Assessing the quality of native vegetation: The 'habitat hectares' approach

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Summary **Assessments of the 'quality', condition or status of stands of native vegetation or habitat are now commonplace and are often an essential component of ecological studies and planning processes. Even when soundly based upon ecological principles, these assessments are usually highly subjective and involve implicit value judgements. The present paper describes a novel approach to vegetation or habitat quality assessment (habitat hectares approach) that can be used in almost all types of terrestrial vegetation. It is based on explicit comparisons between existing vegetation features and those of 'benchmarks' representing the average characteristics of mature stands of native vegetation of the same community type in a 'natural' or 'undisturbed' condition. Components of the index incorporate vegetation physiognomy and critical aspects of viability (e.g. degree of regeneration, impact of weeds) and spatial considerations (e.g. area, distribution and connectivity of remnant vegetation in the broader landscape). The approach has been developed to assist in making more objective and explicit decisions about where scarce conservation resources are allocated. Although the approach does not require an intimate botanical knowledge, it is believed to be ecologically valid and useful in many contexts. Importantly, the index does not provide a definitive statement on conservation status nor habitat suitability for individual species. It purposefully takes a 'broad-brush' approach and is primarily intended for use by people involved with making environmentally sensitive planning and management decisions, but may be useful within environmental research programmes. The 'habitat hectares' approach is subject to further research and ongoing refinement and constructive feedback is sought from practitioners.**

Key words ***assessment biodiversity, habitat quality, vegetation condition.***

Introduction

Effective management of native vegetation requires information on where the vegetation occurs, the type of vegetation, past and continuing ecological processes that have shaped or maintain the vegetation, the roles it plays in the local landscape and how effectively these functions are performed. These latter characteristics are necessarily value judgements and require a context in which these judgements can be made. Native vegetation can be viewed in a variety of contexts including energy capture (including carbon storage), nutrient or water cycling, landscape stability, fodder production for stock, or as habitat for native species. The approach outlined here specifically attends to the biodiversity conservation context of native vegetation and assumes that complementary approaches for other contexts may also be developed.

For biodiversity conservation, the Victorian Department of Natural Resources and Environment (NRE) requires an approach to assessing native vegetation quality that can:

1. Provide an objective assessment of quality that is both reliable and repeatable.
2. Measure the degree of 'naturalness' as a contribution to broader conservation value assessments.
3. Indicate the direction and amount of potential improvement for lower quality sites.
4. Allow comparison between different vegetation types.
5. Combine quality and quantity assessments.
6. Enable calculation of net outcomes, either for trade-off/offset scenarios or for measuring overall performance of policies and program.
7. Be undertaken rapidly by a range of natural resource managers (i.e. not just botanical ecologists).
8. Present a simple and robust message to land managers about the important components of native vegetation and its management.

Additionally, the method must be capable of functional and practical use for a wide variety of different vegetation communities. Some vegetation communities have very simple physiognomy and low species richness (e.g. Inland Saltmarsh may consist of perhaps one or two species; Browne 1982; Land Conservation Council 1987), while others can be highly species rich with a diversity of life forms (e.g. herb-rich woodland; Lunt 1990). Ideally, the method should be capable of assessing both communities with a similar efficacy and relativity.

To meet the intended purposes and applications, 'vegetation quality' is defined here as the degree to which the current vegetation differs from a 'benchmark' representing the average characteristics of a mature and apparently long-undisturbed stand of the same vegetation community. Essentially, this method ('habitat hectares') attempts to assess how 'natural' a site is by comparing it to the same vegetation type in the absence of major ecosystem changes that have occurred following European settlement of Australia. This is not to suggest that our aim is to return all current stands of native vegetation to a former pristine state, as this would clearly be impossible (Oliver *et al.* 2002). Nor is it our intention to imply that native vegetation prior to European settlement was in an ideal state, nor that native vegetation is static and unchanging in composition and function. The choice of an 'average, mature and apparently long-undisturbed' benchmark is simply to provide a consistent and logical reference point for 'naturalness' against which loss of quality and direction for improvement can be considered.

The 'habitat hectares' approach is designed to give a global rather than a 'species-specific' view of quality. It is also intended that the approach will provide a clear focus for discussions with landholders and land managers on management activities appropriate for practical improvement of the quality of remnant native vegetation. However, 'habitat hectares' is *not* intended to identify habitat suitability for individual species, but aims to identify an integrated view of the habitat for all the indigenous species that may reasonably be expected to use a site. Similarly, the method is *not* intended as a measure of the conservation significance of a site (e.g. presence of rare or threatened species or vegetation communities), although the approach is being progressively incorporated into other decision-making processes relating to native vegetation. For example, NRE combines 'habitat hectare' assessments with conservation significance measures as part of a 'Biodiversity Benefits Index' to quantify on-ground management outcomes in a trial of a market-based mechanism ('Bush Tender') for purchasing land management services. It is also possible that 'habitat hectares' may provide a suitable basis for developing bioregional-scale overviews that can be included in indicator or performance measure frameworks.

The method that is described here follows broad national directions (ANZECC 2000) and is based upon an approach initially developed for determining offset scenarios for an environmental assessment project (Costello & Meredith, unpubl. data, 2000; Meredith & Costello, unpubl. data, 2000). The approach was elaborated in the Draft Victorian Native Vegetation Management Framework (NRE 2000) as one of several improvements in identifying priorities for the protection of native vegetation on private land, and was subsequently endorsed by the Victorian Government (NRE 2002).

Vegetation type and condition benchmark

'Habitat hectare' assessments rely on a comparison of remnant native vegetation to a 'benchmark' for the same vegetation type in a mature and long-undisturbed state. The first step in this process is the identification of the vegetation communities (Ecological Vegetation Classes (EVC, Box 1)) present at the site. This may be done from EVC maps; however, these maps inevitably contain inaccuracies due to modelled distributions and/or coarse scale. A more accurate method is to use direct field observations in combination with a vegetation key for a particular region to determine the EVC/vegetation units present. Importantly, benchmarks relate to a single EVC within one bioregion and account for some of the variation of a vegetation community across its natural range.

Each EVC has a characteristic assemblage of plant species and structural variation and condition is measured using these characteristics. For example, tree cover for a particular EVC in 'natural' condition may be described as having between 20 and 35% projective foliage cover. This method uses a single value chosen from this range as the reference 'benchmark' point. Where possible, these benchmark values are generated from existing native vegetation known to be relatively undisturbed. Where this is not possible due to the poor condition of all remaining examples of the vegetation type, benchmark values are devised to represent the presumed long-undisturbed condition of that EVC using historical information and a knowledge of how similar vegetation types have been affected by disturbance regimes. Benchmarks are currently being completed on a bioregional basis for most EVCs across Victoria.

Box 1. Ecological Vegetation Classes

Vegetation is typically described by reference to one or more of its attributes (i.e. floristic composition, structure and important environmental determinants). In Victoria, the principal unit for vegetation circumscription and mapping for land-use planning and management is the Ecological Vegetation Class (EVC). In this hierarchical approach to vegetation typology developed by NRE, the EVC represents a level of detail higher than floristic communities (i.e. plant communities defined solely on the basis of their constituent taxa). As such, EVC represent aggregations of floristic communities with structural, physiognomic and floristic affinities that exist under a common regime of ecological processes within a particular environment (Woodgate *et al.* 1996). While it would be preferable to use floristic communities as the level for assessing vegetation type, it is proposed that EVC be used initially as there is currently a comprehensive coverage of vegetation mapping and description across Victoria at the EVC but not at the floristic community level.

There are theoretical and practical consequences of using a 'single' benchmark to represent a mature example of a particular EVC. First, there is the possibility that some 'fully natural' sites may score less than 100% if they were towards the lower end of the natural range. However, the use of broad class intervals (e.g. ± 50% change) for assessing the components reduces the risk of this occurring, and the consequences of this event are unlikely to be crucial for conservation decisions. Second, immature vegetation will inevitably score lower than mature stands, due to the absence of mature features (e.g. large trees). Again, the consequences of this are not likely to be problematic for conservation decisions, as a mature example is generally more highly valued because mature attributes are much more easily lost than they are gained. Additionally, there may be cases where a stand with a mixture of mature and depleted components will score more than a stand that is fully natural but immature. The 'habitat hectare' score should be used with this limitation in mind.

In some cases, the EVC currently at a site may be different from that which occurred prior to European settlement. For example, decades of grazing or burning regimes may have altered vegetation from a grassland to a woodland, or vice versa. Similarly, a change in river flow, estuarine deposition or salinization may alter the distribution of vegetation types. In these cases, benchmarks for the previous vegetation type may be appropriate for assessing decline, but may no longer be the most practical reference point for 'improvement/restoration scenarios' to achieve a practical and optimal conservation objective (Oliver *et al.* 2002). The decision to use benchmarks for other than the estimated presettlement native vegetation type for assessing 'improvement scenarios' will need to be made on a case-by-case basis and should be explicitly recorded.

What is the 'assessment area' and how should assessments be targeted?

Patches of native vegetation are often heterogeneous and may comprise several different vegetation types or vegetation that has been subjected to noticeably different disturbance regimes. 'Habitat hectare' assessments are importantly constrained to one stand at a time ('stand' is defined as the combination of one vegetation type and condition state) and, preferably, to one land tenure. Therefore, the total number of individual (i.e. stand) assessments required in a patch will vary according to the different land tenures, the number of EVCs and the disturbance/management patterns. This is determined on a case-by-case basis during the initial on-ground reconnaissance, using readily observed differences in the scale and extent of the habitat components being assessed. The 'trigger' for deciding whether the assessment of a new stand is warranted is generally one category difference in the majority of the condition components, or two categories difference in any one of these components.

What is involved in vegetation condition assessments?

The method includes assessments of the retention of characteristics within a site (i.e. 'site condition' components) and the nature of the landscape surrounding the site (viz. Fahrig 2001; i.e. 'landscape context' components). Other characteristics of the surrounding landscape that present risks to the remnant, such as pest animals, salinity or intensive land uses on neighbouring land, are not included in the method and should be considered in more broadly based conservation value assessments. The components of the combined 'habitat score' and their relative weightings are shown in Table 1. Each of these components has been developed for field assessment, although the 'landscape context' components can be derived using other sources (e.g. maps and Geographical Information Systems (GIS) layers).

It will be obvious from Table 1 that not all EVC will contain all components (e.g. assessment of 'large trees' would be inappropriate at a Sandplain Heathland stand). In such circumstances, redundant components are deleted and the sum of the remaining components standardized (see below). Details of necessary adjustments to calculations for specific EVC are provided with individual EVC benchmark statements.

'Site condition' components

A series of 'site condition' components have been selected in consultation with a range of specialist botanists and ecologists. These components are considered to be important for a wide range of species, and suitable for rapid assessment by non-specialist ecologists (Tables 2–9). The condition states and associated scores have been scaled broadly (i.e. often ± 50%) for a number of reasons. First, it is recognized that there can be considerable natural variation within each component in even long-undisturbed vegetation. Second, such broad ranges permit the field assessor to frequently make clear choices between categories, hence reducing the variability between observers. Where necessary, decision rules have been implemented to simplify scoring components, which are expressed as a series of questions relating to the stand. This approach aims to limit the impact of variability in skill levels from highly trained and non-specialist users.

Table 1. Components and weightings of the habitat score

	Component	Max. value (%)
Site condition	Large trees	10
	Tree (canopy) cover	5
	Understorey (non-tree) strata	25
	Lack of weeds	15
	Recruitment	10
	Organic litter	5
	Logs	5
Landscape context	Patch size*	10
	Neighbourhood*	10
	Distance to core area*	5
	Total	**100**

*Components may be derived with assistance from maps and other (e.g. GIS) information sources.

Large trees

Large trees can be a dominant feature of remnant native vegetation and are often old, making them a difficult habitat feature to replace once lost. They provide nesting and food resources and their influence for wide-ranging species can extend for a considerable distance from their location (Law *et al*. 2000) and impact significantly on the local environment (Dawson 1993). For these reasons, a relatively high proportional scoring and weighting is warranted for the retention of large trees, even though they comprise only relatively few species within any EVC.

For this assessment, a large tree is defined as having a mature growth form, usually with a single trunk. Large trees are generally defined as > 80 cm d.b.h. (diameter at breast height, measured over bark 1.5 m above ground level) for eucalypts in EVC typical of favourable growing conditions (e.g. fertile plains/hills, riparian areas) and > 60 cm d.b.h. for eucalypts within EVC in less fertile parts of the landscape. For other environments or species (e.g. acacias, casuarinas) appropriate d.b.h. measurements are specified within each benchmark. Many EVC lack large trees (e.g. grasslands, heathlands and mallee). In such situations, this component is not included and the habitat score is appropriately standardized according to the benchmark. While the importance of hollows within large trees is recognized (Lindenmeyer *et al*. 1991), this attribute is not specifically assessed as they are often difficult to identify and assess from the ground.

The health of large trees is also considered, acknowledging that while large trees decline in health, they (and large dead trees) still have habitat value, although other values (e.g. nectar sources) may be diminished. This 'health assessment' also provides a measure of the future viability of these trees in the landscape and can highlight existing threats requiring attention.

Tree (canopy) cover

This component assesses the projective foliage cover of canopy trees in the stand, relative to the benchmark (Table 3) and can be aided by illustrations of different levels of projective foliage cover (Walker & Hopkins 1990). Considerable variation may be expected in this component, which is reflected in a coarse primary breakpoint (i.e. ± 50% variation). Generally, only species indigenous to the site will be included; however, non-indigenous species that have similar ecological roles may be included if specified in the benchmark.

For the purposes of this assessment, trees are defined as the uppermost stratum of woody vegetation that forms or contributes to the vegetation 'canopy', when individual trees are > 80% of their mature height. This definition allows for canopy cover estimations for vegetation dominated by short and stunted but, nonetheless, mature trees (e.g. in alpine woodlands and mallee). The definition includes all large trees that were assessed in the previous component and acknowledges that these trees are now being assessed for their contribution to the canopy rather than maturity. Saplings or seedlings (i.e. < 80% mature height) are not included within the canopy layer, even when the same species occurs as part of the understorey and/or recruitment components. Trees greater than 5 m tall but less than 80% of their mature height are still included within the understorey assessment.

The 'habitat hectare' approach attempts to assess the current vegetation condition, and not what may be present in the future. While it would be easy to interpret a high density of tall *Eucalyptus* saplings as providing a potential tree canopy, they would currently not qualify for inclusion in canopy cover at this point in time, but may do later in the regeneration sequence.

While trees are a dominant feature of many EVC in south-eastern Australia, some vegetation types typically lack trees (e.g. grasslands, heathlands and herbfields) or contain trees only at low densities or stature (e.g. mallee). Assessments of these EVCs must be standardized following deletion of the tree canopy cover and/or large tree components, as per benchmark statements. Occasionally, trees may also detract from a vegetation community. Treeless communities that now have trees recruited naturally from adjacent treed areas or have had trees planted may score suboptimally. Benchmark statements for EVC will provide information relevant to the presence of both native and 'weedy' trees.

Table 2. Criteria and scores for the number of large trees† present

Large trees	Level of canopy health (%)‡ > 70%	30–70%	< 30%
None present	0	0	0
0–20% of the benchmark number of large trees/ha	3	2	1
20–40% of the benchmark number of large trees/ha	4	3	2
40–70% of the benchmark number of large trees/ha	6	5	4
70–100% of the benchmark number of large trees/ha	8	7	6
≥ the benchmark number of large trees/ha	10	9	8

†Large trees defined by d.b.h. – see Ecological Vegetation Classes (EVC) benchmark. Scoring includes both living and dead large trees.
‡Health of large trees assessed by estimating the proportion of expected canopy cover that is missing due to tree death, decline or mistletoe infestation.

Table 3. Criteria and scores for the tree canopy cover component

Canopy cover	Level of canopy health (%)† > 70%	30–70%	< 30%
> 90% variation from benchmark tree cover	0	0	0
50–90% variation from benchmark tree cover	3	2	1
< 50% variation from the benchmark tree cover	5	4	3

†Health of large trees assessed by estimating the proportion of expected canopy cover that is missing due to tree death, decline or mistletoe infestation.

Table 4. Criteria and scores for the lifeforms of indigenous understorey vegetation present

First decision	Second decision	Value
All strata and lifeforms effectively absent		0
Up to 50% of lifeforms present		5
≥ 50–90% of lifeforms present	Of those present ≥ 50% substantially modified	10
	Of those present < 50% substantially modified	15
≥ 90% of lifeforms present	Of those present ≥ 50% substantially modified	15
	Of those present < 50% substantially modified	20
	Of those present, none substantially modified	25

Cover refers to projective foliage cover.
Include dead material if part of the natural seasonal cycle of that particular species/lifeform.
Where a benchmark includes annual or seasonal species/lifeforms: if it is the wrong season for the lifeform to be present, take a precautionary approach and assume that the lifeform is present. Otherwise assess as usual.
Effectively absent: where the benchmark cover for lifeform is ≥ 10%, then 'effectively absent' if < 10% of benchmark cover or diversity.
Where the benchmark cover for a lifeform is < 10%, then 'effectively absent' if no reproductively mature specimens observed.
Substantially modified: where the benchmark cover for a lifeform is ≥ 10%, then 'substantially modified' if < 50% of benchmark cover or < 50% of benchmark richness.
Where the benchmark cover for a lifeform is < 10%, then 'substantially modified' if the lifeform(s) is present and yet < 50% of benchmark diversity.

Table 5. Criteria and scores for the cover of non-indigenous and native 'weed' plant species present

Weed cover	% of weed cover due to 'high-threat' weeds		
	None	≤ 50%	> 50%
> 50% cover of weeds	4	2	0
25–50% cover of weeds	7	6	4
5–25% cover of weeds	11	9	7
< 5% cover of weeds	15	13	11

Understorey components

The greatest richness of plant species and vegetation lifeforms at a site will almost always be found in the various shrub and forb/herb strata of a community. The complexity and importance of the understorey are clearly reflected in the elevated weighting (25%) of this component. This weighting also reflects an assertion that understorey components can be useful indicators of site disturbance and are important for identifying and recording future improvements in site condition.

For the purposes of this assessment, canopy trees (i.e. > 80% of mature height) are excluded by having been assessed in the previous two components, but immature trees (i.e. < 80% of mature height but > 5 m) and subordinate trees (i.e. fully grown trees of non-canopy species) are included. The understorey assessment includes only indigenous plant species. While weed species may have value as habitat for some fauna, overall habitat value (for both flora and fauna) is closely linked to the 'naturalness' and, hence, the cover and diversity of indigenous species.

Identification of all plant species at all life stages and vigour requires considerable botanical expertise. This skill level will be beyond the capabilities of many condition assessors. Primarily, for this reason, and in the interests of between-observer consistency, the assessment of the understorey components has been based upon the lifeforms present and the estimated diversity of species within these lifeforms (i.e. groupings of plant species sharing a similar three-dimensional structure and dimensions). Examples of lifeform strata include shrubs, herbs, vines/lianes, tufted graminoids, epiphytes and moss/lichen/soil crusts. While these classes are best treated discretely, there will often be useful subclasses within these groupings (e.g. tall and low shrubs).

Assessment of this component requires the observer to first recognize the range of lifeforms present compared to those expected and, second, consider the diversity and cover within each lifeform (i.e. degree of modification; Table 4). While recording the full floristic composition of the stand is unrealistic, assessors should be able to identify a small range of character species and to estimate the number of different species within each lifeform. This level of expertise is also essential for the correct identification of the EVC, an important first step in the whole assessment process. EVC benchmarks will identify the appropriate lifeforms and character species, along with EVC descriptions, notes and stylized vegetation profiles. Estimating cover can be inherently unreliable (Chiarucci *et al*. 1999; Van Hees & Mead 2000), and cover estimations below 10% are generally avoided.

As with the treatment of saplings and trees, the observer is asked to assess what is currently present and not what may be present in the future. For example, heavily grazed 'large tufted graminoids' may be recorded as 'small tufted graminoids' and 'large tufted graminoids' may be considered absent, but may be recorded later if adequate growth followed the removal of grazing.

Cover of weeds

Weeds are plants that can compete successfully with native species and can dominate a site to the exclusion of native plants (Stanton 1994), leading to a change in site conditions so that indigenous plant species formerly present are suppressed (Christian & Wilson 1999). Weeds may change the fuel or litter characteristics of a site, thereby altering the fire regime, and may prevent recruitment of dominant species (Bowman 1999). Consequently, this component receives a relatively high proportional weighting within the habitat score.

Most weed species are derived from overseas (Kloot 1984; Groves & Hosking 1997), but native species can also become weeds when their localized ranges expand or they are imported from elsewhere in Australia (Low 1999; Smith 2000). Native species that would not normally have occurred within the stand are considered as weeds for this component (e.g. eucalypt species inappropriately planted in native grasslands or locally native shrubs that have dispersed from adjacent habitats into grasslands would be considered weeds; Table 5).

Weediness will be assessed by cover (i.e. averaged total projective foliage cover across the stand) and the percentage cover of 'high-threat' weed species. Weeds will be categorized as low, moderate or high threat on the basis of 'invasiveness' and 'direct physical impact' for each vegetation type (McIntyre 1990) and a list of weed species and their threat level will be included within EVC benchmarks. Regional listings of weeds will be regularly updated to accommodate new and emerging taxa.

Recruitment

The 'habitat hectare' method attempts to assess evidence of the long-term viability of the stand. The demonstrated potential for the recruitment of plant species within all major lifeforms and strata is an essential part of the long-term site viability. Ideally, recruitment would be assessed across all lifeforms and species. However, many species at a site may be ephemeral (e.g. many herbaceous species) and recruitment can be difficult to quantify. To maintain consistency between assessments, this component focuses upon woody perennial species. Assessments are also confined to plants beyond the initial seedling (or early germinant) stage and present for at least a full annual cycle of seasons for perennials.

The question of whether a recruitment event has occurred or not is the first question addressed in assessing this component, while the second and third questions address whether this is linked to disturbance events (e.g. fire, flooding), where these are known to initiate recruitment (Table 6). Recruitment of many species of woody trees and shrubs may be infrequent, episodic or unpredictable. For example, eucalypts in many mallee communities may only regenerate immediately following fires, which may be > 60 years apart (Wellington & Noble 1985). The absence of recruitment after a suitable time following a disturbance event is considered as 'recruitment failure'. This may manifest as 'poor' or 'sporadic' regeneration and may constitute a serious problem for the long-term viability of the vegetation remnant. In contrast, an absence of recruitment without appropriate cues is not considered as recruitment failure.

Due to the long intervals between many vegetation recruitment events, assessment of this component of the habitat score is occasionally difficult. Assessment of recruitment is easier at sites dominated by native woody perennial species. In other EVC (e.g. Grassland and Grassy Woodlands EVC) it is more difficult to appraise recruitment. Consequently, these EVC will be dealt with on a case-by-case basis in benchmarks.

Organic litter

Litter is defined here as including both fine and coarse plant debris less than 10 cm diameter. The cover of litter can be indicative of the degree of disturbance of a site and can also be important for the recruitment of some plant species by directly influencing the soil microclimate, struc-

Table 6. Criteria and scores for the recruitment of woody perennial native species present

First decision	Second decision	Third decision	Proportion of benchmark no. woody species ≥ 50%	< 50%
No evidence of a recruitment 'cohort'†	If recruitment is being assessed within an EVC *not* driven by episodic events		0	0
	If recruitment is being assessed within an EVC driven by episodic events‡	Clear evidence of appropriate episodic event	0	0
		No clear evidence of appropriate episodic event	5	5
Clear evidence of at least one recruitment 'cohort' in at least one woody lifeform	Proportion of native woody species present that have adequate recruitment§	< 30%	3	1
		30–70%	6	3
		≥ 70%	10	5

†'Cohort' refers to a group of woody plants established in a single episode.
‡refer to Ecological Vegetation Classes (EVC) benchmark data for clarification.
§Adequate recruitment:
For overstorey trees: If tree canopy cover is less than benchmark then 'adequate' means that there is estimated to be enough recruitment present to re-establish the benchmark cover (assuming favourable circumstances over time) and there is more than one cohort present.
If tree canopy cover is greater than or equal to the benchmark then 'adequate' means that there is more than one cohort present.
For understorey species with continuous recruitment then 'adequate' means the number of immature plants is at least 10% of the number of mature plants.

ture and composition, and can provide an important habitat component for many fauna species (Abensperg-Traun *et al.* 2000). Benchmark values for litter are difficult to determine (i.e. knowledge of litter levels for different vegetation types requires a knowledge of fire frequencies and litter accumulation rates and these data are poorly known for most vegetation communities). Consequently, the primary inflection point for scoring organic litter is coarse (i.e. ± 50%; see Table 7).

Table 7. Criteria and scores for the cover of ground level litter present

Litter cover	% of litter cover due to native species ≥ 50%	< 50%
< 10% of expected cover	0	0
< 50% or > 150% of expected cover	3	2
≥ 50% or ≤ 150% of expected cover	5	4

Table 8. Criteria and scores for the cover of logs present

Total log length	Proportion of log length more than half of the large tree benchmark diameter ≥ 25%	< 25%
< 10% of benchmark length	0	0
< 50% or > 150% of benchmark length	3	2
≥ 50% or ≤ 150% of benchmark length	5	4

Logs

As with litter, logs have considerable influence upon the vegetation community by affecting soil moisture, structure and nutrition, and enhancing recruitment of some plant species (Howard 1973). The presence/absence of logs can also be indicative of disturbance processes, depending on the vegetation community and past land use. Logs also provide habitat for many fauna species, ranging from invertebrates to reptiles and ground-dwelling mammals (Traill 1993; Lohr *et al.* 2002). Logs are defined here as timber fallen and substantially detached from the parent tree, with a lower limit for diameter of 10 cm (variations may be specified in EVC benchmark statements). Dead cut stumps of a height less than 0.5 m are also included in the log assessment, acknowledging that they may provide useful habitat in areas where few logs exist. Scoring is determined by comparing the estimated combined length of logs within a 1000-m^2 sample to combined lengths indicated in the benchmark (Table 8). Similarly, with litter, benchmark values for logs are difficult to derive and the scoring of this component is based upon broad breakpoints. Vegetation communities that lack trees (e.g. grasslands, heathlands) will also lack logs and habitat scores should be standardized as per the EVC benchmark.

'Landscape context' components

Vegetation quality assessments are made from an appraisal of seven different components relating directly to the site. However, the quality and long-term survival of vegetation is also dependent on a suite of other factors influencing the site. These 'landscape context' components are assessed beyond the site and are best calculated using GIS for optimal accuracy and consistency. Nevertheless, it is possible to undertake a simplified form of these assessments in the field with the aid of maps and other data.

Patch size

The size of a patch (i.e. contiguous area) of remnant vegetation is thought to play an important role in its long-term viability (Gilfedder & Kirkpatrick 1998; Lonsdale 1999), with larger patches having a better prognosis for long-term survival (Drayton & Primack 1996; Renjifo 1999). Many factors such as 'edge effects' contribute to the demise of native vegetation fragments, including invasion by weed species (Morgan 1998a; Laurance *et al.* 2002). Species–area relationships suggest that large areas tend to support more species and populations than smaller ones (Burbidge *et al.* 1997), thus retaining greater genetic variability and providing refuge for species susceptible to disturbances (Fischer & Stocklin 1997). For this assessment, a patch can contain several stands and/or several types of vegetation, providing they are contiguous (Table 9).

Table 9. Criteria and scores for the area of the nominated patch

Area	Score
< 2 ha	1
≥ 2 but < 5 ha	2
≥ 5 but < 10 ha	4
≥ 10 but < 20 ha	6
≥ 20 ha but 'significantly disturbed'†	8
≥ 20 ha but 'not significantly disturbed'	10

†Defined in the Regional Forest Agreement Old Growth analyses (NB: effectively all private land remnants in the rural landscape are classified as 'significantly disturbed').

Neighbourhood

The degree of connection between areas of remnant vegetation is also likely to influence both regenerative capacity and long-term viability (Cunningham 2000). While fauna are relatively mobile across the landscape, plants can also 'move' by taking advantage of newly suitable habitat (Morgan 1998b). The ability of plants to occupy new sites is dependent on the arrival of viable propagules at new sites and is, therefore, dependent upon connectivity. Connections may be either broad or narrow physical linkages (e.g. adjacent vegetation stands or narrow corridor 'links') or, alternatively, a disparate (i.e. unlinked) spacing of vegetation fragments that nevertheless allows for the movement of individuals or the dispersal of biotic propagules.

This component assesses the degree of both 'linked' and 'unlinked' native vegetation in the 'neighbourhood'. A total of three 'neighbourhoods' within nested radii (i.e. 100 m, 1 km, 5 km; Fig. 1) are scored and summed (Table 10). The centre of the scoring circles is located at the centroid of the stand being assessed. The question

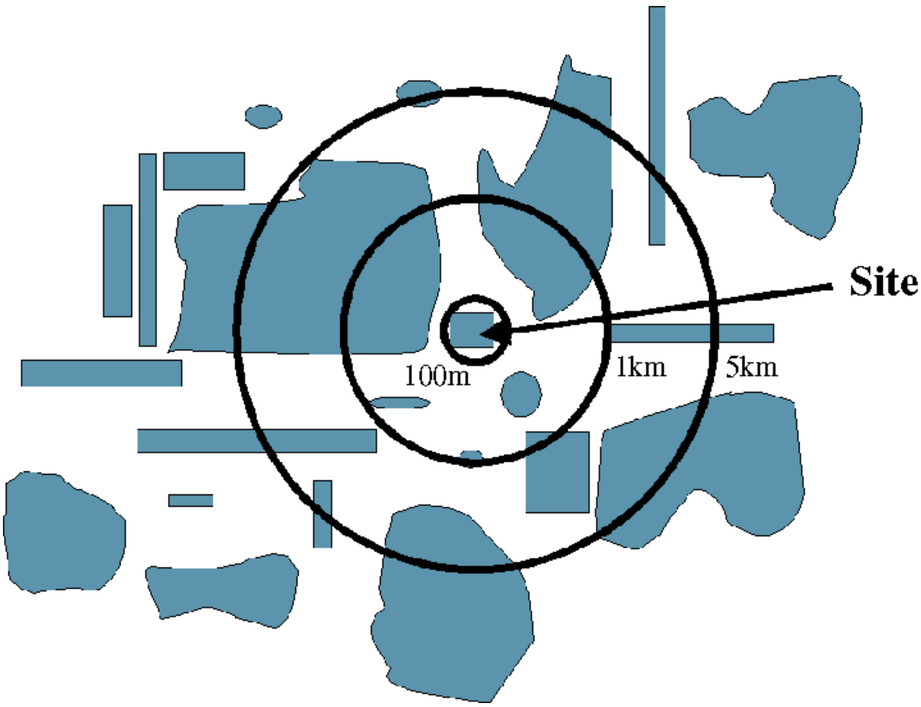

Figure 1. The principle of neighbourhood analysis for vegetation quality assessments. (Diagram not to scale.) Using the scenario in Fig. 1 the neighbourhood score for the site shown would be 3.2 (Table 10).

Table 10. Example calculation of the neighbourhood component for the stand shown in Fig. 1[†]

Radius	% Native vegetation (approx.)	Weighting	Score
100 m	*80*	0.03	2.4
1 km	*40*	0.04	1.6
5 km	*40*	0.03	1.2
		Sub-total	5.2
[‡]'Significantly disturbed'			– 2.0
		Total	3.2
		Total (rounded)	3.0

[†]Italicized figures indicate those estimated in the field.
[‡]If the majority of the neighbourhood (> 50% of 5 km radius) is 'significantly disturbed', as defined in Regional Forest Agreement Old Growth analyses, then subtract 2 from subtotal. (NB: effectively all private land remnants in rural landscapes are usually classified as 'significantly disturbed'.)

Table 11. Criteria and scores for the distance to core area

Distance	Score
> 5 km	0
1–5 km	2[†]
< 1 km	4[†]
Contiguous	5[†]

[†]If core area is 'significantly disturbed' as defined in Regional Forest Agreement Old Growth analyses, then subtract 1.

asked of the observer for each neighbourhood is: 'What proportion of the area within a radius is covered by native (i.e. locally indigenous) vegetation?' To simplify this process, 20% intervals are used (i.e. 0%, 20%, 40%, etc.) for assessing each radius. This analysis will be most accurately and consistently determined using a GIS, but can also be approximated in the field.

Distance to core area

The final component in the landscape context assessment is an estimation of the distance to the nearest 'core area'. For the purposes of this assessment, a 'core area' is defined as a block of native vegetation greater than 50 ha. Where a site is part of a vegetation patch greater than 50 ha, the site would be considered contiguous and would score maximum points. Again, this component is most accurately assessed using GIS, but can be broadly determined using Table 11.

Final habitat score

The final 'habitat score' for the stand is determined by recording and tallying the scores from all 'site condition' and 'landscape context' components (Table 1) and standardizing scores if required by the benchmark. Multiplying the 'habitat score' by the area of the stand offers a quality-quantity measure that is termed a 'habitat hectare'. For example, 10 hectares of mature, fully natural Wet Heathland could be counted as 10 'habitat hectares', whereas 10 hectares of this EVC with a 'habitat score' of 50% would be scored as five 'habitat hectares'.

The 'habitat score' represents the proportion of the complete 'habitat' present and the highest score possible is 100 points. This score would require excellent site condition and for the stand to effectively be part of a 'wilderness' area. This is considered an unlikely situation for most remnant vegetation. In trials conducted to date, high-quality remnants have occasionally scored higher than 80 points, while stands of native vegetation in very poor condition rarely scored lower than 10 points. Research is currently being completed to determine the precision and accuracy of this habitat scoring procedure.

Further work required

While the 'habitat hectares' approach is thought to have wide applicability to vegetation quality assessments, a number of limitations are recognized and these highlight the need for further work. Assessments of treeless vegetation types require the removal of inappropriate components (large trees, tree cover, logs and possibly recruitment of woody perennials) and standardizing the habitat score for the remaining components. However, this reduces the level of discrimination possible within these vegetation types and further work is required to address this limitation. A similar situation occurs in the assessment of wetlands. Assessment of wetlands is also complicated by temporal variation in lifeforms and species diversity that are dependent upon water regimes, and the 'landscape context' component will require further development to include consideration of catchment-level processes.

Although the 'habitat hectares' approach has been developed for extant native vegetation, it may be feasible to use a similar approach for assessing the quality of revegetation using native species. For example, an approach based on 'habitat hectares' has been developed for assessing riparian revegetation efforts, but still requires further development.

Conclusion

There is value in emphasizing key operational points made earlier. First, this approach requires a reasonable level of local knowledge and requires assessors to be aware of their capabilities and skills prior to undertaking field assessments. Second, valid assessments can only be made with reference to a benchmark statement for the vegetation community being assessed. Finally, assessors need to separately record each component of the habitat score rather than just the final score to enable temporal comparison between assessments.

The need for the retention of diverse and healthy native vegetation communities in our landscapes is well recognized. Maintenance of these communities across short- and long-term horizons requires both active and passive management based upon informed and explicit decisions relating to habitat quality. Attempting to develop an assessment approach that works for all types of vegetation in patches of all shapes and sizes has been an ambitious task. While the approach detailed here has undergone critical review by a number of experienced ecologists and botanists, it will undoubtedly continue to develop. In the meantime, it should be used thoughtfully. Several years ago, the notion of 'condition assessments' was considered novel and innovative. In the near future, it is hoped that such approaches may become more common.

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