Databank staff will then help locate the relevant data. Metadata about surveys can be viewed to determine whether a data set will serve your needs. For any given data set, the metadata will state whether there are electronic data available and what access restrictions might apply to the data.

The facilities on the NVS website can be used to locate and compile a list of requested data sets, which can then be automatically requested through the website. If a data user requests a data set that has restricted access, approval from the data owner must be obtained by the person making the request for the data (this is an automated process).

Data can be provided in a variety of electronic formats (e.g. delimited ASCII text files, MS Excel spreadsheets, or that required by PC-Analysis packages). There will usually be no cost associated with reasonable data-retrieval requests. Data users are asked to be conscious that the NVS Databank team do have other work priorities, and responses to requests are unlikely to be immediate. For further information on retrieval of data from the NVS Databank, refer to the NVS website (http://nvs.landcareresearch.co.nz/), or contact the NVS Databank manager (nvs@landcareresearch.co.nz).

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Appendices List

Appendix 1. Glossary

Basal area (BA)	The cross-sectional area of a tree stem at breast height (e.g. 1.35 m along the stem), which may be calculated using a diameter measurement. The term may be used to describe the area occupied by an individual tree or species, as well as the area occupied by all trees in a stand (often expressed as m^2/ha).
Canopy cover	The percentage of ground covered by a vertical projection over the Recce area of all vascular and non-vascular live or dead material (leaves, trunks and branches) >1.35 m above the ground.
Clinometer	An instrument for measuring slope.
Density	A value describing the number of individuals of a species on a unit/area basis.
Epiphyte	A non-parasitic plant that grows on another plant. See section 5 for specific details regarding epiphytes for Recce and stem diameter protocols.
Extrusive	Relating to or denoting rock that has been extruded at the Earth's surface as lava or other volcanic deposits.
Flora	All the plant species present within a particular area or region.
Global Positioning System (GPS)	A navigation system that provides satellite signals that are processed in a GPS receiver to compute its location.
Hectare	10,000 square metres (approximately 2.471 acres).
Hip-chain	A piece of equipment used to measure distance, consisting of a distance counter and spool of cotton. The device operates by measuring the length of cotton drawn from the spool.
Intrusive	Relating to or formed by the intrusion of rock.
Metadata	Often defined as 'data about data'. Metadata includes all important information about a data set that may have a bearing on its use.
Non-vascular plant	A general term for those plants without a vascular system for transporting water and nutrients (i.e. xylem and phloem). Although lacking such tissues, some non-vascular plants possess other tissues specialised for the internal transport of water.

Permolat	A painted aluminium strip, often brightly coloured, used to mark transects, Recce description and plot locations in the field and to mark understorey subplots on permanent plots. Plastic markers (robust and suitably sized) may be used if Permolat cannot be obtained.
Plot	In a general sense, any area of land of any shape (e.g. circle, square, rectangle) or size, which may be used for any purpose (e.g. sampling). In this manual, 'plot' is mainly used in the context of instructions for measuring permanent 20 × 20 m plots.
Quadrat	A specific ecological sampling term that usually refers to a square (or rectangular) sampling plot of a predetermined area or size.
Recce description	A site and vegetation description, similar to those undertaken on ecological relevés or phytosociological descriptions (see Mueller-Dombois & Ellenberg 1974).
Taxa	Plural of 'taxon'.
Taxon	Any unit of any rank within a taxonomic classification (e.g. genus, species, family).
Tier	As used in this document, a horizontal layer of vegetation bounded at fixed heights, for which cover of each species present is recorded on the Recce vegetation description.
Vascular plant	A term used to describe any plant with a vascular transport system for water and nutrients.

Appendix 2. Equipment required to establish and measure Recce descriptions

Equipment

- Recce field manual
- Plant identification texts and a species list from other studies in the area
- Lightweight plant press or hard-covered book for temporarily pressing unknown plants
- Hip-chain
- Laminated copy of the canopy cover scale (Appendix 5)
- Global Positioning System (GPS) receiver
- Topographical maps and aerial photographs
- Geological Survey map
- Clipboards
- Altimeter
- Clinometer or equivalent instrument (e.g. abney level or hypsometer)
- Binoculars, for viewing canopy foliage to identify cryptic, small-leaved species, and for examining browse in the canopy
- Bum-bags or toolbelts for carrying equipment around the Recce site

Consumable items

Adequate supplies of the following consumable items should be available and the field kit restocked each day as necessary:

- pens, pencils, erasers, etc.
- batteries for GPS,
- waterproof plant labels and waterproof marker
- plastic bags for transporting large plant specimens
- plastic bags for storing and transporting Recce sheets
- hip-chain cotton and flagging tape.

Field sheets required per Recce

- Four Recce description sheets are required (two on normal paper and two on waterproof paper),

Permanently marked and fixed-area Recce quadrat descriptions

- Sighting compasses (two)
- Tapes to establish the Recce description boundaries
- Permolat or equivalent markers to mark the route to the Recce
- Aluminium corner pegs (e.g. 7 mm diameter, 45 cm long, pre-bent at the top) or stakes to mark quadrat corners

- Permolat or equivalent markers for marking quadrat corners and corner trees
- Hammer and nails for attaching Permolat to trees (corner trees and trees on the route to the Recce)
- For remeasurement, photocopies of all field sheets from previous measurements

Other items required at the field base

- Species lists and reports from previous vegetation surveys in the area
- Access and/or collection permit from the Department of Conservation and/or other agencies/landowners
- Plant storage and identification equipment – includes plant press, newsprint, blotters, nursery tags, plant identification texts, hand lenses, large plastic bags
- Envelopes and boxes to temporarily store completed field sheets

Appendix 3a. Recce field sheet: site description

RECONNAISSANCE (RECCE) SHEET

National Vegetation Survey Databank (http://nvs.landcareresearch.co.nz/) Page 1 of 2

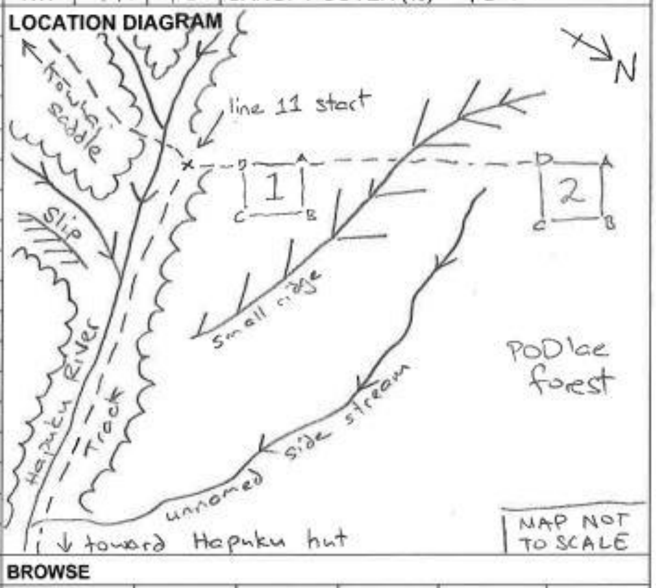
RECCE IDENTIFIER: 11 - 2	DAY/MONTH/YEAR: 7 March 2007
SURVEY: Mt Fyffe	TOPO. MAP NO. & NAME: Topo 50 BT27 Kaikoura
REGION: Kaikoura	GPS REFERENCE: GPS Make & Model: Garmin 64S
CATCHMENT: Hapuku River	Easting: 1652112
SUB-CATCHMENT: unnamed	Northing: 5319823
MEASURED BY: Roger Carran	GPS FIX: Single / (Averaged) 2D (3D) Datum: NZGD49 / (NZGD2000)
RECORDED BY: Alex Fergus	GPS ACCURACY 100%: (Y) / N; ± 4 m
PERMANENTLY MARKED: (Y) / N	GPS LOCATION: (CORNER D) / other: NA

SIZE OF RECCE 20 x 20 m	**MESOSCALE TOPOGRAPHIC & TERRAIN SHAPE INDEX** (°, record +/–)			**SURFACE CHARACTERISTICS:**
ALTITUDE (m) 760 m				Bedrock % 0 %
PHYSIOGRAPHY Ridge, (Face), Gully, Terrace				Broken rock % 10 %
ASPECT (1–359°) 130°				Size of broken rock ~~<30cm~~ / (>30cm)
SLOPE (°) 30°		MTI	TSI	~~Alluvial~~, (Colluvial), ~~Moraine~~, ~~Volcanic~~
PARENT MATERIAL Greywacke ~~Mapped~~ / (Observed)	N	+32	+18	**GROUND COVER %:**
	NE	+16	-6	Vegetation 85%
DRAINAGE: (Good), Moderate, Poor	E	+6	-16	Non-vascular 5%
CULTURAL (None), Burnt, Logged, Cleared,	SE	+21	-27	Litter 90%
Mined, Grazed, Tracked	S	+27	-12	Bare Ground 1%
TREATMENT: NA	SW	+20	+3	Rock 1%
APPROACH: From Hapuku hut	W	+36	+22	AVERAGE TOP HEIGHT (m) 17 m
(E 1653720 N5319765) follow	NW	+40	+32	CANOPY COVER (%) 45%

APPROACH (continued): (E 1653720 N5319765) follow track 1.7 km's towards Kowhai Saddle. Line start is marked on the track. Follow a bearing of 315° from plot 1 corner A (E1652185 N5319654) for 200m to plot 2. Line start and line are marked with red on white permolat.

Corner C was not found and was reestablished.

LOCATION DIAGRAM



VEGETATION DESCRIPTION & NOTES:

PODlae dominates the canopy. There is no subcanopy. The browse tier and understorey are dominated by POLVES, with occassional CAR ser and FUCexc saplings. Sparse non-vascular cover

BROWSE

Species	Severity	Herbivore	Species	Severity	Herbivore
VERONI(C)	L (M) H	possum		L M H	
GRI lit	L (M) H	red deer		L M H	
ASP cra	L M (H)	red deer		L M H	
VER tra	(L) M H	red deer		L M H	
	L M H			L M H	
	L M H			L M H	
	L M H			L M H	
	L M H			L M H	
	L M H			L M H	

FAUNA (e.g. mammal, bird, reptile, invertebrate)

piwakawaka, korimako, kakaruwai, pig-sign, possum-fur, cast red deer antler

Appendix 3b. Recce field sheet: vegetation description

Page 2 of 2

RECCE IDENTIFIER: H171 MEASURED BY: Brian Rance

DAY/MONTH/YEAR: 03 December 2013 RECORDED BY: Alex Fergus

Cover-classes: 1= <1%, 2=1–5%, 3=6–25%, 4=26–50%, 5=51–75%, 6=76–100%.
For a 20×20-m plot area: 1% = 2×2-m (i.e. 4 m²); 5% = 4×5-m (i.e. 20 m²).

	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5	Tier 6
	>25 m	12–25 m	5–12 m	2–5 m	0.3–2 m	<0.3 m
Overall Cover		2	3	4	5	4
		METumb 2	✓ 2	✓ 3	✓ 2	✓ 1
Tier 7			FUScli 2	✓ 3	✓ 2	✓ 1
Epiphytes			HALbif 2	✓ 3	✓ 3	✓ 3
ARCtra 1				LEPint 3	✓ 4	✓ 3
HYMarm 1				LEPsco 2	✓ 1	✓ 1
HYMlya 1				PSElin 1	✓ 1	—
PSElin 1				DRAlon 1	✓ 2	✓ 1
RAUsim 1				WEIrac 1	✓ 2	✓ 1
DRAlon 1				COPfoe 1	✓ 1	✓ 1
HYMmul 1				DRAmen 1	✓ 2	✓ 2
GRIlit 1				LEPjun 1	✓ 1	—
METumb 1				RUBcis 2	—	—
NOThet 1					© GAHpro 3	✓ 2
HYMfla 1					MYRdiv 2	✓ 1
EARmuc 1					COPcol 1	✓ 1
					RAUsim 1	✓ 1
						ASTner 1
						ANDemp 1
						GRIlit 1
						TMEtan 1
						LIBmic 1
						GAScun 1
						LUZpor 1
					(dead)	WAIste P
						© THELYM 1
						APObif 1
						HYMmul 1
						HYMarm 1
						HYMlya 1
				(leaning out)		ARCtra P

Appendix 4. Non-standard species codes for the New Zealand vascular flora

Use this list (current July 2021) to check unintuitive NVS codes (see section 5.1 for details). The taxon that holds the intuitive NVS code has been included in the table below for reference. These have not been included if the taxon name is no longer the preferred name. A full list of species codes used in the NVS Databank can be obtained from the NVS website (http://nvs.landcareresearch.co.nz/).

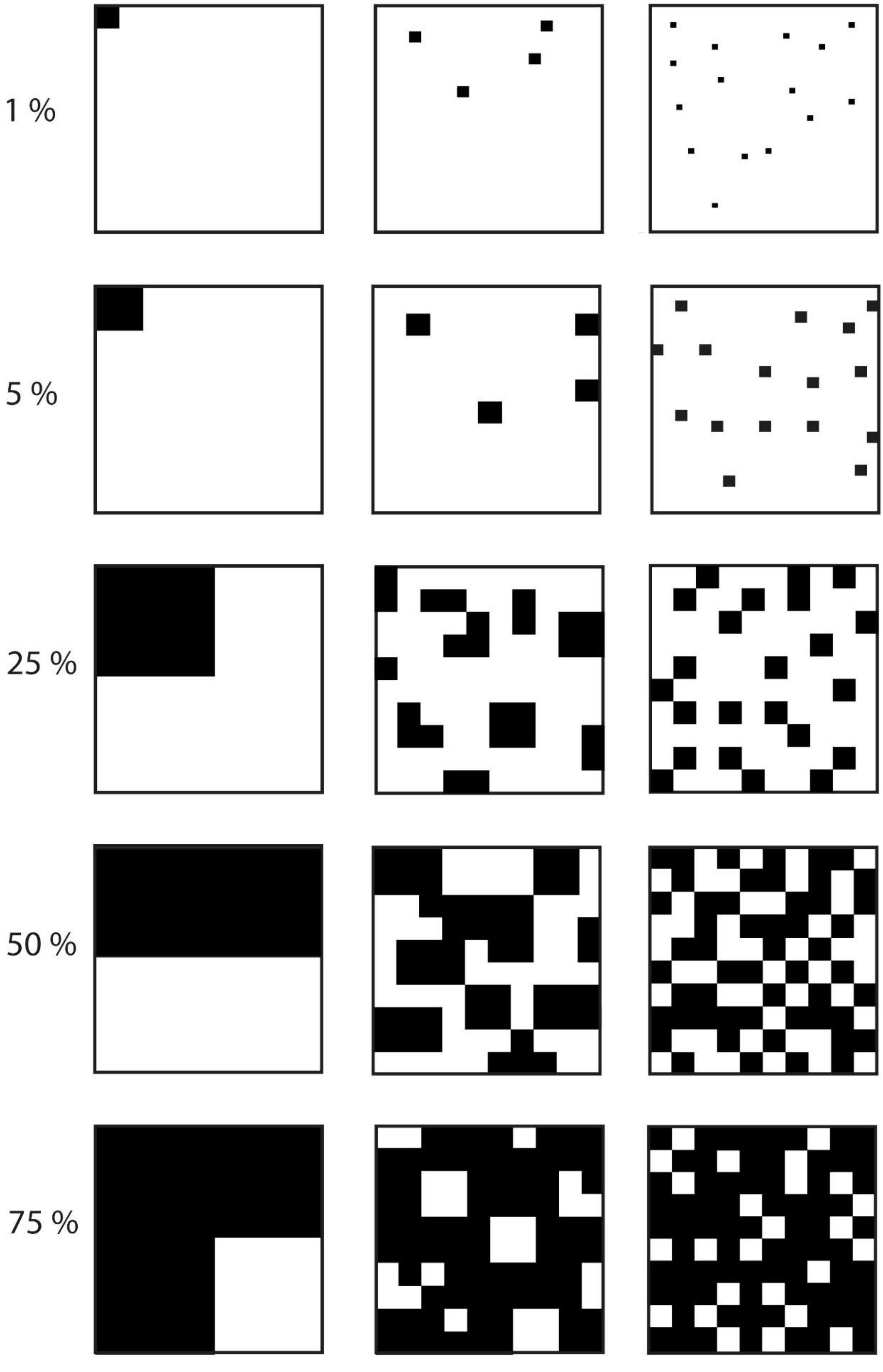
Taxon name	NVS code	Taxon with intuitive NVS code
Abrotanella rostrata	ABRrst	NA
Abrotanella rosulata	ABRrsl	NA
Aciphylla montana	ACImot	*Aciphylla monroi*
Aciphylla simplex	ACIsmp	*Aciphylla similis*
Aciphylla traversii	ACItrv	*Aciphylla traillii*
Agrostis personata	AGRpes	NA
Anisotome aromatica var. *incisa*	ANIinc	NA
Asplenium flabellifolium	ASPflb	*Asplenium flaccidum*
Astelia graminea	ASTgrm	*Astelia grandis*
Brachyscome montana	BRAmnt	*Brachyglottis monroi*
Brachyglottis species	BRACHG	*Brachyscome* species
Cardamine corymbosa	CARcoy	*Carex coriacea*
Carmichaelia corrugata	CARcog	*Carex coriacea*
Carmichaelia appressa	CRMapp	*Carex appressa*
Carex carsei	CRXcar	*Carmichaelia carmichaeliae*
Carex divisa	CARdvs	*Carex divulsa*
Carex flacca	CARflc	*Carex flaviformis*
Carex flagellifera	CARfgl	*Carex flaviformis*
Carpobrotus glaucescens	CARglc	*Carmichaelia glabrescens*
Cardamine lacustris	CARlct	*Carex lachenalii*
Carmichaelia kirkii	CRMkir	*Carex kirkii*
Carex muricata	CARmrc	*Carmichaelia muritai*
Carex petriei	CARptr	*Carmichaelia petriei*
Cardamine subcarnosa	CARsbc	*Carex subdola*
Carex traversii	CARtrv	*Carex trachycarpa*
Carmichaelia uniflora	CRMuni	NA
Cardamine unicaulis	CARunl	NA
Celmisia cordatifolia	CELcrd	*Celmisia coriacea*
Celmisia graminifolia	CELgrm	*Celmisia gracilenta*
Celmisia lindsayi	CELlnd	*Celmisia xlinearis*

Taxon name	NVS code	Taxon with intuitive NVS code
Celmisia macmahonii	CELmcm	*Celmisia mackaui*
Celmisia macmahonii var. *macmahonii*	CELvmc	*Celmisia macmahonii*
Celmisia spedenii	CELspd	*Celmisia spectabilis*
Cenchrus purpurascens	CENpup	*Cenchrus purpureus*
Chenopodium trigonon	CHEtrg	*Chenopodium triandrum*
Chionochloa crassiuscula subsp. *crassiuscula*	CHIscr	*Chionochloa conspicua* subsp. *conspicua*
Chionochloa flavicans	CHIflv	*Chionochloa flavescens*
Clematis marmoraria	CLEmmr	*Clematis marata*
Coprosma distantia	COPdst	*Coprinus disseminatus*
Coprosma dumosa	COPdmo	NA
Coprosma macrocarpa subsp. *macrocarpa*	COPmcm	*Coprosma macrocarpa* subsp. *minor*
Coprosma petiolata	COPptl	*Coprosma petriei*
Coprosma pseudociliata	COPpsc	*Coprosma pseudocuneata*
Coprosma tenuicaulis	COPtec	NA
Coprosma tenuifolia	COPtef	NA
Corunastylis pumila	CORpml	*Cordyline pumilio*
Corokia macrocarpa	CORmcc	*Corybas macranthus*
Craspedia uniflora var. *maritima*	CRAvmr	NA
Cyperaceae	CYPSPP	*Cyperus eragrostis*
Deschampsia species	DESCHM	*Deschampsia chapmanii*
Dracophyllum prostratum	DRAprs	*Dracophyllum pronum*
Echinochloa species	ECHLOA	*Echinopogon* species
Epilobium brunnescens	EPIbrn	*Epilobium brunnescens* subsp. *brunnescens*
Epilobium brunnescens subsp. *brunnescens*	EPIbru	*Epilobium billardiereanum* subsp. *billardiereanum*
Euchiton delicatus	EUCdlc	*Eucalyptus delegatensis*
Genista monspessulana	GENmns	*Gentianella montana*
Hakea salicifolia	HAKslc	NA
Hectorella species	HECTOL	NA
Juncus acutiflorus	JUNact	*Juncus acuminatus*
Juncus acutus	JUNacs	*Juncus acuminatus*
Juncus gerardii	JUNgrd	*Jungermannia* species
Leptinella intermedia	LPTint	*Lepidothamnus intermedius*
Leptostigma setulosum	LEPstl	*Lepidozia setigera*
Linaria maroccana	LINmac	NA
Linum trigynum	LINtrg	*Lindsaea trichomanoides*
Machaerina articulata	MACatc	*Machaerina arthrophylla*
Malus sylvestris	MLSsyl	*Malva sylvestris*

Taxon name	NVS code	Taxon with intuitive NVS code
Melilotus officinalis	MLLoff	*Melissa officinalis*
Microsorum scandens	MICscn	*Microseris scapigera*
Microsorum species	MCROSO	*Microseris* species
Myrsine aquilonia	MYRaql	*Myriophyllum aquaticum*
Nephrolepis species	NEPHRL	*Nephroma* species
Ourisia macrocarpa	OURmcc	NA
Ourisia macrophylla	OURmap	NA
Ourisia macrophylla subsp. *macrophylla*	OURmsp	NA
Pachycladon latisiliquum	PACltq	*Pachyschistochila latiloba*
Persicaria maculosa	PERmcl	NA
Pittosporum crassifolium	PITcrf	*Pittosporum crassicaule*
Plantago lanigera	PLAlng	*Plantago lanceolata*
Plantago unibracteata	PLAunb	NA
Poa anceps subsp. *anceps*	POAsan	*Poa acicularifolia* subsp. *acicularifolia*
Pseudognaphalium species	PSEUDG	*Pseudopanax* species
Pseudopanax colensoi	NEOcol	*Pseudowintera colorata*
Pseudotsuga species	PSEUDT	*Pseudopanax* species
Pseudowintera species	PSEUDW	*Pseudopanax* species
Ranunculus grahamii	RANgrh	*Ranunculus gracilipes*
Ranunculus maculatus	RANmcl	*Ranunculus macropus*
Raoulia subsericea	RAOsbs	*Raoulia subulata*
Rumex acetosa	RUMact	*Rumex acetosella*
Schoenus nitens	SCHnte	NA
Stellaria graminea	STEgrm	*Stellaria gracilenta*
Stenostachys gracilis	STEgrc	*Stellaria gracilenta*
Trifolium striatum	TRIstt	*Trichomanes strictum*
Triglochin palustre	TRIpls	*Triglochin palustris*
Triglochin species	TRIglc	*Trifolium glomeratum*
Triglochin striata	TRIsta	*Trichomanes strictum*
Veronica catarractae	VERcaa	*Veronica catenata*
Veronica colostylis	VERclo	*Veronica colensoi*
Veronica decumbens	VERdcm	*Veronica decora*
Veronica hookeri	VERhok	*Veronica hookeriana*
Veronica macrantha	VERmcr	*Veronica macrocarpa*
Veronica macrocarpa var. *macrocarpa*	VERmvc	*Veronica macrantha* var. *macrantha*
Veronica notialis	VERnol	NA
Veronica stenophylla var. *stenophylla*	VERssv	*Veronica stricta* var. *stricta*
Veronica strictissima	VERsts	*Veronica stricta*

Taxon name	NVS code	Taxon with intuitive NVS code
Veronica subfulvida	VERsbf	*Veronica subalpina*
Veronica tetrasticha	VERttr	*Veronica tetragona*
Veronica vernicosa	VERvrn	*Veronica verna*

Appendix 5. Canopy cover scale



Divisions of the standard cover abundance scale (showing the proportion of the Recce area represented by each division). Use this scale when assigning cover-classes for the Recce vegetation description.