Accounting for Nature®

Guidelines for Developing Methods to Assess the Condition of Native Vegetation

(Formerly known as "Native Vegetation Technical Protocol")

Version 1.0

VERSION CONTROL

Accounting for Nature® Guidelines for developing Methods to assess Native Vegetation Condition

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ACKNOWLEDGEMENT

From 2008 to 2018, the Wentworth Group of Concerned Scientists developed the Accounting for Nature® model. The model sought to establish a practical, affordable and scientifically robust methodology for creating a common unit of measurement to describe the condition of environmental assets and measure any change in the condition of those assets over a period of time.

From December 2018, the Wentworth Group will not take part in any further development of, or application or implementation of, the Accounting for Nature® model. This will be undertaken by AfN Ltd. The Wentworth Group is not responsible for the use of or implementation of the Accounting for Nature® model or any associated services provided by AfN Ltd.

FORMALLY: Technical Protocol for Constructing Native Vegetation Condition Accounts (2020)

SPECIAL ACKNOWLEDGMENTS FOR: Butler D, Thackway R, and Cosier P

Contents

1. Purpose and Application

The purpose of this document is to guide the development of Methods which aim to account for the condition of native vegetation in any area that can be compared with the Reference Condition represented by its undegraded (contemporary best-on-offer, pre-industrial) state. It is not restricted to areas that contain intact/remnant/unmodified native vegetation types.

Methods consistent with this Guideline may be applied in landscapes where vegetation types have been variously modified or transformed, including non-native vegetation cover classes (e.g. plantations, crops and amenity plantings). However, for modified areas, the Methods must prescribe how to assign the original vegetation types (i.e. by using pre-clear mapping of vegetation types), so that the area or site can be benchmarked using an appropriate reference for each indicator.

The scale (i.e. project, property, or region) of an Environmental Account is dependent on the purpose of the account. The scale and purpose of the account will determine the most appropriate Method needed to generate an Account, from both a technical and practical point of view.

All Environmental Accounts must comply with the Accounting for Nature® (AfN) Framework and be constructed in accordance with an AfN Accredited Method. The primary difference between Methods for measuring the condition of an asset at different scales is the resolution of data, sampling design, and data collection techniques that are used to produce an Account.

For the purpose of simplicity, this Guideline focuses on examples of Methods accounting for native vegetation condition at two scales: property level, and regional level, but the principles apply to all scales. Similarly, the examples used throughout this Guideline relate to Australian native vegetation, but the principles are transferable so that it can be used as a guide to method development for any part of the world.

Methods may be written to achieve different confidence levels (1 – Very High, 2 – High, 3 – Moderate). Confidence levels are based on the combination of the comprehensiveness of the set of indicators, as well as the robustness of the sample size and design used to measure the environmental condition within an accounting area and the sensitivity to detect change over time.

2. The Accounting for Nature ® Framework

Accounting for Nature® is a framework for building asset-based Environmental Accounts using a common unit of measure, an Econd®. An Econd® is an index that ranges between 0 and 100, where 100 describes the condition of an environmental asset in its undegraded (contemporary best-on-offer, pre-industrial) state, which is called its reference condition. An Econd® of zero indicates complete loss of the function that the asset supported in its reference condition.

The purpose of the AfN Framework is to provide a practical, scientifically accurate and cost-effective approach to measuring, reporting and verifying changes in environmental condition over time.

Environmental Accounts can be created at various scales and for various purposes, including:

- to describe the condition of an environmental asset and its change in condition through time; and/or,
- to understand the cause of a change in condition of an environmental asset over time, such as whether the change is as a result of management actions.

Under the Framework, the Accounting for Nature® Standard sets out the specific rules for Proponents to achieve certification of Environmental Accounts by AfN. To construct an Environmental Account, Proponents must select (or create) an appropriate accredited Method for each environmental asset in the Account. The selected Method(s) then guide the development of the Environmental Account, including:

- explanation of indicators,
- guidance on how to determine Reference Benchmarks,
- how to collect data,
- how to calculate Indicator Condition Scores (ICS) using the data collected and the Reference Benchmarks; and,
- how to calculate the Econd® using the ICSs.

All new Methods must be submitted to the Science Accreditation Committee for approval. The draft Method must outline a proposed target confidence level(s) and justify why it is appropriate. When the Science Accreditation Committee recommend a Method for approval, they will set the confidence level based on the advice on the Author for their Method. The confidence level reflects the robustness of the Methods processes for the measurement or estimation of the condition of the environmental assets.

It is important to assign a confidence level to a Method for two reasons:

1. It enables users to assess the level of accuracy in measuring the condition and any changes in condition of an environmental asset associated with the procedures in the Method; and
2. It places a limit on the confidence level that can be assigned to accounts that are prepared in accordance with the Method.

Table 1. Definitions of confidence level

Confidence Level	Definition
Level 1	A **Level 1 (Very High)** confidence level would apply to Methods that include a comprehensive set of indicators and are likely to have very high accuracy (≥95%) when measuring the condition of environmental assets and detecting change in their condition through time.
Level 2	A **Level 2 (High)** confidence level would apply to Methods that include a relatively comprehensive set of indicators and are likely to have high accuracy (≥90%) when measuring the condition of environmental assets and detecting change in their condition through time.
Level 3	A **Level 3 (Moderate)** confidence level would apply to Methods that include a limited set of indicators and are likely to have moderate accuracy (≥80%) when measuring the condition of environmental assets and detecting change in their condition through time.

3. Rules & guidance to ensure Methods to assess Native Vegetation Condition satisfy the Method approval criteria

The AfN Standard sets out nine criteria for Method approval. These criteria are set out in the AfN Standard, and their application to Methods for native vegetation Environmental Accounts are discussed in turn below.

Criterion 1:	The Method must contain appropriate rules to ensure Environmental Accounts clearly state their intended **purpose** and **account type**.
Criterion 2:	The Method must contain appropriate rules for the selection of **environmental assets**.
Criterion 3:	The Method must contain an appropriate selection of **indicators** that is suitable for the proposed confidence level(s).
Criterion 4:	The Method must contain appropriate rules for the determination of **Reference Condition Benchmarks**.
Criterion 5:	The Method must contain appropriate rules for the **collection** of data that is suitable for the proposed confidence level(s) as well as appropriate rules for the **analysis and management of data** on the condition of environmental assets.
Criterion 6:	The Method must contain appropriate rules to ensure **time series consistency**.
Criterion 7:	If seeking to estimate the impact of management activities on environmental condition, the Method must contain appropriate rules to do so, using robust **counterfactual analysis**.
Criterion 8:	The Method must contain appropriate rules for the calculation of **Indicator Condition Scores** and the **Econd®**.
Criterion 9:	The Method must contain appropriate rules to ensure accounts are **transparent** and disclose all material uncertainties.

Criterion 1: Accounts clearly state their intended purpose & account type

Criterion 1 is a straightforward matter of clarity of expression and purpose, and its resolution is subject to the Method's specific intent. The AfN Standard states that for a Method to satisfy this criterion, it must include rules that require Environmental Accounts to:

(a) accurately describe their intended purposes, including the target audiences and decisions the accounts are intended to inform;

(b) accurately describe the scale at which they have been prepared (project, property or regional);

(c) accurately describe their scope, which refers to whether they assess:

i. the condition of the environmental assets at a point in time;

ii. the change in the condition of the environmental assets through time; and/or

iii. the impacts of management activities on the condition of the environmental assets, either at a point in time or through time; and

(d) contain a cogent explanation of why their scale and scope are appropriate, having regard to their purposes.

Criterion 2: Selection of environmental assets

The AfN Standard states that the appropriateness of a Method's environmental asset selection rules will be assessed on the basis of the following six principles.

1. **Clarity of scope.** The Method must accurately describe the environmental assets, geographic region and scale to which it applies.
2. **Fit for purpose.** The Method must ensure assets are defined in a way that reflects the intended purposes of the accounts.
3. **Complete**. The Method must ensure assets are defined in a way that is sufficiently comprehensive to describe the condition of the underlying asset.
4. **Not misleading**. The Method must ensure assets are not defined in a way that misrepresents their true condition.
5. **Aggregative.** The Method must ensure environmental assets are defined in a way that facilitates aggregation
6. **Clarity of meaning.** The rules in the Method concerning the selection of environmental assets must be clear and easy to interpret.

These principles require an Environmental Account to cover all relevant parts of the native vegetation asset, which depends on the Accounts purpose, but will generally require dividing the native vegetation asset into sub-assets. Sub-assets are typically vegetation types which have the same Reference Benchmarks. For example, to differentiate vegetation types and/or conservation classes so that relevant details, such as the condition of endangered ecological communities within the broader vegetation assets, are transparently reported.

The AfN principle for accounts to be aggregative (principle #5) is most simply met if the classification of sub-assets follows a relevant standard classification. All Australian States and Territories have mapped vegetation types throughout their jurisdiction (Table 1). Methods should generally integrate the relevant State and Territory vegetation mapping and vegetation classification to ensure sub-assets are appropriately and consistently identified and ensure that accounts are relevant and aggregative. It should be noted that the State and Territory vegetation mapping has generally been developed at the regional scale, and therefore Methods should include instructions to ground-truth the mapping for smaller scale accounts (such as project or property), to ensure the extent and classifications mapped are accurate. Selection of the scale at which vegetation classes are classified will generally have a direct impact on the sampling effort required to generate data for the account. Appendix 7 illustrates the interaction between classification and sampling effort.

The State and Territory Vegetation types are generally supported by published methods and datasets to determine the relevant vegetation types for Reference Condition for each vegetation type (with the exception of Northern Territory and Western Australia).

At a larger scale and lower resolution, Australian native vegetation mapping agencies have developed the National Vegetation Information System (NVIS) to provide consistent national native vegetation information using the NVIS attribute framework (Thackway and Lesslie 2008; Hnatiuk et al. 2009). NVIS was initiated in the late 1990s to translate and compile mapped vegetation data and information generated by the state and territory vegetation management agencies and using NVIS attribute framework (National Land and Water Resources Audit 2001). NVIS data and information products, including maps of vegetation, have been continually improved since 2001 and can be accessed from the Australian Governments' Department of the Environment and Energy NVIS website.

The best available nationally consistent, regional scale mapped information which describe native vegetation types is the Major Vegetation Groups (MVGs) and Major Vegetation Sub-Groups (MVSs), which are based on the NVIS data and information. Maps of these vegetation types have primarily been derived from the relevant state and territory vegetation mapping programs (https://www.environment.gov.au/land/native-vegetation/national-vegetation-information-system).

Table 2 Native vegetation types and vegetation condition assessment frameworks (for Australia)

	Native vegetation mapping (Primarily regional scale mapping)	
Jurisdiction	Native Vegetation types	Key references
Australian Capital Territory	Plant Community Types	Keith D. (2004); Office of Environment and Heritage (2011)
New South Wales	Plant Community Types	Keith D. (2004); Environment, Energy and Science, BioNet Vegetation Maps (2020)
Northern Territory	Vegetation Associations	Brocklehurst et al. (2007); Brocklehurst (2008).
Queensland	Regional Ecosystems	Neldner et al. (2017a & b); Neldner et al. 2019
South Australia	Floristic Groups	Croft et al. (2005); Crossman and Smith (2006)
Tasmania	Vegetation Communities	Harris and Kitchener (2005)
Victoria	Ecological Vegetation Classes	Woodgate et al. (1994); Department of Sustainability and Environment Victoria (2013); State Government of Victoria, Department of Environment, Land, Water and Planning (2019)
Western Australia	Vegetation Associations	Beard & Webb (1974); Beard et al. (2013)
Australian Government	Major Vegetation Groups & Major Vegetation Sub-groups	Bolton et al. (Eds) & NVIS Technical Working Group (2017)

Criterion 3: Selection of Indicators

Indicators

The appropriateness of a Method's indicators will be assessed on the basis of the following two principles.

1. Promotion of indicator principles. The rules in the AfN Standard require Methods to include indicators that are:
    - (a) **Relevant** - a measure of the condition of the relevant environmental asset;
    - (b) **Simple** - easy to interpret and monitor, and are appropriate for community use;
    - (c) **Sensitive** - able to detect change in the condition of the environmental asset;
    - (d) **Measurable** - able to be statistically verified, reproduced and compared ; and
    - (e) **Aggregative** - able to be combined with other indicators to produce more general information about environmental conditions.
2. Clarity of meaning. The rules in the Method concerning the selection of indicators must be clear and easy to interpret.

The regional trials that shaped the AfN Framework established three indicator themes used to describe native vegetation condition consistent with these principles: the extent of vegetation, its composition (such as function, structure and species richness), and its configuration (how the vegetation assets are distributed across the landscape).

Together these three components provide the foundation for indicators required for native vegetation condition methods consistent with this Guideline. Methods must include indicators within each of these three themes:

- Extent,
- Composition, and
- Configuration.

Assessments of changes in vegetation condition generally require the collection and analysis of indicators in the field at the plot-scale for composition, which are then combined with the configuration and extent, to generate an Econd® for mapped 'assessment units'. **Assessment units** are spatial subsets of the accounting area defined, for example, by intersecting sub-assets with broad condition states. Methods should include rules for stratifying the accounting area into assessment units.

Assessment units are typically homogenous areas (that can be comprised of multiple separate areas) that are designed to control for variability within the accounting area and inform the location of sample sites. Materiality is an important consideration when determining assessment units – i.e. if there is an assessment unit that is classified as a restoration area – but there is a small immaterial area of road/track, or a house located within, then it is not necessary to remove these features as an independent assessment unit. But the level that's considered material will be dependent on the confidence level – i.e. lower tolerance for higher confidence level. Appendix 4 details and explains the core steps in developing a typical vegetation condition account, including determining assessment units.

In Australia, the State and Territory vegetation classifications in Table 1 are typically supplemented by ecosystem condition frameworks that provide regionally relevant sets of indicators within the Composition and Configuration themes (Table 3). For example, BioCondition in Queensland (Eyre et al. 2015), Biodiversity Assessment Method in NSW (Office of Environment and Heritage 2017), and Habitat Hectares in Victoria (Parkes et al. 2003). Method developers should clearly identify which components they have taken from state-based protocols, particularly with regard to the selection and assessment of indicators, and also identify and justify any deviation from the state-based protocols.

The '**composition**' theme incorporates the three common indicator types for assessment of vegetation condition established by Noss (1990); that is, structure, function and the species assemblage. Selection of appropriate composition indicators will depend on the characteristics of native vegetation and the pressures upon them, as well as the size and complexity of the accounting area. For a Level 1 Method, indicators should generally be selected to provide information about vegetation structure, ecosystem function and the species assemblage. However due to the specialist skills involved in identifying species richness, the species assemblage theme is not required for Level 2 or 3 Methods (but can be included if the Method developer chooses to).

Indicators in the '**configuration**' theme should provide information about relevant aspects of the spatial arrangements of vegetation assets. This can be achieved by assessment of the landscape context of sites sampled for composition indicators (as it commonly is in State schemes such as BioCondition), or may be achieved using a separate spatial analysis (Appendix 4).

‘**Extent’** can be incorporated into Methods in a number of different ways. At the property and project scale – extent should be incorporated through the stratification process which defines the ‘quantity’ of native vegetation either directly through assessment units or in an initial step of delineating native vegetation areas from non-native vegetation areas (i.e. areas that can be assumed to have zero condition). At regional scales, where adequate coverage of indicators of composition can be problematic, the extent of relatively native or intact ecosystems tends to be a strong focus of Methods. As such assessment units in heavily modified vegetation tends to be conservatively assigned zero composition scores, and therefore zero condition.

Table 3 Native vegetation condition frameworks for biodiversity assessments

Jurisdiction	Terminology	Assessment	Definition
New South Wales	Vegetation integrity	Biodiversity Assessment Method (BAM)	The condition of native vegetation assessed for each vegetation zone against the benchmark, being quantitative measures that represent the ‘best-attainable’ condition, for the Plant Community Type.
Northern Territory	Vegetation condition	NT Vegetation Condition Assessment (NTVCA)	The degree of difference from a benchmark type for a particular vegetation type, where the benchmark type represents its most natural or least disturbed state.
Queensland	Vegetation condition	BioCondition	The relative capacity of a regional ecosystem to support the suite of species expected to occur in its reference state, which refers to the natural variability of the stable land-based vegetation state that is mature and relatively long undisturbed in the contemporary landscape and in ‘Best-on-Offer’ (BOO) condition.
South Australia	Bushland Condition	Bushland Condition Monitoring program	Assesses the condition of open forests and woodlands on the Mount Lofty Ranges. Indicators of vegetation composition, structure and function relative to a reference state at a patch or landscape (community or ecosystem) scale
Tasmania	Site Condition	TasVeg	Measure of the ‘naturalness’ or ‘intactness’ of a zone using a number of site-based attributes assessed against a defined benchmark.
Victoria	Vegetation quality	Habitat Hectares	Measure of the intactness and viability of vegetation in relation to its site condition and landscape context, where site condition is the measure of the ‘naturalness’ or ‘intactness’ of a patch of vegetation using a number of site-based attributes assessed against a defined benchmark.
Western Australia	Vegetation Condition	Native Vegetation Condition Assessment for WA	A measure, for the purpose of biodiversity conservation, of indicators of vegetation composition, structure and function relative to a reference state (i.e. within the context of the presence or absence of threatening processes) at a patch or landscape (community or ecosystem) scale.

Australian Government	Vegetation Condition	Vegetation Assets States and Transitions (VAST)	Assesses the condition of vegetation types using indicators/attributes of regenerative capacity (function), vegetation structure and species composition relative to a fully natural reference state. It is a measure of a site's 'naturalness'. Method is closely tied to land management regimes and enables tracking of change and trend.

Indicators and confidence Levels

The AfN Standard sets out three confidence levels to which Accounts may be certified: Level 1 (Very High), Level 2 (High), and Level 3 (Moderate). Confidence levels are based on the combination of the comprehensiveness of the set of indicators, as discussed above as well as the robustness of the sample size and design used to measure the environmental condition within an accounting area and to detect change over time.

For a Method to achieve a **Level 1 (Very High)** confidence level, the best approach is to include the indicators and sample sizes and design from the relevant state-based condition assessment frameworks (Tables 1, 2 and 3). For example in South Australia, select the Bushland Condition Monitoring manual (Appendix 1).

For a Method to achieve a **Level 2 (High)** confidence level, it may include fewer indicators and a modified, less intense sample design compared to a Level 1 Method. For example, the Tasmanian Land Conservancy (Appendix 2) uses a modified version of the Tasmanian Vegetation Condition Assessment method because it is less expensive to collect the data, yet it still provides sufficient information to provide a high confidence that the Econd® is capable of measuring change in their conservation reserves.

For a Method to achieve a **Level 3 (Moderate)** confidence level, accounts may draw primarily on rapid field assessments and indicators that are less directly measured such as vegetation condition metrics derived from site photos, airborne scanners (e.g. LiDAR), multi-temporal satellite images and from environmental models. Appendix 3 describes an account for which vegetation condition data was assembled partly from site photographs, a technique most consistent with Level 3. Level 3 certification may also be selected in order to increase the length of the time series that can be assessed, for example based on expert opinion (Appendix 5).

Table 2 provides a general guide for Indicators for Level 1, Level 2, and Level 3 Methods at the property or project scale. A Method may omit, modify, or add to the below lists of indicators, depending on the biomes and vegetation types being assessed, however it should justify all choices of indicators, including what are most material given the purpose of the Method.

Table 4 Example of minimum required indicators for Level 1, Level 2 and Level 3 Methods.

Indicator Theme		Indicator	Level 1	Level 2	Level 3
Composition (weighted 75%)	Species Richness	Tree	✓		
		Shrub	✓		
		Grass	✓		
		Forbs/Other	✓		
	Structure	Large Trees	✓	✓	
		Canopy Cover	✓	✓	✓
		Sub-canopy and/or shrub Cover	✓	✓	✓
	Function	Recruitment	✓		
		Woody Debris	✓		
		Ground Cover			✓[1]
		Organic Litter Cover	✓	✓	
		Native Perennial grass Cover	✓	✓	
		Non-Native Plant Cover	✓	✓	✓
Configuration (weighted 25%)		Site Context	✓	✓	✓
Extent		Extent	✓	✓	✓

[1]Level 3 Methods may measure individual indicators for ground cover or an overall assessment of groundcover such as bare ground, organic cover etc.

Indicators and Technology

Since the early 1980s, satellite remote sensing has played an important role in the mapping and monitoring of vegetation (extent, fragmentation/connectivity indicators) as it is cost effective and relatively quick to analyse over large areas. Recent improvements in the pixel size of satellite borne sensors can now provide resolutions down to a few metres, making mapping at property levels, or in more fragmented landscapes (e.g. mapping riparian corridors, or scattered paddock trees) feasible. Despite this, analysis of metrics derived from satellite imagery is currently not sufficiently mature to measure all elements of composition with confidence. New technology will provide opportunities to reduce cost and potentially also increase accuracy in particular indicators, as well as offering new paths to deal with complex challenges such as the application of dynamic benchmarks for indicators such as ground cover. However, changes to indicators or measurement techniques also present challenges to core principles such as time series consistency (Criterion 6). So, while Method developers are encouraged to make appropriate use of remote sensing and emerging technologies for indicator measurement, the resulting Methods are likely to involve some on ground observations to verify their suitability and to maintain consistency in concepts through time.

Criterion 4: Determination of Reference Condition Benchmarks.

The appropriateness of a Method's Reference Condition Benchmark rules must be assessed on the basis of the following five principles.

1. **Determination type**. Methods must use one of the following approaches to the determination of Reference Condition Benchmarks.
   (a) Published or historical record of the undegraded condition of the environmental asset.
   (b) Observation at local reference condition sites.
   (c) A robust model that estimates the undegraded condition of the environmental asset.
   (d) Expert opinion on the undegraded condition of the environmental asset.
2. **Accuracy.** The rules must ensure the reference condition benchmarks are a robust and unbiased estimate of the condition of the environmental assets in their undegraded state.
3. **Simplicity**. The rules should strike a reasonable balance between simplicity, cost and accuracy.
4. **Verifiability.** The rules must ensure the reference condition benchmarks can be verified by third parties.
5. **Clarity of meaning.** The rules in the Method concerning the determination of reference condition benchmarks must be clear and easy to interpret.

Choosing how to identify the Reference Condition Benchmark values for indicators is a matter of judgment (Andreasen, et al. 2001). Most State and Territories within Australia with the exception of Western Australia and Northern Territory have published Reference Benchmark documentation for a range of common indicators included in their Condition Assessment Frameworks (Table 1).

Scientific literature and historical records such as travel diaries of early naturalists, and journals of explorers and settlers are also viable sources to determine reference condition, however these may need to be interpreted with the aid of expert opinion. Unfortunately, such sources do not generally contain quantitative information for metrics such as the density of trees and shrubs and full species lists of grasses and herbs. Therefore, most metrics require a geospatial location where quantitative baseline measures can be taken.

Local Landcare groups, NRM bodies, or, government departments, may also have unpublished, draft, or incomplete Reference Benchmark values or guides that may be utilised. AfN encourages Proponents to contact these groups if there are no published benchmarks, as these groups might also be able to help the Proponent develop Reference Benchmarks if required. Oftentimes methods may prescribe indicators that are not included in the published benchmark documents, where this is the case, one, or a combination of the following three options may be used to determine the Reference Benchmark for the missing indicators.

Where there are no published Reference Benchmarks, it is recommended that if resources and time permit, the next best option is to establish local 'best on offer' reference condition sites at which to measure the indicators to determine the Reference Benchmarks. Eyre et al. 2017 provides guidance on establishing local reference condition sites for vegetation.

Where there are no published Reference Benchmarks and local reference condition sites and robust models are not feasible, then expert opinion may be used to determine Reference Benchmarks. Expert opinion may be sourced from a local expert(s) who are experienced and familiar with the chosen assets and sub-assets. The expert(s) may form the opinion based on anecdotal observations, extrapolated data from other locations or expert interpretation of incomplete data sets. It is encouraged that once the expert(s) have established Reference Benchmark values, an independent review of those Reference Benchmark values is conducted to increase confidence in the values. For example, if an experienced ecologist formulated a set of Reference Benchmark values for a specific vegetation type, it is recommended they request the local Herbarium to verify them.

Several types of reference states for Australia's native vegetation and ecosystems that might be applicable under the Accounting for Nature® Framework have been variously defined (Thackway et al. 2006; ESCAVI 2007) as:

- Pre-European state, taking into account the role that Aboriginal people had in shaping Australia's ecosystems (Thackway and Specht 2015);
- An average of an apparently undisturbed and mature vegetation state (Gould et al. 2001; Parkes et al. 2003);
- A relatively unmodified state, the result of land use and management compared to what still exists i.e. best on offer (Landsberg and Crowley 2004; Low Choy et al. 2005, Eyre et al. 2017);
- A realistically desired functional state (virtual benchmark) (Zerger et al. 2008); and
- A dynamic reference state (Bastin et al. 2012).

Some vegetation types have high natural variability or ecosystem dynamics, and some individual indicators are highly dynamic in response to seasonal conditions, such as ground-cover in rangelands regions. Therefore, it is highly recommended that Accounts that include vegetation types that are sensitive to high natural variability, use **Dynamic Reference Benchmarks**. Dynamic Reference Benchmarks are used to control for the natural variability in a system by establishing local dynamic reference condition sites, using expert opinion or ecosystem models, or through remote sensing. Generally, Dynamic Reference Benchmarks are established according to the ecosystem type (with a focus on its inherent dynamic or variability characteristics) and the purpose of the account.

Criterion 5: Collection, analysis and management of data on the condition of environmental assets

The appropriateness of a Method's data rules will be assessed on the basis of the following five principles.

1. The rules must ensure all data relied on to measure or estimate the condition of environmental assets are reasonably accurate (as determined by the Method's target confidence level), statistically valid and reproducible.
2. The rules must ensure all data are collected using sampling methods that are suitable for the target confidence level and:
   (a) are fit for the issues, questions or hypotheses of interest and the purposes of the accounts;
   (b) provide statistically valid estimates of the relevant parameter;
   (c) are repeatable; and,
   (d) can detect change with a reasonable degree of accuracy.
3. The rules must ensure all data analysis conducted for the purposes of measuring or estimating the condition of the environmental assets is undertaken in accordance with accepted statistical methods and practices.
4. The rules must ensure all datasets are retrievable and accessible.
5. The rules in the Method concerning data collection and management must be clear and easy to interpret.

Data used in an Environmental Account needs to have sufficient precision for the accounts purpose and target confidence level.

Standard condition assessment procedures typically begin by dividing the project area into 'assessment units,' for example, by intersecting sub-assets (vegetation types) with broad condition states. This approach will often result in the creation of a few large areas consisting of the more extensive vegetation types plus a collection of smaller areas of different vegetation types. Assessing the condition of these smaller areas would require additional sites but will only make a minimal contribution to the overall account because they constitute a small fraction of the project extent.

The calculation of overall condition of the account, as estimated by the Econd® involves area-weighted averages of assessment units aggregated into the sub-asset and then aggregated again into the overall asset Econd®. Therefore, methods providing flexibility for projects so that they are not required to sample all assessment units is an effective way to reduce the effort in generating an account. The threshold for **materiality** should reflect the level of assurance sought. Recommended allowances would be up to 5% of the project area for an account aiming for level 1 confidence level, and up to 10% to give level 2 assurance.

An **Information Statement** is also required to accompany each account. Examples can be found on the Accounting for Nature website. The purpose of an Information Statement is to document the rationale behind selection of assets, choice of Method, the origins of the data, the determination of Reference Benchmarks, and the analysis and treatment of data, the construction of the Econd®, and any limitations identified in the Account building process. The Information Statement is made publicly available to provide full transparency of the Account.

Criterion 6: Time series consistency

The appropriateness of a Method's time series consistency rules will be assessed on the basis of the following two principles.

1. The rules must promote the use of consistent methods to ensure time series consistency. This can be achieved by ensuring measurements are taken in consistent and comparable times in the year (i.e. in the same season if measurements are only taken once a year).
2. Where a Method change is deemed necessary, one of the following three approaches is to be used to address consistency issues:
   (a) **full recalculation**, which involves the recalculation of the past Econd® and Indicator Condition Scores using the new Method to ensure time-series consistency;
   (b) **recalculation using a splicing approach**, which involves the recalculation of the past Econd® and Indicator Condition Scores using the ratio between the Econd® and Indicator Condition Scores calculated using the old and new Methods in one or more overlapping accounting period; or
   (c) **breaking the time series**, where the past Econd® and Indicator Condition Scores are not recalculated, but the accounts fully disclose the Method changes and their effects on the trends in the Econd® and Indicator Condition Scores.

For simplicity, methods should require accounts to be based on a consistent extent of 'vegetation assets' within an Account through time. That is, the accounting area extent should not increase or decrease.

Consistent spatial scope avoids significant complexity in sampling through time, because it enables 'composition' indicator(s) to be measured consistently across all areas. Assessment units should only be assigned a condition score of zero where it is conservative to do so given the accounting purpose. Accounts that aim to show an improvement in vegetation condition should include all areas of native vegetation within the accounting area (either current, or planned), for example restoration areas, paddocks with pastures or young woody regrowth that are targets for restorative management in the project, or any areas that may see an improvement in native vegetation condition, should be included within the 'extent' of vegetation assets from the start.

If a new area is added to a project, the extent of the whole account should be modified to create a new time series (i.e. a new baseline) to avoid the addition biasing the account. The new time series could be achieved by either 'hindcasting' condition to cover the new scope, or by 're-starting' the account with its new spatial extent. Re-starting would mean developing a new account for the new area that is ignored for consideration of trends until the area has been measured three times or more.

Criterion 7: Counterfactual analysis for identification of management effects

Methods can choose to either:

1. Assess the change in condition of native vegetation through time without attributing the cause of change to management activities, or,
2. Include techniques (i.e. counterfactual analysis) that allow changes in condition to be the attributed to management activities.

This criterion only applies to the Methods that aim to attribute changes to management activities (option 2, above).

The appropriateness of a Method's rules for isolating the impacts of management activities must be assessed on the basis of the following six principles:

1. **Counterfactual analysis.** The rules must require accounts to estimate the impact of management activities on the condition of the environmental assets by comparing the actual condition (managed) of the assets in the accounting period with both the estimated condition in a control state (i.e. unmanaged) and the Reference Benchmark. For accurate attribute of change to management activities, Dynamic Reference Benchmarks are recommended, to control for natural environmental variability.
2. **Accuracy.** The rules must require the control sites to reflect the likely equivalent condition of the environmental assets in the accounting period in the absence of the relevant management activities.
3. **Conservatism.** The rules must require the estimate of the impact of the management activities to be conservative.
4. **Transparent.** The rules must require the accounts to fully detail the techniques, assumptions and data used to devise control state.
5. **Verifiable.** The rules must ensure the approach used to undertake the counterfactual analysis is verifiable.
6. **Clarity of meaning.** The rules in the Method concerning the estimation of management impacts should be clear and easy to interpret.

If a Method is to generate accounts with the purpose of definitively demonstrating the effect of a management intervention it must require clear justification in the Information Statement for the difference between the observed outcome captured in the account and the likely outcome in the absence of the intervention.

This may for example, require accounts to include specific 'control' sites, to be used as physical models of the counterfactual situation (where management was not changed). Alternatively, methods may include eligibility rules establishing a reasonable belief in a particular outcome under business-as-usual management.

Criterion 8: Calculation of Indicator Condition Scores and the Econd®

The appropriateness of a Method's rules for the calculation of Indicator Condition Scores and Econd® will be assessed on the basis of the following five principles:

1. **Accuracy**. The rules must ensure Indicator Condition Scores and the Econd® provide a robust and unbiased estimate of the condition of the environmental asset relative to its Reference Condition Benchmark and the change in its relative condition through time.
2. **Fit-for–purpose**. The rules must ensure Indicator Condition Scores and the Econd® are calculated in a way that reflects the intended purposes of the accounts.
3. **Simplicity.** The rules should strike a reasonable balance between simplicity, cost and accuracy, having regard to the purposes of the accounts.
4. **Verifiability.** The rules must ensure the Indicator Condition Scores and the Econd® can be verified by third parties.
5. **Clarity of meaning.** The rules in the Method concerning the calculation of Indicator Condition Scores and the Econd® must be clear and easy to interpret.

Indicator Condition Scores

An Indicator Condition Score is typically a proportion of the observed value for an indicator compared to the Reference Benchmark value for that indicator. However, the formulas for calculating the ICS can vary considerably between indicators—some incorporate weightings and conditional clauses to reflect the ecological thresholds associated with some attributes. For example, in an ecosystem where woody thickening is a negative outcome, if the measured value for the indicator exceeds the Reference Benchmark, then the ICS should be reduced.

Econd®

The Indicator Condition Scores, are then aggregated in a meaningful way to produce the Econd®.

Firstly, at the assessment unit level, the individual ICSs are combined to generate an average ICS for each of the composition and configuration themes. The average ICS for each composition and configuration is then combined to give a 'quality' score for the assessment unit. In combining the configuration and composition indicators, each indicator, or indicator theme, is generally weighted to reflect their relative ecological importance. A simple way of doing this is to align any weightings applied in the aggregation of Indicator Condition Scores with those established in State Condition Assessment Frameworks (Table 2). Relative weightings for the components of the quality indicators may vary between vegetation assessment programs. For example, Natural Resources Eyre Peninsula used equal weights of 50% for both composition and configuration, whereas the Habitat Hectares approach in Victoria weights composition with 75% and configuration as 25% of the score.

An Econd ® is then calculated for each assessment unit in the account as the average quality score. Once the Econd® is calculated for the assessment unit, the sub-asset Econd® is calculated as the area-weighted average of the assessment unit Econd® scores. The overall Econd® for native vegetation for the account is then calculated as the area-weighted average of the sub-asset Econd® scores.

This means that the sub-asset and overall Econd® scores represent the average condition (it's 'quality,' calculated as described above) across its pre-clearing or pre-European extent (it's 'quantity'):

Econd® = Quantity x Quality

Area-weighting (including the 'quantity' component) is important to include as it ensures that all assessment units are weighted according to their size. 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).

Econd® scores calculated for each sub-asset (native vegetation type) can be presented visually in the Environmental Account Summary document as a bar graph (Figures 1 and 2), and/or colour coded regional map (e.g. see box 1 in Appendix 4).

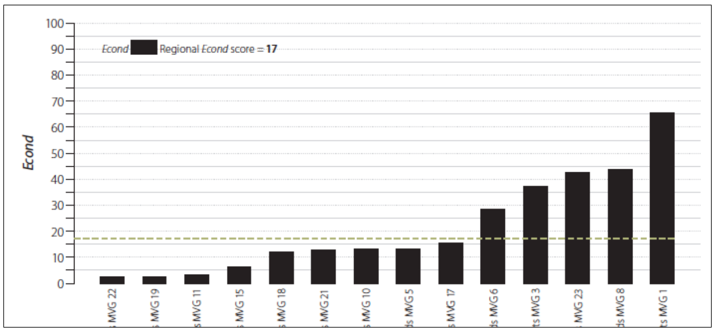

Figure 1: Econd® for native vegetation types (MVS) of Natural Resources Eyre Peninsula region, South Australia

The Econd® provides a summary of the overall condition of an environmental asset. The Indicator Condition Scores are also important because they assist with interpreting the drivers of change in an assessment unit i.e. whether the primary contributor to the overall condition is more likely a low score in the composition or configuration indicators, and in which native vegetation type.

Criterion 9: Accounts are transparent and disclose all material uncertainties

The appropriateness of a Method's transparency will be assessed on the following four principles:

1. **Method disclosure.** The rules should ensure Accounts provide sufficient information to enable third parties to comprehend how the Econd® and Indicator Condition Scores were constructed.
2. **Data disclosure**. The rules should ensure accounts provide sufficient information to enable third parties to comprehend how the data used to calculate the Econd® and Indicator Condition Scores were collected and analysed.

3. **Uncertainty disclosure.** The rules should ensure sufficient information is disclosed on material uncertainties to enable third parties to judge the reliability of the information in the accounts, including on the Econd® and Indicator Condition Scores. In graphical presentation of account data, error bars or confidence intervals should be used to indicate uncertainty.
4. **Clarity of meaning.** The rules in the Method concerning transparency should be clear and easy to interpret.

The Reference Benchmark and current data underpinning each indicator should be provided as part of the native vegetation account, as well as reporting the overall Indicator Condition Score (ICS) for composition or configuration. The native vegetation account must include relevant data tables, which are used to store and calculate data for specific indicators and indices. Where a regional level account is prepared separate tables must be presented for extent, composition and configuration datasets.

The account must also include an asset table, which includes information compiled for each native vegetation type and indicator that make up the environmental account. The methods used to combine the indicators into an Indicator Condition Score for composition and configuration must be recorded in an Information Statement.

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Appendix 1: Eyre Peninsula NRM Region Native Vegetation Account

As part of the continental wide Regional Accounting for Nature trials, the Eyre Peninsula NRM region in South Australia developed its first native vegetation condition account.

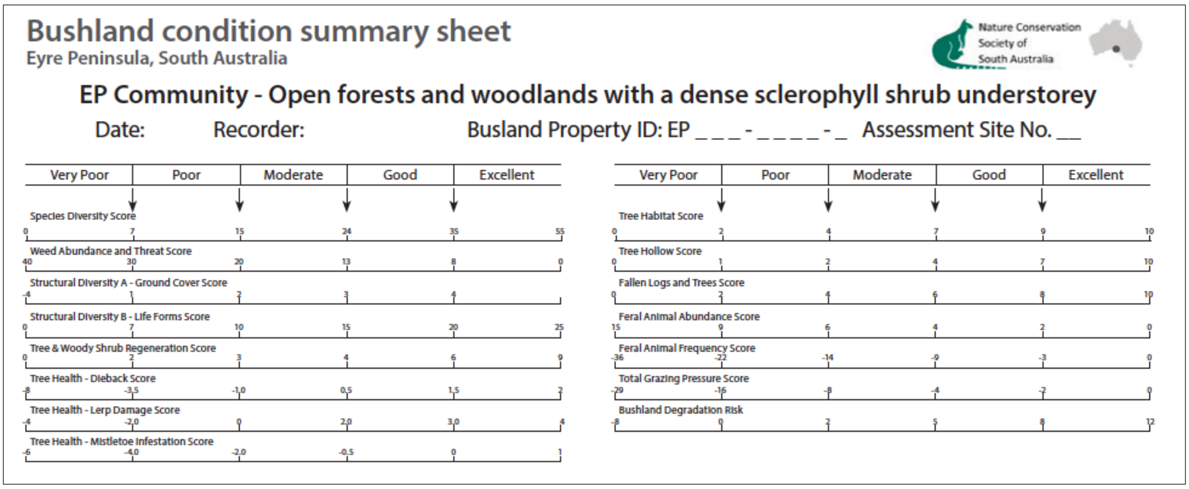
The account measured the condition of 23 vegetation types that exist in the region using pre-European extent and composition benchmark estimates provided by the South Australian government, and a Bushland Monitoring Manual developed by the Nature Conservation Society of South Australia, to survey for composition. The Regional Account was constructed over a two-week period, when representative sampling of each of the vegetation types was undertaken by staff and volunteers.

NATIVE VEGETATION ASSET ACCOUNT - EYRE PENINSULA, SOUTH AUSTRALIA - 2012

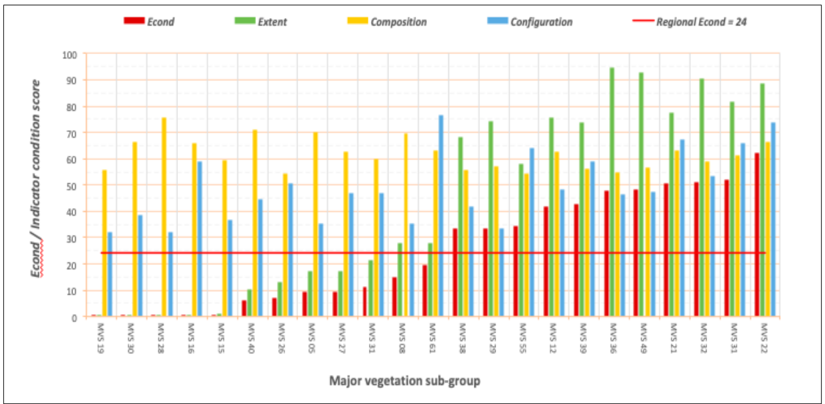
Government of South Australia – Eyre Peninsula Natural Resources Management Board

Regional Area (hectares)	Regional Indicator Condition Score (Extent)	Regional Indicator Condition Score (Composition)	Regional Indicator Condition Score (Configuration)	Regional *Econd* Extent x (Comp+Config/2)
5,130,353	47	60	47	25.0

Asset Category	Indicator of Asset Condition (unit of measure)	Reference Benchmark	% Total Area	2012 Condition Measure	2012 Indicator Condition Score	2012 *Econd*
Eyre Peninsula Region		5,130,353				25.0
Arid & semi-arid acacia low open woodlands & shrublands with						62
	Extent (Ha)	186,558	3.6	165246	89	
	Composition (index)	100		66.30	66	
	Configuration (index)	100		73.62	74	
Arid & semi-arid hummock grasslands						11
	Extent (Ha)	23,320	0.5	5013	21	
	Composition (index)	100		59.67	60	
	Configuration (index)	100		46.67	47	
Callitris forests & woodlands						42
	Extent (Ha)	23,320	0.5	17595	75	
	Composition (index)	100		62.80	63	
	Configuration (index)	100		48.17	48	
Casuarina & Allocasuarina forests & woodlands						7
	Extent (Ha)	233,198	4.5	30911	13	
	Composition (index)	100		54.40	54	
	Configuration (index)	100		50.67	51	
Chenopod shrublands						52
	Extent (Ha)	233,198	4.5	190628	82	
	Composition (index)	100		61.16	61	
	Configuration (index)	100		66.01	66	

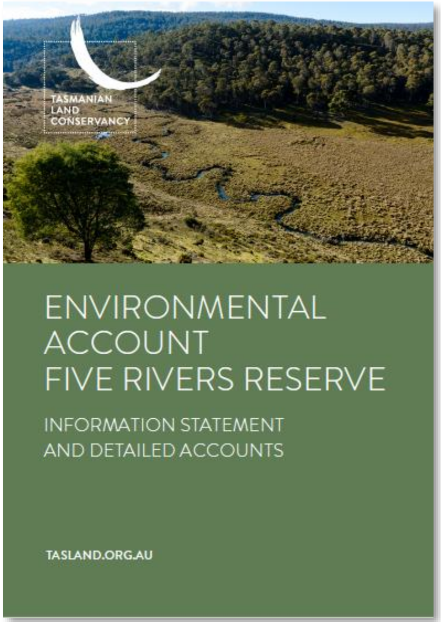


The following graph highlights the level of detail contained in the Eyre Peninsula Regional Native Vegetation Account. It shows the overall condition of native vegetation in the region (Econd® = 25), and of each of the 23 vegetation types (red bars). It also shows, for each vegetation type, how much has been cleared - the extent of the remaining vegetation (green bars), the composition of the vegetation in each of these vegetation groups (orange bars), and the configuration of the vegetation across the landscape (blue bars).



For example, the left hand side shows five vegetation groups that have an Econd® <1, primarily because they have been reduced in area to less than 1 per cent of their original extent, whereas whilst the extent of Temperate tussock grasslands (5th from the right) is high (with an ICS = 93), it has an Econd® of less than 50 because the composition score of that vegetation only 53.

Appendix 2: The Tasmanian Land Conservancy's Five Rivers Conservation Reserve



The Tasmanian Land Conservancy (TLC) is a not-for-profit, community-based organisation that uses the best available science to help protect Tasmania's unique natural places, world heritage values, and rare ecosystems and habitat for threatened plants and animals, on private land. I t has facilitated the protection of over 60,000 hectares of Tasmania's private land, including 19 permanent conservation reserves.

The TLC uses Open Standards to produce Management Plans for each of its permanent reserves. They have adopted Accounting for Nature® as a way of recording, presenting and interpreting their monitoring data in a consistent way. The data used to populate their environmental accounts are derived from the TLC's ecological monitoring program which measures flora and fauna diversity, structural complexity and changes in special values over time.

The first environmental account was for the Five Rivers Reserve, an 11,000 ha reserve in and adjoining the World Heritage listed the Tasmanian highlands.

For their native vegetation monitoring, 100 permanent photo sites have been established and these were assessed in 2014, 2016 and 2018. The Five Rivers Reserve contains 3 types of native vegetation: Highland Forests; Highland Marshes; and a Riparian Zone. Indicators used to describe the condition of native vegetation in the reserve are: Extent, Composition (Diversity, Structural complexity, Recruitment) and Carbon storage.

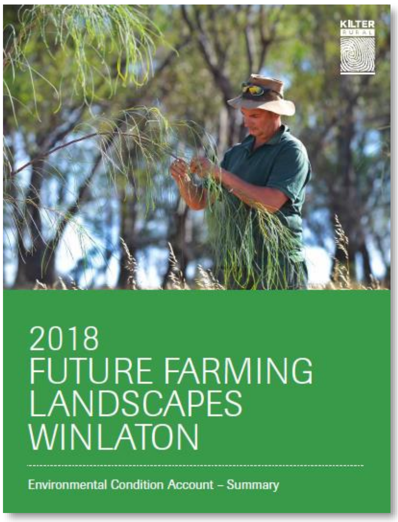
FIVE RIVERS RESERVE

Class	Asset	Sub-asset	2014	2015	2016	2017
LAND	**Native Vegetation**	**Econd**	**98**		**98**	
		Highland Forests	95		94	
		Highland Marshes	100		100	
		Riparian Zone	100		100	
	Native Mammals	**Econd**	**85**	**88**	**89**	**89**
		Carnivores	65	71	70	71
		Herbivores	100	100	100	100
		Omnivores	90	93	98	96
FRESHWATER	**Rivers & Wetlands**	**Econd**		**78**		
		Clarence River		78		
		Kenneth Lagoon		78		
		Nive River		83		
		Pine River		69		
		Serpentine Rivulet		83		

VEGETATION ASSET ACCOUNT - FIVE RIVERS RESERVE

Sub-asset	Indicator		Reference Benchmark	2014			2015			2016			2017		
				Measure	Indicator Condition Score	Econd	Measure	Indicator Condition Score	Econd	Measure	Indicator Condition Score	Econd	Measure	Indicator Condition Score	Econd
						98.3						**98.2**			
All sub-assets	Extent	% native veg on property	11183	10987	98	98.2				10987	98	98.2			
	Configuration	% native veg within 10 km	113953	112127	98	98.4				112127	98	98.4			
						98.2						**98.0**			
Highland Forests	Composition	Richness	10.6	11.7	100	94.6				9.4	99	94.3			
		Structural complexity	4.5	4.8	100					4.2	100				
		Recruitment	2.4	2.5	100					2.3	100				
		Carbon content	130	101.4	78					101.4	78				
Highland Marshes	Composition	Richness	10.8	11.5	100	100.0				10.0	100	99.8			
		Structural complexity	3.1	3.4	100					2.8	99				
		Recruitment	100	100	100					100	100				
		Carbon content	100	100	100					100	100				
Riparian Zone	Composition	Richness	10.49	11.6	100	100.0				9.4	100	100.0			
		Recruitment	100	100	100					100	100				
		Carbon content	100	100	100					100	100				
		Structural complexity	3.1	3.4	100					2.9	100				

Appendix 3: Kilter Rural's Farm Level Environmental Account

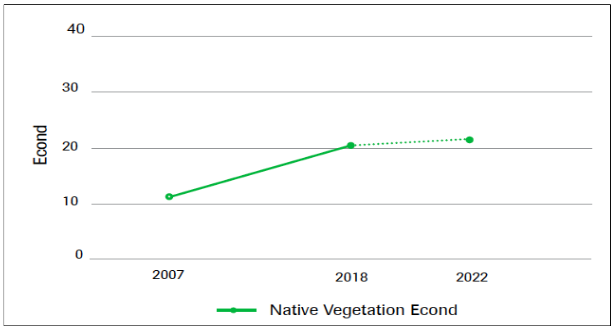


Kilter Rural is a $300 million Australian agri-business that has adopted Accounting for Nature® to monitor ecological changes in the condition of the natural assets of soil and native vegetation on their Winlaton farms in north-west Victoria.

The Winlaton investment comprises 35 properties across 8,900ha of agricultural land (irrigated summer cropping and winter cereals), low impact grazing on native forage, protected biodiversity and forestry.

When the properties were purchased from 2007, more than 95% of the farms had been adversely impacted by what proved to be unsustainable irrigation practices in the past century, where high saline water tables caused widespread soil degradation. Kilter's business model is to restore this degraded farmland and, in the process, provide both a financial return to their investors and create jobs and wealth in the local community.

Kilter believe that having an established and accredited framework to monitor and compare the condition of natural assets is invaluable in informing management decisions to deliver long-term sustainable food and fibre to their customers and long-term value to their investors.



Geographical complexity owing to the 35 separate properties under management, when combined with 3 soil types and 5 native vegetation types, means the spatial basis of the account is similarly complex. Depending on the asset type, environmental condition scores are resolved at a finer land management unit, and then aggregated to each property, and then overall for the whole business.

The selection of the condition indicators for their native vegetation account is based on the principles set out in Victoria's Habitat Hectare approach that considers the attributes of vegetation – extent, composition (structure, diversity and recruitment) and configuration (connectivity and size).

Natural asset	Asset category	Pre-1750 area (ha)	% of landscape
Native Vegetation	EVC: Riverine Chenopod Woodland (RCW)	5390	60%
	EVC: Chenopod Grassland (CG)	1810	20%
	EVC: Semi-arid Chenopod Woodland (SaCW)	915	10%
	EVC: Lignum Swampy Woodland (LSW)	370	4%
	EVC: All others	475	5%
Soil	Black Cracking Clays (Lower floodplain soils)	2440	27%
	Grey Cracking Clays (Higher floodplain soils)	4525	51%
	Loamy Medium Clays (Lighter rise soils)	1910	22%

Table 1: FFL account classification of native vegetation and soil assets.

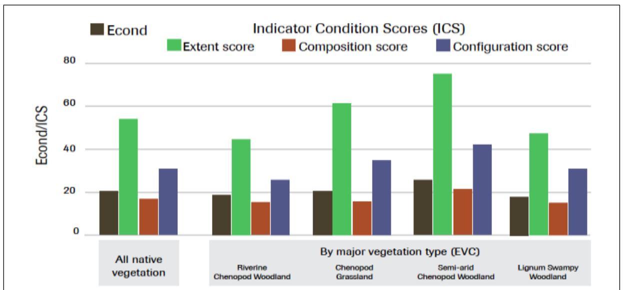


Figure 4: NV Econds, contributing condition indicators, and their breakdown for major vegetation types.

Significant investments in landscape restoration have seen the condition of native vegetation across the 35 properties increase from an Econd® of 11 in 2007 to an Econd® of 22 in 2018. The historical 2007 Econd® was calculated by assessing publicly available Google Earth satellite imagery supported by early photopoint records. A data quality score of 2 recognises the coarser level of analysis for the 2007 account, whereas a data quality score of 4 was achieved for their 2018 account as a result of the more intensive level of on-ground survey (Table 4).

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Appendix 4. Examples and discussion of typical method for vegetation condition accounting

This appendix provides additional background and examples to outline four steps involved in a typical vegetation condition accounting process.

Step 1: Defining the accounting area

The output of Step 1 is:

- A digital geospatial layer showing polygon features defining the accounting area compatible with geographical information systems, such as a shapefile, in a commonly applied datum such as the Geographic Datum of Australia 1994, or the Map Grid of Australia.

An account's purpose is the primary consideration when defining the spatial scope of assets to be included. Whether accounts of vegetation condition should be assembled for an ecological region e.g. bioregion, an entire business enterprise, a project area, a paddock, a property, depends on the purpose of the account. This should be clearly stated in the Method.

Native vegetation types (i.e. lists and maps of plant communities) are commonly used to describe and map native vegetation assets, using a combination of functional, taxonomic, structural and floristic attributes. Guidelines for surveying, classifying and mapping of native vegetation at particular scales and for different purposes are provided in chapter 8 of Guidelines for Surveying Soil and Land Resources (2nd edition) and in Australian Soil and Land Survey Field Handbook (3rd Edition). An example of pre-European mapped boundaries of vegetation assets is presented in Figure 2a.

Land management regimes, in both intensively and extensively managed landscapes, include a mosaic of land cover types including; native classes (plant community types), non-native vegetation cover classes (plantations, crops and amenity plantings) and non-vegetated classes (bare sand, soil, mud and rock) (Thackway and Lesslie 2008, Table 1).

These land cover classes can assist when considering whether a whole of landscape approach is required to account for status, change and trend in native vegetation condition. The 2017 Australian Vegetation Attribute Manual: National Vegetation Information System, Version 7.0 defines how these land cover classes are to be translated and compiled into the NVIS dataset (Bolton et al. 2017).

It should be noted that this Protocol is not restricted to developing an account of intact /remnant / unmodified native vegetation types. This Protocol is also designed to be applied in landscapes where native plant community types have been modified including unmodified, modified and transformed as well as non-native vegetation cover classes (plantations, crops and amenity plantings). Application of this Protocol across these modification classes does require that such areas can be assigned to their original plant community types so that the area or site can be benchmarked using an appropriate reference condition. Under the AfN Framework transformed and removed/replaced classes (defined in Thackway and Lesslie 2008, Table 1) would be assessed as low condition i.e. a low Econd®.

The Accounting for Nature® Framework and this Protocol explicitly define an undegraded or unmodified state for each vegetation type as the reference condition against which the current condition for that location (area or site) is assessed/reported over time. This Protocol defines how to benchmark vegetation condition for an area/site relative to its native vegetation type.

At a regional level, developing an account of native vegetation condition requires an appropriate map showing the extent Pre-European or pre-clearing vegetation types across the accounting area.

When developing an account at a property and project level, a regional scale map of plant community types can be used to generate an expected list of native vegetation (plant community) types likely to be present at that scale, but it may also be helpful to refine the mapping to capture variation at property scale.

At a property level the purpose of an account will also dictate the range of modification classes of native vegetation types that are included in or are excluded from the account. For example, all heavily modified ecosystems that are part of a 'project area' can be included, whether these areas are spatially contiguous or not. Only areas where it is conservative to assign a condition score of zero should be excluded from the 'current extent' of relevant vegetation assets at the start of the accounting time series. Such excluded areas would include landscapes or sites that are intensively cultivated or dominated by infrastructure, and where land-use change is not planned and will not materially affect vegetation condition.

For simplicity, and to be conservative in terms of improvements in methods for tracking changes and trends in native vegetation condition, this Protocol requires the adoption of fixed spatial units depicting the mapped boundaries of pre-European vegetation assets (e.g. Figure 2a). That is, the boundary extent of these original or reference native vegetation types should not expand or contract during the accounting timeframe, whereas the mapped boundaries of condition classes are expected to change over time (e.g. Figure 2c and Figure 2d). To illustrate this at a regional level; where the condition of a vegetation type has been minimally modified i.e. there is little or no modification in the condition of the original vegetation type, it scores close to 100% ((Unmodified (VAST Class I) and Modified (VAST Class II)) i.e. Casuarina forests and woodlands (Figure 2e). Whereas, where a pre-European vegetation type has been completely removed and transformed for agricultural production ((Removed and replaced (VAST Class 5)), no native vegetation remains, i.e. Acacia forests and woodlands (Figure 2e).

Step 2: Compile existing published standardised data for native vegetation types

The outputs of Step 2 are:

1. A table listing all plant community types present in the accounting area, along with their descriptions.
2. Polygon features defining the pre-European or pre-clearing extent of the native vegetation types in the accounting area within a spatial data file compatible with geographical information systems, such as a shapefile, in a commonly applied datum such as the Geographic Datum of Australia 1994, or the Map Grid of Australia.
3. Reference condition benchmarks for the native vegetation types in the accounting area for which published benchmarks are available.

Consistent with the AfN Standard, this Protocol requires the use of peer reviewed standardised approaches to ecosystem classification and assessment of native vegetation condition relative to a fully natural reference state for each of the three components that make up a native vegetation condition account: extent, composition and configuration.

The key datasets at regional and property levels include:

1. Pre-European or pre-clearing native vegetation types, required as a starting point to calculate the extent of original native vegetation types in the account area (Table 2)
2. Extant or present extent of native vegetation types, also known as remnant native vegetation (Table 2)
3. Native vegetation regulatory maps that show which vegetation types at the property level govern how native vegetation can be managed primarily relating to clearing/thinning
4. Reference condition benchmarks for fully natural native vegetation types (Table 2 and Table 3).

The best approach for developing a native vegetation condition Account for an accounting area is to adopt the native vegetation geospatial data infrastructure developed by the relevant jurisdiction. Most state governments have developed a vegetation data infrastructure which provides peer reviewed standardised approaches to ecosystem classification and assessment of vegetation condition relative to a fully natural reference state.

The benefits of adopting this data infrastructure developed by the state governments include to reduce duplication and uncertainty, and to improve consistency in monitoring and reporting at regional, state and national levels. In addition, state governments are likely to provide technical assistance to support that infrastructure where it is required to implement the approved accounting method that is endorsed by the jurisdiction.

Additional resources are provided online by each jurisdiction's vegetation management agencies, including descriptions of plant community types and more detailed 'technical descriptions'. Most jurisdictions enable data and information to be downloaded.

Vegetation data infrastructure on native vegetation types varies in its availability vary from state/territory to state/territory and consequently, the required data may or may not be available. Where a proponent has high quality mapping of existing vegetation, but does not have pre-European mapping, the proponent will need to establish the reference benchmark for each native vegetation type they wish to incorporate into their vegetation condition account (see section 3.2).

Data for assessment of changes in extent

The extent of native vegetation is the aggregate areas of all native vegetation types distributed across the landscape assessed at a particular level of detail and at specific points in time.

Assessments of change in extent should be measured relative to the reference state, e.g. pre-European (1750), by spatially comparing the present extent of native vegetation relative to the reference state. Spatial coverage of the present extent of native is established at the same resolution as for the reference state e.g. 100 m ground distance.

Most state and territory governments have datasets of reference state extent and one or more contemporary spatial coverage which can be used to assess changes in extent over time.

In many cases, state/territory governments produce datasets of native vegetation at a regional scale. For example, Corangamite and North Central Catchment Management Authorities use datasets provided by the Victorian Government's Department of Environment and Primary Industries based on the EnSym environmental systems modelling platform, whereby a pre-1750 extent and condition ("habitat hectares" (Parkes et al. 2003)) had been determined for each ecological vegetation class.

Where a regional body does not have access to up to date, regional scale mapping from which to derive extent data, relevant data for foliage projective cover (representing tree canopy cover) can be downloaded from the TERN Portal AusCover archive (http://www.tern.org.au/AusCover-pg17728.html). Care does however need to be exercised to ensure that these data are understood by the spatial analyst and fit for the desired purpose.

Several multi-temporal spatial data archives are also available which may provide relevant datasets for monitoring of changes in extent over time. Examples include: the Queensland Statewide Landcover and Trees Study (SLATS) program which generates datasets across Queensland's forests and woodlands to assess vegetation extent and clearing activities (Department of Environment and Resource Management Queensland 2012); the Terrestrial Ecosystem Research Network's Auscover Facility and the National Carbon Accounting System (NCAS). Geoscience Australia's 'datacube' project is being used to test vegetation condition metrics such as those developed for the SLATS program to generate national coverage. These multi-temporal spatial datasets must be used advisedly because most have not been validated to assess whether they are fit for particular purposes, particularly at a project or property level.

The availability of appropriate native vegetation datasets for regional level accounting varies from state/territory to state/territory and data may or may not be available from the relevant state agencies. Where a region has high quality mapping of existing vegetation, but does not have pre-European mapping, it will be necessary to establish the reference benchmark for each vegetation type within the project boundary of the native vegetation asset condition account.

This could be achieved by:

- engaging a qualified vegetation expert from a Regional body, relevant state/territory government agency or a tertiary institution to compile a 'preliminary' or 'interim' reference benchmark map, from which to derive the reference benchmark for each vegetation type (see Box 1); or
- commissioning a specific study, such as has been conducted by the Central West (DECC 2006) and Namoi Catchment Management Authorities in NSW, where a combination of soil, native vegetation maps and other sources of data were used to derive reference benchmarks.

For native vegetation types without published reference state benchmarks, proponents should seek advice from the relevant state vegetation management agency regarding development of a benchmark for each native vegetation type. An example of the approach used in Queensland to establish a reference benchmark requires 2-3 sites to be surveyed and described (Eyre et al. 2017). These sites must be mature and relatively long undisturbed in the contemporary landscape and in 'Best-on-Offer' condition.

Box 1: Collecting reference condition and current condition data on native vegetation extent in the absence of existing published records, Eyre Peninsula, SA (Poole and Wiebkin 2013)

- The Eyre Peninsula Natural Resources Management Board did not have estimates of pre-European extent of native vegetation available. In order to obtain such information they sought expert guidance from the state Department of Environment, Water and Natural Resources (DEWNR).
- Experts at DEWNR developed estimates at the required regional level based on literature research pertinent to the peninsula, previous scientific work, biological surveys and ground truthing. They were also based the resultant maps on-ground expert knowledge developed over 25 years of extensive field work on the peninsula and two broad maps of the peninsula's vegetation communities.
- In order to collect extent data for the year 2012, field experience, literature, survey quadrats, current and historical vegetation mapping were combined to digitise polygons for the 23 MVSs (using ArcMap at 1:50000 scale). The polygons were drawn on a satellite imagery background, and at times coloured aerial photography, where vegetation definition was less clear.
- The total area of the Eyre Peninsula IBRA region was calculated using the ArcMap program and the area of the individual polygons for each MVS was also totalled and calculated as a percentage of the total IBRA region.
- The NRM region identified that a soil map is required for a more detailed estimate of pre-European vegetation to be modelled

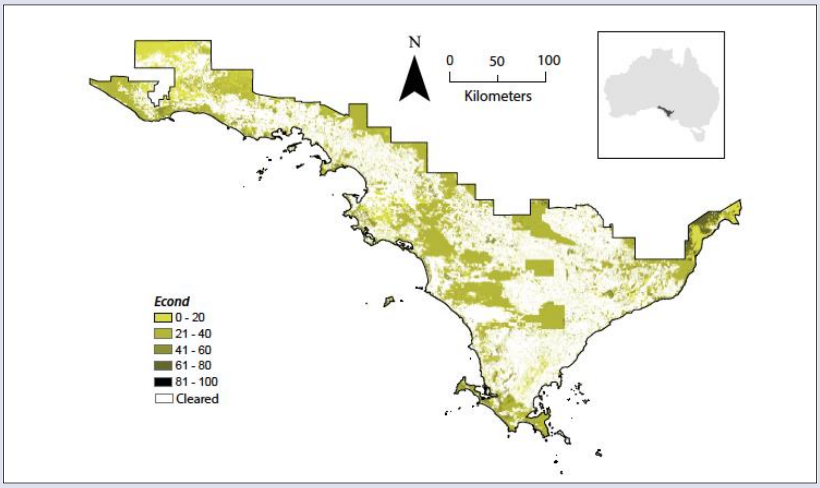

Figure A4.1: Econd of remaining native vegetation in Natural Resources Eyre Peninsula region, South Australia, mapped by major vegetation subgroup (MVS)

Step 3: Stratifying accounting area into assessment units

The output of Step 3 will be:

A geospatial coverage showing polygon features defining assessment units within the pre-European or pre-clearing native vegetation types in the accounting area (from Steps 1 and 2). These must be stored within a spatial data file compatible with geographical information systems, such as a shapefile, in a commonly applied datum such as the Geographic Datum of Australia 1994, or the Map Grid of Australia.

Assessment units are mapped entities that break the accounting area into consistent sub-units. At their simplest these units might be combinations of native vegetation types and broad condition states.

In some areas of Australia, Pre-European native vegetation types (Figure A4.2a) are depicted as completely cleared of native vegetation and converted for grazing modified pastures or production forestry land uses (Figure A4.2b). These transformed landscapes are represented in present vegetation type maps as 'white space' (Figure A4.2c) i.e. no longer native vegetation. However, in many areas the native vegetation, rather than being completely cleared, is now a mosaic of removed/replaced (non-native), and native vegetation condition classes including residual/unmodified, modified and transformed (Figure A4.2d). Land managers in such mosaic landscapes are looking for land use options, including partially restoring areas, which are defined and mapped as modified and transformed native vegetation condition.

An example of the transformation of the of the pre-European native vegetation types (Figure A4.2a) found on the Naracoorte Coastal Plain bioregion (located mainly southeast South Australia) is shown if Figure A4.2e. The figure shows the extent to which each native vegetation type (Figure A4.2a) in that bioregion has been modified into various condition states including removed or replaced, modified and transformed as well as removed and replaced. This bioregion has developed as an important region for grazing modified pastures and production forestry.

Given the large area that is managed for grazing modified and transformed native vegetation (Figure A4.2d), land managers are now looking to restore the original woody native vegetation to sequester carbon. Paul & Roxburgh (2020) present a national methodology for predicting carbon sequestration of woody biomass following land restoration for native vegetation types and condition classes.

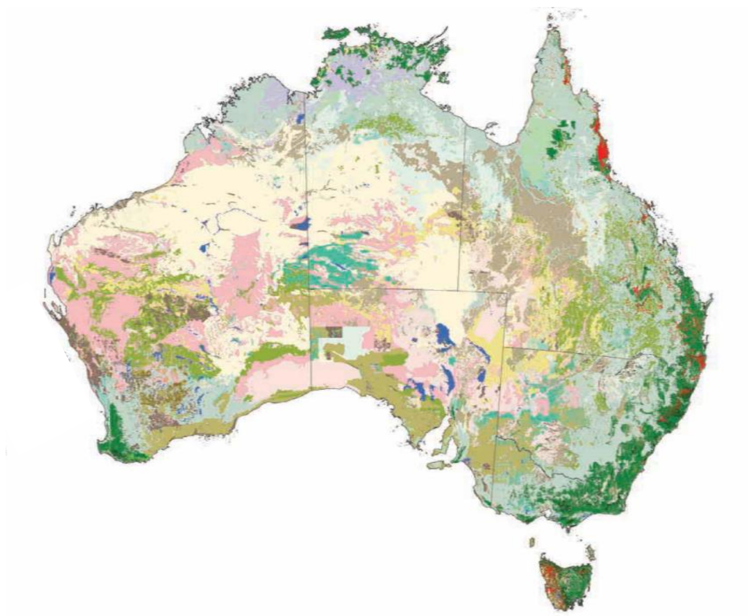

Figure A4.2a. Pre-European native vegetation types - NVIS Major Vegetation Groups (DEWR 2007)

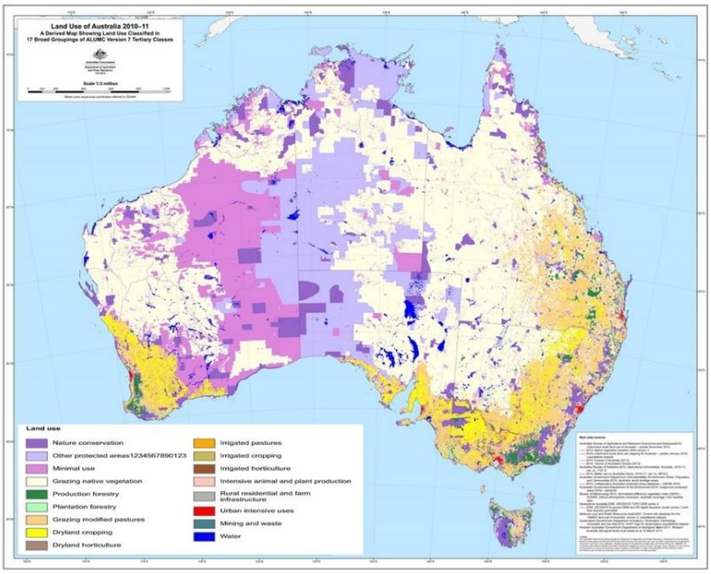

Figure A4.2b. Present land use (ABARES 2016)

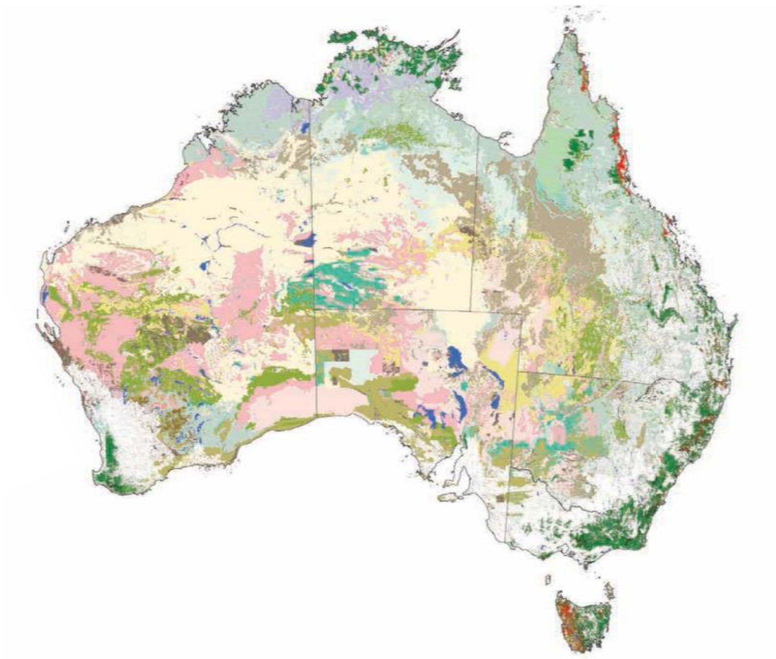

Figure A4.2c. Present native vegetation types - NVIS Major Vegetation Groups (DEWR 2007)

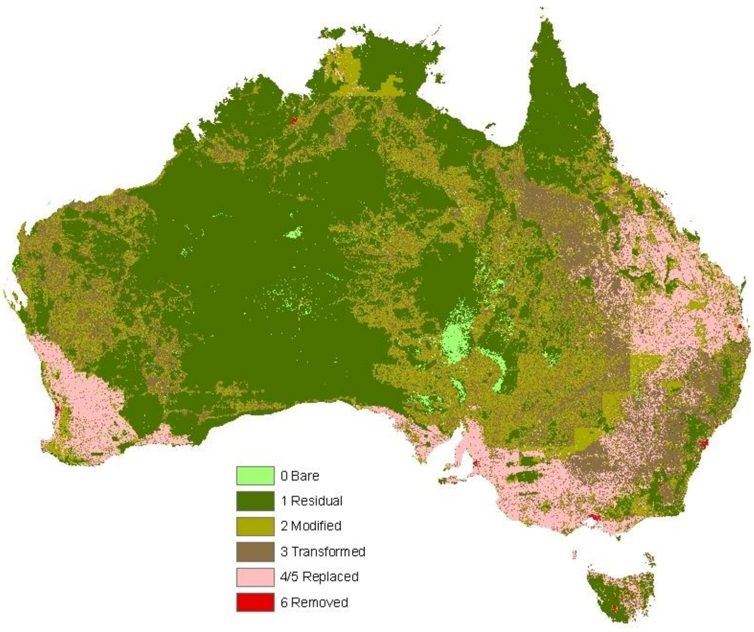

Figure A4.2d. National VAST (version 2) dataset (Thackway and Lesslie 2008, Figure 1). Appendix 6 defines each VAST class.

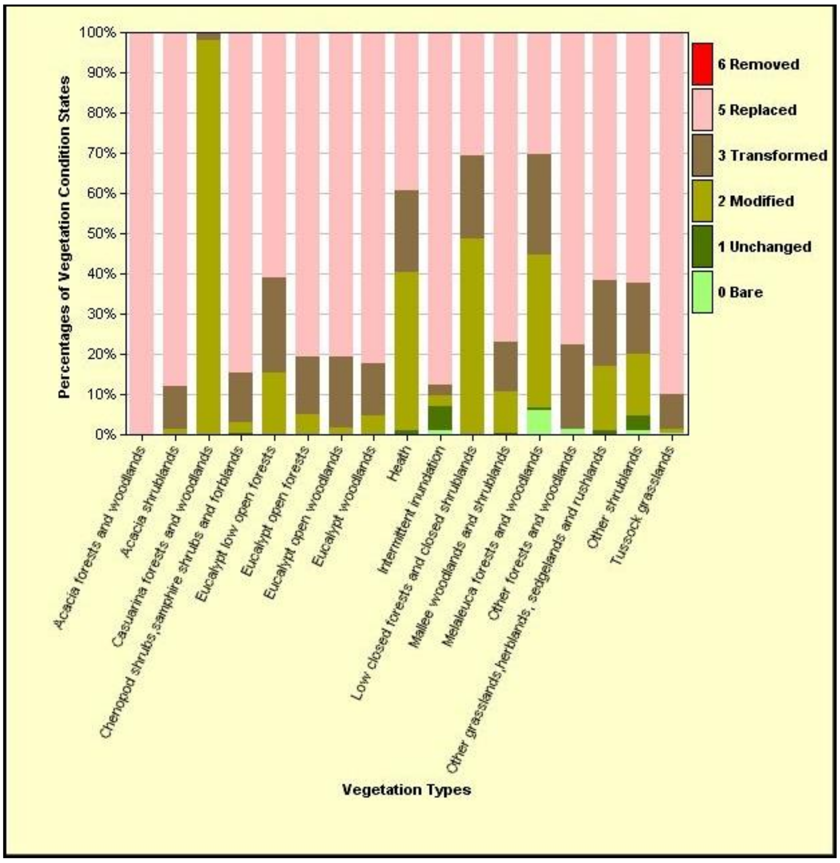

Figure A4.2e. Transformation of the Pre-European native vegetation types (MVG) (Figure A4.2a) Naracoorte Coastal Plain bioregion into various condition classes (VAST) (Figure A4.2d). Appendix 6 defines each VAST class.

Assessment units at a property level should be relatively homogenous and defined by a unique native vegetation type as well as a broad condition state, such as:

- Regional ecosystem 11.9.5 remnant
- Regional ecosystem 11.9.7 remnant
- Regional ecosystem 11.9.5 non-remnant
- Regional ecosystem 11.9.7 non-remnant

Where the intent of a property level project is to develop an account for regeneration, regrowth areas should also be shown on a map.

At a property level, assessment units do not need to be a single contiguous area. Assessment units can be composed of multiple isolated areas, but all should generally be larger than one hectare. An example of the approach used in Queensland to establish 'assessment units' is shown in Figure A4.3.

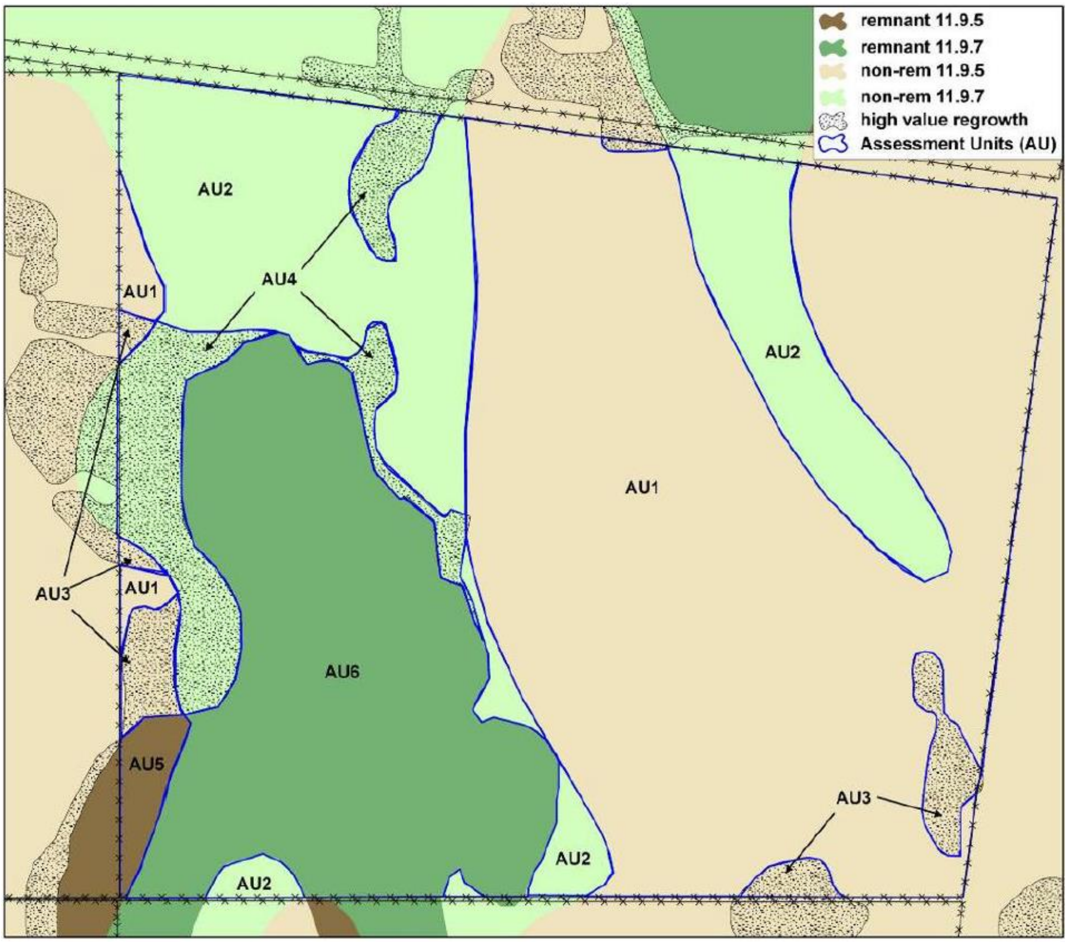

Figure A4.3 Example of 'assessment units' at a property level for a hypothetical project (from BioCondition manual, Eyre et al 2015). In this example, six assessment units (AU) have been identified for a paddock based on RE and broad condition classes.

Assessment units may also be further subdivided into administrative classes, such as paddocks or project boundaries, for reporting. If the account includes any 'non-project' areas they must be separate assessment units, so that no assessment unit crosses the project boundary and the account for the project can easily be extracted.

Step 4: Measure indicators

The outputs of Step 4 will be:

- a list of locations (spatial coordinates in the relevant datum) for at least the number of sites specified from Step 3; and
- establishing the number of plots needed to sample the ecological variability in each assessment unit.

This step sets out the guidelines for field survey design for measuring native vegetation Composition (status, change and trend) at the property and regional levels. (Developing an account of Extent and Configuration was discussed in Step 2).

Composition refers to the taxonomic and structural integrity of the native vegetation types. Composition also refers to landscape complexity (e.g. succession in fire-dominated landscapes).

Attributes of Composition are directly measured at sites and include key species, vertical structure, tree and ground cover, and proportion of weedy and endemic plants (Table 3 in protocol). Sites are allocated to survey assessment units delineated in Step 3. The process of delineating assessment unit defined relatively homogenous map units with labels depicting unique native vegetation types and broad condition classes.

Step 4 also establishes the number of plots needed to sample the ecological variability in each assessment unit. As a general rule the larger the total area of assessment units the more sites that are required.

Adequacy of sampling and assignment of confidence/ assurance scores

The adequacy of sampling in the accounting area is assigned a data quality rating (Table 4 in protocol). The larger the number of sites assigned to the total area of each Assessment Unit, the higher the level of quality assurance in the account.

A moderately high confidence / assurance level (Level 2) would be assigned where there are fewer sampling sites, whereas a high-quality assurance level (Level 1) is assigned where a greater number of sampling sites have been assigned. Guidance regarding these assurance levels is set out in the AfN Standard.

Where an existing sampling design is not available, statistical expertise should be sought to ensure the survey results are not confounded by factors such as high levels of natural variation around composition indicators within some plant community types.

A statistically rigorous sampling design is desirable, but is not essential, to aid in the selection of representative sites for each native vegetation type. For example, accounts that deliver a Level 2 quality assurance, using for example the Queensland BioCondition manual, are ‘representative’ of the assessment unit. In contrast, where a method is used to generate a Level 1 account, it may be necessary for proponents to allocate random plots.

Measures of Composition

Indicators of Composition and Configuration i.e. measures of Nativeness are fit for purpose at the property level and the fine scale but can be more difficult to adequately quantify at a regional scale.

State and territory vegetation management agencies have developed native vegetation condition frameworks for assessing the status, change and trend of ‘nativeness’ using indicators of Composition and Configuration (Tables 2 & 3 in protocol).

Examples of ‘nativeness’ indicators include: measures of species diversity or richness, tree cover 2m high and 20% cover, vertical height profile/number of strata, foliage projective cover of the overstorey strata, structural diversity (i.e. age classes) of the overstorey strata, and numbers of local indigenous plant species compared to non-indigenous plant species.

Regional level assessments of changes in composition measures also require an analysis of ground-truthed, or reference attributes at the plot-scale, that are then interpolated at a regional scale to provide spatial models of condition indices. Sbrocchi et al. (2015) summarise the various approaches and indicators applied in the regional-scale native vegetation condition accounts for the trial NRM Regions from 2010 to 2015.

The AfN framework seeks to measure and report environmental outcomes using an accounting framework. Assessments of vegetation condition should refrain from mixing metrics of threats and pressures and vegetation condition. The composition of native vegetation can be assessed in the context of threatening processes and pressures that affect condition of a native vegetation type however it is important to keep the two metrics separate.

Where a proponent may wish to attribute changes in condition to pressures and threats this can be accommodated by separately measuring threats and pressures from direct measures of indicators of condition and subsequently choosing to analyse and interpret condition and threat metrics using a systematic chronology that links both to a vegetation asset (Thackway and Specht 2015; Thackway and Freudenberger 2016). Threats or pressures arising from total grazing pressure of domestic animals (e.g. sheep and cattle) and pest species (e.g. rabbits, pigs, deer and goats) should be measured separately. Measuring changes and trends in condition indicators should focus on directly measurement of indicators including: Native plant species richness of the dominant ground cover lifeforms; Native perennial grass cover (%); Bare ground; and Total plant cover.

Choosing to keep vegetation condition indicators separate from pressures and threats will also ensure that benchmarking of change relative to a reference state is a straightforward process.

Fire dominated landscapes

Many of rangeland Australia's ecosystems have evolved with fire (Russell-Smith et al. 2007) and have developed and been maintained by Aborigines who used fire to manage the vegetation for their purposes (Gammage 2011; Pascoe 2014). As such, localised traditional-owner fire regimes are an important driver of change, and the maintenance of, native vegetation condition. Inappropriate fire regimes can have a major effect on Composition indicators when assessed relative to a fully natural reference state.

The issue of whether wildfire is a natural disturbance process/ event or is part of a deliberate or inadvertent management regime will affect how wildfire is treated relative to a reference state and how it is benchmarked using indicators of vegetation condition.

What is regarded as an appropriate fire regime is specific to a native vegetation type and a bioregion. Fire can markedly change the structure and composition of native vegetation through its extent (area burnt), frequency, distribution, intensity (severity of the fire) and patchiness (number of distinct areas burnt at any one time) (McDonald et al. 2014). Inappropriate fire regimes can result in changes the structure and composition of native vegetation types e.g. can prevent regeneration, can lead to thickening and incursions of native and/or non-native plant species, can simplify species diversity /richness, prevent the setting of seed, and can eliminate some fire intolerant species from an ecosystem.

Where fire is used as a deliberate management tool the outcome of its use can be measured at site and landscape levels using indicators of vegetation condition that can be measured at sites including: Large trees, Tree canopy height, Recruitment of canopy species, Tree canopy cover (%), Shrub layer cover (%), Coarse woody debris, Native plant species richness for four lifeforms, Non-native plant cover, Native perennial grass cover (%), Litter cover, Bare ground, and Total plant cover.

In addition to these on ground indicators mosaic pattern measures can be used to demonstrate how continuous and complex the landscape is in relation to dominant ecological processes in certain landscapes, such fire dominated ecosystems in the northern Australia (Andersen et al. 2005). In these, and other ecosystems, incorporating composition indicators of mosaic landscapes can, at relatively low cost, add a further layer of information to inform vegetation condition and change over time.

Assessing changes in configuration

Configuration is also an important element of ecosystem function, population viability, seed dispersal, and habitat suitability, particularly in highly-cleared or fragmented landscapes, where the additional effects of fragmentation are detrimental to the structure and composition of native vegetation (McIntyre and Hobbs 1999; Mutendeudzi and Thackway 2008).

Fragmentation refers to the breaking apart of habitat as an outcome above and beyond habitat loss itself (Fahrig 2003). Jaeger (2000) describes fragmentation as consisting of a series of phases of habitat division and reduction. Fragmentation is often measured through indicators such as connectivity, and patch metrics (Figure A4.4).

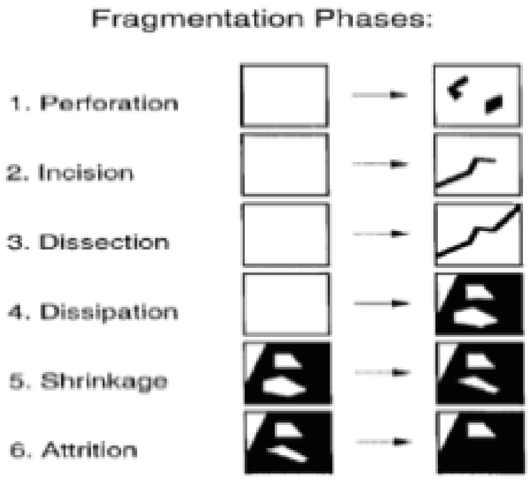

Figure A4.4. Fragmentation consists of a series of phases of habitat division and reduction (white areas are habitat) (Jaeger 2000)

McIntyre and Hobbs (1999) proposed a framework for conceptualizing the effects of landscape fragmentation and increasing degrees of site modification and understanding their relevance to management (Figure A4.5). The framework is widely known and understood and assists conservation biologists and natural resource managers to address the full spectrum of human impacts observed across agricultural and fragmented landscapes (Yapp and Thackway 2015).

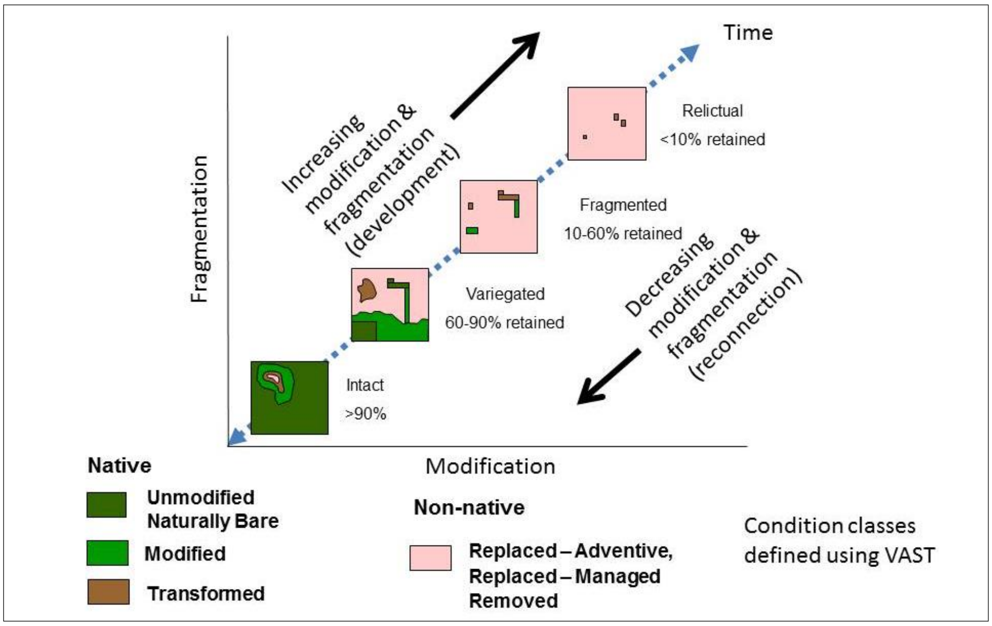

Figure A4.5. A framework for characterising landscape alteration levels based on increasing fragmentation and increasing degrees of modification defined in terms of VAST classes.

Connectivity measures the degree of structural fragmentation of native vegetation patches (both across all native vegetation types and within specific vegetation types, e.g. mangroves) and commonly is measured using indicators such as 'mean nearest neighbour 'and 'neighbourhood'. Such metrics are imbedded in most state-based composition landscape indices (Table 2 and Table 3 in protocol). Example of such landscape metrics include the Victorian Habitat Hectares (Parkes et al. 2003), Biodiversity Assessment Method in NSW (Office of Environment and Heritage 2017) and BioCondition in Queensland (Eyre et al. 2015).

Lindenmayer and Fisher (2007) and SKM (2009) recommend some simple metrics, such as the cost surface connectivity modelling methods, providing a useful first pass of connectivity. Summerell et al. (2011) provide a more detailed method using vegetation assessments based on concentric circles. Drielsma, et al. (2012) have developed methods and generated datasets for assessing and reporting levels of fragmentation for ecosystem types in NSW.

Patch metrics measure the size of native vegetation patches and structural complexity across the landscape. Indicators used in patch metrics include patch size, number of patches and distance to core area.

Establishing an Indicator Condition Score for Configuration for regional level accounting can be achieved by using a GIS analysis of mapped vegetation types and their extents across a region using various analytical tools and datasets. GIS software and associated modelling and statistical tools, can be used to calculate various configuration metrics such as 'mean nearest neighbour' and patch sizes, based on available extent and reference extent maps as well as any subsequent time series data sets. A good example of an approach to systematic conservation assessment that is designed to address the conservation objective of 'maximising the long-term persistence of compositional diversity at a collective level' is the NSW Terrestrial Biodiversity Forecasting Tool (BFT) (Drielsma et al. 2012). The BFT was developed to inform two broad levels of systematic conservation assessment: 1) looking back to determine the conservation effectiveness of a proposed single management action or management regimes, and 2) investigating future alternative management configurations. Data generated from this tool in NSW could be used for regional accounting. Application of this tool in other jurisdictions would generate similar data products for regional accounting.

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Appendix 5. Examples relating to use of historical information to report trends

Understanding the health of an environmental asset not only requires an understanding of the condition of an asset at a particular point in time: the direction and rate of change are of equal significance. Changes in quantity and quality should therefore be repeated regularly to create trend datasets. In addition, as more data or methodologies become available, new or improved indicators should be incorporated into the accounts.

Expert advice should be sought to ensure that as the accounts evolve, the ability to compare condition scores across years (a key advantage of using reference condition) is not lost. Historical information can be used to establish a reliable estimate of trend in condition accounting. For example, Central West CMA in NSW tested the utility of the tree cover database developed for the national carbon account (NCAS) for regional environmental asset condition accounting (Greenhalgh 2012). The database used epochs of Landsat satellite imagery dating back to the 1970s and can be used to construct trend data on changes in vegetation extent. ABARES also used the NCAS time series dataset to report regional level trends in the extent of revegetation and rehabilitation across Australia by looking for pixels that were observed to be non-woody in 1980 and woody in 1990 and subsequent epochs.

An example of a methodology that visually depicts changes and trends in Composition at the site level, using soil-landscape types as assessment units, is the VAST-2 framework state (Thackway and Specht 2015; Thackway and Freudenberger 2016). VAST-2 uses the systematic combination of quantitative and qualitative observations including direct measures and expert assessment have been developed to provide a graphical summary depicting the response of indicators of plant communities to changes in land use and land management regimes relative to a fully natural reference state. Fundamental to the approach is access to credible published sources of information that describe where, when, and what changes in land use and land management practices and how these were observed/measured to affect benchmark indicators of a vegetation community type including function, structure and composition. The sources of this information are multi-temporal and multidisciplinary, including land management regimes, remote sensing, and several branches of ecological science: landscape, vegetation and restoration. Much of the historic information is qualitative, compared to contemporary information, which is mostly quantitative.

Developing trend information assists decision makers to track progress and the effectiveness of different management approaches or programs. Such data can be used by decision makers to ascertain which vegetation assets which are in decline, and the reasons for changes in condition across the landscape.

When condition is visually displayed relative to a reference state it makes it easy for managers, investors and consumers to better appreciate the current condition of an asset in relation to the optimal condition and assists in the setting of realistic targets for management outcomes. An example is shown in Figure A5.1, that of a patch of subtropical rainforest at the Rous Water Rainforest Reserve, Rocky Creek Dam, NSW that was restored between 1983 – 2016 https://site.emrprojectsummaries.org/2016/03/06/subtropical-rainforest-restoration-at-the-rous-water-rainforest-reserve-rocky-creek-dam-1983-2016/

It describes an assessment of change in indicators of vegetation condition in a 25 ha area. This depicts the degree of recovery of Lowland Subtropical Rainforest found at Rocky Creek Dam, Big Scrub, NSW against a pre-clearing reference. The method used to generate the graph is described in Thackway, R. and Specht, A., (2015). Synthesising the effects of land use on natural and managed landscapes. Science of the Total Environment. 526:136–152 doi:10.1016/j.scitotenv.2015.04.070.) Condition indices for transition Phase 4 were derived from prior reports including Sanger et al. 2008 and Woodford 2000. Metadata can be viewed at http://portal.tern.org.au/big-scrub-rocky-queensland-brisbane/16908 . (Graph reproduced with permission).

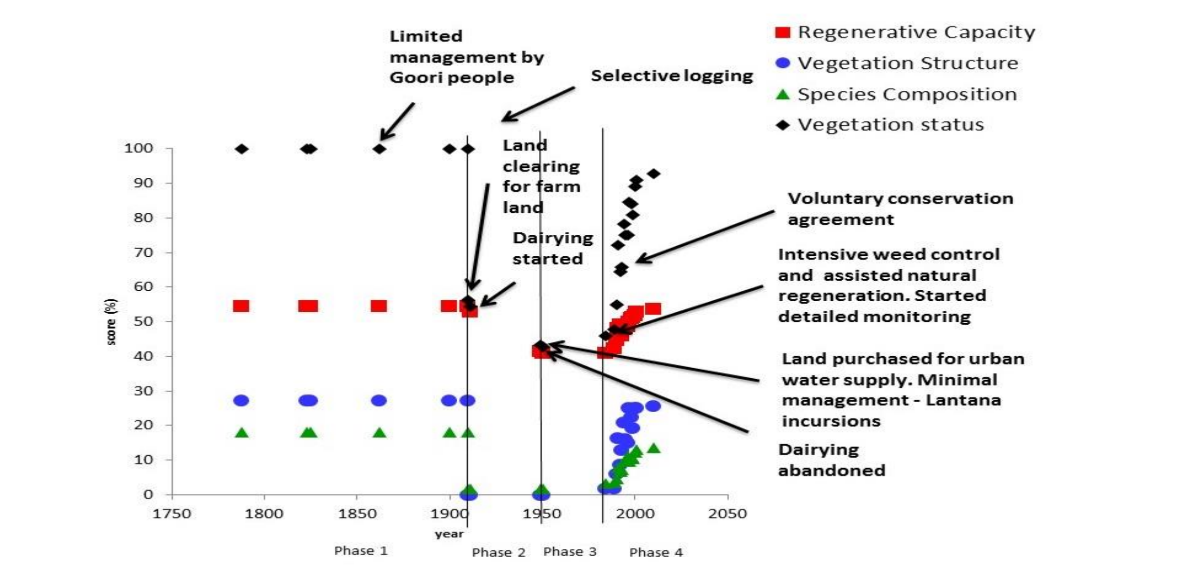

Figure A5.1. Recovery of Lowland Subtropical Rainforest found at Rocky Creek Dam, Big Scrub, NSW against a pre-clearing reference

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Appendix 6. Definitions of Vegetation Assets, States and Transitions (VAST classes).

Increasing vegetation modification from left to right

			Native Vegetation Cover Dominant structuring plant species indigenous to the locality and spontaneous in occurrence – i.e. a vegetation community described using definitive vegetation types relative to estimated pre1750 states			Non-native Vegetation Cover Dominant structuring plant species indigenous to the locality but cultivated; alien to the locality and cultivated; or alien to the locality and spontaneous		
Vegetation Cover Classes		State 0: NATURALLY BARE areas where native vegetation does not naturally persist and recently naturally disturbed areas where native vegetation has been entirely removed. (i.e. open to primary succession)	State I: UNMODIFIED native vegetation community structure, composition, and regenerative capacity intact – no significant perturbation from land use/land management practice	State II: MODIFIED native vegetation community structure, composition and regenerative capacity intact - perturbed by land use/land management practice	State III: TRANSFORMED native vegetation community structure, composition and regenerative capacity significantly altered by land use/land management practice	State IV: REPLACED - ADVENTIVE native vegetation replacement – species alien to the locality and spontaneous in occurrence	State V: REPLACED - MANAGED native vegetation replacement with cultivated vegetation	State VI: REMOVED vegetation removed - alienation to non-vegetated land cover
Diagnostic criteria	Current regenerative capacity	Complete removal of in-situ regeneration capacity except for ephemerals and lower plants	Natural regenerative capacity unmodified	Natural regeneration capacity persists under past and /or current land management practices	Natural regenerative capacity limited / at risk under past and /or current land use or land management practices. Rehabilitation and restoration possible through modified land management practice	Regeneration potential of native vegetation community has been suppressed and in-situ resilience at least significantly depleted. May still be considerable potential for restoration using assisted natural regeneration approaches	Regeneration potential of native vegetation community likely to be highly depleted by intensive land management. Very limited potential for restoration using assisted natural regeneration approaches	Nil or minimal regeneration potential. Restoration potential dependent on reconstruction approaches
	Vegetation structure	Nil or minimal	Structural integrity of native vegetation community is very high	Structure is predominantly altered but intact e.g. a layer / strata and/or growth forms and/or age classes removed	Dominant structuring species of native vegetation community significantly altered e.g. a layer / strata frequently and repeatedly removed	Dominant structuring species of native vegetation community removed or predominantly cleared or extremely degraded	Dominant structuring species of native vegetation community removed	Vegetation absent or ornamental
	Vegetation composition	Nil or minimal	Compositional integrity of native vegetation community is very high	Composition of native vegetation community is altered but intact	Dominant structuring species present - species dominance significantly altered	Dominant structuring species of native vegetation community removed	Dominant structuring species of native vegetation community removed	Vegetation absent or ornamental
Examples		Bare mud; rock; river and beach sand, salt freshwater lakes, rock slides and lava flows	Old growth forests; Native grasslands that have not been grazed; Wildfire in native forests and woodlands of a natural frequency and/or intensity;	Native vegetation types managed using sustainable grazing systems; Selective timber harvesting practices; Severely burnt (wildfire) native forests and woodlands not of a natural frequency and/or intensity	Intensive native forestry practices; Heavily grazed native grasslands and grassy woodlands; Obvious thinning of trees for pasture production; Weedy native remnant patches; Degraded roadside reserves; Degraded coastal dune systems; Heavily grazed riparian vegetation	Severe invasions of introduced weeds; Invasive native woody species found outside their normal range; Isolated native trees/shrubs/grass species in the above examples	Forest plantations; Horticulture; Tree cropping; Orchards; Reclaimed mine sites; Environmental and amenity plantings; Improved pastures. (includes heavy thinning of trees for pasture); Cropping; Isolated native trees/ shrubs/ grass species in the above examples	Water impoundments; Urban and industrial landscapes; quarries and mines; Transport infrastructure; salt scalded areas

Source: Modified from Thackway and Lesslie (2008)

Appendix 7. How many BioCondition sites are needed for vegetation asset accounts at property or regional scales?

The objective of this Appendix is to provide a rough guide to the numbers of vegetation condition sites that would need to be sampled to achieve the target error levels identified in this Guideline. It was originally developed to estimate site numbers suitable for an Accounting for Nature® vegetation condition accounting method developed for the Land Restoration Fund, which is based on BioCondition (Eyre et al. 2015). The approach is to use existing data to assess the standard error that would be associated with mean site scores developed from sample sets of different sizes (i.e. varying numbers of sites).

A collection of 235 BioCondition sites from south central Queensland were sourced from a Queensland Herbarium ecological site database (T. Eyre pers com). Sites were surveyed over a ten year period from 2007 to 2017, through multiple projects assessing grazing land condition in southern Queensland (principally Eyre et al 2011). The projects applied stratified sampling of vegetation condition targeting assessment units representing remnant vegetation (large and fragmented), regrowth and pasture sites across three broad ecosystem types; mulga, brigalow, and polar box. Site locations are displayed in Figure A7.1. One important caveat to this assessment is that the sites were not located within strata in a simple random fashion. Sites were generally at least 1km apart (because they were also used for bird surveys) and also avoided boundaries of condition classes (i.e. ecotones) or paddocks (fencelines) and close proximity water points (<200m).

BioCondition scores are presented here as ranging from zero to one, and do not include consideration of landscape-scale indicators. Mean scores are in Table A7.1, and Figure A7.2 presents frequency distributions of BioCondition scores for subsets of the data representing combinations of vegetation types (mulga, brigalow, box) and broad condition states (remnant, fragmented remnant, regrowth, pasture).

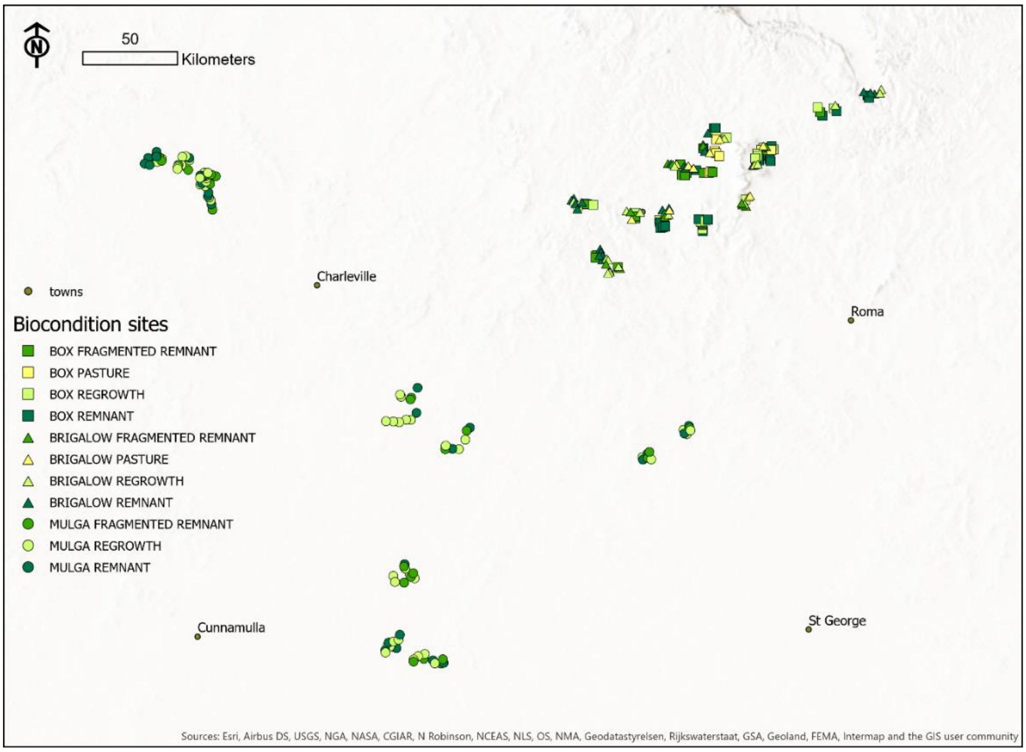

Figure A7.1 Location and broad classes for condition and vegetation type of 235 BioCondition sites used in this assessment.

Table A7.1 Mean site-based BioCondition scores for combinations of vegetation and condition classes. Numbers of sites in brackets.

	Remnant	Fragmented Remnant	Regrowth	Pasture
Box	0.74 (22)	0.75 (16)	0.52 (16)	0.31 (12)
Brigalow	0.78 (22)	0.73 (14)	0.42 (16)	0.28 (12)
Mulga	0.75 (28)	0.73 (25)	0.63 (52)	NA

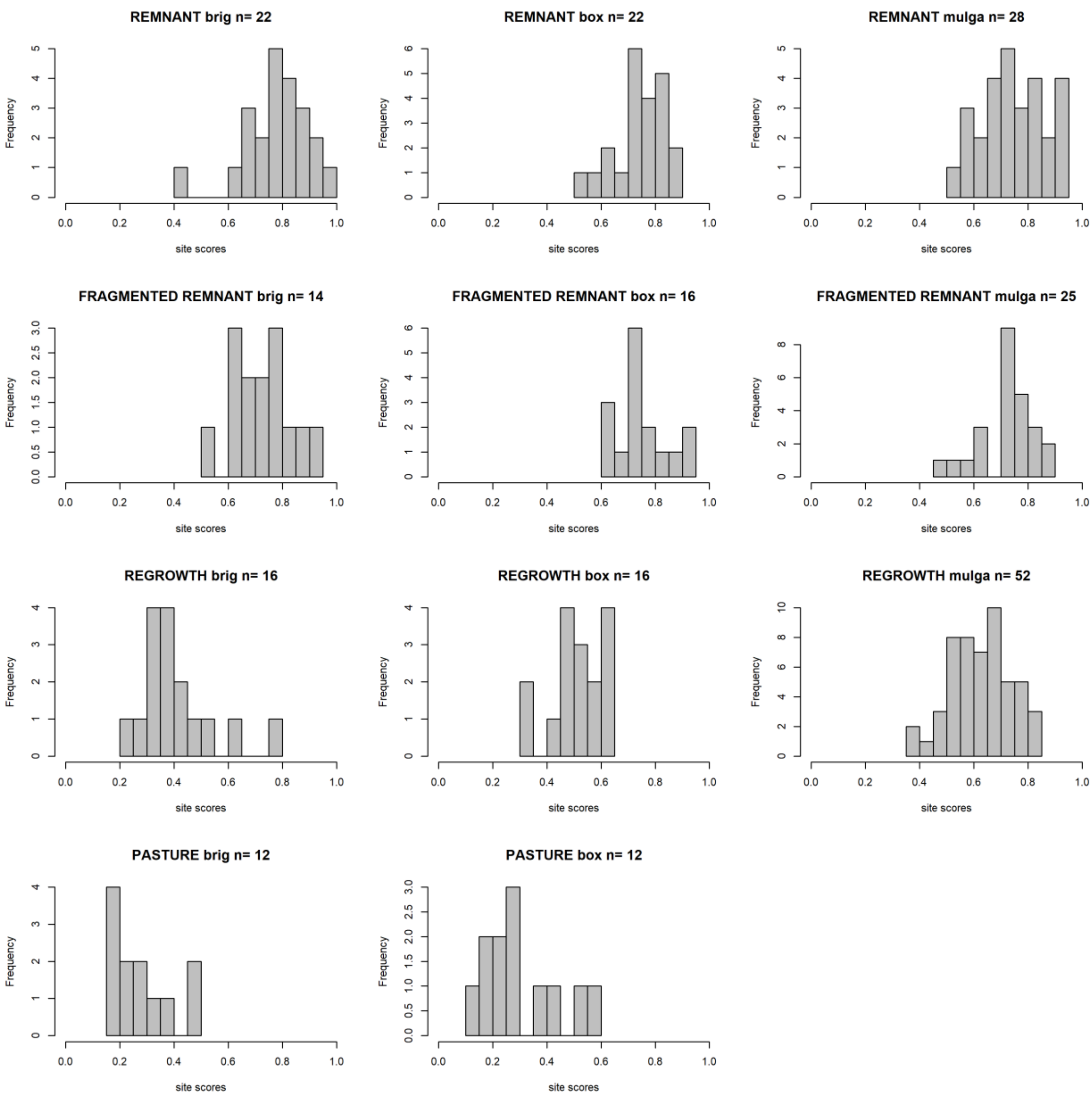

Figure A7.2Frequency distributions of BioCondition scores for 235 sites in south-central Queensland grouped by combination of vegetation type and condition class

The first step in a standard BioCondition assessment is to stratify the study area in to assessment units based on vegetation types (Regional Ecosystems) and broad condition states. The four condition states identified in the BioCondition site data are broad and the sites are also arrayed across hundreds of kilometres (i.e. regional scale), so the variance represented in these data arguably represent a worst case scenario. The effect of moving to smaller spatial subsets, based on properties and subregions, is assessed further below, as is the relative influence of vegetation and condition classes.

Random sampling of the dataset was used to quantify the influence of sample size on the standard error of a mean from that sample. Subsets of two to twenty samples were randomly selected (with replacement) 1000 times for each of the eleven broad combinations of condition and veg type represented in the site data. The standard error was calculated for each random sample. The relationship between the average standard errors and sample size are presented in Figure A7.3.

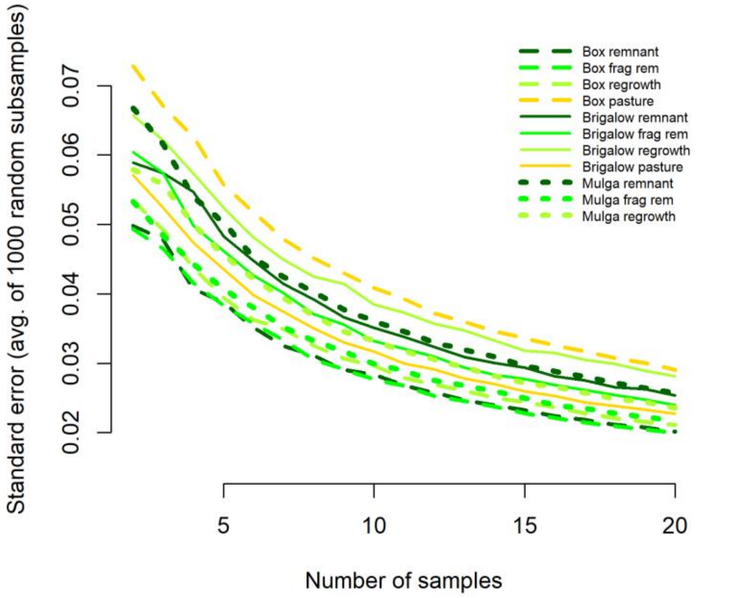

Figure A7.3 Relationship between standard error and sample size based on 1000 random subsets of Biocondition sites from south-central Queensland

Figure A7.3 suggests that 15-20 samples per strata are required to deliver a standard error of 3% of the 0-1 scoring range, which would represent a high standard for data adequacy, while 5 samples would typically be adequate to provide a standard error of 5%. However, the stratification of sites into broad condition states across a region is very broad, so it is likely that the errors could be further reduced through more effective stratification. To assess this potential the 235 BioCondition sites were subdivided into spatial subsets at two scales: a. subregional clusters, and; b. properties (Figure A7.4). The standard error was calculated for the real subsets of the BioCondition sites from clusters and properties within the same strata based on vegetation classes and condition states (Figure A7.5).

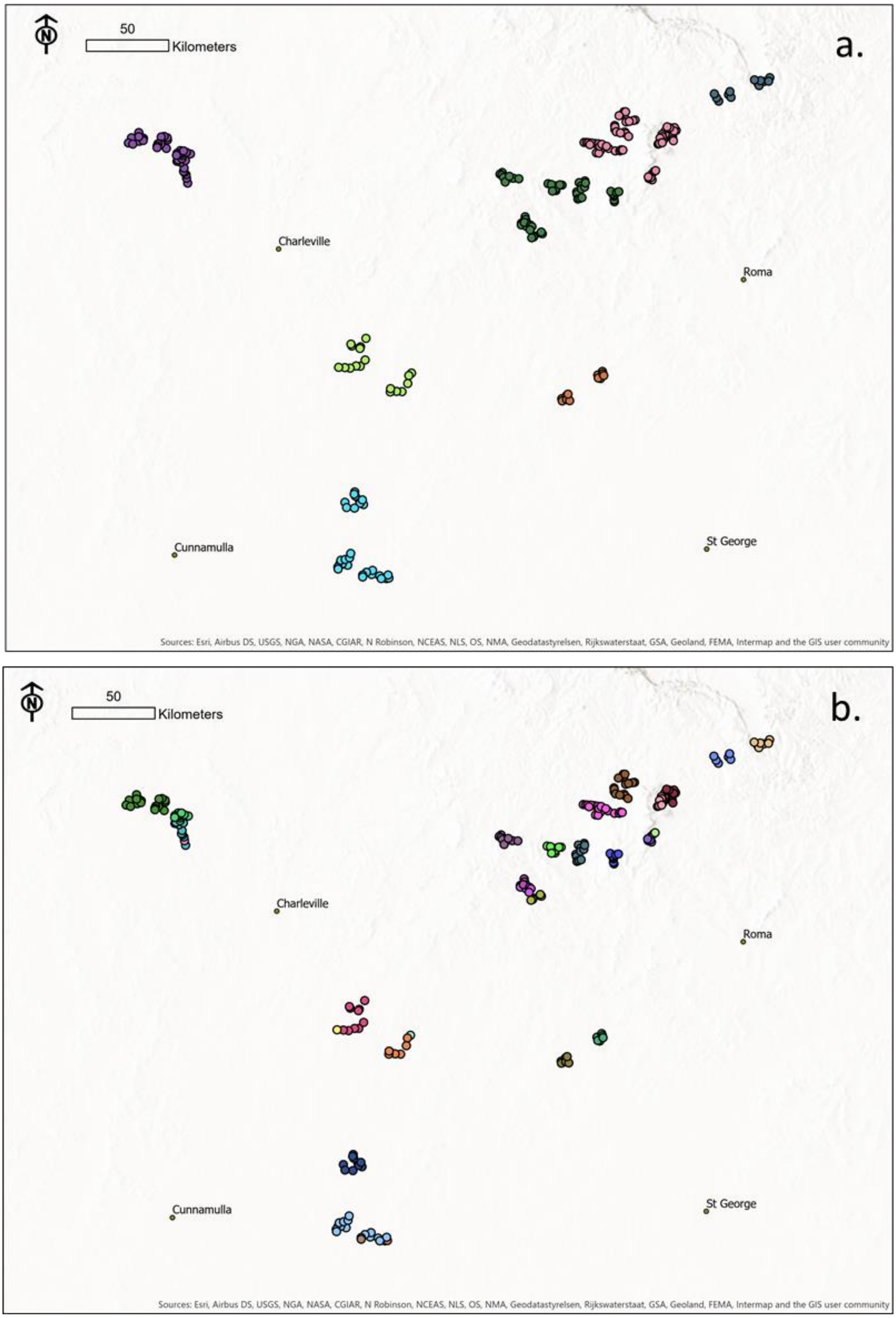

Figure A7.4 Subregional clusters (a) and properties (b) used to subdivide 235 BioCondition sites from south-central Queensland

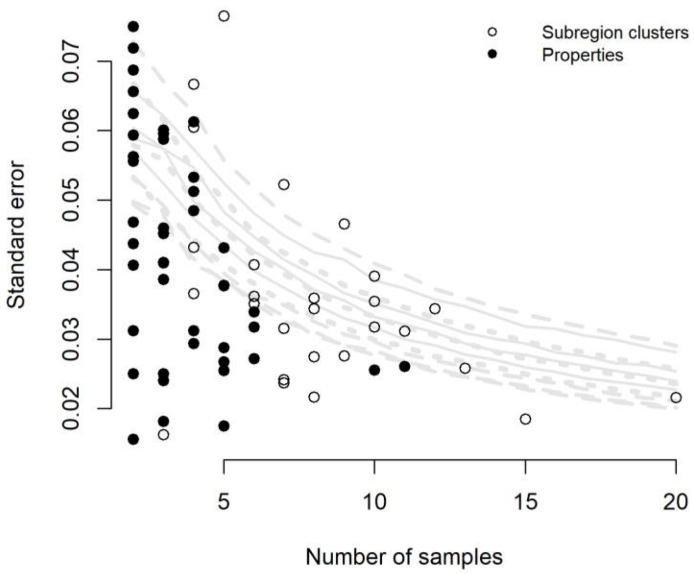

Figure A7.5 Standard errors for subsamples of Biocondition sites representing subregional cluster (open circles) or properties (closed circles) from south-central Queensland. Grey lines are those from Figure 3.

The effect of subdividing the regional dataset into spatial subsets demonstrated reduced error at property scale (larger spatial scale). The subregional clusters conformed fairly closely to the patterns identified through the randomised trials presented in Figure A7.3. A well-constructed stratification within properties will generally further reduce error in property scale sampling.

Information on land condition is unsurprisingly the key to stratification for effective and efficient BioCondition sampling. Figure A7.6 shows the standard errors returned when subsamples of BioCondition sites are assembled without regard to condition or vegetation classes (i.e. unstratified - thick black line). Note that the blue lines representing standard errors for subsamples of the BioCondition site data based on vegetation classes but ignoring condition classes suggest that vegetation classes do little to reduce error. However, stratification based on the broad vegetation condition classes yielded standard errors within the range of those returned through stratification by both vegetation and condition classes. The high standard error for regrowth BioCondition in figure A7.6 is largely explained by the difference in BioCondition scores between the mulga and brigalow bioregions.

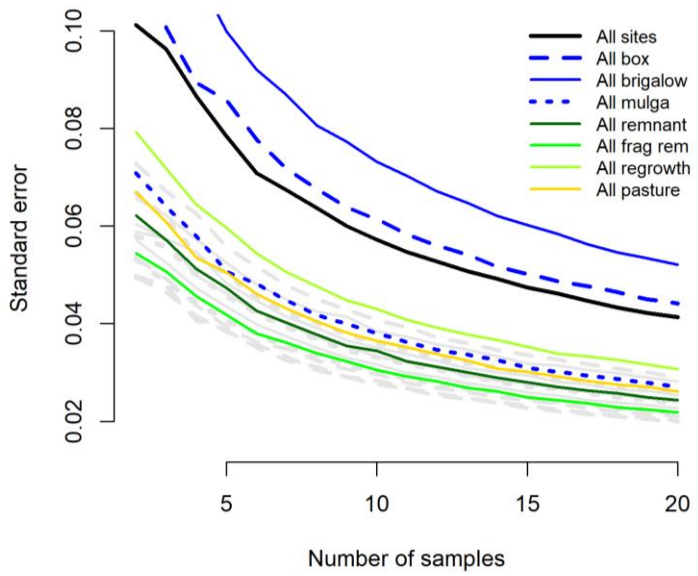

Figure A7.6 Illustration of the relative effects of different approaches to sampling stratification on standard errors from BioCondition site scores. Strata based on vegetation classes (blue lines - box, brigalow, mulga) and broad condition states (green/yellow line - remnant, fragmented remnant, regrowth, pasture) are plotted along with standard error for selections without stratification (black line).

Conclusion

Based on data from 235 sites across southern-central Queensland, regional scale sampling with stratification based on broad classes of vegetation and condition will typically require 15 samples per strata to deliver a standard error of 3% or less, and at least 5 samples per strata to generally achieve a more modest target for standard error equivalent to 5% of the BioCondition scoring range. The data suggest errors are broadly similar across eleven sampling strata based on the intersection of three vegetation types and four condition classes. Not surprisingly, stratification by vegetation classes alone (ignoring condition groups) was far less effective in reducing standard error than stratification by broad condition classes was. This suggests that defining 'assets' and their components at the broadest relevant level (i.e. smallest scale) will be most effective in reducing sampling requirements without sacrificing accuracy.

For larger spatial scales (smaller areas), particularly for property accounts, it seems likely that fewer samples will be necessary to produce acceptably small standard errors for mean values, primarily because variation will be more limited. It is estimated that 5-10 samples will generally be sufficient to provide a standard error roughly 3% of the scoring range, and that 3-5 samples will be sufficient to achieve a standard error of around 5%. Effective stratification will reduce error at property scale.

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