Method to assess the productive and environmental condition of permanent perennial pastures throughout Australia

DOCUMENT DETAILS

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Method to assess the productive and environmental condition of permanent perennial pastures throughout Australia

A methodology for producers and graziers across Australia to measure and track the change in productive and environmental condition of permanent perennial pastures

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Version

Version	Date	Description	Author	Approver
1.0	2021-08-26	Review by Standards and Accreditation Committee	Chrissy Elmer	Standards and Accreditation Committee
1.1	2021-12-02	Update sample size and extent	Chrissy Elmer	Standards and Accreditation Committee
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1. Introduction

Grazing land condition (as defined by the Queensland Department of Agriculture, Fisheries and Forestry, 2013) describes the current capacity of land to respond to rain and grow pasture. It measures how well the ecosystem functions by demonstrating how much of the lands 'potential productivity' is converted to 'actual productivity.' Therefore, the objective of assessing Production Condition (Pcond) is to assess the quality, quantity, dependability, and sustainability of livestock forage production.

Many graziers are wanting to monitor both the environmental and productive condition of their land. This Method aims to provide scientifically robust and verified metrics of environmental and productive condition of grazing land to understand the potential environmental co-benefits and the trade-offs associated with using land for grazing. As an example, in a relatively un-modified native perennial pasture system, the productive and environmental condition might both be high, compared to a sown perennial pasture system that uses exotic pasture species, where the Pcond might be high while the Econd® might be low. While this Method does not include species richness as an indicator, it does assess species composition at a higher level by including the cover of native and non-native species as indicators. Therefore, this Method can be used to help understand the environmental and productive trade-offs of native vs exotic pastures. Identifying the trade-offs between productive and environmental condition can help inform land management decision relating to landscape regeneration. The Method can also help to better understand how to manage resources and can be used to both monitor and support claims surrounding the productive and environmental condition of properties.

This Method takes concepts from the Meat and Livestock Australia, Grazing Land Condition Scorecard system as well as the Queensland Governments Land Condition Assessment Tool (LCAT), to assess the productive condition of grazing land, and incorporates simplified metrics from the Queensland BioCondition Assessment framework to assess the environmental condition of permanent perennial pastures. This method has been developed to assess the condition at the project or property scale (i.e. within grazing paddocks) and is targeted at landholders and producers with grazing land.

1.1. Aim and Scope of this Method

Purpose	This Method is developed for farmers and graziers to assess the productive and environmental condition as measured by the Pcond and Econd® of permanent perennial pastures throughout Australia and track the change in condition over time. By measuring both the Econd® and Pcond, farmers and graziers can identify and understand trade-offs between environmental and productive condition and monitor how the environmental and productive condition can change over time under management.
Data Collection	Field sampling, remote sensing, and GIS Analyses.
Application	This Method can be applied to permanent perennial pastures anywhere in Australia.
Scale	Project or property scale (If property, the productive condition indicators do not need to be measured for land use other than permanent perennial pastures).
Target Audience	Farmers and Graziers.
Decisions to inform	To inform management practices and to report long term changes in condition.
Confidence Level/s	Level 3 (Moderate) *A **Level 3 (Moderate)** confidence level would apply to Methods that have a limited set of indicators and are likely to have high accuracy (≥80%) when measuring the condition of environmental assets and the change in their condition through time.*

1.2. Justification of Confidence Level

This method has been developed by drawing on a number of published and established methods. To assess Productive Condition, the method has referred to the QLD Governments LCAT, as well as the MLA Grazing Land Condition Scorecard. By incorporating aspects from both assessment tools, this method presents a scientifically rigorous, easy to use productive condition assessment framework that is designed to be quick and easy to implement by landholders.

To assess environmental condition, this method takes the indicators and sample design outlined in the approved Accounting for Nature and Landcare Native Vegetation Method (Accredited by the Standards and Accreditation Committee on the 8th of February 2021).

Therefore, as this method has been designed to be cost, time and resource efficient, while still providing moderately accurate condition results, it is considered to comply with the Accounting for Nature Confidence Level 3.
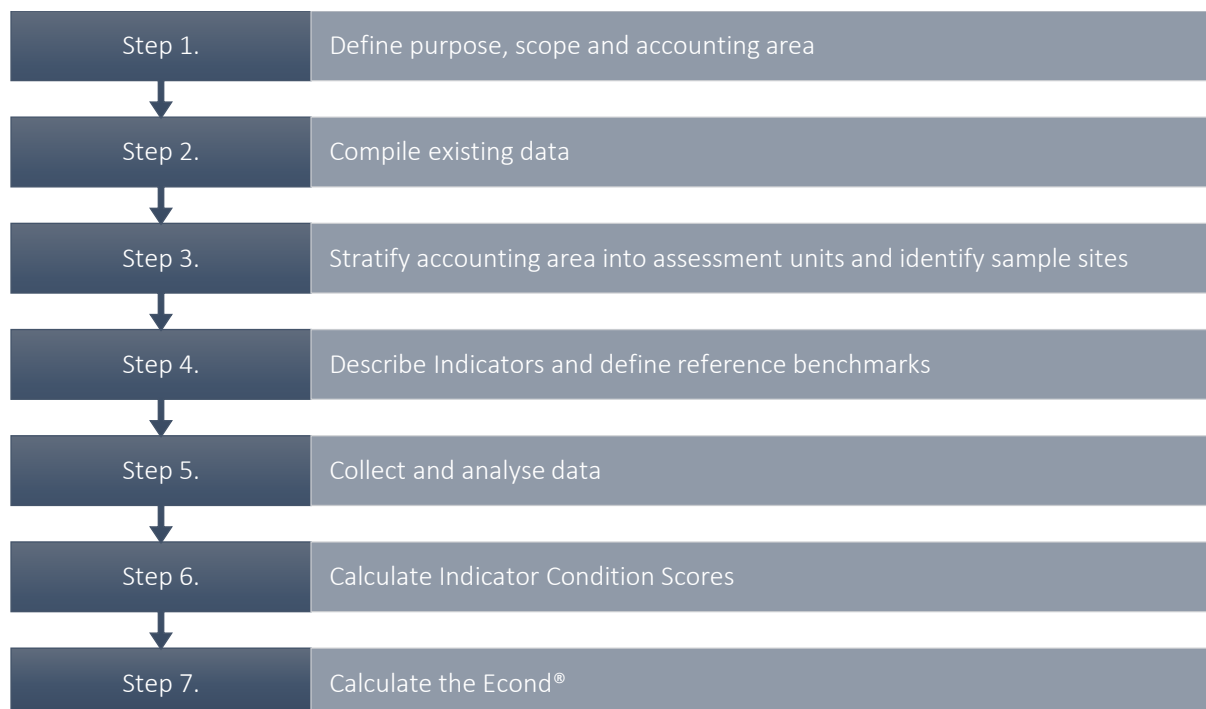
1.3. What an Environmental account looks like

The *Accounting for Nature®* Framework requires accounts to be comprised of four listed key components 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®.
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** or **Self Verification Report** that verifies the Account was prepared in accordance with the approved Methods, the *AfN Standard* and *AfN Audit rules*.
   - 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
   - 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).

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:

Step 1.	Define purpose, scope and accounting area
Step 2.	Compile existing data
Step 3.	Stratify accounting area into assessment units and identify sample sites
Step 4.	Describe Indicators and define reference benchmarks
Step 5.	Collect and analyse data
Step 6.	Calculate Indicator Condition Scores
Step 7.	Calculate the Econd®

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 informs all subsequent decisions associated with the Account. The purpose of the Account should be clear enough to provide context for third parties or the general public viewing the Account. For example, this level 3 Method is suitable for farmers wanting to develop an Environmental Account to measure production and environmental condition and track change over time, to better understand and inform management of their land.
Account Type:	Describe the type of account: - *Snapshot* – a one-off assessment of condition of native vegetation - *Change over time* – an ongoing annual assessment of the change of environmental condition 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 should encompass all grazing paddocks within a property or selection of properties. *NB. The accounting area must stay the same for the lifespan of the account. If the accounting area changes (such as a new area to be added, or an area to be removed), then a new account must be developed, or the account must be 're-set' and started again with the new accounting area.*

> **Output of Step 1 – describe the location, purpose, and scope of the Account**
>
> - 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

Step 2.   Compile existing data

Data collection – vegetation mapping (extent and type)

Download relevant State Mapping for the accounting area (refer to Appendix B, for where to find the mapping). The mapping layers should include:

- Current native vegetation extent, ideally separate younger regrowth from more mature or intact vegetation
- Pre-clearing or historic vegetation mapping indicating the type of vegetation the land would support

Local Landcare, regional NRM groups, or State Herbarium or Environment Departments should be able to assist with this. These groups may also be able to assist in states with no vegetation mapping. In the absence of state-based mapping, federal vegetation mapping under the National Vegetation Information System (NVIS) may be used.

Sub-assets

In the context of native vegetation, **sub-assets** describe the different vegetation types or communities that comprise the 'native vegetation environmental asset'. The pre-clear state vegetation mapping is to be used to identify the sub-assets contained within the accounting area. Broader Vegetation Mapping may be used for larger properties (e.g. Broad Vegetation Group in QLD). The selection of vegetation classification should be appropriate for the intended purpose of the accounts and consider the size of the accounting area and practical considerations associated with monitoring

In addition to the mapping, most State Department websites provide detailed descriptions of each vegetation type mapped within the accounting area. Using these descriptions, the vegetation types mapped within the accounting area should be ground-truthed to confirm the mapping is appropriate and accurate.

Management Unit Map

You will also need to generate a map of the management units across the accounting area, such as a property map of various paddocks or management areas (eg. cattle grazing, mixed grazing, remnant vegetation). The management units do not have to be continuous, but rather, can be comprised of multiple smaller parts, for example if you have multiple paddocks under the same management, you may choose to label them all as the same management unit. Consider how precise you want to be with this map as each paddock/management unit prescribed will receive its own Econd® and Pcond index, but more units will require more monitoring.

To do so, generate a map of the accounting area that identifies areas, such as paddocks that fall into different land use/management zones, or broad condition state categories (e.g. remnant bushland, ungrazed regrowth, grazed regrowth). When determining different land-uses it is important to consider the purpose of the account and how each land-use interacts with vegetation condition.

If the accounting area contains land-uses that are intensively cultivated or dominated by infrastructure, or are expected to never have native 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® of 0 for these assessment units, and support with photos).

Other land-uses, such as paddocks with pastures, young woody regrowth that are targets for restoration, or any area that is destined to become native vegetation (e.g. through plantings or regeneration) or expected to score higher than 0 for condition, should also be identified and included so that the resultant assessment units can each be sampled to determine an Econd® and track its change over time (even if it is very low in the first year of the account).

Materiality is an important to consideration when determining land-uses – i.e. if there is a paddock that contains a 10 m wide tree line along the edge, then it is generally not necessary to separate the tree line as an independent land-use category.

Output of Step 2 – Compile existing data, identify vegetation types, generate a map of management units.

- A map, table, and description of pre-clear vegetation types within the Accounting Area
- A map, table, and description of the accounting area – delineated by paddocks or management units.

Step 3.　　　Stratify the accounting area and identify sampling sites

Stratify the accounting area

Generate 'assessment units' by combining the management unit map with the state vegetation mapping. Assessment units are homogenous units with a common pre-clearing vegetation type, in the same broad condition state (e.g. pasture, regrowth, native woodland) within the same management unit, which means that one management unit may have multiple assessment units depending on the underlying vegetation type and the range of condition states it contains. Assessment units determine where samples are to be taken.

Remember, assessment units 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 underlying pre-clear vegetation type and are located within a single management unit).

If appropriate, assessment units that are smaller than 1ha may be merged with larger assessment units, provided they are all within the same vegetation community and have an overall similar broad condition state regardless of land use. This excludes assessment units that have been pre-assigned an Econd® of 0.

Select sample sites

Once your assessment units have been defined, permanent sample sites must be established within them. **Table 1** prescribes how to select and establish sample sites within each assessment unit. Of note, the Pcond does not need to be measured in every assessment unit – but rather only those that are considered 'productive'. However, every assessment unit must receive an Econd® (either assigned 0 or measured).

If broader vegetation mapping has been used to generate assessment units (e.g. BVG in QLD), then the lowest level of vegetation classification will need to be determined for each site (e.g. RE in QLD), to determine the relevant reference benchmarks for that site.

Note. Any assessment units that have land-use/broad condition states that are intensively cultivated or dominated by infrastructure, or where land-use change is not materially affecting vegetation condition, it is fair to assume the condition of these areas is 0, and they are not required to be sampled in (i.e. automatically assign an Econd of 0 in Step 7, and support with photos in the Information Statement).

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

Sample	Implementation
Number of sites per assessment unit	At least one permanent sample site is to be established per 5 ha within each assessment unit, up to a maximum of 5 samples within assessment units that exceed 25 ha (however, you can choose to do more sample sites if needed).

Sample	Implementation
Site selection	Sites within each assessment unit should be located to represent the paddock they are assessing (e.g. they should not be located within dense clumps of retained woody vegetation within a paddock that is predominantly cleared). If there are multiple patches comprising one assessment unit, you can choose to establish a sample site within each patch to increase the precision of data and understand condition within each individual patch. For ease of access, sampling sites may be preferentially located within 200 m of an access-track, but where reasonable, should be located further than 50 m from infrastructure or 'edges' such as roads, dams, and clumps of vegetation.
Site establishment	The central coordinates of each sample site should be recorded, and a labelled star picket should be permanently installed at this location (refer to Step 5 for further details on establishing the permanent monitoring sites). It is recommended to use phone apps such as Google Maps, WildTracker or Avenza to help locate sites in the field.
Timing	Field sampling should be undertaken at roughly the same time each year to minimise the possible effects of seasonal variability. Efforts should be made to assess condition at the **end of the dry season at a minimum,** as this is generally when indicators would be at their lowest, but more frequent sampling (such as at the end of the dry season and wet season) is supported.

Output of Step 3 – Mapping of assessment units

- A map and table showing the assessment units (paddocks/management units intersected with vegetation mapping) of the accounting area
- A map and table with central coordinates of each **sample site** within the accounting area.

Describe environmental indicators and determine reference benchmarks

Indicators

The Native Vegetation Technical Protocol (Butler et al, 2020) states that **indicators** for assessing the condition of vegetation must represent the following three indicator classes: extent, configuration, and composition.

Extent	*Only applicable in calculation of the Econd®*
	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, and therefore within the entire accounting area. Therefore, extent is captured through the stratification process and in Step 7 – where all assessment unit Econd® scores (including those that are assigned an Econd® of 0) are aggregated into a sub-asset Econd® using **area weighted averages**, and the sub-asset Econd® is then aggregated into an overall Econd® score using **area weighted averages**. Refer to step 7 for more details.
Configuration	*Only applicable in calculation of the Econd®*
	The **configuration** of native vegetation relates to the positioning of a specific area of native vegetation within the landscape with regard to its connectivity, context and patch size. In this Method, the configuration indicator is site context, which is measured as the percent of retained remnant vegetation within a 1 km radius of each sample site.
Composition	*Applicable for both Econd® and Pcond*
	The **composition** of vegetation relates to its structure, function and the assemblage of species. Composition will be assessed primarily through remote sensing and simple field measurements.

The composition indicators for the Pcond are based on the Grazing Land Management – Grazing BMP self-assessment indicators of land condition, while the Econd® indicators are based on the approved Landcare and AfN Native Vegetation Method (Level 3, approved 8 February 2021). The indicators are summarised below in **Table 2.**

Table 2. Summary of Composition Indicators for each of the Pcond and Econd® for Vegetation within Grazing Land. All indicators are measured independently.

Indicator Group	Description	Pcond Indicator	Related Econd® Indicator (follows L3 Native Veg Method)
Forage/Grass Cover	3P species (Palatable, Productive and Perennial) are the most important for pastural systems because they have the highest efficiency water use and nutrient cycling. Being perennial, they do not die off quickly and therefore help protect the soil from drying out and eroding. *All accounts must list what species they consider 3P species in their Information Statement and include a source that supports the decision.*	% Cover of 3P Species (Native and non-native)	% Cover of native perennial grass
		Diversity of Palatable Species	
Ground Cover	Ground cover includes any organic material (dead and alive grasses, forbs, low shrubs, cryptograms and leaf litter). High ground cover reduces the risk of erosion and loss of nutrients and water. *Ground-cover recommendations indicate the ideal level of ground cover at the end of the dry season.*	% Organic Ground Cover	% Litter Cover
		Erosion	
Presence of weeds	Weeds can outcompete pasture plants for nutrients and water. Weeds also indicate low land condition as they generally exploit disturbed and bare areas.	% Unpalatable plant cover	% Non-native plant Cover (including exotic forage species)
Woody Cover	Woody plants are important structural components of ecosystems, including agro-ecosystems. They provide shade, shelter and resources for wildlife and stock. They can promote water infiltration and nutrient cycling in grazing land, but also compete with pastures and may reduce forage production and affect carrying capacity for domestic stock. Woody thickening and shrub encroachment reduce productive condition of grazing land, thereby reducing the Pcond. In contrast, in previously cleared country woody thickening may increase the Econd®. Woody thickening is measured on a categorical scale as this allows the score to be assigned based on the underlying ecosystem type.	Woody Thickening	% Tree Cover
			% Sub-canopy Cover
			% Shrub Cover
Height	Height is an important indicator of overstorey condition for the Econd® calculation.	NA	Tree Height
			Sub-canopy Height

Reference Benchmarks

The key difference between the Econd® and the Pcond, is that the **Reference Benchmarks of the Pcond** are based on the maximum potential of the grazing land to optimise productive output, while the **Reference Benchmarks of the Econd®** are based on their natural "undegraded" or "best on offer" condition.

Pcond Reference Benchmark

The Pcond Reference Benchmark values are the optimal values that are expected to maximise productive output of the grazing land. However, these values will be heavily dependent on the grazing system (i.e. the region/location of the account, the livestock, the underlying vegetation type, and system and climate). The values can generally be guided by the BMP Grazing Score-card figures, which are also supplemented with the recommendations in the MLA Grazing land Management – Sustainable and productive natural resource management booklet and Ogilvy et al, in review. Landholders are encouraged to seek assistance in determining appropriate Pcond Reference Benchmarks for their land-type, for example, local Landcare, NRM groups and/or Government Primary Industries/Agriculture Departments may be able to assist or provide resources that will help with determining appropriate Reference Benchmark values for the Pcond Indicators.

Once appropriate Reference Benchmark values for the Pcond Indicators are identified, they may be used for all subsequent years of the account, where appropriate. If the grazing system changes (i.e. new livestock, with different palatability preferences), then new Reference Benchmarks may need to be determined.

In areas particularly prone to climatic variability where some Indicator Condition Scores are expected to vary due to rainfall or drought, it is strongly encouraged that **Dynamic Reference Benchmarks** are used to control for the variation in indicators due to climatic variables, such as rainfall. Dynamic Reference Benchmarks may also be useful in areas prone to natural disturbance such as areas that are prone to burning. For some indicators, Dynamic Reference Benchmarks can be determined using remote sensing (Bastin et al., 2012).

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

Econd® Reference Benchmark

Most states, with the exception of Western Australia and Northern Territory, have published Vegetation Condition Benchmark documents that correspond to the lowest level of vegetation community mapping (e.g. Regional Ecosystem in QLD, Plant Community Types in NSW; refer to **Appendix B**) and can be used to estimate this Reference Condition. In the absence of published Reference Condition Benchmark documentation, it is recommended that the state government (e.g. Herbariums), local NRM or Landcare groups are consulted to determine whether they have any draft or unpublished Reference Condition Benchmark data.

Alternatively, if there are no existing benchmark data available, then 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 Condition Benchmark sites. It should be noted that Reference Condition Benchmarks only need to be determined once, at the start of the account, unless a **Dynamic Reference Benchmark** is used. However, if new information is learned about the Reference Benchmark, they may be updated accordingly.

In areas particularly prone to climatic variability where some Indicator Condition Scores are expected to vary due to rainfall or drought, it is strongly encouraged that instead of using published benchmarks, local Reference Benchmark Condition sites are established. This is a type of **Dynamic Reference Benchmark** and can be used to control for the variation in indicators due to climatic variables, such as rainfall. Dynamic Reference Benchmarks may also be useful in areas prone to natural disturbance such as areas that are prone to burning. For some indicators, Dynamic Reference Benchmarks can be determined using remote sensing (Bastin et al., 2012).

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

The source of the Reference Benchmark for each Indicator is summarised below in **Table 3 and Table 4.**

Table 3. Summary of composition vegetation indicators and Reference Benchmarks for the Econd®

Indicator Group	Pcond Indicator Measurement Method	Pcond Reference Benchmark	Related Econd® Indicator (from L3 Native Veg or Soil Method) Measurement Method	Econd® Reference Benchmark
Forage/ Grass Cover	% Cover of 3P Species (Native and non-native)	The ideal % cover of 3P plants depends on the location of the farm (in general it will be 90% but may be lower in more arid regions) and is to be determined by the account developer.	% Cover of native perennial grass	The Reference Benchmark for the Econd® is derived from the relevant State's condition assessment framework or by establishing local 'best on offer' Reference Condition Benchmark sites.
	Diversity of Palatable Species	The ideal diversity of palatable depends on the location of the farm and is to be determined by the account developer.		
Ground Cover	% Total Ground Cover	The ideal % Total ground cover depends on the location of the farm (in general it will be 80% but may be lower in more arid regions) and is to be determined by the account developer.	% Litter Cover	The Reference Benchmark for the Econd® is derived from the relevant State's condition assessment framework or by establishing local 'best on offer' Reference Condition Benchmark sites.
	Erosion	No Erosion		
Presence of weeds	% Unpalatable plant cover	0%	% Non-native plant Cover (including exotic forage species)	0%
Woody Cover	Woody Thickening	No Woody Thickening	% Tree Cover	The Reference Benchmark for the Econd® is derived from the relevant State's condition assessment framework or by establishing local 'best on offer' Reference Condition Benchmark sites.
			% Sub-canopy Cover	
			% Shrub Cover	
Height	NA	NA	Tree Height	The Reference Benchmark for the Econd® is derived from the relevant State's condition assessment framework or by establishing local 'best on offer' Reference Condition Benchmark sites.
			Sub-canopy Height	

Table 4. Configuration Reference Benchmarks for calculating the Econd®

Indicator Class	Indicator	Reference Benchmark
Configuration	**Indicator assessed with GIS** - Context (%)	The reference condition of context will be measured as the pre-clear extent of vegetation within 1 km of each sample site (assumed to be 100 %).

Output of Step 4 – Understand indicators and reference benchmarks

- 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 underlying vegetation type.

Step 5.   Collect and analyse data

Data collection for the Environmental Account involves both data collection in the field (i.e. field measurements), and desktop analyses (using remote sensing, such as CSIRO Vegmachine for groundcover and GIS). Prior to collecting field data, permanent monitoring sites must be established at each sample site, refer to **Figure 1,** below.

If a landholder wishes to conduct the field assessment themselves but are not confident with the below indicators (particularly the identification of native perennial and 3P decreaser grasses), it is recommended that they contact their local Landcare group or local NRM group to assist with the first few sampling rounds. You can find your local Landcare group here: https://landcareaustralia.org.au/landcare-get-involved/findagroup/?postcode=. You can find your local NRM group here: https://www.nrmrq.org.au/find-your-regional-group/.

Establishing a permanent monitoring site

A permanent monitoring site ensures that data is collected from the same location each monitoring round, which is a way of controlling for spatial variation. This ensures that results are consistent and comparable from year to year. To establish a permanent monitoring site you will need **a 1.8 m star picket** and a **50 m transect tape**. A star picket is to be installed at the sample site coordinates and a 50 m transect run.

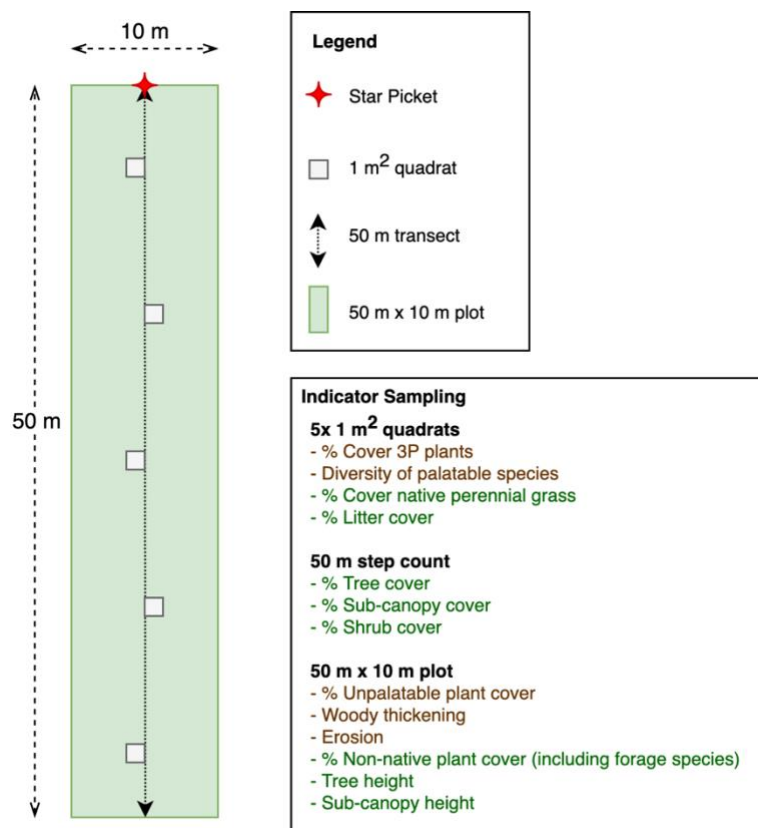The sampling is to be conducted in accordance with Figure 1.

Figure 1. Diagram of permanent monitoring site to be established at each sampling site. Remember sample sites should be established at least 100 m from an edge, refer to Table 1 for details.

Within each sampling site, the indicators summarised in Table 5 are to be measured according to the outlined sampling technique.

Table 5. Summary of sampling areas to measure indicators in the field

5x 1 m² quadrats	
Pcond Indicators	• % Cover of 3P Species • Diversity of Palatable Species
Econd Indicators	• % Cover Native Perennial grass • % Litter Cover
50 m step count	
Econd Indicators	• % Tree Cover • % Sub-Canopy Cover • % Shrub Cover
50 x 10 m plot	
Pcond Indicators	• % Unpalatable Plant Cover • Woody Thickening • Erosion
Econd Indicators	• Tree Height • Sub-canopy Height • % Non-native Plant Cover (including exotic forage species)

Field Sampling methodology

Specific guidance on how to estimate composition indicators in the field are explained in Appendix D.

1. Start at the sites star picket and run a 50 m transect out from the star picket.
2. Take the following photos:
   - Take a landscape photo at the start of the transect, looking towards the transect, with the horizon and transect tape in the centre of the image.
   - Take a canopy photo (landscape orientation) looking up by resting the camera/smart phone on the star picket.
3. Walk along the transect, visualising 5 m either side (i.e. a 50 x 10 m plot) and estimate the following:
   - Non-native plant cover (two estimates, one that includes exotic forage species, and one that excludes exotic forage species),
   - The amount of woody thickening
   - The degree of erosion evident
   - Tree and sub-canopy height
4. Every 10 m set up a 1 m² quadrat. Take a photo (landscape orientation) of each quadrat (standing on the transect and looking down). Estimate the following:
   - % Litter Cover

- % Cover 3P Species (and a list of 3P species)
- Diversity of Palatable Species (record species in a list)
- % Native Perennial grasses

5. Walk back along the transect and estimate the tree, sub-canopy and shrub cover using the step-count method (refer to Appendix D).

The Erosion indicator and Woody Thickening indicator for the Pcond are both scored on an ordinal scale, in accordance with the below descriptions adapted from the Best Management Practices for Maintaining and Improving Land Condition on Grazing Lands (Department of Agriculture and Fisheries, 2017), refer to Table 6 and Table 7.

Table 6. Summary of scoring for Pcond Indicators of Erosion

Score	Degree of Erosion
1	No sign or only early signs of erosion
2	Some signs of previous erosion and potential for current erosion in some areas
3	Obvious signs of erosion with current susceptibility to erosion high
4	High degree of erosion
5	Severe erosion with evident gullying

Table 7. Summary of scoring for Pcond Indicators of Woody Thickening

Score	Degree of Woody Thickening compared to underlying ecosystem type
1	No sign or only early signs of woody thickening
2	Some thickening in density of woody plants
3	General thickening in density of woody plants
4	Thickets of woody plants cover most of the area
5	Thickets of woody plants cover all of the area

Desktop/remote sensing analyses

The desktop analyses for **total ground cover,** and **configuration** can be completed before or after the field work.

Total ground-cover assessments for each assessment unit should be carried out using remote sensing imagery (total ground cover = green fractional cover + brown fractional cover). The CSIRO VegMachine (2021) is recommended, however there are a range of other sources, such as TERN's fractional cover mapping. The monthly ground-cover values for each assessment unit should be averaged to give an annual average ground-cover value which should be used in the Indicator Condition Scoring (Step 6 and Step 7).

The **configuration** analyses can be conducted using the following data layers/mapping:

- Aerial/satellite imagery
- Assessment units (generated in Step 3)
- Sample sites (generated in Step 3)
- State Remnant/Regrowth Vegetation Mapping (if available)
- State Pre-clear vegetation Mapping (if available)

If relevant layers are not available, contact your local Landcare group and/or regional NRM body for advice and assistance.

Refer to **Appendix C** for details on how to conduct these analyses for **configuration**.

Output of Step 5 – Collect Data

- A **data table** (e.g. a spreadsheet) containing all the measured data for each environmental indicator for each sample
- A **folder** (preferably stored on the cloud) containing all photographs appropriately labelled according to the sample.

Step 6.	Calculate Indicator Condition Scores

In general terms the 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.

Where assessment units were generated with the lowest level of vegetation classification (e.g. in QLD RE or in NSW Plant Community types), the composition values measured across all sites within a single assessment unit should be averaged, and these averaged values used to calculate the ICS.

Where a higher level of vegetation classification was used to generate assessment units (e.g. BVG in QLD), then ICS will need to be calculated for each site and the ICS for each indicator then aggregated to give average assessment unit ICS – refer to BVG worked example.

Pcond Indicator Condition Scores

Table 8 summarises the Indicator Condition Scoring for the Pcond Indicators. Values associated with an ICS of 100 indicate the Reference Benchmark for the Pcond, or the ideal value for maximum productivity.

Table 8. Summary of scoring for Pcond Indicators Condition Scores

Indicator Group	Indicator	Pcond ICS
Forage plants (The Pcond does not require differentiation of native vs non-native species)	• % Cover of 3P Species	<table><tr><th>3P Plant Cover</th><th>ICS</th></tr><tr><td>If cover$_{OBS}$ ≥ cover$_{REF}$</td><td>100</td></tr><tr><td>If cover$_{OBS}$ < cover$_{REF}$</td><td>$100 * \frac{\% \text{ Cover}_{OBS}}{\% \text{ Cover}_{REF}}$</td></tr></table>
	• Diversity of Palatable Species	<table><tr><th>Diversity of Palatable Species</th><th>ICS</th></tr><tr><td>If diversity$_{OBS}$ ≥ diversity$_{REF}$</td><td>100</td></tr><tr><td>If diversity$_{OBS}$ < diversity$_{REF}$</td><td>$100 * \frac{\text{Diversity}_{OBS}}{\text{Diversity}_{REF}}$</td></tr></table>
Ground Cover	• % Total Ground Cover	The ground-cover ICS has been adapted from the Landcare Soil Method (accredited February 2021). <table><tr><th>Cover (as % of benchmark)</th><th>ICS</th></tr><tr><td>>95%</td><td>100</td></tr><tr><td>90-94%</td><td>90</td></tr><tr><td>80-89%</td><td>80</td></tr><tr><td>70-79%</td><td>60</td></tr></table>

Indicator Group	Indicator	Pcond ICS		

		60-69%	40
		50-59%	20
		<50%	0

	• Degree of Erosion	Score	Degree of Erosion	ICS
		1	No sign or only early signs of erosion	100
		2	Some signs of previous erosion and potential for current erosion in some areas	70
		3	Obvious signs of erosion with current susceptibility to erosion high	40
		4	High degree of erosion	10
		5	Severe erosion with evident gullying	0

Presence of weeds	• % Unpalatable plant Cover	% Unpalatable plant cover	ICS
		0 %	100
		1 − 5%	75
		6 − 15 %	50
		16 − 30 %	20
		31 − 60%	10
		>61 %	0

Woody Cover	• Woody Thickening	Score	Degree of Erosion	ICS
		1	No sign or only early signs of woody thickening	100
		2	Some thickening in the density of woody plants	70
		3	General thickening in density of woody plants	40
		4	Thickets of woody plants cover most of the area	10
		5	Thickets of woody plants cover all of the area	0

Econd® Indicator Condition Scores

Configuration indicator

The methods used to calculate the Indicator Condition Scores for configuration indicators are explained in Table 9.

Table 9. Summary of how to calculate Indicator Condition Scores for configuration indicators

Indicator	Indicator Condition Score (ICS)
Context (%)	The ICS for Context is calculated as the percentage of native vegetation cover within a 1 km radius of the central coordinate (star picket) of the sampling sites. It is calculated using GIS For example, a 57% cover of native vegetation within a 1km radius of the sample site, gives an ICS for Context of 57.

Composition indicators

Table 10 summarises the Indicator Condition Scoring for the Econd® Indicators. Values associated with an ICS of 100 indicate the Reference Benchmark for the Econd®.

Table 10. Summary of how to calculate Indicator Condition Scores for Composition indicators

Indicator Group	Indicator	Econd ICS
Grass Cover	• Native Perennial Grass Cover	The Econd is concerned with only Native perennial grasses. **Cover (as % of benchmark)** / **ICS** ≤100% : $ICS = \dfrac{Score}{Reference} \times 100$ >100% : 100
Ground cover	• % Litter Cover	An ICS will be calculated for organic litter cover in accordance with below table (simplified from LRF Method (Butler, 2020)): **Cover (as % of benchmark)** / **ICS** <10 % : 0 10- 50% : $ICS = 250 \cdot \dfrac{Score}{Reference} - 25$ 51 -200 % : 100 201- 250% : $ICS = -80 \cdot \dfrac{Score}{Reference} + 260$ >250% : 60

Indicator Group	Indicator	Econd ICS
Presence of weeds	• % Non-native plant Cover (including exotic forage species)	The Econd® only requires the % non-native plant cover including 3P grasses:
Tree and Shrub Cover	• % Tree cover • % Sub-canopy Cover	An ICS will be calculated for the cover of trees and sub-canopy in accordance with below table (simplified from LRF Method (Butler, 2020)):
	• % Shrub Cover	An ICS will be calculated for the cover of trees and sub-canopy in accordance with below table (simplified from LRF Method (Butler, 2020)):

Presence of weeds table:

% Non-native plant cover (including exotic forage species)	ICS
0 %	100
1 – 5%	75
6 – 15 %	50
16 – 30 %	20
31 – 60%	10
>61 %	0

Tree and Sub-canopy cover table:

Cover (as % of benchmark)	ICS
0 – 49 %	$ICS = 200 \cdot \dfrac{Score}{Reference}$
50 – 150%	100
151 -200 %	$ICS = -40 \cdot \dfrac{Score}{Reference} + 140$
>200%	60

Shrub cover table:

Cover (as % of benchmark)	ICS
<10%	0
10 – 49 %	$ICS = 200 \cdot \dfrac{Score}{Reference}$
50 – 200%	100
201 -250 %	$ICS = -40 \cdot \dfrac{Score}{Reference} + 160$
>250%	60

Indicator Group	Indicator	Econd ICS	
Height	• Tree height • Sub-canopy Height	**Height (as % of benchmark)**	**ICS**
		<10 %	0
		10 – 19%	8
		20 – 29%	25
		30 – 39%	41
		40 – 49%	58
		50 – 59%	76
		60 – 69%	93
		≥70%	100

Output of Step 6 – Indicator Condition Scores

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

Step 7. Calculate the Econd® and Pcond

As this Method is focussed on land management and production of grazing lands, the Method allows for aggregation of the Econd® and Pcond at the management unit/paddock level or the sub-asset or vegetation type. Using the former, a Pcond and Econd® score is generated specific to each paddock/management unit so that change in each individual paddock/management unit production and environmental condition can be tracked over time.

Calculating the Pcond

The Pcond, similar to the Econd®, is an index that describes the productive condition of land. In the context of this Method, a Pcond of 100 represents that the land is at maximum production potential, while a Pcond of 0 represents a completely unproductive landscape.

Calculating the Pcond involves the same steps as the Econd® and includes the following steps.

1. First, an Pcond index must be calculated for each **assessment unit** by calculating the average of all Pcond composition ICS.
2. Next, the **sub-asset** Pcond is calculated with the area-weighted average of the **assessment unit** Pcond.
   - *Note: Area weightings for assessment units should be calculated as a proportion of the assessment unit area (ha) to the total accounting area (ha). Remember, the sum of all assessment units should equal the total accounting area.*

   - *Note. You may choose to also aggregate to the **management unit** level, which would give a Pcond score for each Management unit, and therefore help you compare productive condition between management units.*

3. Next, the Pcond for the grazing land is calculated for the account as a whole as an area-weighted average of the **sub-asset** Pcond indices.

Calculating 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 for all assessment units, whereas the Pcond only needs to be calculated in 'productive' assessment units.

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. Next, calculate the **sub-asset Econd®** as the area weighted average of the assessment unit Econd scores, being sure to include **ALL assessment units even those that were assigned 0** (area weighting is critical as it accounts for the <u>extent</u>/size of each assessment unit)

   - *Note: Area weightings for assessment units should be calculated as a proportion of the assessment unit area (ha) to the total accounting area (ha). Remember, the sum of all assessment units should equal the total accounting area. As an example, if a 1,000 ha property comprised two assessment units, one covering 800 ha and the other covering 200 ha, then the property Econd® would be: (Econd® AU1 x 0.8) + (Econd® AU2 x 0.2)*

   - *Note. You may choose to also aggregate to the **management unit** level, which would give a Econd® score for each Management unit, and therefore help you compare environmental condition between management units.*

3. Next, the Econd® for the native vegetation asset is calculated for the Account as a whole (i.e. project or property) as an area-weighted average of the **sub-asset** Econd® indices.

A worked example of how to organise your Environmental Account, and calculate the assessment unit Econd® and Pcond, sub-asset Econd® and Pcond, and overall Econd® and Pcond is included in Appendix G - Worked Example.

Output of Step 7 – Calculate the Pcond and Econd®

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

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, because the purpose of the account is to detect change and the more frequently you measure the condition the more easily you can detect change.

An Environmental Account may incorporate multiple Environmental Assets, and always needs to include the following information:

- Information Statement and Environmental Account Summary,
- Environmental Account (including raw data tables), and;
- An **Audit Report** or **Self Verification Report** that verifies the Account was prepared in accordance with the approved Methods, the *AfN Standard* and *AfN Audit rules*.

    - 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
    - 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).

If you wish for your account to be 'certified,' it must be verified in accordance with the *Accounting for Nature®* Standard, which outlines the criteria that must be satisfied. The benefit of having an account certified is that AfN allows you to display the Certified Account logo and you are able to make public claims about your account. AfN Certified accounts require the Environmental Account Summary and Information Statement to be made publicly available.

4. References

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Appendix A. Glossary

Table A1. Summary of key words

Term	Definition
Assessment unit	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).
Composition	The composition of native vegetation relates to its structure, function and the assemblage of species.
Configuration	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.
Econd®	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.
Indicator Condition Score	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.
Native plant	A native species is considered to be any plant that naturally occurs within the pre-clear vegetation type.
Pcond	An index between 0 and 100 that describes the productive condition of an asset, where 0 means the asset is completely unproductive, and 100 means the asset is producing its maximum output.
Perennial	A plant which lives for 3 or more years
Reference Benchmark	The Reference Benchmark is the condition of the native vegetation sub-asset 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.
Remnant	**Woody vegetation** is deemed remnant where the dominant canopy has greater than 70 % of the height and 50 % of the cover relative to the undisturbed height and canopy of that vegetation type and is comprised of species characteristic of that vegetation's undisturbed canopy. **Non-woody vegetation** is deemed remnant where there is no evidence of disturbance in the last 15 years, and the species composition reflects the vegetation type.

Table A2. Summary of Econd® Indicators (definitions derived from Eyre et al, 2015).

Indicator	Definition
Non-native plant cover	Non-native plants include exotic or introduced plant species and **includes all species that do not naturally occur within the pre-clear vegetation type**. Non-native plant cover is assessed within a ~10 m quadrat using Braun-Blanquet Cover Scores.
Canopy height and cover	The canopy refers to the layer formed collectively by the crowns of adjacent trees, it usually refers to the Ecologically Dominant Layer (the EDL), refer to Figure A1, below. The canopy height is estimated as the median height of the canopy, while the canopy cover, is the percent cover of **living native canopy trees**, estimated using the step count method, refer to Appendix D.
Sub-canopy height and cover	The sub-canopy sits below the canopy, refer to Figure A1. The sub-canopy height should be estimated as the median height of the sub-canopy, while the sub-canopy cover, is the percent cover of **living native sub-canopy trees**, estimated using the step count method, refer to Appendix D.
Shrub cover	Shrubs are woody plants that are multi-stemmed from the base or within 20 cm of the ground level), or if single stemmed, less than 2 m tall. Shrub cover refers to the percent cover (estimated using the step count method) of **living native shrubs**.
Organic litter ground cover	Organic litter cover includes both fine and coarse organic material such as fallen leaves, twigs, and branches <10 cm in diameter. It does not include rocks. Organic litter cover is estimated from a ~1m quadrat.
Native perennial grass cover	Native perennial grasses include any native perennial plant in the family *Poaceae,* including tussock and hummock grasses (but not including grass-like forbs or graminoids). Native perennial grass cover is estimated from a ~1m quadrat.
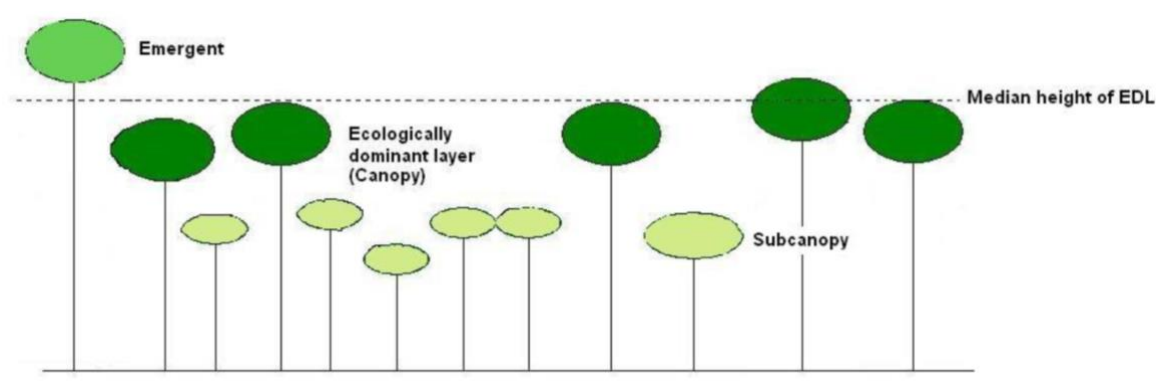
Figure A1. *A depiction of the canopy and sub-canopy strata in an ecosystem (Eyre et al (2015).*

Eyre, T.J., Kelly, A.L, Neldner, V.J., Wilson, B.A., Ferguson, D.J., Laidlaw, M.J. and Franks, A.J. (2015). BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2. Queensland Herbarium, Department of Science, Information Technology, Innovation and Arts, Brisbane

Table A3. Summary of Pcond Indicators

Indicator	Definition
Cover of 3P Species	3P species (Palatable, Productive and Perennial) are the most important for pastural systems because they have the highest efficiency water use and nutrient cycling. Being perennial, they do not die off quickly and therefore help protect the soil from drying out and eroding. *All accounts must list what species they consider 3P species in their Information Statement and include a source that supports the decision.*
Diversity of palatable species	Palatable species are those considered to be preferentially grazed by livestock. *All accounts must list what species they include in their palatable species list in their Information Statement and include a source that supports the decision.*
Total ground cover	Ground cover includes any organic material (dead and alive grasses, forbs, low shrubs, cryptograms and leaf litter). High ground cover reduces the risk of erosion and loss of nutrients and water. Total Ground Cover is estimated for an Assessment unit each month, which is then averaged to give an Average Total Ground-cover for the reporting year.
Unpalatable plant cover	Weeds can outcompete pasture plants for nutrients and water. Weeds also indicate low land condition as they generally exploit disturbed and bare areas. In the context of the Pcond, a weed is an unpalatable or nuisance plant. Unpalatable plant cover is assessed within a 50 x 10 m plot.
Woody Cover	Woody plants are important structural components of ecosystems, including agro-ecosystems. They provide shade, shelter and resources for wildlife and stock. They can promote water infiltration and nutrient cycling in grazing land, but also compete with pastures and may reduce forage production and affect carrying capacity for domestic stock. Woody thickening and shrub encroachment reduce.

Appendix B. Overview of sources of State mapping and Reference Benchmarks (based on States' Condition Assessment Frameworks)

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

State	Vegetation Mapping	Link
ACT	Vegetation Communities	ACT Vegetation Map 2018 https://actmapi-actgov.opendata.arcgis.com/datasets/act-vegetation-map-2018 Data provided by the ACT Government, 2018.
NSW	NSW Plant Community Types	NSW Bionet Vegetation Map Data Collection https://datasets.seed.nsw.gov.au/dataset/nsw-bionet-vegetation-map-catalogue-collection36515 Data provided by State Government of NSW and Department of Planning, Industry and Environment, 2016.
NT	Vegetation Associations (Uses NVIS framework)	No state-wide vegetation mapping download product available (as of November 2020), although various vegetation resource surveys are available, otherwise NVIS v 5.1 data should be used. https://nrmaps.nt.gov.au/nrmaps.html (online map) https://denr.nt.gov.au/land-resource-management/info-systems/natural-resource-maps/spatial-data-requests (geospatial data catalogue)
QLD	Regional Ecosystems	Biodiversity Status of Pre-clearing Regional Ecosystems – Queensland (v11) http://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={22E1BC4E-BDFA-470A-AED8-04F38B4FCFC3} Data provided by State Government of Queensland and Department of Environment and Science 2018.
SA	Floristic Groups (uses NVIS framework)	No vegetation mapping download product available (as of November 2020). Online mapping available (see below), otherwise NVIS v5.1 data should be used. https://data.environment.sa.gov.au/NatureMaps (online map)
TAS	Vegetation Communities	TASVEG- the Digital Vegetation Map of Tasmania (v3.0) www.dpipwe.tas.gov.au/tasveg Data able to 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	Native Vegetation – Modelled 1750 and Ecological Vegetation Classes https://discover.data.vic.gov.au/dataset/native-vegetation-modelled-1750-ecological-vegetation-classes Data provided by the Victorian Government and Department of Environment, Land, Water and Planning, 2020 https://www.environment.vic.gov.au/biodiversity/naturekit (online map)
WA	Vegetation Associations	Pre-European Vegetation https://catalogue.data.wa.gov.au/dataset/pre-european-dpird-006
Australia Wide	Major Vegetation Groups and Sub-groups	National Vegetation Information System (v5.1) https://www.environment.gov.au/land/native-vegetation/national-vegetation-information-system/data-products#mvg51 Data provided by Commonwealth of Australia, 2018.

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

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

Appendix C. How to conduct the spatial analyses for configuration

Configuration

Configuration is measured as the site context. Site context is taken to be the percent of retained remnant vegetation within a 1 km radius of each sample site. It is calculated by adding a 1 km radial buffer around each sample site and then calculating the area of retained remnant vegetation within that buffer. The area of retained vegetation is then divided by the total area of the circle to give the % site context.
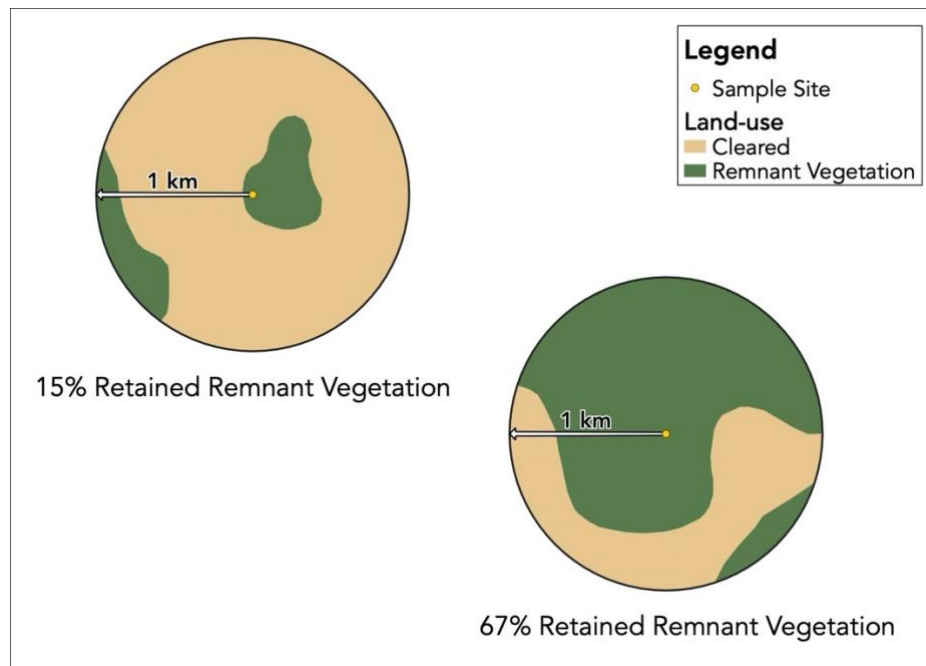
Figure C1. A visualisation of how the configuration indicator site context (%) is calculated.

Appendix D. How to collect composition field measures

Tree height

Stick or pencil method (requires two people)

1. Select a tree that represents the average height of the strata you are assessing (canopy/sub-canopy)
2. Prepare a stick about 30 – 40 cm long (a 20 cm ruler would also suffice) and mark the stick at a point 10% of its length, this is the 'bottom' of the stick (e.g. if the stick is 30 cm long, mark it 3 cm from one edge)
3. Hold the stick vertically at full arm's length. Line up the bottom of the tree with the bottom of the stick (or if using a ruler, at 0 cm), and the top of the tree with the top of the stick (or if using a ruler, at 30 cm).
4. Have your colleague stand by the tree and measure from the ground up to the point where the 10 % mark aligns on the tree (or the 3 cm mark on a ruler). You will need to direct your colleague to ensure the 10 % mark on the tree is correct
5. As the mark on the stick was 10 % of the total length, the mark on the tree is also 10 % of the total tree height, therefore multiple the measured distance on the tree by 10 to get the total tree height.
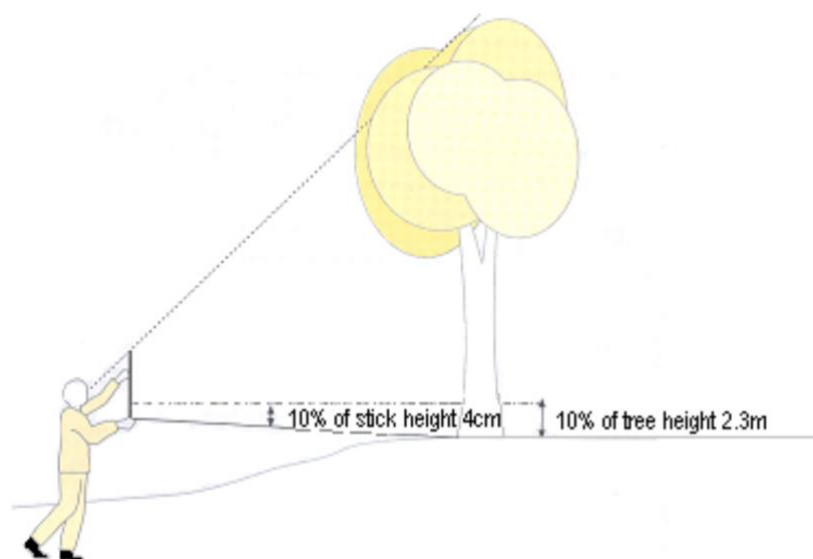
Method by

Eyre, T.J., Kelly, A.L, Neldner, V.J., Wilson, B.A., Ferguson, D.J., Laidlaw, M.J. and Franks, A.J. (2015). BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2. Queensland Herbarium, Department of Science, Information Technology, Innovation and Arts, Brisbane

And adapted from

Abed, T., and Stephens, N.C. (2002*). Tree measurement manual for farm foresters - Practical guidelines for farm foresters undertaking basic inventory in farm forest plantation stands*. National Forest Inventory, BRS, Canberra.

Tree height

Clinometer method

1. Select a tree that represents the average height of the strata you are assessing (canopy/sub-canopy)
2. Start at the base of the tree, and walk outwards, counting your steps (approx. 1 m) until you can see the top of the tree. **= Distance**
3. Look through the clinometer, and line up the horizontal line with the top of the tree, record the angle (in degrees on the left, do not use percent) = $\boldsymbol{\theta_{top}}$
4. Line up the horizontal line in the clinometer with the base of the tree and record the angle (in degrees). = $\boldsymbol{\theta_{base}}$
5. Calculate the height of the tree:

- If your **eyes** are **in-line with or above** the base of the tree:

$$Height_{above} = \frac{Distance \cdot \sin(\boldsymbol{\theta_{top}} + \boldsymbol{\theta_{base}})}{\sin(90 - \boldsymbol{\theta_{top}})}$$
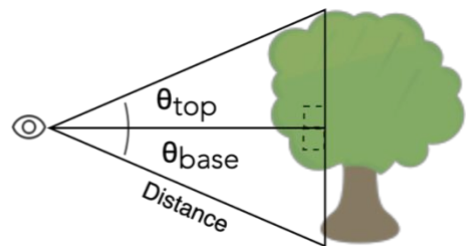
- If your **eyes** are **below** the base of the tree:

$$Height_{below} = \frac{Distance \cdot \sin(\boldsymbol{\theta_{top}} - \boldsymbol{\theta_{base}})}{\sin(90 - \boldsymbol{\theta_{top}})}$$
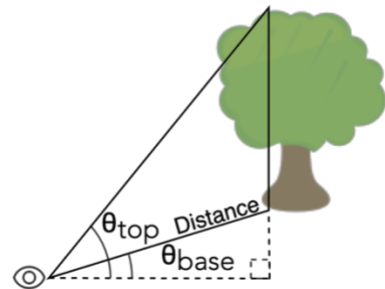
NB. It is recommended to simply record the three measurements and automatically generate height in an excel spreadsheet using the following formulas (the excel 'SIN' function requires values in radians):

$Height_{above}$ = ({Distance}*SIN(RADIANS({θ_{top}} + {θ_{base}}))/SIN(RADIANS(90-{θ_{top}})))

$Height_{below}$ = ({Distance}*SIN(RADIANS({θ_{top}} - {θ_{base}}))/SIN(RADIANS(90-{θ_{top}})))

Method adapted from

Eyre, T.J., Kelly, A.L, Neldner, V.J., Wilson, B.A., Ferguson, D.J., Laidlaw, M.J. and Franks, A.J. (2015). BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2. Queensland Herbarium, Department of Science, Information Technology, Innovation and Arts, Brisbane

Abed, T., and Stephens, N.C. (2002*). Tree measurement manual for farm foresters - Practical guidelines for farm foresters undertaking basic inventory in farm forest plantation stands*. National Forest Inventory, BRS, Canberra.)

Canopy and sub-canopy cover (also optional for shrub cover)

Cover will be estimated in the field, as it can be extremely hard to estimate from photos. A simplified step-count method has been implemented, see below. This example shows 30 steps; however, the Method requires a **50 m step count.**

1. Start at the star picket
2. Face south and slowly step (approx. 1 m) forward.
3. At each step, look straight up and record whether or not you are under a canopy and/or sub-canopy by ticking the relevant box in the example data table below.
4. Transform each score into a percent.
   - For example, if you recorded 15 out of 50 steps under canopy. Then 15/50 = 30% canopy cover for this site.

Strata	Step																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Canopy																														
Sub-Canopy																														
Shrub																														
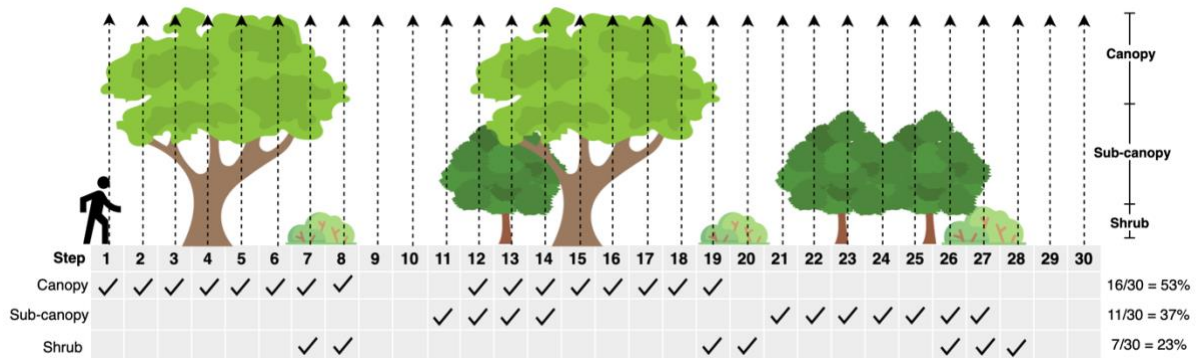
Icon source: Flaticon.com

1 m quadrat – ground-cover estimates

1. Every 10 m along the 50 m transect, use a 1 m quadrat, 1 m stick, or stand with your legs approximately 1 m wide to help visualise a 1 m quadrat.
2. Within that 1 m quadrat individually estimate the percent cover of ground-cover indicators. It is encouraged to round estimates to the nearest five or ten, to improve consistency.
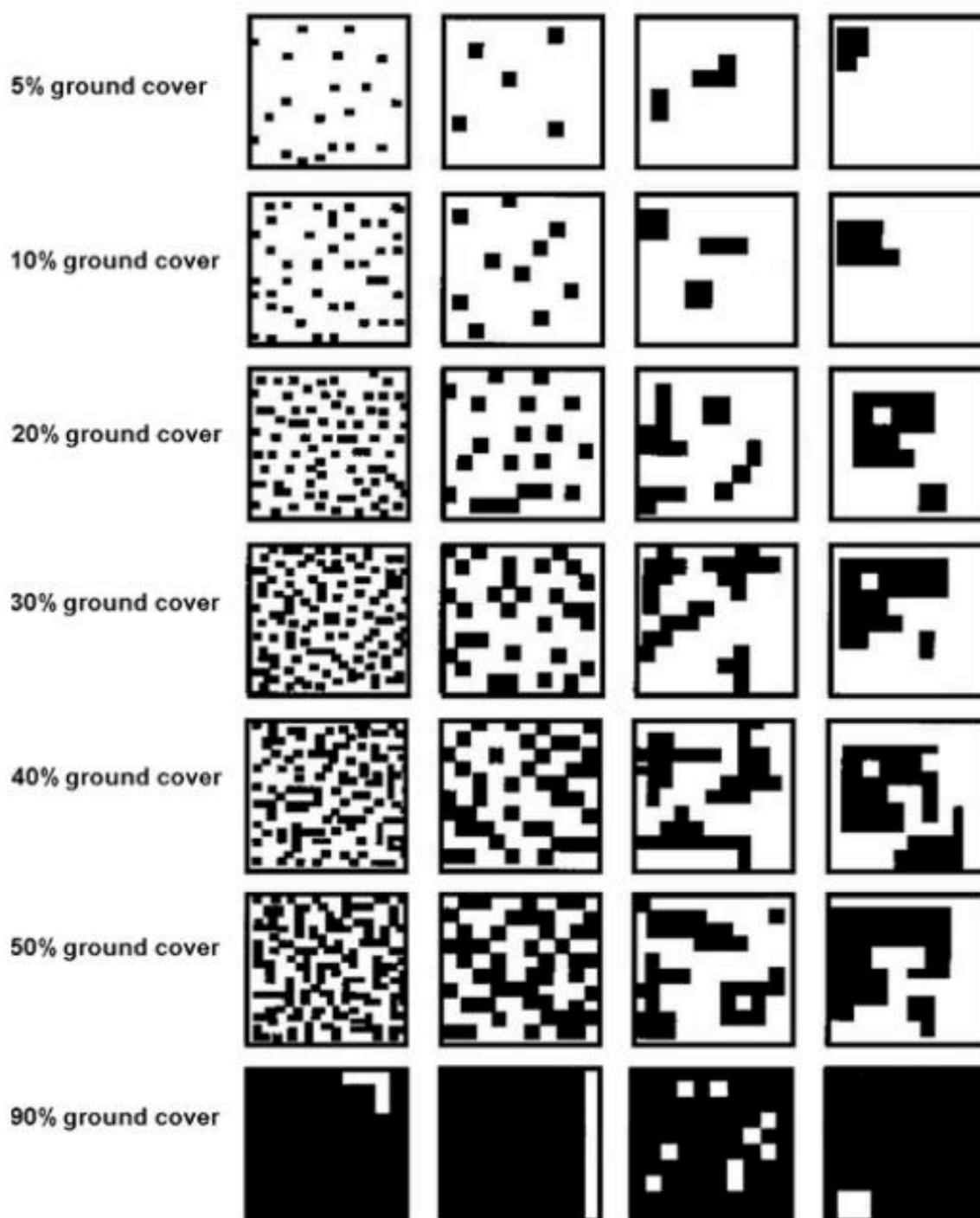
Figure D1. Stylised Guide to help with assessing ground-cover in a 1 m quadrat. (Source: Eyre, et al. 2015)

50x10 m plot - Non-native plant cover

Non-native plant cover is estimated the same way as outlined in the Queensland BioCondition Manual (Eyre et al. 2015). For the Econd® non-native plant cover is the percentage cover of the total vegetation cover that is comprised of exotic and non-indigenous species, assessed within the 50 x 10 m plot. Where there are non-native plants present in more than one layer, such as grass in the ground layer and shrub in the shrub layer, then the cover in each layer is added together. The benchmark for non-native plant cover for any vegetation community is zero. Non-native plant cover for the Pcond is assessed in the same way, but non-native forage plants are not included in the estimate of non-native plant cover.

Appendix E. Excel formulas for Indicator Condition Scores

Econd® Indicator Condition Score Formulae

In the below formulas:

OBS = Observed value

REF = Reference Benchmark Value

Non-native plant cover	=IF(OBS >60, 0, IF(OBS >30, 10, IF(OBS >15, 20, IF(OBS >5, 50, IF(OBS >=1, 75, 0)))))
Canopy cover	=IF(REF=0,"NA",IF((OBS/REF)<=0.49,200*(OBS/REF),IF((OBS/REF)<=1.5,100,IF((OBS/REF)<=2,-40*(OBS/REF)+140,60))))
Sub-Canopy cover	=IF(REF=0,"NA",IF((OBS/REF)<=0.49,200*(OBS/REF),IF((OBS/REF)<=1.5,100,IF((OBS/REF)<=2,-40*(OBS/REF)+140,60))))
Shrub cover	**For Woody Ecosystems:** =IF(REF=0,"NA",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)+160,60))))) **For Grasslands:** =IF(REF=0,((IF(OBS=0,100,IF((OBS/1)<=0.1,0,IF((OBS/1)<=0.49,200*(OBS/1),IF((OBS/1)<=2,100,IF((OBS/1)<=2.5,-40*(OBS/1)+160,60)))))),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)+160,60))))) **Combined Formula:** =IF(CANOPY COVER REF<>0,IF(REF=0,"NA",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)+160,60)))))),IF(REF=0,IF(OBS=0,100,IF((OBS/1)<=0.1,0,IF((OBS/1)<=0.49,200*(OBS/1),IF((OBS/1)<=2,100,IF((OBS/1)<=2.5,-40*(OBS/1)+160,60)))))),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)+160,60))))))
Litter cover	=IF(REF=0,"NA",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 perennial grass cover	=IF(REF=0,"NA",IF((OBS/REF)<1,(OBS/REF)*100,100))
Canopy 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)<=0.69,41,100))))))))
Sub-canopy 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)<=0.69,41,100))))))))

Pcond Indicator Condition Score Formulae

In the below formulas:

OBS = Observed value

REF = Reference Benchmark Value

Cover of 3P Species	=IF(OBS >= REF, 100, OBS / REF *100)
Diversity of 3P Species	=IF(OBS >= REF, 100, OBS / REF *100)
Total Organic Ground Cover	=IF(OBS/REF<0.5,0,IF(OBS/REF<=0.59,20,IF(OBS/REF<=0.69,40,IF(OBS/REF<=0.79,60, IF(OBS/REF <=0.89,80,IF(OBS/REF<=0.94,90,100))))))
Erosion	=IF(OBS=5, 0, IF(OBS=4, 10, IF(OBS =3, 40, IF(OBS =2, 70, IF(OBS =1, 100)))))
Unpalatable Plant Cover	=IF(OBS >60, 0, IF(OBS >30, 10, IF(OBS >15, 20, IF(OBS >5, 50, IF(OBS >=1, 75, 0)))))
Woody Thickening	=IF(OBS=5, 0, IF(OBS=4, 10, IF(OBS =3, 40, IF(OBS =2, 70, IF(OBS =1, 100)))))

Appendix F. Example data collection table

Date		Assessors	
Assessment unit			
Reference Vegetation Type (eg. RE, EVC etc)			
Photos ID			
Comments/Observations			

Score	Degree of Erosion
1	No sign or only early signs of erosion
2	Some signs of previous erosion and potential for current erosion in some areas
3	Obvious signs of erosion with current susceptibility to erosion high
4	High degree of erosion
5	Severe erosion with evident gullying

Score	Degree of Woody Thickening compared to underlying ecosystem type
1	No sign or only early signs of woody thickening
2	Some thickening in density of woody plants
3	General thickening in density of woody plants
4	Thickets of woody plants cover most of the area
5	Thickets of woody plants cover all of the area

Sample Area	Indicator	Reference Value	Site ID: Lat/long (North Star Picket):	Site ID: Lat/long (North Star Picket):	Average
50 m step count	Canopy cover (%)				
	Sub-canopy cover (%)				
	Shrub cover (%)				
50 m x 10 m plot	Unpalatable plant cover (%)				
	Erosion (Score)				
	Woody Thickening (Score)				
	Econd Non-native plant cover (%)				
	Canopy height (m)				
	Sub-canopy height (m)				
1 m quadrat	Cover 3P Plants				
	Diversity Palatable Species				
	Organic litter ground cover (%)				
	Native perennial grass cover (%)				

Appendix G. Monitoring site establishment

Legend

✦ Star Picket

▫ 1 m² quadrat

↕ 50 m transect

▮ 50 m x 10 m plot

Indicator Sampling

5x 1 m² quadrats
- % Cover 3P plants
- Diversity of palatable species
- % Cover native perennial grass
- % Litter cover

50 m step count
- % Tree cover
- % Sub-canopy cover
- % Shrub cover

50 m x 10 m plot
- % Unpalatable plant cover
- Woody thickening
- Erosion
- % Non-native plant cover (including forage species)
- Tree height
- Sub-canopy height

Appendix F. Worked Examples

The worked example is also available as an excel spreadsheet (and also shows the optional aggregation to management level). Please contact methods@accountingfornature.org to request a copy.

Grazing Land Method - Econd Worked Example

NATIVE VEGETATION ENVIRONMENTAL ACCOUNT CALCULATIONS

Step 1: Sub-asset	Step 2: Assessment unit	Step 3:	Indicator	Reference Benchmark Measurement	Step 5: Average Measure	Step 6: Indicator Condition Score (ICS)		Assessment unit Econd®	Sub-asset Econd®	Asset Econd®
RE 11.5.1	Paddock 1 - RE 11.5.1		Configuration - site context (%)	100.0	50.0	50.0		55.2	57.1	61.7
		Composition	Tree canopy height (m)	20.0	20.0	100.0	56.9			
			Sub-canopy canopy height (m)	9.0	7.0	100.0				
			Tree canopy cover (%)	25.0	5.0	40.0				
			Sub-canopy cover (%)	20.0	5.0	50.0				
			Native shrub cover (%)	6.0	1.0	33.3				
			Non-native plant cover (% Score)	0.0	32.0	10.0				
			Native perennial grass cover (%)	23.0	80.0	100.0				
			Litter cover (%)	45.0	10.0	22.2				
	Paddock 2 - RE 11.5.1		Configuration - site context (%)	100.0	81.2	81.2		87.1		
		Composition	Tree canopy height (m)	20.0	18.8	100.0	89.1			
			Sub-canopy canopy height (m)	9.0	8.0	100.0				
			Tree canopy cover (%)	25.0	19.5	100.0				
			Sub-canopy cover (%)	20.0	16.0	100.0				
			Native shrub cover (%)	6.0	8.4	100.0				
			Non-native plant cover (% Score)	0.0	6.0	50.0				
			Native perennial grass cover (%)	23.0	17.5	76.1				
			Litter cover (%)	45.0	38.9	86.4				
RE 11.3.2	Paddock 1 - RE 11.3.2		Configuration - site context (%)	100.0	74.1	74.1		69.5	69.5	
		Composition	Tree canopy height (m)	18.0	16.7	100.0	68.0			
			Sub-canopy canopy height (m)	0.0	0.0	NA				
			Tree canopy cover (%)	40.0	29.0	100.0				
			Sub-canopy cover (%)	0.0	0.0	NA				
			Native shrub cover (%)	2.0	0.5	0.0				
			Non-native plant cover (% Score)	0.0	1.0	75.0				
			Native perennial grass cover (%)	35.0	22.0	62.9				
			Litter cover (%)	30.0	21	70.0				
RE 11.4.4	Paddock 2 - RE 11.4.4		Configuration - site context (%)	100.0	52.0	52.0		50.8	50.8	
		Composition	Tree canopy height (m)	0.0	0.0	NA	50.4			
			Sub-canopy canopy height (m)	0.0	0.0	NA				
			Tree canopy cover (%)	0.0	0.0	NA				
			Sub-canopy cover (%)	0.0	0.0	NA				
			Native shrub cover (%)	0.0	3.0	60.0				
			Non-native plant cover (% Score)	0.0	7.0	50.0				
			Native perennial grass cover (%)	50.0	22.0	44.0				
			Litter cover (%)	21.0	10	47.6				

AREA WEIGHTINGS

Sub-asset	Assessment Unit	Total Area (ha)	Weighting
RE 11.5.1		809	33%
	Paddock 1 - 11.5.1	760	94%
	Paddock 2 - 11.5.1	49	6%
RE 11.3.2		1,171	47%
	Paddock 1 - 11.3.2	1,171	100%
RE 11.4.4		500	20%
	Paddock 2 - 11.4.4	500	100%
TOTAL		2,480	

INDICATOR WEIGHTING FOR ECOND™

CONFIGURATION	25%
COMPOSITION	75%

Grazing Land Method - Pcond Worked Example

NATIVE VEGETATION ENVIRONMENTAL ACCOUNT CALCULATIONS

Step 1: Sub-asset	Step 2: Assessment unit	Step 3:	Reference Benchmark Measurement	Step 5: Average Measure	Step 6: Indicator Condition Score (ICS)	Step 7: Assessment unit Pcond	Sub-asset Pcond	Asset Pcond
RE 11.5.1	Paddock 1 - RE 11.5.1	Cover 3P Species (%)	90.0	85.0	94.4	85.7	83.8	60.8
		Diversity of 3P Species (Count)	5.0	6.0	100.0			
		Total Organic Ground Cover (%)	90.0	85.0	100.0			
		Erosion (Score)	1.0	1.0	100.0			
		Unpalatable plant cover (%)	0.0	30.0	20.0			
		Woody Thickening (Score)	0.0	1.0	100.0			
	Paddock 2 - RE 11.5.1	Cover 3P Species (%)	90.0	50.0	55.6	54.3		
		Diversity of 3P Species (Count)	5.0	2.0	40.0			
		Total Organic Ground Cover (%)	90.0	100.0	100.0			
		Erosion (Score)	1.0	3.0	40.0			
		Unpalatable plant cover (%)	0.0	30.0	20.0			
		Woody Thickening (Score)	0.0	2.0	70.0			
RE 11.3.2	Paddock 1 - RE 11.3.2	Cover 3P Species (%)	90.0	70.0	77.8	61.3	61.3	
		Diversity of 3P Species (Count)	5.0	7.0	100.0			
		Total Organic Ground Cover (%)	90.0	5.0	0.0			
		Erosion (Score)	1.0	1.0	100.0			
		Unpalatable plant cover (%)	0.0	30.0	20.0			
		Woody Thickening (Score)	0.0	2.0	70.0			
RE 11.4.4	Paddock 2 - RE 11.4.4	Cover 3P Species (%)	90.0	5.0	5.6	22.6	22.6	
		Diversity of 3P Species (Count)	5.0	2.0	40.0			
		Total Organic Ground Cover (%)	90.0	10.0	0.0			
		Erosion (Score)	1.0	3.0	40.0			
		Unpalatable plant cover (%)	0.0	40.0	10.0			
		Woody Thickening (Score)	0.0	3.0	40.0			

AREA WEIGHTINGS

Sub-asset	Assessment Unit	Total Area (ha)	Weighting
RE 11.5.1		809	33%
	Paddock 1 - 11.5.1	760	94%
	Paddock 2 - 11.5.1	49	6%
RE 11.3.2		1,171	47%
	Paddock 1 - 11.3.2	1,171	100%
RE 11.4.4		500	20%
	Paddock 2 - 11.4.4	500	100%
TOTAL		2,480	

Sub-asset	Assessment unit	Assessment unit Econd●	Sub-asset Econd●	Asset Econd●	Assessment unit Pcond	Sub-asset Pcond	Asset Pcond
RE 11.5.2	Paddock 1 - RE 11.5.1	55.2	57.1	61.7	85.7	83.8	60.8
RE 11.5.2	Paddock 2 - RE 11.5.1	87.1	57.1	61.7	54.3	83.8	60.8
RE 11.3.2	Paddock 1 - RE 11.3.2	69.5	69.5	61.7	61.3	61.3	60.8
RE 11.4.4	Paddock 2 - RE 11.4.4	50.8	50.8	61.7	22.6	22.6	60.8