GreenCollar Native Vegetation Condition Monitoring Method

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GreenCollar Native Vegetation Condition Monitoring Method

Native Vegetation

	GreenCollar Native Vegetation Condition Monitoring Method
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2.2	20-11-2021	Minor edits to terminology	Luke Shoo and Jenny Sinclair	Accounting for Nature

Summary

Purpose	The purpose of this Method is to deliver environmental accounts that provide regular, standardised and objective information on the condition and trend of native vegetation in a way that is practical, affordable, scientifically robust and can be applied nation-wide across Australia.
Application	Accounts prepared in accordance with this Method are intended for use in environmental markets including (but not limited to) co-benefit verification for carbon projects.
Scale	This Method is intended for nation-wide application (across different states and territories throughout Australia).
Scope	This Method is intended to be used to quantify change in the condition of the environmental asset through time at the project and property levels. Individual accounts can also be aggregated to report on environmental assets at the enterprise or project portfolio scale.
Target Audience	Governments, corporations, farmers, producers, Indigenous and private land conservation groups, and other landholders.
Decisions to inform	To inform land management practices and provide assurance of outcomes from environmental market projects (i.e. long-term changes in condition).

	Accuracy Level – 90%
Assessment units	Assessment units are unique combinations of sub-assets (i.e. pre-clear vegetation types) and broad condition states (e.g. remnant, regrowth, cleared)
Sample size	At least one permanent sample site is to be established per assessment unit, up to a maximum of 7 samples per assessment unit. For example, for larger assessment units that exceed 500 ha, 7 samples will suffice.
Indicators	Basal area or biomass (trees or shrubs or both combined); large trees; native plant species richness (trees); native plant species richness (shrubs); non-native plant cover; recruitment of canopy species; site context
Data collection	Data collection is primarily from field surveys with the exception of site context which is assessed using a combination of GIS and vegetation mapping.
Expertise required	This Method is expected to be most suited for application by skilled environmental practitioners and in the context of a dedicated monitoring program (i.e. high level skills in identifying tree and shrub species, basic recognition of non-native cover and technical capacity to work with vegetation mapping information).

1. Introduction

1.1. Aim and background of this Method

This Method has been developed to assess the condition of native vegetation at Project, Property and Portfolio scales and is applicable Australia-wide.

The purpose of this Method is to deliver environmental accounts that provide regular, standardised and objective information on the condition and trend of native vegetation in a way that is practical, affordable, scientifically robust and can be applied nation-wide across Australia. Accounts prepared in accordance with this Method are intended for use in environmental markets including (but not limited to) co-benefit verification for carbon projects.

Development of this Method has been informed by:

- the Accounting for Nature Standard, the Technical Protocol for Developing Native Vegetation Condition Account Methods (Butler et al. 2020), the Land Restoration Fund (LRF) Native Vegetation Monitoring Method (Butler 2020);
- existing state vegetation assessment frameworks for Queensland (BioCondition) and New South Wales (Biodiversity Assessment Method).
- GreenCollar's data collection protocols for carbon projects

This Method builds off stratification approaches developed for state vegetation assessment frameworks (i.e. BioCondition and BAM) and is intended to be complementary to the Clean Energy Regulator's guidance on stratification for carbon projects under carbon farming methods. The two main factors guiding stratification in this Method are sub-assets (i.e. vegetation type) and broad condition state.

Selection of indicators has primarily been informed by existing state vegetation assessment frameworks (e.g. BioCondition, BAM) and GreenCollar's past and ongoing program for monitoring carbon projects. Complementarity with existing state vegetation assessment frameworks serves two functions: the Method builds off scientific consensus on the most suitable indicators for assessing native vegetation condition; and, facilitates the process of comparing indicator values against existing published reference condition benchmarks for vegetation types.

An initial review of different state vegetation assessment frameworks confirmed broad similarity in indicators used to assess vegetation condition. A point of difference with this Method is that basal area or biomass of trees and shrubs is used as structural attributes instead of cover. This is an intentional strategy to enable structural indicators of trees and shrubs to be developed from stem diameter measurements that are routinely collected for carbon or forestry projects and to avoid the need to navigate differences in field-based protocols used to measure cover among states and territories (e.g. differences in classification of growth form and differentiation of vegetation strata).

Another intentional decision was to not include indicators for ground cover or species richness of perennial grasses, forbs or other growth forms. Instead, this Method simply uses a field assessment of non-native cover to assess condition of ground vegetation. This design element achieves several important practical outcomes: (1) reduces the potential for assessment of vegetation condition to be confounded by fluctuating environmental conditions that disproportionally influence the structure and composition of ground cover; (2) avoids dependency on specialized practitioners required for species level identification of perennial grasses and forbs; and (3) reduces the time, sampling effort and cost of establishing native vegetation accounts.

Wherever possible, reference condition benchmarks for indicators are established using published state or territory "benchmarks" available through relevant government agencies. In instances where indicator measurement comparable the relevant state or territory benchmarks cannot be established using a consistent field data collection protocol, this Method requires that benchmark values for indicators are derived independently from published data or data collected from reference sites.

1.2. Justification of Accuracy Level

This Method enables environmental accounts to be constructed at high Accuracy (90% under the Accounting for Nature® Standard). Requirements for stratification and sample sizes are directly equivalent to high accuracy under the Land Restoration Fund (LRF) Native Vegetation Monitoring Method (Butler 2020). The breadth of indicators is intermediate between very high (95%) and high (90%) accuracy under the Land Restoration Fund (LRF) Native Vegetation Monitoring Method (Butler 2020). Specifically, this Method requires measurement of native plant richness for trees and shrubs that is not required for high (90%) accuracy under the LRF Method. However, this Method does not require measurement of perennial grass cover, species richness of forbs or other life forms, or coarse woody debris that are required for very high (95%) accuracy under the LRF Method.

1.3. What an Environmental account looks like

The Accounting for Nature® Framework is used to produce Certified Environmental Accounts, which are used to underpin credible public or confidential Claims in the market regarding the state of nature. Environmental Accounts are spatially explicit and cover a discrete area of any size, from tens of hectares to millions of hectares.

An Environmental Account is a single registered environmental accounting project that reports on the Condition of one or more Environmental Assets. Environmental Accounts are comprised of individual Environmental Asset Accounts ('Asset Account') which individually reflect the Condition of one Environmental Asset as specified by a single accredited Method. The Asset Account(s) must be contained within the Boundary of the Environmental Account, but they each can be a smaller area. The area of the Asset Accounts depends on the Purpose of the Environmental Account and where the Asset exists within the Environmental Account Boundary.

An Environmental Account includes all underlying data and calculations which is summarised into an **Information Statement.** The Information Statement is a critical document that transparently describes, in non-technical terms, the Purpose of developing an Environmental Account, the rationale for the selection of Environmental Assets and Method(s), an overview of the data collection, analysis and results, disclosure of any limitations and the account Certification status. The Information Statement is Certified by AfN as part of an Environmental Account.

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.
Scope:	Describe the scope of the account. The two main scopes this method supports are: - *Snapshot* – a one-off assessment of condition of Native Vegetation - *Change over time* – an ongoing assessment of the change of environmental condition through time - *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. NB. If the accounts are to be used for the purpose of definitively demonstrating the effect of a management intervention, the information statement must provide a clear justification of the difference between the observed outcome captured in the account and the likely outcome in the absence of intervention (Butler et al. 2020). The analysis must follow the principles of counterfactual analysis, accuracy, conservatism, transparency, verification and clarity of meaning defined in the Technical Protocol (Butler et al. 2020) which may require accounts to include specific 'control areas'.
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 spatial scope of the accounting area depends on the purpose of the account but could be at the project or property scale. 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, 're-set' and started again with the new accounting area.

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

Step 2. Compile existing data

Data collection

Effective stratification of the accounting area into 'homogeneous' assessment units is fundamental to establishing the conditions necessary to minimise effort required for data collection without compromising the accuracy of the account. This Method builds off stratification approaches developed for state vegetation assessment frameworks (i.e. BioCondition and BAM) and is intended to be complementary to the Clean Energy Regulator's guidance on stratification for carbon projects under carbon farming methods. The two main factors guiding stratification in this Method are sub-assets (i.e. vegetation type) and broad condition state. A point of difference with state assessment frameworks is that higher level vegetation classification can be used for the purposes of stratification which is intended to improve the cost-effectiveness of sampling for data collection (see Appendix 7 in Butler et al. 2020).

Sub-assets

The account must cover all relevant parts of the native vegetation asset which will generally require dividing the native vegetation asset into sub-assets (Butler et al. 2020). This method defines sub-assets as vegetation types. Sub-assets that occur within the boundaries of the accounting area must be identified and spatially defined. Sub-assets must be defined using best-available and consistent national, state, territory or regional mapping information that describes the pre-clearing distribution of native vegetation types as per the Technical Protocol (Butler et al. 2020). Use of standard vegetation classifications allows accounts to be aggregated. This Method allows sub-assets to be defined using either: the same vegetation classifications that are typically used in state or territory vegetation condition assessment frameworks (e.g. Queensland – Regional Ecosystems, New South Wales – Plant Community Types); or, higher-level classifications (e.g. National – Major Vegetation Subgroups, Queensland - Broad Vegetation Groups, New South Wales – Vegetation Classes). The selection of vegetation classification should be appropriate for the intended purpose of the accounts.

Broad condition states

The objective should be to define the minimum number of broad condition states that are required to achieve relatively homogeneous assessment units. A useful starting point for stratification is to first delineate areas of residual (intact) vegetation that are equivalent to a high-quality broad vegetation state. This can be supported by national, state, territory or regional mapping information that describes the remnant distribution of native vegetation types. Additional broad condition states can then be defined using a combination of information on current land use, structural attributes of the dominant stratum (i.e. forest cover) and evidence of past land clearing (mechanical or chemical disturbance) (e.g. pasture, regrowth, disturbed vegetation). Existing frameworks for classifying vegetation by degree of human modification can also provide useful guidance for stratification (e.g. VAST modification classes - residual, modified, transformed, replaced, removed, Thackway and Lesslie 2006). Useful information sources to support stratification of broad condition states include (modified from Federal Register of Legislation 2015):

Evidence of land use

(a) remotely-sensed imagery;
(b) farm management records/mapping;
(c) elicitation from property owners/mangers

Evidence of forest cover

(a) remote sensed imagery;

(b) forest cover data layers (e.g. NCAS)

Evidence of clearing history

(a) remotely-sensed imagery;
(b) clearing permits;
(c) farm management records;
(d) tax invoices;
(e) published vegetation mapping;
(f) derived vegetation cover data.

Output of Step 2

- A map, table and description of sub-assets. In cases where sub-assets are defined using a higher-level vegetation classification, component vegetation types that are to be used for benchmarking must also be listed.
- A map and table of broad condition states within the accounting area

Step 3. Stratify the accounting area and identify sampling sites

Stratify the accounting area

Each sub-asset must be stratified into assessment units that are a unique combination of sub-asset (i.e pre-clear vegetation type) and broad condition state. The number of broad condition states depends on the complexity of current and past land use and modification within the accounting area.

Ideally, individual assessment units should have the same recent land use and be uniformly similar in terms of canopy cover and recent clearing history at the time of initial stratification. Assessment units can be comprised of multiple isolated areas (do not need to be contiguous) but all units must be larger than 1 ha. In instances where initial stratification generates assessment units that are less than 1 ha or 5% of the accounting area, these polygons may be merged with another assessment unit that is of the same condition state. The aggregated area of merged polygons should not exceed 10% of the accounting area.

Select sample sites

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 assessment unit, up to a maximum of 7 samples per assessment unit. For example, for larger assessment units that exceed 500 ha, 7 samples will suffice.
Site selection	Locations of sampling points should be randomly generated to avoid bias in selecting sites on the ground. For ease of access, sample sites can be preferentially located within 200 m of a road, but ideally should be further than 50 m from infrastructure or 'edges' such as roads, dams, paddocks, or other areas of 'intense disturbance' etc.
Site establishment	It is recommended that a site map is produced that shows the general location of the sampling points at a landscape scale with an overlay of the assessment units (e.g. aerial image). Include an approximate scale (scale bar, e.g. 0 100 m) and North arrow. Sampling points must be located on the ground using a GPS. Permanent marking of survey sites, for example with a steel picket or peg, can also assist with relocating sites on the ground.
Timing	This method does not require sampling to be undertaken at a particular time of year. However, it is recommended that repeat sampling is undertaken at roughly the same time each year to minimise the possible effects of seasonal variability.

The objective of the sampling design should be to minimise (as much as is practicable) the uncertainty in average site scores for an assessment unit. Guidance on selection of sample sites is provided in **Table 1**. An initial guidance for the minimum number of sampling points required to deliver accounts at a high Accuracy Level has been informed by Butler (2020) and is provided below (**Table 2**) (see also supporting analyses in Appendix 7 in Butler et al 2020).

Typically, it will also be useful at this step to assign sites to the lowest level in the vegetation classification hierarchy (e.g. Queensland – Regional Ecosystems, New South Wales – Plant Community Types or Vegetation Classes). The resulting list of vegetation types can then be used to identify and compile information on existing published benchmarks derived from state or territory frameworks (see below).

Table 2. Minimum numbers of sampling points per assessment unit for High (90%) Accuracy

Assessment unit area	Minimum number of sampling points for high (90%) Accuracy
1 to 2 ha	1
> 2 and ≤20 ha	2
> 20 and ≤60 ha	3
> 60 and ≤500 ha	5
> 500 ha	7

Output of Step 3

- A map and table showing the **stratification** of the accounting area
- A map and table with central coordinates of each **sample site** within the accounting area.

Step 4. Describe environmental indicators and determine reference benchmarks

Indicators

This method uses multiple indicators (**Table 3**) that encompass ‘Composition’ and ‘Configuration’ themes as required by the Technical Protocol (Butler et al. 2020). No indicators of the ‘Extent’ theme are included. Instead, ‘Extent’ is captured through the stratification process and subsequent area weighting of the indicator condition scores for assessment units within sub-assets and sub-assets within the native vegetation asset.

Structural indicators for trees and shrubs have intentionally been developed from stem diameter measurements that are routinely collected for carbon or forestry projects. This method includes flexibility to report structural indicators as basal area or biomass. Structural indicators can be reported for trees and shrubs combined (combined weighting of 30%) or separately for trees and shrubs (each with a weighting of 15%) (**Table 3**). The selection of indicators must stay the same for the lifespan of the account. If the selection of indicators changes, then a new account must be developed, or the account, ‘re-set’ and started again using the new selection of indicators.

Table 3. Indicators of native vegetation condition assessed for generating accounts at a high Accuracy Level. Also shown is the primary data source used to estimate indicators and relative weightings for the different indicators used in calculation of overall site condition scores.

Attributes	Primary Data Source	High Accuracy (90%) Weighting (%)
Site based attributes		**80**
1. Basal area (m^2 per ha) OR biomass (tonnes dry mass per ha)	Field survey	either: 30 (combined); OR 15 for each of trees and shrubs
2. Large trees	Field survey	15
3. Native plant species richness (trees)	Field survey	10
4. Native plant species richness (shrubs)	Field survey	10
5. Non-native plant cover	Field survey or photopoint	10
6. Recruitment of canopy species	Field survey	5
Landscape attributes		**20**
7. Site context – amount of native-vegetation retained in the surrounding landscape (%)	GIS and vegetation mapping	20

Reference Benchmarks

The reference condition is the benchmark against which change in any indicator is measured and reflects the condition of the environmental asset in its undegraded (natural, pre-industrial or potential) state (AfN Standard). In practice, few landscapes are totally free of impacts so it is more pragmatic to define reference states as mature, long undisturbed examples of vegetation types or Best on Offer (BOO) (Eyre et al. 2015, 2017). This Method uses observations at reference condition sites to establish reference condition benchmarks. Reference condition benchmarks for indicators can also be established from: (a) published State or Territory benchmarks (see Table 2, Butler et al. 2020); or, (b) derived independently from published data or data collected at sites that are that are representative of the environmental asset in its undegraded state (i.e. reference condition sites); or, (c) a combination of both. For vegetation types or indicators where benchmark estimates are not available, it will be necessary to locate and sample a minimum of three reference condition sites for each vegetation type. For the location of reference condition sites, it is recommended that proponents seek advice from relevant government agencies that are responsible for curating information on reference benchmarks or follow published state or territory guidelines (e.g. Eyre et al. 2017).

For accounts prepared according to this Method, it should be possible to establish reference benchmark estimates for most indicators using published sources (i.e. large trees, recruitment of canopy species, native plant species richness (trees, shrubs)). For Queensland, reference benchmark estimates for basal area are also reported in the Technical Descriptions for regional ecosystems. Reference benchmark estimates for non-native plant cover and site context do not require observations at reference condition sites. Instead, reference benchmark for non-native cover for any vegetation type is zero and the benchmark for site context is assumed to be 100%.

In several instances, the definition and protocol for deriving values for indicators differs between states or territories (e.g. plot size used to estimate species richness, classification of growth form and differentiation of vegetation strata when assessing structural attributes). This represents a design challenge for developing a Method that can be applied nation-wide using a consistent data collection protocol but still enable comparison with published State or Territory benchmarks. This method provides flexibility for proponents to use combinations of the following design solutions to address this issue whilst fulfilling the objective to retain a consistent data collection protocol for implementing accounts:

i. adapt the analytical approach to derive indicators values to directly match the relevant state or territory framework for assessing vegetation condition (i.e. adopt and apply state specific classifications of growth form)
ii. where the data collection protocol differs from state or territory data protocols, provide evidence that the protocol yields indicator values that are substantially equivalent to indicator values obtained using the relevant state or territory framework for assessing vegetation condition. That is, provide evidence that differences in protocol will not lead to material differences in the derived condition score for the indicator (i.e. different plot sizes used to estimate species richness);
iii. transform indicator values using an evidence-based calibration so that they are directly equivalent to the indicator values obtained using the relevant state or territory framework for assessing vegetation condition.

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 sub-asset.

Step 5. Collect and analyse data

This Method requires consistent data collection protocols to ensure time series consistency. Detailed data collection protocols for field and vegetation mapping indicators are described below. Where a change in the data collection protocol is deemed necessary, one of the three approaches specified in the Technical protocol to address consistency issues must be used – full backcasting, backcasting using a slicing approach or breaking the time series (Butler et al. 2020).

SITE BASED ATTRIBUTES (500m^2 plot)

Plot layout

The location of each sampling point serves as the starting point to establish a plot. The plot size is 500m^2. The basic shape for a plot is 50 x 10 m. Other plot shapes may also be used provided that the plot size does not change (e.g. 100 x 5 m = 500 m^2).

Once the plot has been established each plot requires a series of data to be recorded. This includes:

- Trip ID
- Plot ID
- Assessment unit number
- Latitude and longitude
- Date and time
- The GPS error (m)
- Initials of the surveyors

Additionally, a geo-tagged photo (photopoint) of the plot is required. Photos are to be taken from the sampling point facing into the plot.

Tree and shrub measurement procedure

For each tree or shrub (excluding deadwood) within the plot, a number of parameters are to be recorded on the data sheet these include:

- species;
- growth form;
- Diameter at Breast Height (DBH) – trees only; and,
- Diameter at 10cm (D10) – both shrubs and trees.

<u>Protocol for identifying growth form</u>

Two possible growth forms are distinguished:

(1) Tree: woody plant, that is a minimum of 3m tall unless there are less than 3 DBH measurements or the combined DBH measurement is over 7cm.
(2) Shrub: woody plant, that is a maximum of 3 m tall with a combined DBH measurement of less than 7 cm.

<u>Protocol for ‘on the line’ trees and shrubs</u>

If a tree falls ‘on the line’ (edge of plot) the decision whether it is to be included or not is determined by the number of the plot being surveyed. For all even numbered plots, on the line trees are counted as in, conversely, for all odd numbered plots, trees are counted as out. For example, a tree that is on the line in plot 24 is counted as in. Note: if a multi stemmed tree i.e. Eucalyptus Mallee falls on the line, the entire tree is to be classified as an ‘in/out’ tree.

<u>Protocol for Diameter measurements</u>

If there are any anomalies on the trunk at the point of measurement then the measurement can be moved above or below the anomaly. If the trunk splits at the point of measurement, again the measurement can be taken above or below the split. If taken above, two or more measurements will be recorded depending on how many branches exist. If the trunk is leaning (rather than standing vertically upright) the diameter is to be taken at the height ALONG the length of the leaning trunk instead of the height from the ground. If there is a tree with multiple trunks and/or branches at the D10 and/or DBH then ALL branches ≥1cm are to be measured and recorded as the same tree or shrub.

Basal area or biomass of trees

Basal area is the total cross-sectional area of all stems in a plot expressed as per hectare of land area. Biomass is an estimate of dry mass of trees per hectare. This Method uses predicted biomass derived from a combination of ground-based measurements of tree diameters and published allometric equations. Cost-effective prediction of biomass across a wide range of stands can be achieved using generic allometric models based on plant growth forms or functional types (e.g. Paul et al. 2013, 2016). It is envisaged that this Method may be expanded in the future to also allow remote sensed estimation of biomass.

Basal area or biomass of shrubs

As above but for shrubs

Large trees

Large trees are measured as the number of living trees per hectare with a DBH greater than the DBH threshold for large trees specified in the relevant state or territory benchmark document. In some cases, benchmark documents specify different diameter thresholds for large eucalypt and non-eucalypt trees species. For geographic regions or vegetation types where a DBH threshold for large trees is not available, it is recommended that proponents seek advice from relevant government agencies or herbaria.

Native plant species richness (trees)

Native plant species richness (trees) is the count of native tree species within the plot. It is recommended that the procedure for assigning growth form be adapted to match the relevant state or territory framework for assessing vegetation condition. For example, in Queensland (BioCondition) growth form is based on the growth form expressed at the time of assessment. As such, individual species may contribute to indicator condition scores for both trees and shrubs where they are represented at a site by multiple life forms. Whereas, in New South Wales (BAM) allocation of native species (including juveniles) to growth form is based on the most common growth form expressed by the mature plant across the extent of the species’ range.

Native plant species richness (shrubs)

As above but for shrubs

Non-native plant cover

Non-native plant cover is a visual assessment of the percentage of total vegetation cover that is comprised of non-native species within a 500m^2 plot. Non-native cover is assessed separately for trees and shrubs, perennial grasses and other growth forms (forbs, vines, succulents) and summed to derive a combined estimate of non-native cover.

In bioregions where it can be demonstrated that non-native grasses are not a material issue, non-native cover for perennial grasses may be assumed to be zero. Data on spatial distribution of non-native grasses in Australia can be obtained from online herbaria such as the Australia Virtual Herbarium (Council of Heads of Australasian Herbaria; http://avh.chah.org.au/).

Recruitment of canopy species

Recruitment of canopy species is the count of canopy species that are present as recruits within the plot. It is recommended that the procedure for defining recruitment be adapted to match the relevant state or territory framework for assessing vegetation condition. For example, in Queensland (BioCondition) recruitment is defined as the percentage of dominant canopy species that are regenerating (individual trees with a DBH <5cm) where canopy equates to the ecologically dominant layer. Whereas in New South Wales (BAM) recruitment (‘tree regeneration’) is defined as the presence or absence of trees < 5cm DBH.

LANDSCAPE ATTRIBUTES

Site context

Site context is the area of native vegetation retained within a 1km buffer around the sampling point (i.e. surrounding landscape). For the purposes of this indicator, this Method adopts the same approach as Butler (2020) and defines native vegetation as vegetation that is ‘structurally remnant’ based on the height, cover and composition of the vegetation (as per Neldner et al. 2017).

Output of Step 5

- A **data table** (e.g. a spreadsheet) containing all the raw data for each environmental indicator for each sample

Step 6. Calculate Indicator Condition Scores

The indicator condition score (ICS) is a standardised value of an indicator measure against the reference benchmark, on a scale of 0 to 100. The formulas for calculating indicator condition scores vary between indicators and some incorporate weightings and conditional clauses to reflect the ecological thresholds associated with some vegetation attributes (see below and Appendix A).

Basal area or biomass of trees

This Method follows Eyre et al. (2015) and adopts an approach that allows underabundance and overabundance to be represented as a biologically important departure from benchmark condition for basal area or biomass of trees (e.g. overabundant invasive native scrub). Specifically, the ICS for basal area or biomass of trees is derived by first calculating observed basal area or biomass of trees as a percentage of the benchmark. This 'percentage of benchmark' value is then converted to an ICS using a linear function with break points at 100% to represent a peak condition score and again at 200% to penalise overabundance.

The percentage of benchmark value (*P*) for basal area or biomass of trees is derived as follows:

$$P = \frac{I_i}{I_0} \times 100$$

where:

I_i = basal area or biomass of trees indicator measure at time 'i'

I_0 = reference benchmark for basal area or biomass of trees indicator

The ICS for basal area or biomass of trees is derived as follows:

if {$P \leq 100$} ($ICS=P$)

if {$100 > P \leq 200$} ($ICS=100$)

if {$200 > P \leq 500$} ($ICS=100 - (P - 200) / 3$)

if {$P > 500$} ($ICS=0$)

Worked total tree and shrub cover:
Benchmark estimate of basal area of trees is 14m^2/ha. The estimate from the sampling point is 36.4m^2/ha. The percentage of benchmark is 260. As *P* is greater than 200 and less than 500 (overabundance), the indicator condition score for total tree and shrub cover is 80 (i.e. 100 – (260-200)/3)

Basal area or biomass of trees

As above but for shrubs

Large trees

The ICS for large trees is considered to be 100 where the number of large trees exceeds the benchmark number of large trees. The ICS for large trees is derived as follows:

$$ICS = \frac{I_i}{I_0} \times 100$$

if {*ICS*>100} (*ICS*=100)

where:

I_i = large tree indicator measure at time 'i'

I_0 = reference benchmark for large tree indicator

Worked example of scoring large trees (modified from Eyre et al. 2015):

Benchmark document has a DBH threshold for eucalypts of 58 cm with 12 large trees per hectare. For non-eucalypts the DBH threshold is 26cm with 16 large trees per hectare. The benchmark is 12 + 16 = 28 large trees per hectare.

The estimate from the plot survey was 18 large trees per hectare (i.e. 12 large eucalypt trees (>58cm DBH) plus 6 non-eucalypt trees (>26cm DBH) per hectare). The indicator condition score for large trees is 64 (i.e. 18/28 x 100)

Native plant species richness (trees)

The ICS for species richness is considered to be 100 where species richness exceeds the benchmark species richness. The ICS for native plant species richness (trees) is derived as follows:

$$ICS = \frac{I_i}{I_0} \times 100$$

if {*ICS*>100} (*ICS*=100)

where:

I_i = species richness indicator measure at time 'i'

I_0 = reference benchmark for species richness indicator

Worked example of scoring native plant species richness (trees):

Benchmark document has a species richness for trees of 8 species. The number of tree species recorded present on the plot survey is 6. The indicator condition score for species richness (trees) is 75 (i.e. 6/8 x 100).

Native plant species richness (shrubs)

As above but for shrubs

Non-native plant cover

The observed indicator measure is converted to an ICS using a negative linear function to represent a decline in condition with increasing non-native cover. A constant of 2 is included to impose a rapid decline in the ICS in response to increasing cover. The ICS for non-native plant cover is considered to be zero where non-native cover exceeds 50%. The ICS for non-native plant cover is derived as follows:

$$ICS = 100 - 2 \times (I_i - I_o)$$

if {*ICS*<0} (*ICS*=0)

where:

I_i = non-native plant cover indicator measure at time 'i'

I_0 = reference benchmark for non-native plant cover indicator which is zero

Worked example of scoring non-native plant cover:

The non-native plant cover on the plot is 10%. The reference benchmark is zero. The indicator condition score for non-native plant cover is 80 (i.e. 100 - 2 x (10 - 0)).

Recruitment of canopy species

The ICS for recruitment is considered to be 100 where the number of species present as recruits exceeds the benchmark number of species. The ICS for recruitment is derived as follows:

$$ICS = \frac{I_i}{I_0} \times 100$$

if {*ICS*>100} (*ICS*=100)

where:

I_i = recruitment indicator measure at time 'i'

I_0 = reference benchmark for recruitment indicator

Alternatively, where the indicator is measured as presence or absence, the indicator condition score (ICS) for recruitment on a scale of 0 to 100 is derived as follows:

if {I_i = present } (*ICS*=100) else {ICS=0}

where:

I_i = recruitment indicator measure at time 'i'

Worked example of scoring recruitment:

Benchmark document recognises 4 dominant canopy species. The number of dominant canopy species from the plot survey that were present as recruits was 1. The indicator condition score for recruitment is 25 (i.e. 1/4 x 100)

Site context

The reference benchmark for site context is 100. The ICS for site context is derived as follows:

$$ICS = \frac{I_i}{I_0} \times 100$$

where:

I_i = site context indicator measure at time 'i' (i.e. percentage area of 1km buffer around the sampling point that is retained native vegetation)

I_0 = reference benchmark for site context indicator (i.e. 100)

Worked example of scoring site context:

The percentage area of 1km buffer around the sampling point that is retained native vegetation is 32%. The indicator condition score for site context is 32 (i.e. 32/100 x 100)

Overall Indicator condition scores

The overall indicator condition score (ICS_o) for each sampling point can be derived using the indicator weightings in **Table 3**.

Equation 1: High (90%) Accuracy

$$ICS_o = 0.15*a + 0.15*b + 0.15*c + 0.1*d + 0.1*e + 0.1*f + 0.05*g + 0.2*h$$

where:

a = basal area or biomass (trees) ICS

b = basal area or biomass (shrubs) ICS

c = large trees ICS

d = native species richness (trees) ICS

e = native species richness (shrubs) ICS

f = non-native plant cover

g = recruitment of canopy species ICS

h = site context

In instances where a vegetation type is considered to have one or more 'naturally missing attributes', the relevant indicator/s may be omitted from the calculation used to derive the *Econd®* for the assessment unit and the *Econd®* standardised to between 0 and 100 to account for the missing weighting assigned to these indicators.

Condition scores for survey sites must be recorded within a Data Table, in the format below.

Example Data Table 1. Condition of sampling points within assessment units

Sub-asset	Broad condition state	Assessment unit	Plot	Indicator	Benchmark	Observed	% of benchmark	Indicator condition score

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®* (condition score) must be calculated for all assessment units. This can be achieved by either:

(i) calculating the *Econd®* at each sample site as the sum of weighted Indicator Condition Scores across all indicators and then calculating the mean of sample site *Econd®* within each assessment unit; or,

(ii) calculating the mean of sample site Indicator Condition Scores for each indicator within each assessment unit and then calculating the sum of weighted Indicator Condition Scores across all indicators within each assessment unit.

The sub-asset *Econd®* is the sum of the area-weighted assessment unit *Econd®*

The asset *Econd®* is the sum of the area-weighted sub-asset *Econd®.*

Condition scores for assessment units and sub-assets must be recorded within Data Tables, in the format below.

Example Data Table 2. Condition of assessment units within sub-assets

Sub-asset	Broad condition state	Assessment unit	Area (ha)	Percentage of sub-asset by area	Number of samples	Indicator condition score mean

Example Data Table 3. Condition of sub-assets within the accounting area and overall condition of asset

Sub-asset	Short description	Present in assessment units	Area (ha)	Percentage of accounting area	Econd®
		List relevant assessment units			

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.

3. Compile Environmental Account and submit for certification

Steps five to seven should be repeated at regular intervals (at least once every five years and in accordance with the chosen Reporting Period), as specified under the **Accounting for Nature® Standard**, to establish a trend over time.

For an Environmental Account to be Certified, it must be audited in accordance with the **Accounting for Nature® Standard** and **Accounting for Nature® Audit Rules** and adhere to the **Accounting for Nature® Environmental Account Rules**[1]. Once an Environmental Account is Certified, it is listed in the Environmental Account Registry and the Proponent gains access to the **Accounting for Nature® Trustmark** and must adhere to the **Accounting for Nature® Claims Rules**.

For information on the process of having an Environmental Account Certified, refer to **Accounting for Nature® Environmental Account Rules**.

[1] In development

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Appendix A Excel formulas for indicator condition scores

In the below formulas:
OBS = Observed value
REF = Reference Benchmark Value
P = Percentage of benchmark (i.e. (OBS/REF)*100)

Indicator	Equation
Basal area OR biomass	=IF(P<=100,P,IF(P<=200,100,IF(P>500,0,100-(P-200)/3)))
Large trees	=IF(P<100, P, 100)
Native plant species richness (trees)	=IF(P<100, P, 100)
Native plant species richness (shrubs)	=IF(P<100, P, 100)
Non-native plant cover	=IF(OBS>=50,0,100-2* OBS)
Recruitment of canopy species	=IF(P<100, P, 100)
Site context	=(OBS/REF)*100