



## Bush Heritage Australia – Vegetation Assessment Methodology

### DOCUMENT DETAILS

**Method Name:** Bush Heritage Australia – Vegetation Assessment Methodology

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**Confidence Levels:** Level 1, Level 2, Level 3

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# Bush Heritage Australia – Vegetation Assessment Methodology

## 1. Introduction

### 1.1. Aim and Scope of this Method

This Method has been developed to assess the condition of Conservation Targets of native vegetation as defined at the Property/Landscape scale where Bush Heritage works and is applicable across Australia.

As a member of the Conservation Measures Partnership (CMP), Bush Heritage applies the concepts and terminology used in the Conservation Standards (formerly known as the Open Standards for the Practice of Conservation). The term ‘Conservation Target’ refers to specific, tangible entities that each project team is working to conserve that represent and encompass the ultimate aims of the project (using AfN terminology, Conservation Target equates to a ‘sub-asset’).

Bush Heritage is a not-for-profit conservation organisation that manages 1.2 million ha of high conservation value reserves in 36 sites across Australia and an additional 10 million ha in partnership with our Aboriginal Partners. Over its 30-year history Bush Heritage has always taken a scientific approach to its management and has developed and tested various assessment techniques and technologies, working in collaboration with many scientific organisations, and State and Federal government data to fill our management knowledge gaps for the biodiversity on reserves. We are now working on harmonising our vegetation assessment approach into a consistent and comparable method across reserves (and possibly partners’ lands) to understand and inform land management and communicate the outcomes to our supporters and donors using the Econd.

This Method will be used to assess vegetation condition in a wide variety of landscapes from arid rangelands to heathlands and grassy woodlands. The Method will build on the current monitoring and evaluation program that Bush Heritage uses to inform the Conservation Management Process. The application of the Econd® to Bush Heritage reserves will help communicate the health of the native vegetation on reserves and, through the process, refine the current system of Indicator Ratings.

<b>Purpose</b>	This method in conjunction with Bush Heritage’s Conservation Management Process outlines a process to develop an Environmental Account under the Accounting for Nature® Framework that complies with the Conservation Standards and will detect long-term change in the condition of native vegetation. It is intended to support Bush Heritage and other land managers to measure and track the condition of native vegetation over time.
<b>Application</b>	Australia-wide
<b>Scale</b>	Reserve or Property scale
<b>Scope</b>	Change over time
<b>Target Audience</b>	All land managers including conservation reserve managers, indigenous managers and farmers, and their funders
<b>Decisions to inform</b>	To inform and assess land management outcomes over time.
<b>Confidence Level/s</b>	Level 1, Level 2 or Level 3 depending on survey intensity.

## 1.2. Justification of Confidence Level

The same Indicators are measured using the same method at each Level, except where they do not apply to that vegetation type (e.g. grasslands or wetlands with no tree cover). The comprehensive list of Indicators are consistent with those used by State-based condition assessment frameworks and is also consistent with the AfN-approved Land Restoration Fund methodology. Additional Indicators currently used by Bush Heritage have been included. There is a high level of accuracy associated with each method if they are undertaken by suitably trained people. Therefore, the confidence level is set primarily on the number of sample sites per assessment unit. In addition, the area of the sample unit is used to determine the appropriate number of sample sites per assessment unit (refer to Table 1 for the sampling regime) which is generally consistent with the existing AfN approved LRF Native Vegetation Method (AfN-METHOD-NV-01, 2020). A Level 3 (Moderate) confidence level would apply where there are only the minimum number of sample sites per assessment unit.

### 1.3. What an Environmental account looks like

The *Accounting for Nature*<sup>®</sup> Framework requires accounts to be comprised of three key components for them to be certified:

1. An **Environmental Account Summary** – a public document that summarises the results of the environmental account in a form that is readily communicated to the public.
2. An **Information Statement** – describes in detail the method used and the actions taken to address each of the eight steps under the framework including rationale behind asset selection, choice of indicators, Method used, analysis and management of data and calculation of the Econd<sup>™</sup>.
3. The **Environmental Account** – a database (such as an excel file) that contains all the data described in Asset Tables, Data Tables, and Balance Sheets.
4. An **Audit Report** – an independent report that is completed by an AfN Accredited Auditor, that verifies the Account was prepared in accordance with the approved Methods, the *AfN Standard* and AfN Audit rules.

Upon certification of the account, the Environmental Account Summary and Information Statement will be published on the AfN Environmental Account Certification Registry.

### 1.4. Overview of Process

This method includes the following seven steps:



## 2. Creating the Environmental Account

## Step 1. Define purpose, scope, and accounting area

The preliminary step to developing an Environmental Account is to **describe** the Environmental Account through defining its intended **purpose, scope** and **accounting area**.

**Purpose:** Describe the specific purpose of the account.

The purpose of the account is to assess the vegetation condition over time and inform management practices for the conservation and improved health of the target vegetation communities.

**Scope:** Describe the scope of the account.

- *Change over time* – an ongoing assessment of the change of environmental condition through time.

And, in some cases,

- *Cause of change* – determine how the impacts of management activities change the condition of environmental assets, either at a point of time or through time.

**Accounting Area:** Describe the accounting area (include location and size details). Provide a map of the accounting area that shows location and size information.

The accounting area is defined by the extent of the Conservation Target vegetation communities on each conservation reserve/property. The Conservation Targets usually cover the entire extent of each conservation reserve/property, but there are some exceptions to this rule (such as highly modified agricultural land or small but distinct vegetation type(s)).

*The accounting area may change if a new area is added to the reserve or the Conservation Targets are redefined, however, in these circumstances, a new account will be developed, or the account 're-set' and started again with the new accounting area or configuration.*

### Output of Step 1

- A description of the accounting area including **location** and **size**
- A table describing the **purpose** and **scope** of the account
- A **map** showing the accounting area (conservation reserve/property)

## Step 2. Compile existing data

### Data collection

The Conservation Targets on each reserve are often defined using existing state-based vegetation classifications, but they may also be defined or refined using on-ground knowledge. Note, under the AfN Framework, a Conservation Target is referred to as a sub-asset/vegetation type. A Conservation Target may be an amalgamation of two or more vegetation classes from the state-based classification where there are strong similarities (e.g. both vegetation classes are grassy woodlands but with different dominant species or a slightly different understorey).

The state-based mapping is used as the initial basis of the Conservation Target map but is usually modified following on-ground verification surveys and examination of other relevant information (e.g. aerial photography, soil mapping etc). Mapping of the pre-1750 vegetation (where available) is used in addition to the current remnant vegetation. This layer assists with assigning areas of previously cleared or degraded land to the most applicable Conservation Target. Where maps of pre-1750 vegetation are unavailable, other information is used such as maps of the geology and topography. Mapping information on each Conservation Target is stored on a Geographic Information System (GIS).

### Output of Step 2

- A map, table and description of the Conservation Targets on the reserve.

### Step 3. Stratify the accounting area and identify sampling sites

#### Stratify the accounting area

Each Conservation Target may need to be stratified into Assessment units depending on the size of the reserve and whether a Conservation Target has more than one condition state (e.g. areas of intact native vegetation and areas of degraded or cleared native vegetation). Each Conservation Target should be stratified based on previous or current land-use where this management has significantly altered the condition of the Conservation Target e.g:

- tree clearing
- conversion to introduced pasture or cropping,
- loss of understorey through stock grazing,
- forestry,
- remnant vegetation managed for carbon and/or conservation,
- retained regrowth vegetation managed for carbon and/or conservation, and
- regeneration/restoration.

Each Assessment unit should be relatively homogenous, but a unit does not necessarily have to be a single geographic area (i.e. it may be split and occur in different sections of the reserve). Each assessment unit should be composed of one Conservation Target and share the same land-use history. An assessment unit may need to be split (in future assessments) if only part of a unit is severely affected by fire such as catastrophic wildfire (but not including cool season planned burns).

If the Accounting Area contains land-uses that are intensively cultivated or dominated by infrastructure, or are expected to never have vegetation, or where vegetation condition can be assumed to be 0, they should be identified and included in the accounting area (note that these types of land uses may not always be present, in particular not in project scale accounts). For these areas, it is generally fair to assume their condition is 0, and as such, the resulting assessment units with these land-uses do not need to be sampled in (i.e. automatically assign an Econd<sup>®</sup> of 0 for these assessment units, and support with photos).

## Select sample sites

Sampling sites are assigned to each Assessment unit according to the criteria listed below in Table 1. The sampling sites are permanent monitoring sites that characterise each Assessment unit.

Table 1. Overview of how to select and establish sampling sites within each assessment unit

Sample	Implementation																				
<p><b>Number of sites per Assessment unit</b></p>	<p>At least three sample sites will typically be established per Assessment unit to allow a mean and standard error to be calculated. On most Bush Heritage reserves, the number of sites per Assessment unit is five sites, though for very small Assessment units (<math>\leq 20</math> ha) the number may be as low as two. For Assessment units that exceed 500 ha, up to 10 sample sites should be sufficient. As the size of Bush Heritage reserves ranges from <math>&lt;10</math> ha to over 200,000 ha, the most appropriate number of sample sites per unit depends largely on an on-ground assessment of the variability within each unit, as well as logistical and financial constraints.</p> <table border="1" data-bbox="528 931 1386 1413"> <thead> <tr> <th data-bbox="528 931 743 1122">Assessment unit area*</th> <th data-bbox="743 931 956 1122">Minimum number of sites for Confidence Level 1*</th> <th data-bbox="956 931 1168 1122">Minimum number of sites for Confidence Level 2</th> <th data-bbox="1168 931 1386 1122">Minimum number of sites for Confidence Level 3</th> </tr> </thead> <tbody> <tr> <td data-bbox="528 1122 743 1196"><math>\leq 20</math> ha</td> <td data-bbox="743 1122 956 1196">3</td> <td data-bbox="956 1122 1168 1196">2</td> <td data-bbox="1168 1122 1386 1196">2</td> </tr> <tr> <td data-bbox="528 1196 743 1270"><math>&gt;20</math> and <math>\leq 60</math> ha</td> <td data-bbox="743 1196 956 1270">5</td> <td data-bbox="956 1196 1168 1270">3</td> <td data-bbox="1168 1196 1386 1270">3</td> </tr> <tr> <td data-bbox="528 1270 743 1344"><math>&gt;60</math> and <math>\leq 500</math> ha</td> <td data-bbox="743 1270 956 1344">7</td> <td data-bbox="956 1270 1168 1344">5</td> <td data-bbox="1168 1270 1386 1344">4</td> </tr> <tr> <td data-bbox="528 1344 743 1413"><math>&gt;500</math> ha</td> <td data-bbox="743 1344 956 1413">9</td> <td data-bbox="956 1344 1168 1413">7</td> <td data-bbox="1168 1344 1386 1413">5</td> </tr> </tbody> </table> <p>* Table modified from Land Restoration Fund (Queensland) Native Vegetation Monitoring Method which specifies the following number of sites for different size-classes of assessment units for Levels 1 and 2 only.</p>	Assessment unit area*	Minimum number of sites for Confidence Level 1*	Minimum number of sites for Confidence Level 2	Minimum number of sites for Confidence Level 3	$\leq 20$ ha	3	2	2	$>20$ and $\leq 60$ ha	5	3	3	$>60$ and $\leq 500$ ha	7	5	4	$>500$ ha	9	7	5
Assessment unit area*	Minimum number of sites for Confidence Level 1*	Minimum number of sites for Confidence Level 2	Minimum number of sites for Confidence Level 3																		
$\leq 20$ ha	3	2	2																		
$>20$ and $\leq 60$ ha	5	3	3																		
$>60$ and $\leq 500$ ha	7	5	4																		
$>500$ ha	9	7	5																		
<p><b>Site selection</b></p>	<p>The location of samples sites should be randomised within each Assessment unit but with ready access to on-property tracks (e.g. within a 200m buffer either side of a property track. This can be achieved using a specific randomisation tool within a GIS or through a similar unbiased process. Sites should not be set up near infrastructure such as buildings, dams, or busy tracks/roads (minimum 200 metre buffer). Sites should not be located in the transition zone between two or more accounting units (e.g. ecotones). Logistics should also be considered to avoid setting the majority of sample sites far from tracks and roads.</p> <p>Sites should be located <math>&gt;1</math> km apart, although this can be difficult to achieve if the Assessment units are <math>&lt;200</math> ha. This is more of a concern if the sites are also</p>																				



	<p>used for monitoring more mobile fauna species such as birds and large mammals.</p> <p>Where an Assessment unit is split into more than one area, then the sample sites should be split proportionally between these areas. There are some exceptions such in circumstances where one (or more) section of the accounting unit has poor/no access.</p> <p>Where a counter-factual is required, sample sites should be selected in the same vegetation classification and within the same landscape unit and climatic area. For practicality where the land use is applicable as a control site, the closest TERN Ausplot will be the control.</p>
<b>Site establishment</b>	<p>Sites are marked by two star-pickets that are 50 metres apart. The main site marker is typically the picket (A-peg) closest to the nearest access track and all measurements are taken from this picket. The coordinates of the A- and B-pegs are recorded using a device with a Global Positioning System, preferably a dedicated GPS device. The site information (including vegetation class, geology etc) is stored in a dedicated monitoring database. A landscape photograph is taken from each end facing the other peg to assist with relocating the transect in case a star picket is removed. The map datum should be noted (typically Latitude and Longitude or GDA'94 or GDA2020).</p>
<b>Timing</b>	<p>The reserve is sampled at the same time of year to ensure consistency in the results. As all the reserves have different seasonal conditions, the most appropriate month to survey can vary considerably, but in general vegetation surveys are best done during the flowering/fruited season to facilitate species identification. The most appropriate season to sample in southern Australia tends to be in spring (September to November), whereas in tropical Australia, the most appropriate time to sample are the months following the end of the wet season. Ideally the surveys should be conducted in the same month in each sampling year, but some flexibility is permitted in case the current conditions are exceptional (e.g. wintery conditions extend into September). From time to time, surveys will occur in areas experiencing long-term drought. In these circumstances, the reference condition sites (on reserve or nearby) could be surveyed to help calibrate/interpret the results, and to help achieve Confidence Level 1.</p>

### Output of Step 3

- A map and table showing the **stratification** of the accounting area based on the condition state(s) or the Conservation Targets.
- A map and table with the two key coordinates (A- and B-peg) of each **sample site** within each accounting area.

## Step 4. Describe environmental indicators and determine reference benchmarks

### Indicators

- The Native Vegetation Technical Protocol (Butler et al., 2020) established three indicator themes used to describe native vegetation condition. The indicator themes for native vegetation must represent the following three classes: the **extent** of vegetation (the proportion remaining in the landscape), its **configuration** (how the vegetation assets are distributed across the landscape) its and **composition** (such as structure and species richness). Together these three components provide the foundation for indicators required for native vegetation condition methods consistent with this Protocol. Methods must require indicators within each of these three themes:
- Extent: The **extent** of native vegetation refers to the area of 'native' vegetation within the accounting area. This Method assesses the condition of vegetation within every assessment unit, within the entire accounting area. Therefore, extent is captured through the stratification process and in Calculating the final Econd<sup>®</sup> – where all assessment unit Econd<sup>®</sup> scores (including those that are assigned an Econd<sup>®</sup> of 0) are aggregated into a sub-asset Econd<sup>®</sup> using **area weighted averages**, and the sub-asset Econd<sup>®</sup> is then aggregated into an overall Econd<sup>®</sup> score using **area weighted averages**.
- Configuration: The configuration of native vegetation relates to its connectivity, context and patch size within the local landscape (i.e. in the vicinity of the sample site). This Method uses the context of each sample site as a measure of the configuration. Configuration is the percent of remnant vegetation retained within a 1-km radius and a 5-km radius of each sample site (from A-peg), weighted 0.6 and 0.4 respectively. Remnant vegetation is defined as any area mapped as a native vegetation community (State-based mapping), though verification on-ground or from aerial photography is necessary to exclude areas that have been more recently cleared or are highly degraded (e.g. native trees above introduced pastures).
- Composition: The composition of native vegetation relates to its structure and the assemblage of species. In this Method, composition will be assessed using various attributes measured along transect and within quadrats. These indicator classes and their relevant indicators are further outlined below in Table 2, and further defined in Appendix D.

### Reference Benchmarks

The AfN Framework refers to the Reference Condition Benchmark ('Reference Benchmark') as the 'undegraded' state of each native vegetation type. As such, these areas would not have experienced any negative impacts as a result of disturbance (e.g. stock grazing or vegetation clearing), edge effects, invasive weeds, or altered management regimes (e.g. flood or fire). Most States have published vegetation condition benchmark documents that apply to that region's vegetation community mapping (refer to Appendix B for the current publication in each State and Territory). These benchmarks can be used to estimate the most applicable Reference Benchmark for the purposes of this method. However, the techniques used by Bush Heritage to collect the data does not necessarily follow those developed for the state-based condition assessment frameworks. For example, a line-intercept method is used by Bush Heritage in some instance where a quadrat is used by the state system, or the size of the quadrats

differ between the methods. Modifications to Bush Heritage's traditional techniques have been adopted to address some of these differences.

In the absence of published benchmark documentation (such as in Western Australia) or an equivalent Indicator under a state-based system, alternative sources should be approached to obtain equivalent or more local benchmarks, such as State government (e.g. Herbarium, and vegetation ecologists in the Environment or Agriculture departments), regional NRM bodies or local experts. Draft or unpublished benchmark data may exist. Alternatively, if there are no existing benchmark data available, the assessor must establish local, 'best on offer' reference condition sites which may be interpreted with expert opinion. Refer to Eyre et al. (2017) for help with selecting local Reference Benchmark sites.

Table 2. Indicator classes and indicators

Indicator class	Indicator	Reference Benchmark
<b>Configuration</b>	Indicator assessed using a GIS and a current vegetation map and on-ground/aerial photography verification. Configuration (%)	The Reference Benchmark for Context will be taken as the pre- 1750 extent of all vegetation types within 1 km and 5 km of each sample site, which is typically 100 %.
<b>Composition</b>	Indicators <sup>1</sup> assessed in the field: A) Native tree canopy height (metres) B) Native tree canopy health score (%) C) Native tree canopy cover (%) D) Native tree density (stems/ha) E) Native species count for tree canopy and shrub layer species (number) F) Native shrub cover (%) G) Non-native shrub / tree cover H) Native herbaceous cover (%) I) Native species count for herbaceous species (number) J) Non-native herbaceous species cover (%) K) Organic litter ground cover (%) L) Cryptogam cover (%) (may exclude algae crust if no reference condition is available) M) Fallen logs >100mm diameter (metres/0.1ha)	The Reference Condition Benchmarks of the Composition indicators will be derived from the published benchmarks in the applicable condition assessment framework for that State or Territory (refer to Appendix B). Expert opinion may be used to estimate the Reference Benchmark only if one or two indicators are missing from the applicable State or Territory benchmarks.  <b>OR</b>  If there is no published benchmark, then 'Best on Offer' Reference Condition Benchmark sites or data may be used to derive these figures. Such sites and the benchmarks will be determined by expert opinion but could include information from (for example) AusPLOT sites in comparable vegetation located in established public or private conservation reserves in the same region.

<sup>1</sup> Refer to *Australian Vegetation Attribute Manual: National Vegetation Information System*, (2017) for definitions of lifeforms (Table 5 and 6).

Regardless of the source of the Reference Condition Benchmarks, to ensure full transparency the source of the benchmarks used in the Account must be described in the accompanying Information Statement.

Not all the Composition Indicators listed in Table 2 will be applicable to all vegetation types (e.g. trees and tall shrubs in native grasslands). In these circumstances, the score will be recorded as 'NA' and in the Econd calculation these will be ignored (i.e. 'not applicable'). In these circumstances it is worth checking if the vegetation mapping is correct or whether the vegetation has been incorrectly assigned to a particular vegetation type. For example, sparse mature tree cover in a native grassland indicates the area would naturally be an (open) woodland.

However, where trees or shrubs have been planted into a natural grassland (or another treeless ecosystem), then the indicator scores for tree and/or shrub cover (only) will be '1'. Canopy height and species richness for shrubs and trees will be ignored. This will indicate that the condition of the vegetation has been degraded through this inappropriate management action.

Some indicators, such as herbaceous cover in arid and semi-arid regions, respond dramatically to seasonal rainfall conditions. In these areas, a Dynamic Reference Benchmarks (such as a local reference site) would be useful to help differentiate between effects of management and natural variability. Such sites don't need to be large but may need fencing from stock and pest herbivores such as rabbits, deer and goats, as well as carefully maintained to eliminate weeds. Therefore, the year-to-year changes in herbaceous cover will be largely due to the influence of rainfall.

#### Output of Step 4

- A table describing the **environmental indicators** to be measured in the account
- A table that includes the **Reference Benchmark value** for each indicator for each Conservation Target.

## Step 5. Collect and analyse data

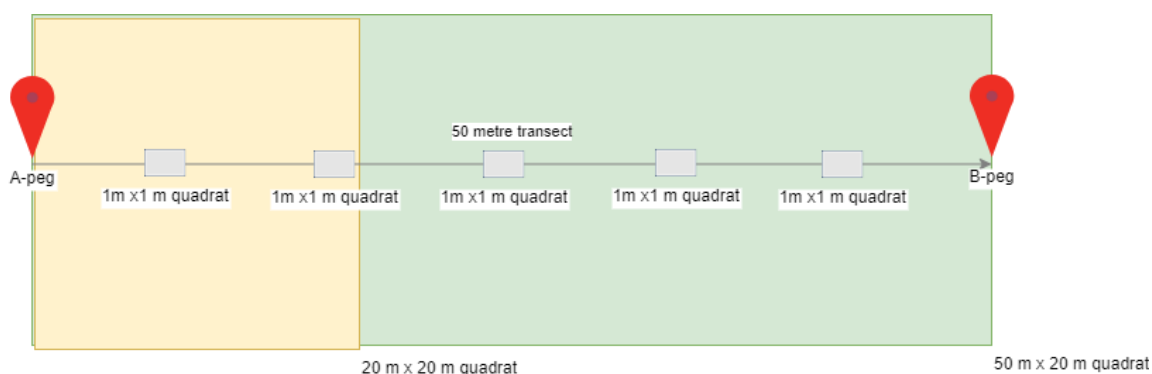
Data collection for the Environmental Account involves desktop analyses using GIS (i.e. for Extent and Configuration) and data collection in the field (i.e. measurements along transects and within quadrats).

**Desktop analyses** The desktop analyses for Configuration require the following GIS data layers:

- Aerial imagery
- Pre-1750 vegetation mapping (if available)
- Assessment units (generated in Step 3)
- Sample sites (generated in Step 3)
- State (current) vegetation mapping (if available).

**Establish permanent sampling sites** Permanent sampling sites are set up to collect data for the Composition indicators. The sampling sites are marked by two star-pickets that mark the two ends of a line transect (Figure 1). On Bush Heritage reserves, the transects are all at least 50 metres long. Longer transects (100 m) or additional transects are sometimes used on arid reserves or areas previously cleared to adequately assess sparse vegetation types. Data is collected along the line transect using the Line Intercept technique (i.e. start and end points are recorded for vegetation intercepting the transect). The Line Intercept technique is used to collect data on the shrub and tree layers, but in some cases large/tall herbaceous species are also recorded (such as spinifex, tall sedges etc). The Point Intercept technique is an alternative option used on some reserves where the number of intercepts along each transect is very high or where the transect length is  $\geq 100$  metres. Using this method, all vegetation intercepting the transect is recorded at defined points along the transect (usually at every 1-metre mark). All plant species including small herbaceous species and soil surface types (e.g. cryptogams, litter etc) are recorded using the Point Intercept technique.

Figure 1. Sample site layout. The yellow area indicates the position of the 20 m x 20 m quadrat, and the green area indicates the position of the 50 m x 20 m quadrat (which includes the 20 m x 20 m quadrat).



Quadrats are also used at the sampling sites and straddle the line transect. On most Bush Heritage reserves there are five 1 m by 1m quadrats evenly spaced along the transect at 5-6 m, 15-16 m, 25-26 m, 35-36 m and 45-46 m. These Quadrats are used to collect data on the ground-cover (herbaceous) vegetation and soil surfaces (e.g., bare ground, litter, fallen logs etc). Larger quadrats are used to measure tree and/or shrub density and/or to record species presence. These large quadrats are also aligned with the line transect. A 20 m x 20 m quadrat is used in young to mature forest areas where stem density can be high, and a 50 m x 20 m quadrat is used in sparsely wooded areas where stem

density of stems is usually lower. Where the density of stems in the shrub and tree layer is very high (such as heathlands and densely shrubby vegetation types), the Line Intercept method along the 50-metre transect is adequate to count the number of shrub and tree species at a sampling site (i.e. Indicator K, Table 3).

Table 3 summarises the techniques used to measure each of the Composition Indicators.

*Table 3 Indicators and the source and measures used for each Indicator*

Indicator	Source / Measure <sup>2</sup>
A) Native tree canopy height (metres)	Line Intercept Transect (mean value along transect; tape measure or range finder, estimate)
B) Native tree canopy health score (%)	Quadrat – one 50m x20m, 0.1 ha (for sparsely wooded areas) OR Quadrat – one 20m x 20m, 0.04 ha (for forest areas) (mean value per sample site, for all standing trees ≥10 cm dbh)
C) Native tree canopy cover (%)	Line Intercept Transect (cumulative distance on transect expressed as a percentage of transect length)
D) Native shrub cover (%)	Line Intercept Transect (cumulative distance on transect expressed as a percentage of transect length)
E) Non-native shrub / tree cover (%)	Line Intercept Transect (cumulative distance on transect expressed as a percentage of transect length)
F) Native herbaceous cover (%)	Quadrats– five 1m x1m (mean value per sample site)
G) Non-native herbaceous cover (%)	Quadrats – five 1m x1m (mean value per sample site)
H) Organic litter ground cover (%)	Quadrats – five 1m x1m (mean value per sample site)
I) Cryptogam cover (%) (bryophytes, lichens as well as algal crust, unless no State-based reference condition is available)	Quadrats – five 1m x1m (mean value per sample site)
J) Native tree density (mature tree stems/ha)	Quadrat – one 50m x20m, 0.1 ha (number of stems ≥10 cm diameter x 10)

<sup>2</sup> Two measures are listed against some Indicators. In these cases, the most appropriate method will be used which depends on the vegetation type at the sampling site. For example, dense forest areas require a smaller quadrat area to achieve representative and accurate measures for some indicators compared to sparsely wooded areas.

Indicator	Source / Measure <sup>2</sup>
K) Number of native species present for canopy and shrub layer species (number)	Line Intercept Transect (for heathlands and shrubby vegetation types) (cumulative count on transect) OR Quadrat – one 50m x20m (for most other vegetation types) (cumulative count in quadrat)
L) Number of native species present for herbaceous species (number)	Quadrats – five 1m x1m (for most vegetation types) (cumulative count across all quadrats) OR Quadrat – one 20m x20m (for vegetation types with complex groundcover such as grasslands and grassy woodlands) (cumulative count in quadrat)
M) Fallen timber > <u>100mm diameter (metres/ha)</u>	Quadrat – one 50m x20m (for sparsely wooded areas) (summed lengths in quadrat x 10) OR Quadrat – one 20m x 20m (for forest areas) (summed lengths in quadrat x 25)

All data are entered into forms created in the ESRI-based 'Survey 123' app which is then uploaded to a central database. Alternatively, this information can be recorded on a paper data sheet.

**Procedure to layout and collect transect data using the line intercept method (woody species):**

- Lay out the tape along the transect:
  - The transect starting point (tape = 0 m) is marked with a star picket, the 'A-peg'. The end point is marked with another post (the 'B-peg'). The A-peg should be labelled with a metal tag with the site number. A compass bearing from the A-peg to the B-peg should be recorded.
  - A flexible tape measure is laid out along the transect and is always be laid in the same direction (e.g., A-peg = 0m, B-peg = 50m) and distance on successive surveys to allow comparisons over time. The tape is straightened and tightened till the transect line is perfectly straight and taut (no kinks or loose sections) and as low to the ground as possible.
  - If the stems of trees or large shrubs interrupt the line of the transect, then photos taken on previous surveys are used to determine which side of the trunk to place the tape. In thick vegetation it is often helpful to indicate the position of the transect with flagging tape to hasten the process of laying out the tape on successive visits.
- Record intercepts/points along the transect:
  - The minimum length of an intercept is 10 cm (i.e., each intercept must have a plant(s) overlapping the transect for at least 10 cm or it is not recorded). The measurements (i.e. the start and end points on the measuring tape which are overlapped by plant(s)) are recorded to the nearest centimetre/ 0.01 metre) along with the species name. If there is a gap in the projected foliage (+ branches) of an individual plant of 10 cm or more along the transect, then the intercept should be split so that the gap is not counted. However, in the canopy layer (i.e., >5 metres above the ground), no intercept is recorded if there is a gap of 50 cm or more (due to difficulties in accurately measuring small gaps at greater heights).
  - If there is a cluster of plants of the same species with overlapping foliage, then record only one intercept and record the height of the tallest plant. If the plants within a cluster are clearly in two different strata (i.e. the taller plant is  $\geq 2$  metres higher than the smaller plant), then measure and record two intercepts including the section of overlap.
  - If there is a cluster of plants from two (or more) different species with overlapping foliage, then record a separate intercept for each species including the section of overlap.
    - The only exception to this rule regards the canopy layer where the canopy height is approximately 5 m or greater and it is difficult to discern one species from the other (e.g., mixed eucalypt vegetation types). In these circumstances it is extremely difficult to differentiate the foliage of one species from the other. Therefore, record only one intercept (i.e., do not split them into separate species intercepts). However, record the names of all species in the cluster and record the maximum height.
    - Similarly, if there is no discernible difference between the sub-canopy and the canopy layer, then deal with them as one intercept and record the names of all species in the cluster and record the maximum height.
  - Intercepts for taller plants will require a densiometer (or equivalent device) to accurately measure these intercepts (i.e., to ensure the intercept is directly above the line transect).
- Record the maximum height of each plant that intercepts the transect:
  - The height of the entire plant is recorded, not the height at which it overlaps the transect. For example, if the lower branch of a tree is overlapping the transect, then find the highest point



of the tree and measure its height (using a tape measure or range finder). If a cluster of two or more plants of the same species overlap the transect and are measured as one intercept, then record the maximum height of the tallest shrub/tree.

- A field herbarium should be created for species that cannot be readily identified by people with limited familiarity with the local vegetation (i.e. it is not necessary to include common and readily identifiable species).
  - When the specimens have been reliably identified to the species (or genus) level, be sure to transfer that knowledge: relabel the samples in the field and Reserve herbarium, and update intercept/point records in the database (enter the known species name and transfer the old unknown species ID to the notes field for that record). The temporary name should be removed from the database species list only if all records have been changed to the correct name.

#### Procedure to layout and collect transect data using the point intercept method (all species):

- The layout is same procedure as per the line intercept method except that the data is collected at fixed intervals (points) along the transect(s). The spacing between points is usually 1 metre. All species and soil surfaces (see next section below for details) that occur above or below each point on the line are recorded along with their respective height (i.e., record the canopy, shrub layer and groundcover (if present) and the soil surface).

#### Procedure to layout and collect 1m x 1m quadrat data (herbaceous species and soil surfaces):

- The quadrat is usually marked on the ground using a plastic or wooden frame.
- Record the projected cover (to the nearest percent i.e., 10 cm x 10 cm) for the following soil surfaces:
  - Bare ground (including animal diggings/scratching);
  - Ant nests/Termite mounds/Burrows;
  - Algal Crust;
  - Bryophytes/Lichens/macro-Fungi;
  - Plant base i.e. the area occupied on the soil surface by plants (not foliage cover);
  - Litter (dead material no longer attached to the plant);
  - Fallen branches (>6mm) and thin logs <100mm diameter;
  - Fallen logs ≥100mm diameter;
  - Surface Rock >2cm diameter;
  - Gravel/Gibber/Stones 0.5-2cm diameter.
 (Note: Cryptogams = Algal Crust + Bryophytes/Lichens/macro-Fungi).
- Record the herbaceous species present in the quadrats. Note: as this is a cumulative list for each sample site, species only need to be recorded once even if they occur in more than one quadrat.
- Record the projected foliage cover separately of 1) the annual/biennial species and 2) the perennial herbaceous species in each quadrat. Herbaceous species includes all grasses, graminoid species and forbs (but excluding grass trees, cycads, tree ferns, epiphytes, and lianas). The percentage of the annual/biennial cover and the perennial cover that is composed of exotic (non-indigenous) species is also recorded. For example, if the cover of annual species is 4% and half the cover is composed of exotic species then record the percentage of exotic species as 50% (i.e. not 2%).
  - Splitting species into perennial or annual classes can be difficult if you are not familiar with the local species. It is a good idea to familiarise yourself with the flora before undertaking this survey (and the vegetation structure survey too).
  - Orchids, lilies, 'resurrection' ferns and other geophytes should be treated as annuals (even though they persist underground) because they may or may not emerge from year to year and they typically die back to the tuber/rootstock/corm etc after a period of several months. Therefore, geophytes do not provide perennial cover on the ground.

**Procedure to layout and collect 50m x 20m or 20m x 20m quadrat data (all plant species and soil surfaces):**

- The quadrat is marked on the ground using a flexible tape (with tent pegs in the corners to help with the layout).
- Record the length of any fallen timber where the diameter of the log is greater than 100 mm.
- Record the species and diameter of any tree species with a diameter of  $\geq 100$  mm at breast height<sup>3</sup> (DBH;  $\sim 1.4$  m high), or the broadest single stem of any multi-stemmed tree (e.g. mallee trees). First mark all standing live and dead trees within the quadrat with flagging tape and remove the tape from a tree once the diameter (and health score, see next point) has been recorded.
  - If there are multiple re-sprouted stems originating from below a dead trunk, only record the diameter of the broadest living trunk.
- Record the health score of the canopy of any trees with a diameter of  $\geq 100$  mm at breast height (DBH).
  - Determine the crown health / condition stage by applying the following criteria and by comparing it with diagrams (see Appendix C). The crown of each tree is scored on a scale from 0 (completely dead trees) to 5 (healthy crowns with very few dead branches or leaves).
  - Category 5: The canopy is 'full' - the volume of the canopy matches the diameter of the trunk. There are no fallen major limbs and there is only natural attrition of the foliage and/or minor branches. Epicormic growth is typically absent. Canopy loss of up to 10% is permitted.
  - Category 4: Canopy loss of between 10-25 %.
  - Category 3: Canopy loss of between >25-50 %.
  - Category 2: Canopy loss of between >50-75 %.
  - Category 1: Canopy loss of over >75 %.
  - Category 0: Completely dead tree.
  - Note: for trees where the entire main trunk has died due to drought or fire, any epicormic shoots from the base of the tree are assessed against the diameter of the new, emerging trunk. The reduced stature of the plant will be reflected in the diameter measurement which will affect the tree density score at that sampling site. Therefore, if the resprouted foliage is healthy, the health score is Category 5. If the main stem is not dead, then any resprouting foliage on the plant is assessed against the expected canopy size for that trunk diameter. Therefore, if the plant was recently defoliated by fire but it is resprouting from epicormic shoots on the trunk or major limbs, then the score is likely to be Category 1.

**Procedure to photograph the transect:**

- Photographs of the transect are required to help demonstrate the changes occurring at a sampling site over time. Currently, no data are extracted from the photographs. The photographs can also help with re-establishing the transect if a star-picket is removed. All photographs should be taken in landscape orientation (not portrait).
  - The first photograph is taken from 1-2 metres behind the A-peg such that the top of the star-picket is in the bottom of the view and the top of the B-peg is in the middle of the photograph. This provides a view of the general landscape and most of the transect. A photograph is also taken in the same way at the B-peg looking back towards the A-peg. Additional photos can be taken of the surrounds at the A-peg at 90°, 180° and 270° relative to the transect direction. Photos of the canopy (where present) can also be taken by pointing the camera to the sky directly above the A-peg and B-peg star-picket.
  - The photographs are labelled with the sample site number and the peg from which the photo is taken. Photos are stored on the database along with the ecological data.

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<sup>3</sup> The minimum threshold for stem diameter depends on the vegetation type and the available benchmark (e.g. for trees it may be a minimum of 100 mm at breast height but for large shrubs it might be 30 mm at 20 cm above ground level).

### Output of Step 5

- A **data table** (e.g., a spreadsheet) containing all the raw data for each environmental indicator for each sample can be extracted from the database (field data input via Survey 123 app or equivalent data capture app or data sheet).
- A **folder** containing all photographs appropriately labelled according to the sample are stored on the database.

## Step 6. Calculate Indicator Condition Scores

Indicator Condition Scores (ICS) generally represent the observed values expressed as a percentage of the Reference Benchmark value. Each indicator within the Configuration and Composition Indicator Classes is converted to an index ranging from 0-100, where 100 represents the Reference Benchmark value. There are formulas for calculating these indices that vary considerably between the indicators. In some cases, weightings and/or conditional clauses are applied to reflect certain ecological thresholds (e.g., tree density or canopy cover values may be intermediate at the Reference Benchmark value, so the condition index increases to an optimal value/range, above which the condition index decreases to reflect deteriorating condition).

To calculate the Configuration Indicator Condition Score (the only Configuration Indicator Class), a GIS is used to calculate the proportion of remnant vegetation retained within a 1-km radius and a 5-km radius of each sample site (taken from the A-peg), weighted 0.6 and 0.4 respectively. If the percentage of native vegetation within a 1 km radius of the sample site is 86% and 56% within 5 km, then the ICS is 74.

For the Composition Indicators listed in Table 3, a continuous scoring system (i.e., not an interval score system) is applied to the field data using the applicable transformation formula outlined in Table 4. The composition values measured across all sample sites within each assessment unit should be averaged, and these averaged values used to calculate the ICS. Where attributes are naturally missing in a Conservation Target vegetation community (e.g., tree indicators in treeless vegetation types such as grasslands, wetlands) they do not contribute to the score for that sampling site.

Table 4. How to calculate Indicator Condition Scores for Composition Indicators.

Measure	Method	Indicator Condition Score (ICS)																		
<b>Height and Health</b>																				
<b>Native Tree Canopy (m)</b>	Line transect or Quadrat	An ICS will be calculated for the height of the canopy stratum in accordance with below table (simplified from LRF method (Butler, 2020)):																		
		<table border="1"> <thead> <tr> <th>Height as % of benchmark</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>&lt;10%</td> <td>0</td> </tr> <tr> <td>10 – &lt;20%</td> <td>8</td> </tr> <tr> <td>20 – &lt;30%</td> <td>25</td> </tr> <tr> <td>30 – &lt;40%</td> <td>41</td> </tr> <tr> <td>40 – &lt;50%</td> <td>58</td> </tr> <tr> <td>50 – &lt;60%</td> <td>76</td> </tr> <tr> <td>60 – &lt;70%</td> <td>93</td> </tr> <tr> <td>≥70%</td> <td>100</td> </tr> </tbody> </table>	Height as % of benchmark	ICS (0-100)	<10%	0	10 – <20%	8	20 – <30%	25	30 – <40%	41	40 – <50%	58	50 – <60%	76	60 – <70%	93	≥70%	100
		Height as % of benchmark	ICS (0-100)																	
		<10%	0																	
		10 – <20%	8																	
		20 – <30%	25																	
		30 – <40%	41																	
		40 – <50%	58																	
		50 – <60%	76																	
60 – <70%	93																			
≥70%	100																			
If benchmark is 0, then ICS is 'NA'																				

<p><b>Native tree canopy health score (%)</b></p>	<p>Quadrat(s)</p>	<p>An ICS will be calculated for the canopy health of trees* in accordance with table below:</p> <table border="1" data-bbox="699 273 1310 495"> <thead> <tr> <th>Health as % of benchmark</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>&lt;90 %</td> <td><math>ICS = \frac{Score}{Reference} \times 100</math></td> </tr> <tr> <td>≥90%</td> <td>100</td> </tr> </tbody> </table> <p>*Any individual tree with DBH ≥100 mm. If benchmark is 0, then ICS is 'NA'</p>	Health as % of benchmark	ICS (0-100)	<90 %	$ICS = \frac{Score}{Reference} \times 100$	≥90%	100						
Health as % of benchmark	ICS (0-100)													
<90 %	$ICS = \frac{Score}{Reference} \times 100$													
≥90%	100													
<p><b>Cover</b></p>														
<p><b>Tree Canopy cover (%)</b></p>	<p>Line transect</p>	<p>An ICS will be calculated for the cover of the canopy in accordance with table below (modified from LRF Method (Butler, 2020)):</p> <table border="1" data-bbox="699 752 1310 1115"> <thead> <tr> <th>Cover as % of benchmark</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>0 – &lt;50 %</td> <td><math>ICS = 200 \times \frac{Score}{Reference}</math></td> </tr> <tr> <td>50 – 150%</td> <td>100</td> </tr> <tr> <td>&gt;150 -250 %</td> <td><math>ICS = -40 \times \frac{Score}{Reference} + 140</math></td> </tr> <tr> <td>&gt;250%</td> <td>40</td> </tr> </tbody> </table> <p>If benchmark is 0, then ICS is 'NA'</p>	Cover as % of benchmark	ICS (0-100)	0 – <50 %	$ICS = 200 \times \frac{Score}{Reference}$	50 – 150%	100	>150 -250 %	$ICS = -40 \times \frac{Score}{Reference} + 140$	>250%	40		
Cover as % of benchmark	ICS (0-100)													
0 – <50 %	$ICS = 200 \times \frac{Score}{Reference}$													
50 – 150%	100													
>150 -250 %	$ICS = -40 \times \frac{Score}{Reference} + 140$													
>250%	40													
<p><b>Shrub cover (%)</b></p>	<p>Line transect</p>	<p>An ICS will be calculated for the cover of shrub layer in accordance with table below (modified from LRF method (Butler, 2020)):</p> <table border="1" data-bbox="699 1330 1310 1700"> <thead> <tr> <th>Cover as % of benchmark</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>&lt;10 %</td> <td>0</td> </tr> <tr> <td>10 – 49 %</td> <td><math>ICS = 200 \times \frac{Score}{Reference}</math></td> </tr> <tr> <td>50 – 200%</td> <td>100</td> </tr> <tr> <td>201 -250 %</td> <td><math>ICS = -40 \times \frac{Score}{Reference} + 180</math></td> </tr> <tr> <td>&gt;250%</td> <td>60</td> </tr> </tbody> </table> <p>If benchmark is 0, then ICS is 'NA'</p>	Cover as % of benchmark	ICS (0-100)	<10 %	0	10 – 49 %	$ICS = 200 \times \frac{Score}{Reference}$	50 – 200%	100	201 -250 %	$ICS = -40 \times \frac{Score}{Reference} + 180$	>250%	60
Cover as % of benchmark	ICS (0-100)													
<10 %	0													
10 – 49 %	$ICS = 200 \times \frac{Score}{Reference}$													
50 – 200%	100													
201 -250 %	$ICS = -40 \times \frac{Score}{Reference} + 180$													
>250%	60													

<b>Non-native shrub &amp; tree cover (%)</b>	Line transect	<p>An ICS will be calculated for the cover of non-native canopy and shrub species with table below:</p> <table border="1" data-bbox="699 286 1310 495"> <thead> <tr> <th>Cover (benchmark = 0%)</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>≤40 %</td> <td>ICS = 100 - (2.5 x Score)</td> </tr> <tr> <td>&gt;40%</td> <td>0</td> </tr> </tbody> </table>	Cover (benchmark = 0%)	ICS (0-100)	≤40 %	ICS = 100 - (2.5 x Score)	>40%	0						
Cover (benchmark = 0%)	ICS (0-100)													
≤40 %	ICS = 100 - (2.5 x Score)													
>40%	0													
<b>Native herbaceous cover (%)</b>	Quadrat(s)	<p>An ICS will be calculated for the cover of native herbaceous species with below table (modified from LRF perennial grass cover method (Butler, 2020)):</p> <table border="1" data-bbox="699 667 1310 884"> <thead> <tr> <th>Cover as % of benchmark</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>≤100 %</td> <td>ICS = <math>\frac{\text{Score}}{\text{Reference}} \times 100</math></td> </tr> <tr> <td>&gt;100%</td> <td>100</td> </tr> </tbody> </table>	Cover as % of benchmark	ICS (0-100)	≤100 %	ICS = $\frac{\text{Score}}{\text{Reference}} \times 100$	>100%	100						
Cover as % of benchmark	ICS (0-100)													
≤100 %	ICS = $\frac{\text{Score}}{\text{Reference}} \times 100$													
>100%	100													
<b>Non-native herbaceous cover (%)</b>	Quadrat(s)	<p>Non-native plant cover will be given an ICS in accordance with the below:</p> <table border="1" data-bbox="699 1037 1310 1243"> <thead> <tr> <th>Cover (benchmark = 0%)</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>≤50 %</td> <td>ICS = 100 - (2 x Score)</td> </tr> <tr> <td>&gt;50%</td> <td>0</td> </tr> </tbody> </table>	Cover (benchmark = 0%)	ICS (0-100)	≤50 %	ICS = 100 - (2 x Score)	>50%	0						
Cover (benchmark = 0%)	ICS (0-100)													
≤50 %	ICS = 100 - (2 x Score)													
>50%	0													
<b>Organic litter ground cover (%)</b>	Quadrats	<p>An ICS will be calculated for the cover of organic litter with below table (simplified from LRF method (Butler, 2020)):</p> <table border="1" data-bbox="699 1395 1310 1794"> <thead> <tr> <th>Cover as % of benchmark</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>&lt;10 %</td> <td>0</td> </tr> <tr> <td>10 – 50%</td> <td>ICS = <math>250 \times \frac{\text{Score}}{\text{Reference}} - 25</math></td> </tr> <tr> <td>51– 200%</td> <td>100</td> </tr> <tr> <td>201 -250 %</td> <td>ICS = <math>-80 \times \frac{\text{Score}}{\text{Reference}} + 260</math></td> </tr> <tr> <td>&gt;250%</td> <td>60</td> </tr> </tbody> </table>	Cover as % of benchmark	ICS (0-100)	<10 %	0	10 – 50%	ICS = $250 \times \frac{\text{Score}}{\text{Reference}} - 25$	51– 200%	100	201 -250 %	ICS = $-80 \times \frac{\text{Score}}{\text{Reference}} + 260$	>250%	60
Cover as % of benchmark	ICS (0-100)													
<10 %	0													
10 – 50%	ICS = $250 \times \frac{\text{Score}}{\text{Reference}} - 25$													
51– 200%	100													
201 -250 %	ICS = $-80 \times \frac{\text{Score}}{\text{Reference}} + 260$													
>250%	60													

Cryptogam cover (%)	Quadrat(s)	<p>An ICS will be calculated for the cover of cryptogams with below table (modified from LRF method (Butler, 2020)):</p> <table border="1" data-bbox="699 286 1310 696"> <thead> <tr> <th>Cover as % of benchmark</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>&lt;10 %</td> <td>0</td> </tr> <tr> <td>10 – 50%</td> <td><math>ICS = 250 \times \frac{Score}{Reference} - 25</math></td> </tr> <tr> <td>51– 200%</td> <td>100</td> </tr> <tr> <td>201 -250 %</td> <td><math>ICS = -80 \times \frac{Score}{Reference} + 260</math></td> </tr> <tr> <td>&gt;250%</td> <td>60</td> </tr> </tbody> </table> <p>If benchmark is 0, then ICS is 'NA'</p>	Cover as % of benchmark	ICS (0-100)	<10 %	0	10 – 50%	$ICS = 250 \times \frac{Score}{Reference} - 25$	51– 200%	100	201 -250 %	$ICS = -80 \times \frac{Score}{Reference} + 260$	>250%	60
Cover as % of benchmark	ICS (0-100)													
<10 %	0													
10 – 50%	$ICS = 250 \times \frac{Score}{Reference} - 25$													
51– 200%	100													
201 -250 %	$ICS = -80 \times \frac{Score}{Reference} + 260$													
>250%	60													
<b>Counts</b>														
Native tree species density (mature tree stems/ha)	Quadrat	<p>An ICS will be calculated for the density of mature trees in accordance with table below:</p> <table border="1" data-bbox="699 913 1310 1350"> <thead> <tr> <th>Density as % of benchmark</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>&lt;10 %</td> <td>0</td> </tr> <tr> <td>&gt;10 – 50 %</td> <td><math>ICS = 250 \times \frac{Score}{Reference} - 25</math></td> </tr> <tr> <td>&gt;50 – 150%</td> <td>100</td> </tr> <tr> <td>&gt;150 - 250 %</td> <td><math>ICS = -40 \times \frac{Score}{Reference} + 140</math></td> </tr> <tr> <td>&gt;250%</td> <td>40</td> </tr> </tbody> </table> <p>If benchmark is 0, then ICS is 'NA'</p>	Density as % of benchmark	ICS (0-100)	<10 %	0	>10 – 50 %	$ICS = 250 \times \frac{Score}{Reference} - 25$	>50 – 150%	100	>150 - 250 %	$ICS = -40 \times \frac{Score}{Reference} + 140$	>250%	40
Density as % of benchmark	ICS (0-100)													
<10 %	0													
>10 – 50 %	$ICS = 250 \times \frac{Score}{Reference} - 25$													
>50 – 150%	100													
>150 - 250 %	$ICS = -40 \times \frac{Score}{Reference} + 140$													
>250%	40													
Native species count – canopy and shrub species (number)	Quadrat or Line Transect	<p>An ICS will be calculated for the count of canopy and shrub species in accordance with table below:</p> <table border="1" data-bbox="699 1503 1310 1720"> <thead> <tr> <th>Count as % of benchmark</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>≤80 %</td> <td><math>ICS = \frac{Score}{Reference} \times 125</math></td> </tr> <tr> <td>&gt;80%</td> <td>100</td> </tr> </tbody> </table> <p>If benchmark is 0, then ICS is 'NA'</p>	Count as % of benchmark	ICS (0-100)	≤80 %	$ICS = \frac{Score}{Reference} \times 125$	>80%	100						
Count as % of benchmark	ICS (0-100)													
≤80 %	$ICS = \frac{Score}{Reference} \times 125$													
>80%	100													

<p><b>Native species count – herbaceous species (number)</b></p>	<p>Quadrat(s)</p>	<p>An ICS will be calculated for the count of herbaceous species in accordance with table below:</p> <table border="1" data-bbox="699 293 1310 512"> <thead> <tr> <th>Count as % of benchmark</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>≤80 %</td> <td><math>ICS = \frac{Score}{Reference} \times 125</math></td> </tr> <tr> <td>&gt;80%</td> <td>100</td> </tr> </tbody> </table>	Count as % of benchmark	ICS (0-100)	≤80 %	$ICS = \frac{Score}{Reference} \times 125$	>80%	100				
Count as % of benchmark	ICS (0-100)											
≤80 %	$ICS = \frac{Score}{Reference} \times 125$											
>80%	100											
<p><b>Fallen timber &gt;100mm diameter (m/ha)</b></p>	<p>Quadrat(s)</p>	<p>An ICS will be calculated for the length of fallen logs (&gt;100mm diameter) in accordance with table below:</p> <table border="1" data-bbox="699 616 1310 976"> <thead> <tr> <th>Distance as % of benchmark</th> <th>ICS (0-100)</th> </tr> </thead> <tbody> <tr> <td>&lt;50%</td> <td><math>ICS = 200 \times \frac{Score}{Reference}</math></td> </tr> <tr> <td>&gt;50 - 150</td> <td>100</td> </tr> <tr> <td>&gt;150 - 250</td> <td><math>ICS = -40 \times \frac{Score}{Reference} + 160</math></td> </tr> <tr> <td>&gt;250</td> <td>60</td> </tr> </tbody> </table> <p>If benchmark is 0, then ICS is 'NA'</p>	Distance as % of benchmark	ICS (0-100)	<50%	$ICS = 200 \times \frac{Score}{Reference}$	>50 - 150	100	>150 - 250	$ICS = -40 \times \frac{Score}{Reference} + 160$	>250	60
Distance as % of benchmark	ICS (0-100)											
<50%	$ICS = 200 \times \frac{Score}{Reference}$											
>50 - 150	100											
>150 - 250	$ICS = -40 \times \frac{Score}{Reference} + 160$											
>250	60											

**Output of Step 6**

- A **Data Table** (e.g. a spreadsheet) containing all the data (including calculated Indicator Condition Scores)



## Step 7. Calculate the Econd®

The Econd® is an index between 0 and 100, where 100 describes the ‘ideal’ or ‘undisturbed’ reference condition of an environmental asset, and 0 indicates the asset is completely degraded. The Econd is calculated as the product of the Quantity (extent) times the Quality (composition and configuration). As the condition and type of native vegetation typically varies over an area, the Account must adequately express these differences. In the simplest example, if an area contained 50% intact native grassland, and 50% sown pastures (assumed to have an Econd of 0), then the highest Econd the Account can get is 50.

This Method prescribes instructions for calculating Econd indices for each Assessment unit, and then aggregating these into an Econd for each Conservation Target and then aggregating these into the overall Econd for the native vegetation Environmental Asset.

The following steps must be taken to calculate the Econd®:

1. First, an Econd index must be calculated for each **Assessment unit** (AU) by calculating the weighted average of the configuration ICS (weighted 25%) and the average of all composition ICS (weighted 75%).
2. Second, the **Conservation Target** (CT) Econd is calculated as the area-weighted average of the **Assessment unit** Econd.
  - a. *Note: Area weightings for Assessment units should be calculated as a proportion of the Assessment unit area (ha) to the total accounting area (ha). The sum of all Assessment units should equal the total accounting area. As an example, if a 1,000-ha reserve comprised only two Assessment units, one covering 800 ha and the other covering 200 ha, then the reserve Econd would be: (Econd AU1 x 0.8) + (Econd AU2 x 0.2).*
3. Lastly, the Econd for the native vegetation asset is calculated for the Account as a whole (i.e. project or reserve) as an area-weighted average of the **Conservation Target** Econd indices.

A worked example of how to organise your Environmental Account, and calculate the Assessment unit Econd, Conservation Target Econd, and overall Econd® is shown on the following page.

### Output of Step 7

- A **data table** (e.g. a spreadsheet) containing all the raw data for each indicator for each sample, including the calculations for the ICS and Econd®.
- A **summary table** showing the Econd® scores.

Worked Example – Native Vegetation Account									
Step 1 and 2:	Step 3:	Step 4:			Step 5:	Step 6:		Step 7:	
Conservation Target	Assessment unit	Indicator	Reference Benchmark Value	Average Measure	Indicator Condition Score (ICS)		Assessment unit Econd <sup>o</sup>	Conservation Target Econd <sup>o</sup>	Reserve Econd <sup>o</sup>
Grassy Woodlands	Previously grazed woodland	<b>Configuration</b> - site context (%)	100.0	50.0	<b>41.0</b>		<b>62.15</b> (Weighted average of composition (75%) and configuration (25%) ICS)  $= (69.2 * 0.75) + (41 * 0.25)$	<b>76.54</b> (Area-weighted average of Assessment Unit Econd <sup>o</sup> )  $= (62.15 * 0.53) + (92.75 * 0.47)$	<b>76.53</b> (Area weighted average of each Conservation Target Econd <sup>o</sup> )  $= (76.54 * 0.92) + (76.38 * 0.08)$
		Tree canopy height (m)	20	18	100	<b>69.2</b> (Average of all composition Indicators)			
		Native tree canopy health score (%)	5	3.45	69				
		Tree canopy cover (%)	15	11	100				
		Native shrub cover (%)	22	5	45				
		Non-native shrub / tree cover (%)	0	4	90				
		Native herbaceous cover (%)	75	47	63				
		Non-native herbaceous cover (%)	0	41	18				
		Organic litter ground cover (%)	20	18	100				
		Cryptogam cover (%)	5	2	75				
		Native tree density (stems/ha)	10	4	75				
		Native species count -shrubs + trees	12	4	42				
	Native species count -herbs	24	12	63					
	Fallen timber (m/ha)	300	90	60					
	Remnant woodland	<b>Configuration</b> - site context (%)	100.0	81.2	<b>90.2</b>		<b>92.75</b> (Weighted average of composition (75%) and configuration (25%) ICS)  $= (93.6 * 0.75) + (90.2 * 0.25)$	<b>76.54</b> (Area-weighted average of Assessment Unit Econd <sup>o</sup> )  $= (62.15 * 0.53) + (92.75 * 0.47)$	<b>76.53</b> (Area weighted average of each Conservation Target Econd <sup>o</sup> )  $= (76.54 * 0.92) + (76.38 * 0.08)$
		Tree canopy height (m)	20	22	100	<b>93.6</b> (Average of all composition Indicators)			
		Native tree canopy health score (%)	5	4.6	100				
		Tree canopy cover (%)	15	14	100				
		Native shrub cover (%)	22	16	100				
		Non-native shrub / tree cover (%)	0	2	95				
		Native herbaceous cover (%)	75	78	100				
		Non-native herbaceous cover (%)	0	15	70				
		Organic litter ground cover (%)	20	18	100				
		Cryptogam cover (%)	5	2	75				
Native tree density (stems/ha)		10	11	100					
Native species count -shrubs + trees		12	8	83					
Native species count -herbs	24	18	94						
Fallen timber (m/ha)	300	240	100						
Grasslands	Previously grazed grassland	<b>Configuration</b> - site context (%)	100.0	74.1	<b>82.6</b>		<b>74.3</b> (Average of all composition Indicators – excluding those naturally absent)	<b>76.38</b> (Weighted average of composition (75%) and configuration (25%) ICS)  $= (74.3 * 0.75) + (82.6 * 0.25)$	<b>76.38</b> (Area-weighted average of Assessment Unit Econd <sup>o</sup> )  $= (76.38 * 1.00)$
		Tree canopy height (m)	NA	NA	NA				
		Native tree canopy health score (%)	NA	NA	NA				
		Tree canopy cover (%)	NA	NA	NA				
		Native shrub cover (%)	10	6	100				
		Non-native shrub / tree cover (%)	0	NA	NA				
		Native herbaceous cover (%)	88	67	76				
		Non-native herbaceous cover (%)	0	26	48				
		Organic litter ground cover (%)	10	3	50				
		Cryptogam cover (%)	5	3	100				
		Native tree density (stems/ha)	NA	NA	NA				
		Native species count -shrubs + trees	5	2	50				
		Native species count -herbs	47	36	96				
		Fallen timber (m/ha)	NA	NA	NA				



AREA WEIGHTINGS			
Sub-asset	Assessment unit	Area	
		Total Area (ha)	Area Weighting
<b>Grassy Woodlands</b>		1435	<b>92%</b>
	Previously grazed woodland	760	<b>53%</b>
	Remnant woodland	675	<b>47%</b>
<b>Grasslands</b>		125	<b>8%</b>
	Previously grazed grassland	125	<b>100%</b>
<b>TOTAL</b>		<b>1560</b>	

INDICATOR WEIGHTING FOR ECOND®	
Configuration	25%
Composition	75%
<b>Total</b>	<b>100%</b>

### 3. Compile Environmental Account and submit for certification

Steps five to seven should be repeated at regular intervals (a minimum of every five years or where Base Year recalculation is required, as specified under the *Accounting for Nature* Framework) to establish a trend over time. Ideally, site surveys should occur annually, even if accounts are only certified once every five years.

For your account to be certified, it must be verified in accordance with the *Accounting for Nature*<sup>®</sup> *Standard*, which outlines the criteria that must be satisfied. An environmental account may incorporate multiple Environmental Assets, and always needs to include the following information:

- Environmental Account summary;
- Information Statement,
- Environmental Account; and;
- An **Audit Report** or **Self-verification Report** that verifies the account was prepared in accordance with the approved Methods, the AfN Standard and Audit Rules.
  - o An **Audit Report** is completed by an AfN Accredited Auditor and is required if you are seeking to have your account “Certified” (Tier 1); OR
  - o A **Self-verification Report** contains the results of your self-verification assessment and AfN’s technical Assessment and is required if you are seeking to have your account “Self-verified” (Tier 2).



## 4. References

Butler, D (2020). Land Restoration Fund Native Vegetation Condition Monitoring Method, Accounting for Nature Limited, Sydney, Australia

Butler, D. Thackway, R. and Cosier, P. (2020). Technical Protocol for Constructing Native Vegetation Condition Accounts Version 1.0 – May 2020. Accounting for Nature Limited, Sydney, Australia.

Eyre TJ, Kelly AL and Neldner VJ (2017). Method for the Establishment and Survey of Reference Sites for BioCondition. Version 3. Queensland Herbarium, Department of Science, Information Technology and Innovation, Brisbane.

NVIS Technical Working Group (2017) Australian Vegetation Attribute Manual: National Vegetation Information System, Version 7.0. Department of the Environment and Energy, Canberra. Prep by Bolton, M.P., deLacey, C. and Bossard, K.B. (Eds)

## Appendix A

### Glossary

Term	Definition
<b>Assessment unit</b>	Assessment units are homogenous units within the accounting area which determine where samples are to be taken. They do not have to be continuous, but rather, can be comprised of multiple small parts (so long as all parts of a single assessment unit have the same vegetation type and land use/management/condition).
<b>Composition</b>	The composition of native vegetation relates to its structure, function, and the assemblage of species.
<b>Configuration</b>	The configuration of native vegetation relates to the configuration of that area of native vegetation within the landscape, with regard to connectivity, context and patch size.
<b>Conservation Target</b>	The specific, tangible entities that each project team is working to conserve that represent and encompass the ultimate aims of the project (using AfN terminology, Conservation Target equates to a 'sub-asset').
<b>Econd®</b>	An index between 0 and 100 that describes the condition of an environmental asset where 0 means the asset is completely degraded, and 100 means the asset is in pristine condition.
<b>Extent</b>	The extent refers to the area of native vegetation within the accounting area.
<b>Indicator Condition Score</b>	In general terms, the Indicator Condition Score (ICS) is a proportion of the observed value compared to the Reference Benchmark value. However, the formulas for calculating this can vary considerably between indicators—some incorporate weightings and conditional clauses to reflect the ecological thresholds associated with some vegetation attributes.
<b>Native plant</b>	A native plant is any plant that naturally occurs within the vegetation type pre-1750.
<b>Reference Benchmark</b>	The Reference Benchmark is the condition of the Conservation Target in an 'undegraded' state. For example, a vegetation community that has not experienced any negative impacts as a result of disturbance, edge effects, invasive species, or altered management regimes (e.g. fire) would be considered to exist in an 'undegraded' or 'ideal' state.
<b>Remnant</b>	Areas are deemed 'remnant' if the relevant State-based vegetation map (or on-ground assessment) categories a polygon as a native vegetation mapping unit (i.e. not cleared land, agricultural land, infrastructure etc).

## Appendix B.

### Sources of State-based mapping and reference benchmarks (based on each States' Condition Assessment Framework)

Table B1. Summary of vegetation mapping in each State and Territory

State	Vegetation Mapping	Link	Data name and source
ACT	Vegetation Communities	<a href="https://actmapi-actgov.opendata.arcgis.com/datasets/act-vegetation-map-2018">https://actmapi-actgov.opendata.arcgis.com/datasets/act-vegetation-map-2018</a>	ACT Vegetation Map Data provided by the ACT Government.
NSW	NSW Plant Community Types	<a href="https://datasets.seed.nsw.gov.au/dataset/nsw-bionet-vegetation-map-catalogue-collection36515">https://datasets.seed.nsw.gov.au/dataset/nsw-bionet-vegetation-map-catalogue-collection36515</a>	NSW Bionet Vegetation Map Data Collection Data by State Government of NSW and Department of Planning, Industry and Environment.
NT	Vegetation Associations (Uses NVIS framework)	<a href="https://nrmaps.nt.gov.au/nrmaps.html">https://nrmaps.nt.gov.au/nrmaps.html</a> (online map) <a href="https://denr.nt.gov.au/land-resource-management/info-systems/natural-resource-maps/spatial-data-requests">https://denr.nt.gov.au/land-resource-management/info-systems/natural-resource-maps/spatial-data-requests</a> (geospatial data catalogue)	No state-wide vegetation mapping download available (as of December 2021), although various vegetation resource surveys are available. Otherwise the latest version of NVIS should be used
QLD	Regional Ecosystems	<a href="http://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={22E1BC4E-BDFA-470A-AED8-04F38B4FCFC3}">http://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={22E1BC4E-BDFA-470A-AED8-04F38B4FCFC3}</a>	Biodiversity Status of Pre-clearing Regional Ecosystems – Queensland Data by State Government of Queensland and Department of Environment and Science.
SA	Floristic Groups (uses NVIS framework)	<a href="https://data.environment.sa.gov.au/NatureMaps">https://data.environment.sa.gov.au/NatureMaps</a> (online map)	No state-wide vegetation mapping available to download (as of December 2021). Online mapping available or the latest version of NVIS can be used.
TAS	Vegetation Communities	<a href="http://www.dpipwe.tas.gov.au/tasveg">www.dpipwe.tas.gov.au/tasveg</a>	TASVEG- the Digital Vegetation Map of Tasmania Data can be provided by the Tasmanian Government by contacting the Geodata Client Services Section of the Information and Land Services Division, Department of Primary Industries, Parks, Water and Environment.
VIC	Ecological Vegetation Classes	<a href="https://discover.data.vic.gov.au/dataset/native-vegetation-modelled-1750-ecological-vegetation-classes">https://discover.data.vic.gov.au/dataset/native-vegetation-modelled-1750-ecological-vegetation-classes</a> (downloadable data) <a href="https://www.environment.vic.gov.au/biodiversity/naturekit">https://www.environment.vic.gov.au/biodiversity/naturekit</a> (online map)	Native Vegetation – Modelled 1750 and Ecological Vegetation Classes Data by the Victorian Government and Department of Environment, Land, Water and Planning
WA	Vegetation Associations	<a href="https://catalogue.data.wa.gov.au/dataset/pre-european-dpird-006">https://catalogue.data.wa.gov.au/dataset/pre-european-dpird-006</a>	Pre-European Vegetation
Australia Wide	Major Vegetation Groups and Sub-groups	<a href="https://www.environment.gov.au/and/native-vegetation/national-vegetation-information-system/data-products#mvg51">https://www.environment.gov.au/and/native-vegetation/national-vegetation-information-system/data-products#mvg51</a>	National Vegetation Information System Data by Commonwealth of Australia.



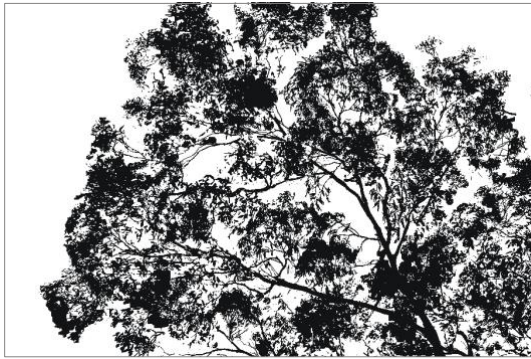
Table B2. Summary of published composition benchmark documentation for each State and Territory

State	Composition Benchmarks	Link
ACT	Vegetation Benchmarks Database	<a href="https://www.environment.act.gov.au/_data/assets/excel_doc/0004/719122/Vegetation-Benchmarks-Database.xls">https://www.environment.act.gov.au/_data/assets/excel_doc/0004/719122/Vegetation-Benchmarks-Database.xls</a>
NSW	BioNet Vegetation Condition Benchmarks	<a href="https://www.environment.nsw.gov.au/topics/animals-and-plants/native-vegetation/vegetation-condition-benchmarks">https://www.environment.nsw.gov.au/topics/animals-and-plants/native-vegetation/vegetation-condition-benchmarks</a>
NT	Not available	-
QLD	BioCondition Benchmarks	<a href="https://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks%23benchmarks">https://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks%23benchmarks</a>
SA	Native Vegetation Council (NVC) Bushland Assessment Manual	<a href="https://www.environment.sa.gov.au/topics/native-vegetation/clearing/vegetation-assessments">https://www.environment.sa.gov.au/topics/native-vegetation/clearing/vegetation-assessments</a>
TAS	TasVeg Vegetation Condition Assessment	<a href="https://dpiwve.tas.gov.au/conservation/development-planning-conservation-assessment/planning-tools/monitoring-and-mapping-tasmanias-vegetation-(tasveg)/vegetation-monitoring-in-tasmania">https://dpiwve.tas.gov.au/conservation/development-planning-conservation-assessment/planning-tools/monitoring-and-mapping-tasmanias-vegetation-(tasveg)/vegetation-monitoring-in-tasmania</a>
VIC	Bioregions and EVC Benchmarks	<a href="https://www.environment.vic.gov.au/biodiversity/bioregions-and-evc-benchmarks">https://www.environment.vic.gov.au/biodiversity/bioregions-and-evc-benchmarks</a>
WA	Not available	-
Australia Wide	Not available	NB. NVIS descriptions could contain some broad benchmark information.

## Appendix C.

Tree Health - Proportion of expected healthy cover present.

*(Diagram taken from Department of Sustainability and Environment (Victoria) Vegetation Quality Field Assessment Sheet, Appendix 4)*



Proportion of healthy canopy cover present : 100%



Proportion of healthy canopy cover present : 45%



Proportion of healthy canopy cover present : 75%



Proportion of healthy canopy cover present : 30%



Proportion of healthy canopy cover present : 65%



Proportion of healthy canopy cover present : 20%



Proportion of healthy canopy cover present : 55%



Proportion of healthy canopy cover present : 10%

## Appendix D.

### Excel formulas for Indicator Condition Scores

In the below formulas:

**OBS** = Observed value

**REF** = Reference Benchmark Value

Tree height	=IF(REF=0,"NA",IF((OBS/REF)<0.1,0,IF((OBS/REF)<0.19,8,IF((OBS/REF)<0.29,25,IF((OBS/REF)<0.39,41,IF((OBS/REF)<0.49,58,IF((OBS/REF)<0.59,76,IF((OBS/REF)<=0.69,93,100))))))))))
Native tree canopy health score	=IF((OBS/REF)<1,(OBS/REF)*100,100)
Tree Canopy cover	=IF((OBS/REF)<=0.49,200*(OBS/REF),IF((OBS/REF)<=1.5,100,IF((OBS/REF)<=2.5,-40*(OBS/REF)+140,40)))
Native shrub cover	=IF((OBS/REF)<=0.1,0,IF((OBS/REF)<=0.49,200*(OBS/REF),IF((OBS/REF)<=2,100,IF((OBS/REF)<=2.5,-40*(OBS/REF)+180,60))))
Non-native shrub / tree cover	=IF((OBS/REF)<=0.5,100-(200*(OBS/REF)),0)
Native herbaceous cover	=IF((OBS/REF)<1,(OBS/REF)*100,100)
Non-native herbaceous cover	=IF((OBS/REF)<=0.5,100-(OBS/REF)*200,0)
Organic litter ground cover	=IF((OBS/REF)<=0.1,0,IF((OBS/REF)<=0.5,250*(OBS/REF)-25,IF((OBS/REF)<=2,100,IF((OBS/REF)<=2.5,-80*(OBS/REF)+260,60))))
Cryptogam cover	=IF((OBS/REF)<=0.1,0,IF((OBS/REF)<=0.5,250*(OBS/REF)-25,IF((OBS/REF)<=2,100,IF((OBS/REF)<=2.5,-80*(OBS/REF)+260,60))))

Native tree density	=IF((OBS/REF)<=0.1,0,IF((OBS/REF)<=0.5,250*(OBS/REF)-25,IF((OBS/REF)<=1.5,100,IF((OBS/REF)<=2.5,-40*(OBS/REF)+160,50))))
Native species count –shrubs and trees	=IF((OBS/REF)<=0.8,(OBS/REF)*125,100)
Native species count - herbs	=IF((OBS/REF)<=0.8,(OBS/REF)*125,100)
Fallen timber	=IF((OBS/REF)<=0.49,200*(OBS/REF),IF((OBS/REF)<=1.5,100,IF((OBS/REF)<=2.5,-40*(OBS/REF)+160,60)))